PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA

DISEÑO E IMPLEMENTACIÓN DE UN SISTEMA DE MONITOREO DE DESEMPEÑO DE UNA MICRO-RED BASADA EN PANELES SOLARES Y TURBINAS EÓLICAS

Tesis para obtener el título profesional de Ingeniero Electrónico

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RESUMEN

En el presente trabajo de tesis se diseñó e implementó un sistema de monitoreo de adquisición y registro de los parámetros eléctricos y atmosféricos para el control de desempeño de una micro-red eléctrica híbrida. Se propone un sistema que cumpla con los estándares, como la Comisión Electrotécnica Internacional (IEC por sus siglas en Inglés), que sea de bajo costo, debido a que su diseño cumple únicamente con lo estrictamente necesario para la adquisición de datos, para el tamaño de la micro-red eléctrica formada por paneles fotovoltaicos y turbinas eólicas de 12KW de potencia total, que se encuentra instalada en una zona costera de Lima, alejada del sistema eléctrico nacional y que provee de energía eléctrica a la población de la zona.

En este documento se detalla el estudio realizado de las tecnologías existentes correspondientes al monitoreo de micro-redes eléctricas y el diseño del sistema. Concluyendo con su implementación y verificación de los resultados obtenidos mediante este sistema.

Este trabajo de tesis está dedicado a aquellas personas que demuestran día a día que lo imposible puede realizarse cuando hay amor de por medio.

A todas las personas de escasos recursos económicos que llevan adelante a sus familias.

A aquellos habitantes de pueblos rurales que sufren la exclusión social.

A quienes viven en la oscuridad pues carecen de energía eléctrica.

A aquellos que el mundo ha olvidado pero que Dios siempre tiene presentes.

Richard Vicente

Quiero agradecer en primer lugar a aquel que lo hace todo posible, el que permitió que esté donde estoy y sobre todo haber conocido su gran amor. Gracias Abba, porque tu amor nos conducirá hacia un mundo mejor.

A mis padres, quienes me criaron con un ejemplo firme de sacrificio y entrega, quienes me apoyaron siempre cuando más los necesitaba, me dieron todo lo que pudieron y más.

A mis hermanos, Andy y Darleen, porque siempre estaban conmigo en las buenas y las malas, porque un hermano es para toda la vida.

A todas aquellas personas que formaron parte de mi vida en algún momento de la historia, porque sin ellas no sería quien soy.

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INTRODUCCIÓN

Durante la última década, la demanda de energía y la preocupación por la contaminación del medio ambiente se han ido incrementando dramáticamente. Esto ha ocasionado que la generación centralizada de energía y su distribución a través de largas distancias a altos niveles de tensión no sean óptimas para las necesidades futuras, así como de zonas rurales y/o alejadas que no cuentan con acceso a la red eléctrica [1].

Dentro de este panorama es que surgieron las micro-redes eléctricas; sistemas que pueden solucionar algunos de los problemas presentes en las redes de generación eléctrica convencionales. Sin embargo, estas micro-redes, que se encuentran en proceso de investigación, no pueden funcionar sin supervisión para que sean más eficientes.

Con el fin de solucionar el inconveniente de la falta de supervisión, se emplean sistemas de monitoreo; siendo el principal problema que estos suelen ser de alto costo por las múltiples funciones que poseen, las cuales no son empleadas en su totalidad. Lo que implica que en pequeños proyectos de esta índole no sean viables. En vista de la necesidad de contar con un sistema de desempeño confiable y de bajo costo, se vienen realizando estudios para encontrar las soluciones más adecuadas.

El objetivo de este proyecto es diseñar e implementar un sistema de monitoreo que adquiera y registre los parámetros eléctricos y atmosféricos de una micro-red, en base a los métodos recomendados por la IEC y que sea adecuado para la micro-red eléctrica formada por paneles fotovoltaicos y turbinas eólicas de 12KW de potencia total, que se encuentra instalado en una zona costera de Lima, alejada del sistema eléctrico nacional.

Así mismo, como parte del sistema, se debe diseñar e implementar el acoplo de los sensores hacia el dispositivo principal de monitoreo. A su vez, se tiene como objetivo complementario el desarrollar el dispositivo central de monitoreo que convierta, procese y almacene las señales anteriormente mencionadas.

CAPÍTULO 1: MICRO-REDES ELÉCTRICAS

1.1 Definición

Una micro-red eléctrica es un grupo de fuentes de energía distribuida, como paneles solares o turbinas eólicas, ubicadas en el lado de distribución de la red y que puede proveer de energía a pequeñas áreas geográficas. [2]

1.2 Características y Aplicaciones

Las micro-redes poseen características que las diferencian de las redes eléctricas convencionales. Por ejemplo:

- Utilizan fuentes de energía renovables
- Trabajan a menor tensión comparado con las redes de energía tradicionales.
- Pueden trabajar de dos formas:

- Conectado a la red: La micro-red puede consumir o entregar energía a la red principal de energía.
- Aislado: La micro-red trabaja de forma independiente, necesita de un sistema de respaldo como baterías o un grupo electrógeno. Este es el modo más común en las zonas rurales donde la red eléctrica no llega. [1]

Las micro-redes constan de 6 componentes o etapas:

- Generación: En esta etapa se genera la energía eléctrica a través de los distintos equipos como paneles solares, turbinas eólicas, etc.
- Regulación: Se encarga de regular los valores variables provenientes de los generadores hacia un valor fijo o variable constante.
- Almacenamiento: Consta de sistemas capaces de almacenar la energía eléctrica proveniente de los generadores. Pueden ser baterías, condensadores de ultra capacidad, etc.
- Cargas: Compuesta por distintos tipos como motores, alumbrado, etc.

- Interruptores: Son los puntos de interconexión entre los demás componentes. Por ejemplo: generación y almacenamiento, control y carga, etc.
- Control: Esta etapa se encarga de controlar los niveles de energía generados, almacenados y suministrados para evitar daños en la micro-red. [3]

1.3 Fuentes de Generación de Energía Renovable

Son aquellas que hacen uso de recursos de energía renovable (recursos que no se agotan, o se regeneran de forma natural en un corto tiempo) para generar energía eléctrica. Entre los principales recursos de energía se puede encontrar [4]:

- Solar: Se aprovecha mediante el uso de paneles fotovoltaicos, también llamados paneles solares; son superficies, usualmente planas, que contienen un conjunto de celdas solares. Estas celdas trabajan bajo el proceso fotovoltaico que significa convertir energía solar (rayos solares, fotones) en energía eléctrica (niveles de tensión). Los paneles fotovoltaicos han ido evolucionando en las últimas décadas; a lo largo de este tiempo se pueden distinguir tres generaciones de celdas solares, las cuales representan un avance en la relación costo-efectividad. [5]. Actualmente, en muchas partes del mundo es común el empleo de paneles solares de forma casera (especialmente en Europa) puesto que su uso es eficiente y no muy complicado, sin embargo también se las puede encontrar en largos campos abiertos. Cuando se tiene grandes áreas cubiertas por estos paneles, se les conoce como granjas solares.
- Eólica: Para su obtención se hace uso de turbinas eólicas. Estos dispositivos funcionan transformando la energía generada por la fuerza que aplica el viento sobre sus aspas en energía eléctrica. Suelen estar montadas en altos niveles para aprovechar su rendimiento. Es común que se les encuentre de forma aislada en aplicaciones distintas como el bombeo de agua o comunicaciones. Esto se debe a que el giro de las aspas hace girar un motor, que puede generar energía eléctrica o mecánica

dependiendo de la necesidad del usuario. En aplicaciones de energía se les puede encontrar en conjunto con paneles solares. [6]

1.4 Declaración de la Problemática

En aplicaciones de fuentes de energía renovables, la adquisición de datos y el sistema de monitoreo son esenciales para recolectar información acerca del rendimiento del sistema instalado y para varios propósitos de evaluación [7].

El comportamiento de estos sistemas es complejo y variable debido a factores que no se pueden controlar, como los cambios de factores climáticos [8].

Los datos requeridos para el monitoreo de este tipo de sistemas son: tensión, corriente y potencia de los generadores; tensión, corriente y potencia de la red; irradiación solar, velocidad y dirección del viento, y temperatura ambiente [7].

La tendencia a nivel mundial, correspondiente a la industria, es emplear los estándares propuestos por la IEC que son más generales y pueden ser ampliamente distribuidos. Esto se ve justificado gracias a que el costo de este sistema, a pesar de ser elevado, genera en la micro-red un mejor entendimiento y aprovechamiento que se traduce en mayores ingresos. Sin embargo, a nivel de estudios o proyectos de investigación, se busca realizar sistemas de monitoreo dimensionados específicamente para cumplir los objetivos planteados.

Más adelante se procederá a detallar algunos casos de sistemas de monitoreo orientados a micro-redes para evaluar la situación actual en la que se encuentran. Del mismo modo se buscará encontrar los elementos comunes entre estos sistemas a fin de poder contar con una idea general de su composición y funcionamiento.

1.5 Análisis de la Problemática

El tema de tesis propuesto está orientado a una micro-red eléctrica con características de potencia y fuentes de generación particular, pero busca poder ser aplicable en distintos escenarios.

La micro-red en cuestión es aislada y está conformada por paneles solares y turbinas eólicas y cuenta, además con un datalogger que, junto con los sensores, realizan la función de monitoreo. Siendo el datalogger el dispositivo encargado de almacenar los datos registrados.

Este sistema implementado constituyó un gran costo para la compañía, sin embargo, este equipo es capaz de medir valores meteorológicos únicamente. Esto ocasiona que no se tenga un registro de los parámetros eléctricos presentes en la micro-red y por consiguiente no se pueda hacer una evaluación de eficiencia energética.

Es en base a esta necesidad que se buscará diseñar e implementar un sistema de monitoreo que sea capaz de medir no solo parámetros atmosféricos, sino eléctricos también para que puedan ser almacenados y analizados.

CAPÍTULO 2: SISTEMAS DE MONITOREO DE DESEMPEÑO

2.1 Estado del Arte

2.1.1. Estado de la investigación

En la actualidad, existen diversos sistemas de monitoreo de desempeño enfocados a sistemas de generación de energías renovables. Muchos de estos se integran con sistemas de supervisión y control; sin embargo, estos suelen ser más complejos que los requeridos, por lo que su precio se eleva.

Como se puede observar en la referencia [9], un sistema de monitoreo de desempeño (SMD), por más básico que sea, debe poder gestionar un gran número de datos de forma automática. Para lograr acceder y elaborar cálculos en grupos relevantes de datos, se debe contar con tres etapas principales:

- Adquisición de datos: Conformado por sensores y transductores, se encarga de recopilar datos del sistema y/o entorno.
- Almacenamiento: Encargado del almacenamiento de los datos adquiridos. Puede ser un dispositivo externo dedicado o interno al sistema.
- Procesamiento de datos: Consiste en procesar los datos obtenidos para brindar una información que sea entendible por el usuario.

Dependiendo de los requerimientos y necesidades del sistema, así como su entorno, el sistema de monitoreo puede ser alámbrico o inalámbrico.

Por ejemplo, en el sistema de mediciones implementado en la Universidad Distrital Francisco José de Caldas ubicada en Bogotá, Colombia; referencia [8], se hace uso de una Red Inalámbrica de Sensores (WSN por sus siglas en inglés).

Una WSN está conformada de 2 tipos de nodos, nodo sensor y nodo sumidero. Esta se conecta luego a un servidor que sirve de puerta entre la WSN y un administrador de tareas que se encarga del procesamiento de los datos, tal como es ilustrado por la figura 1.

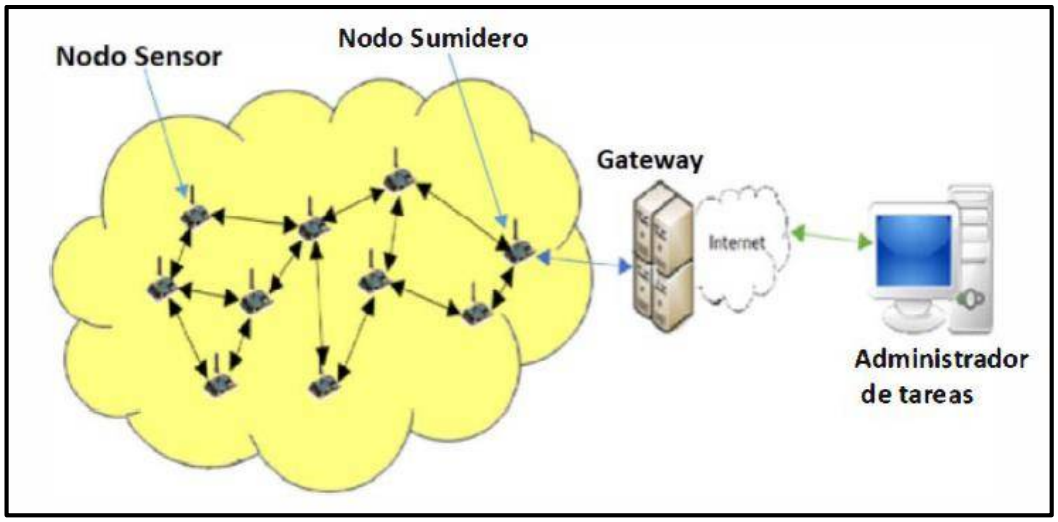


Figura 1. Clásico despliegue de una WSN [8]

Tal y como detalla la referencia [8], el tipo de tecnología de comunicación a implementarse depende básicamente del arreglo geográfico donde un nodo de sensor ha sido posicionado y que depende del despliegue geográfico de la micro-red. De esta forma se puede hacer uso de wi-fi, ondas microondas, fibra óptica, entre otros.

Para la adquisición de datos se empleó un sistema AMI (Infraestructura Avanzada de Medición en inglés) que es capaz de adquirir información en tiempo real o a ciertos intervalos. El sistema AMI tiene como características más importantes: fecha y tiempo exacto de medición, habilidad para auto-detectar, configurar y reparar problemas de configuración, habilidad de lectura remota, precisión de datos adquiridos de la red.

Un esquema general de este sistema es presentado en la figura 2, donde los sensores adquieren los datos deseados que luego son transformados de señales analógicas a digitales por los ADC. Para después ser procesados y almacenados en un módulo de datos.

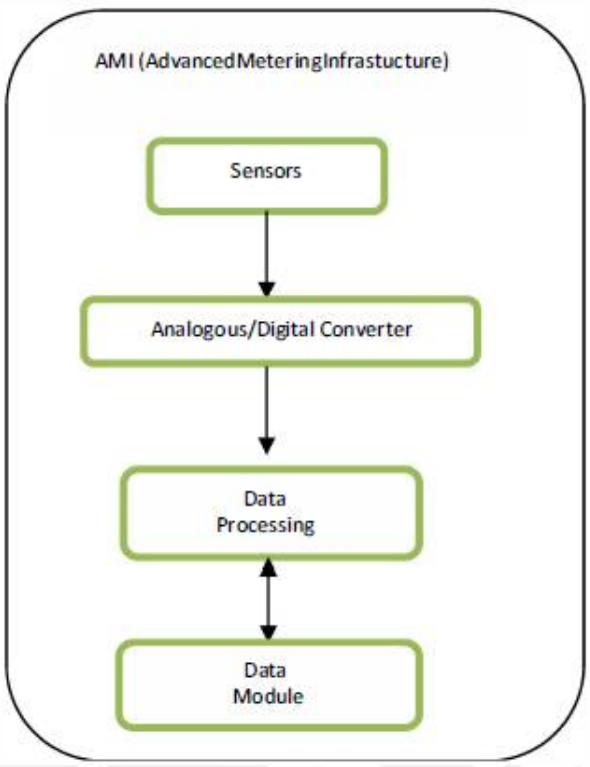


Figura 2. Esquema general de un colector o nodo sensor para un sistema AMI [8]

De permitirlo el despliegue del sistema, los nodos de sensado pueden ser conectados de forma alámbrica y disminuir costos.

Si bien es cierto que el tema de micro-redes es relativamente nuevo, ya existen ciertos estándares como la IEC 61850 o la IEEE 1547 que buscan regularizar su diseño, operación y control.

En la referencia [10] se detalla los resultados de una encuesta realizada sobre los distintos sistemas de monitoreo actuales correspondientes a Paneles Fotovoltaicos. Así mismo, estos sistemas pueden ser aplicados para la medición de eficiencia de las turbinas eólicas.

A continuación se presenta los métodos evaluados:

a) El primer método sigue las instrucciones de la Comisión Electrotécnica Comercial (IEC por sus siglas en inglés). Este método es el más usado por estudios enfocados en la evaluación inicial del sistema. El método es más costoso debido a que requiere equipos apropiados de sensado y adquisición de datos. Para el escenario de paneles fotovoltaicos se cuenta

con la norma IEC 61724, mientras que para las turbinas eólicas se tiene la norma IEC 61400-12-1 [10].

b) Un segundo método consiste en utilizar los dispositivos de regulación ya empleados en el sistema. Este método permite un ahorro de componentes, presupuesto, así como de espacio. El inconveniente radica en la manipulación del dispositivo para realizar las modificaciones pertinentes. En el caso de paneles solares se puede hacer uso del regulador Seguidor Punto de Máxima Potencia (MPPT por sus siglas en inglés) o Modulación por Ancho de Pulsos (PWM); mientras que en las turbinas eólicas, el inversor.

c) Otro método conlleva la especialización en el caso de estudio. Esto quiere decir que, dependiendo de la situación exacta de estudio o proyecto, se implementa un forma novedosa de monitoreo. Por ejemplo, la Unión Europea, en su proyecto PVSAT-2, adoptó un método que hace uso de un satélite y un sistema de bajo costo de interfaz de usuario para monitorear un sistema fotovoltaico [10].

d) Dependiendo de dónde se realicen las mediciones, los datos varían y con ellos la aplicación de estudio. Por ejemplo, en [11] se realizan las mediciones en cada celda del panel PV. Esto debido a que se buscaba medir de forma indirecta la eficiencia de estos paneles. En el caso de una micro-red, los puntos de medición suelen ser en las distintas etapas, tratando de no profundizar en cada elemento.

2.1.2. Síntesis sobre el asunto de estudio

Los sistemas de monitoreo de desempeño son indispensables para tener los datos en tiempo real de las micro-redes o redes de generación; Ya sea que se tenga como fin la evaluación del desempeño del sistema, el control o supervisión del mismo. Para que se pueda diseñar e implementar estos sistemas de monitoreo se debe tener en consideración, no solo los factores que intervienen, sino también el motivo y finalidad que se le dará.

2.2 Dispositivos para Adquisición de Datos

Son aquellos dispositivos encargados de sensar parámetros y señales para que puedan ser procesadas; ya que en su estado inicial no son reconocidas por el procesador, o pueden dañar el sistema.

En el presente sistema se requiere hacer la medición de las siguientes variables:

a) Tensión Alterna: Es la más común en redes de potencia ya que es la usada por los dispositivos de consumo eléctrico. Su valor suele ser elevado para los ADC, por esto se acondiciona la señal. Algunos de los métodos de acondicionamiento son los siguientes:

- Divisor resistivo: Consiste en utilizar un arreglo de resistencias que divide el valor de tensión entre algún factor de relación. El mayor problema de este método es la pérdida de energía.
- Transformador de tensión: Transforma el valor de tensión mediante un factor de transformación. Tiene como ventaja que la pérdida de energía depende de la calidad del transformador, mas suele ser mínima. Solo pueden ser empleados en tensión alterna.

b) Tensión Continua: Componentes como los paneles fotovoltaicos o las baterías entregan tensión continua. Su valor también suele ser elevado, por eso se emplea el siguiente método de acondicionamiento:

- Divisor resistivo: Arreglo de resistencias que divide el nivel de tensión. Presenta pérdidas de potencia.

c) Corriente Alterna: Debido a que los ADC funcionan con valores de tensión, se debe buscar una relación entre la corriente que se desea medir y la tensión obtenida. Para esto existen los siguientes tipos de transductores:

- Resistencia shunt: Es una resistencia muy pequeña que se coloca en serie con la línea de energía. La tensión generada en los extremos de esta resistencia es proporcional a su corriente y es de un valor pequeño.

- Transformadores de corriente: Aprovecha el campo magnético alrededor de la línea para generar un valor de tensión proporcional a dicha corriente. Estos transformadores pueden ser de distintas formas dependiendo del diseño de su núcleo.

✓ Núcleo entero: El núcleo es de una sola pieza. Necesita interrumpir la conexión de la red para que el cable pase por su centro.

Figura 3. Transformador de corriente de núcleo entero [12]

✓ Núcleo partido: Cuenta con una apertura por la cual puede ingresar el cable de corriente. No necesita interrumpir la conexión de la red.

Figura 4. Transformador de corriente de núcleo partido [13]

d) Corriente Continua: A diferencia de la corriente AC, un transformador común no podría detectar la corriente DC puesto que no varía constantemente. Para poder medir su corriente se usan los sensores de efecto Hall:

- Circuito integrado: Detecta el campo electromagnético inducido por la corriente y lo transforma en un valor de tensión para que pueda ser medido.
- Transformador de corriente toroidal: Este transformador incorpora un sensor de efecto Hall en el núcleo, que le permite sensar la corriente DC que pasa por su interior.

e) Velocidad de viento: Es proporcional a la energía generada por los aerogeneradores. Por lo tanto su medición es importante para evaluar el desempeño de las turbinas. Esta se realiza mediante un aparato llamado anemómetro, el cual transforma la energía del viento en una señal eléctrica cuya frecuencia es proporcional a la velocidad del viento

f) Dirección de viento: Las corrientes de aire tienen su estudio propio, el cual es usado para provecho de las instalaciones. Por ende es vital evaluar que vientos son los que transitan por la micro-red. La dirección se evalúa mediante una veleta que transforma la dirección del viento en un nivel de tensión proporcional a la misma.

g) Intensidad luminosa: Los paneles fotovoltaicos funcionan transformando la energía luminosa en eléctrica. Siendo la intensidad luminosa proporcional a la energía generada. Su medición se realiza mediante un piranómetro que la convierte en una señal de corriente eléctrica proporcional.

2.3 Dispositivos para Procesamiento de Datos

Para el procesamiento de datos se necesitan componentes capaces de realizar distintas operaciones con los valores obtenidos de los sensores. Debido a que las operaciones posibles a realizar son muchas, los dispositivos existentes también lo son y varían de acuerdo a las necesidades.

Hay componentes que son capaces de realizar operaciones lógicas básicas como AND u OR, otras que pueden hacer operaciones de suma y resta, hasta componentes capaces de realizar múltiples operaciones en simultaneo como los CPU's de las computadoras. Debido a la complejidad del proyecto, se pueden encontrar 2 tipos de dispositivos factibles de ser empleados:

- Microprocesadores: Su desarrollo está orientado al mercado de los ordenadores personales y estaciones de trabajo. Soporta una elevada potencia de cálculo, manejo de gran cantidad de memoria y gran velocidad de procesamiento. Son más caros que los microcontroladores.

- Microcontroladores: Son usados en aplicaciones donde se deben realizar un pequeño número de tareas al menor costo. Ejecutan un programa

almacenado permanentemente en su memoria, el cual trabaja con algunos datos almacenados temporalmente e interactúa con el exterior a través de las líneas de entrada y salida de que dispone.

2.4 Dispositivos para Almacenamiento de Datos

La variedad de dispositivos de almacenamiento es muy amplia hoy en día. Estos han ido evolucionando a través de la historia, pasando desde los disquetes, discos duros, CD-ROM, hasta las unidades flash como los USB's y las tarjetas SD's. Para nuestro proyecto se necesitan dispositivos pequeños y livianos que no aumenten la complejidad del dispositivo pero que ofrezcan garantía a los datos obtenidos.

2.5 Modelo Teórico

El sistema de monitoreo de desempeño es necesario e indispensable para un sistema de energía, en especial para una micro-red. Debido a que esta no es de gran escala como una planta de generación industrial, los sistemas de monitoreo comerciales resultan muy costosos para su implementación. Es en este contexto que surge la necesidad de diseñar un sistema que sea confiable y de bajo costo.

Para poder escoger el tipo y características del sistema de monitoreo se debe tener en consideración las características de la micro-red. En nuestro caso, se cuenta con una micro-red basada en energía generada por paneles fotovoltaicos y turbinas eólicas. El sistema de generación se encuentra instalado sobre el techo de un local comunal y el sistema de regulación se encuentra dentro del mismo.

Las etapas de generación y regulación se encuentran contiguas físicamente, esto implica que los puntos de sensado también se ubicarán de forma cercana. Al contar con una micro-red de estas características, se optará por un sistema de monitoreo alámbrico, que no solo ahorrará la necesidad de adquirir módulos de comunicación inalámbrica, sino que le otorgará simplicidad al sistema.

La zona en la que está ubicada la micro-red es Laguna Grande, Paracas. Las coordenadas de la zona son 14°8’50.16”S 76°16’06.46”O. En esta zona vive una comunidad pesquera que no cuenta con señal telefónica y por consiguiente con conexión a internet. De la misma forma, al no contarse con un personal dedicado a la evaluación constante del desempeño de la micro-red, la única opción que se tendría para poder hacer un monitoreo en tiempo real es que haya una comunicación inalámbrica entre esta zona y Lima (donde se encuentra la empresa encargada de la instalación y monitorización de la micro-red). Dado que no se cuenta con conexión telefónica y los dispositivos punto a punto no tienen tanto alcance, se optará por un monitoreo por periodos. El periodo propuesto es de 1 mes, periodo en el cual es factible realizar una evaluación del comportamiento de la micro-red, después del cual se acercará una persona encargada a recoger los datos obtenidos.

En la figura 5 se muestra la ubicación exacta donde se encuentra instalada la micro-red.

Figura 5. Ubicación de la micro-red

Figura 6. Ubicación de la micro-red en Ica

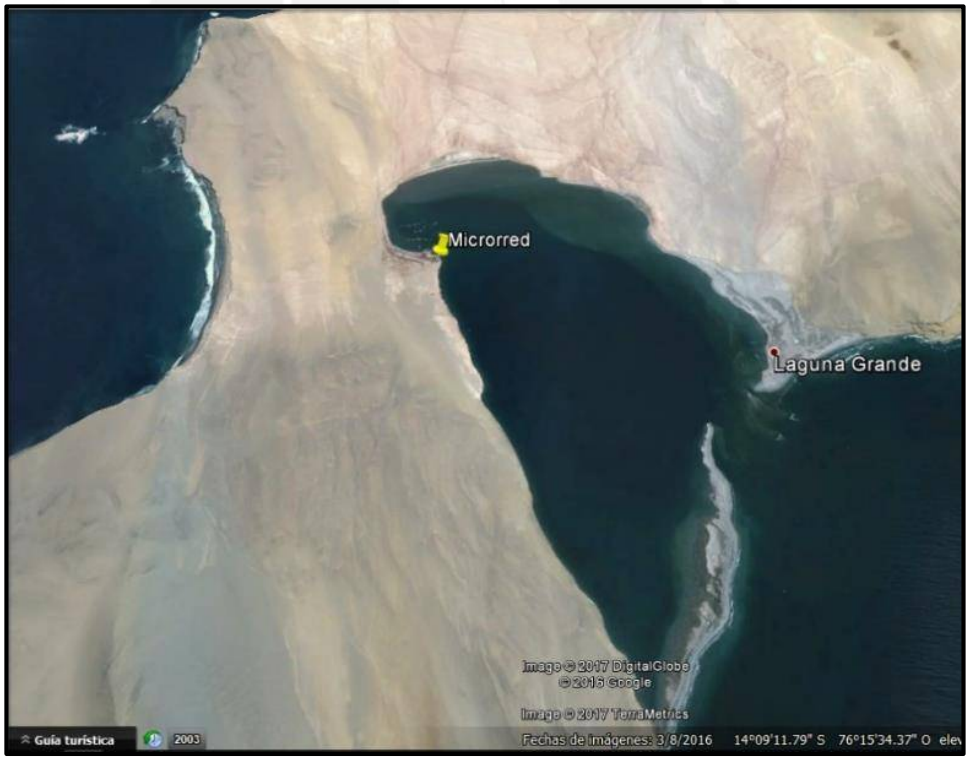


Figura 7. Ubicación de la micro-red en Laguna Grande

Para el almacenamiento se cuenta con distintas opciones, todas muy similares en precio y capacidad. Sin embargo, se optará por una tarjeta SD ya que es la más comercial en sistemas de monitoreo.

Como se mencionó anteriormente, el tipo de monitoreo que sigue las normas IEC 61724 e IEC 61400-12-1 es el más preciso para evaluar desempeño. Sin embargo implica un costo mayor por los dispositivos de sensado de condiciones climáticas. En nuestro caso, la micro-red instalada cuenta con ciertos sensores como un anemómetro, veleta y un piranómetro que recaudan datos y los almacenan en un datalogger de modelo NRG SYMPHONIEPLUS 3. El presente proyecto no solo busca determinar la eficiencia de la micro-red de forma comercial, sino también mejorarla a través de un estudio posterior. Por dicha razón, el sistema a desarrollar debe ajustarse a las necesidades específicas de la micro-red.

El sistema de monitoreo deberá ser capaz de sensar todas las variables necesarias para poder realizar un estudio, y posterior mejora, de la eficiencia de la micro-red. Los datos adquiridos, en su mayoría analógicos, serán digitalizados y procesados por la unidad de procesamiento. Esta unidad se encargará a su vez de realizar las distintas evaluaciones para obtener valores derivados de los sensados; por ejemplo, la potencia eléctrica del sistema en los distintos puntos de medición. Luego de ser procesados, estos datos serán almacenados en la tarjeta SD determinada en un formato que identifique los valores con sus respectivas fechas y horas. Por último, haciendo uso de un software, ya sea personalizado o general, la persona encargada deberá ser capaz de visualizar los valores medidos con sus distintas fechas.

En la figura 8 se presenta un diagrama tentativo del sistema de monitoreo de desempeño que será diseñado e implementado.

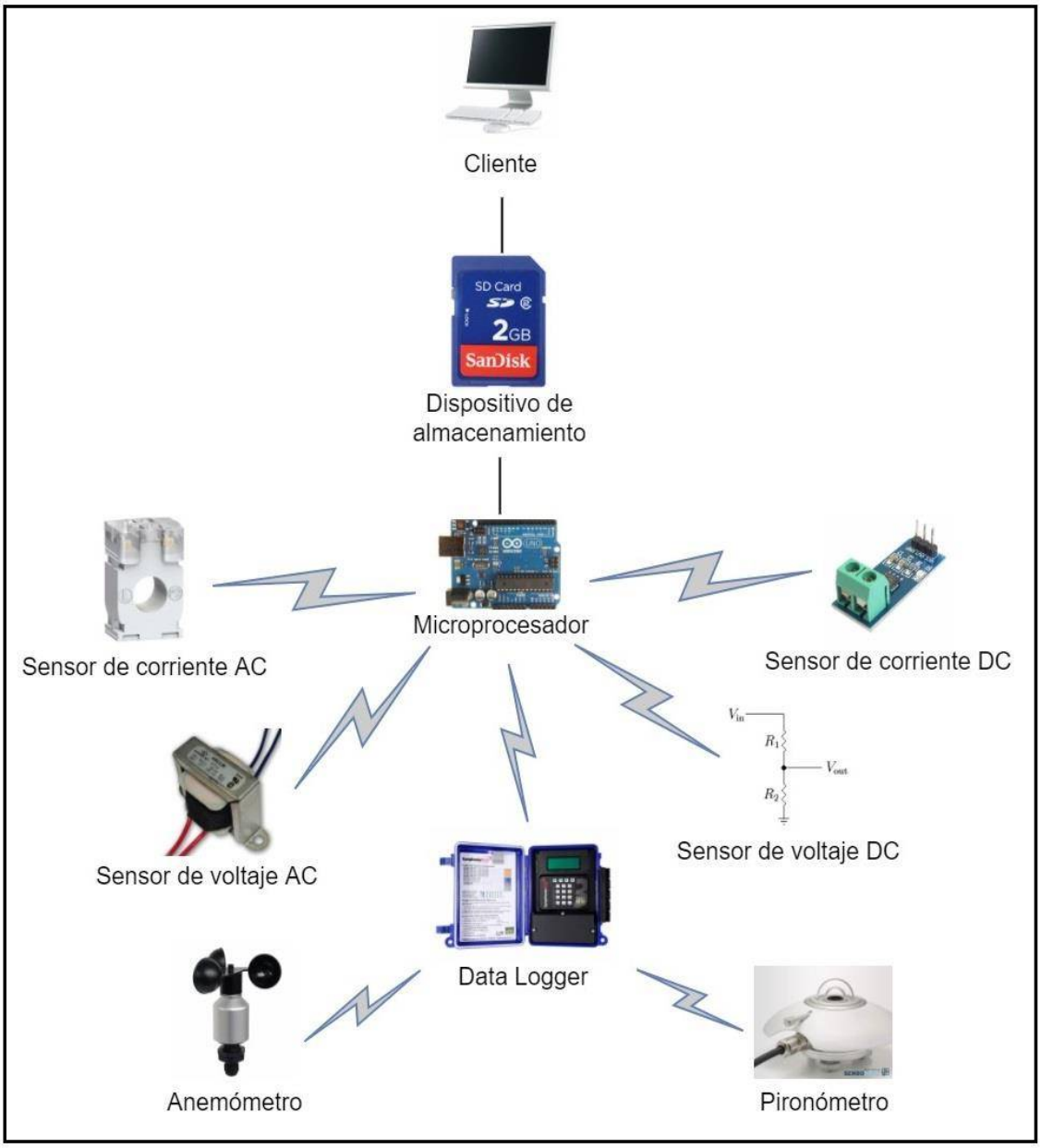


Figura 8. Diagrama tentativo del sistema de monitoreo propuesto basado en el proyecto de Retno Tri Wahyuni y Yusmar Palapa Wijaya [14]

CAPÍTULO 3: DISEÑO DE UN SISTEMA DE MONITOREO DE DESEMPEÑO DE BAJO COSTO PARA UN MICRO-RED

3.1 Objetivos

3.1.1 Objetivo General

Diseñar un sistema de monitoreo que adquiera y registre los parámetros eléctricos y atmosféricos de una micro-red en Laguna Grande, que presente un error de medición no mayor al 2% y que sea de bajo costo.

3.1.2 Objetivos Específicos

a) Diseñar los dispositivos de acoplo de los sensores hacia el dispositivo principal.
b) Desarrollar el dispositivo central que convierta las señales de los sensores, los procese y los almacene.
c) Evaluar la precisión y error de las mediciones.

3.2 Análisis del sistema

La micro-red en nuestro estudio se encuentra en Laguna Grande y fue instalada por Waira Energía Sac. La misma que cuenta con 2 turbinas eólicas, un arreglo de paneles fotovoltaicos de 6000W, un banco de baterías, así como controladores, inversores y reguladores tal como se muestra en la figura 9. En este se puede identificar las conexiones de los componentes (líneas blancas) además de los puntos donde se planean medir los parámetros eléctricos (puntos verdes).

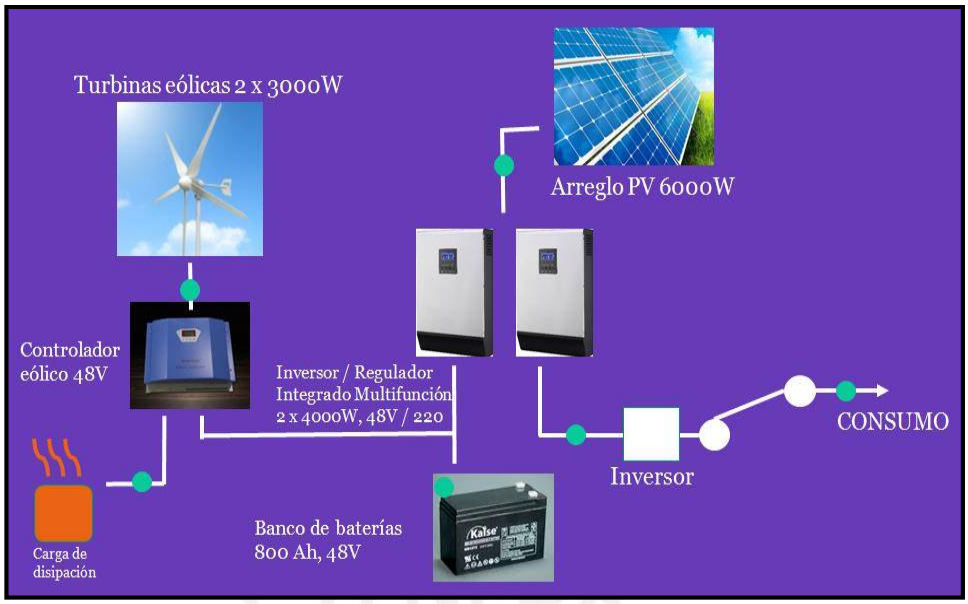


Figura 9. Esquema de micro-red híbrida en Laguna grande

Esta micro-red cuenta con un sistema de monitoreo para factores únicamente meteorológicos. Este sistema está conformado por un datalogger *Symphonie PLUS3* de NRG Systems, un anemómetro *NRG 40C*, una veleta *NRG 200P* y un piranómetro *li-cor 200* [Anexos A, B y C].

Como se mencionó al, los sistemas de monitoreo de desempeño cuentan con 3 etapas principales. Estas son:

- Adquisición de Datos
- Procesamiento de Datos
- Almacenamiento y Análisis de Datos

3.2.1 Adquisición de Datos

En esta etapa se recolectarán los datos (meteorológicos y eléctricos) mediante el uso de sensores y transductores. Para esto se debe considerar los rangos de valores que se tienen para la medición así como el tipo de funcionamiento de cada uno.

- Velocidad de viento: Para su medición se utilizará el anemómetro NRG 40C, cuyas características obtenidas de su hoja técnica son mostradas en la tabla 1.

Tabla 1. Características del anemómetro

Modelo	NRG 40C
Rango de sensor	1 a 96 m/s
Señal de salida (proporcional)	0 a 125 Hz
Error máximo	1%

En la figura 10 se puede observar el anemómetro NRG 40C que cuenta con tres aspas y dos terminales.

Figura 10. Anemómetro NRG 40C [15]

- Dirección de viento: Para su determinación se empleará la veleta NRG 200P que cuenta con las características señaladas en la tabla 2 obtenidas de su hoja de datos. Esta funciona con un voltaje de excitación (5V en nuestro caso) y ofrece un voltaje de salida proporcional al grado de rotación.

Tabla 2. Características de la veleta

Modelo	NRG 200P
Rango de sensor	360° de rotación continua
Señal de salida (proporcional)	0 a Voltaje de excitación
Error máximo	± 0.45 m/s a 10 m/s

La figura 11 muestra la veleta de modelo NRG 200P, la cual es usada por la empresa Waira Energia.

Figura 11. Veleta NRG 200P [16]

- Intensidad luminosa: Se empleará el piranómetro li-cor 200R que entrega una señal de corriente. Este necesita de un Módulo Acondicionador de Señal para ser reconocido por el Symphonie, pero si se quisiese leer con el Arduino se necesitaría de una resistencia. La resistencia de 22Kohm que da valores de tensión entre 0 y 4.95V fue obtenida de la ecuación 1. En la tabla 3 se muestran las especificaciones del piranómetro li-cor 200R obtenidas de su hoja técnica.

$$R = (V_{max} - V_{min}) / (I_{max} - I_{min}) \quad \ldots..(1)$$

Tabla 3. Características del piranómetro

Modelo	Li-cor 200R
Rango de sensor	0 a 3000 W/m2
Señal de salida (proporcional)	0 a 225uA
Error máximo	1%

El piranómetro li-cor 200 se puede observar en la figura 12.

Figura 12. Piranómetro li-cor 200R [17]

- Corriente alterna: Para la medición de corriente alterna se optó por un sensor de núcleo partido. Este permitirá maniobrar el sensor sin necesidad de interrumpir la conexión. Tomando en consideración que la corriente máxima en la red es de 70A, se procedió a comparar distintos sensores optando por el del fabricante CR Magnetics Inc, cuyo modelo posee las características detalladas en la tabla 4, la resistencia externa R fue calculada con la ecuación 2 brindada por el fabricante.

$$R = (V_{max} * 3750) / I_{max} \quad \ldots..(2)$$

Tabla 4. Características del sensor de corriente AC

Modelo	CR3111-3000
Rango de sensor	0 a 100A
Señal de salida (proporcional)	0 a 1.492V (R=47Ohm)

En la figura 13 se observa el sensor de corriente AC escogido.

Figura 13. Sensor de corriente AC de núcleo partido CR3111-3000 [18]

- Corriente continua: En el caso de la corriente continua, se optó por usar un sensor de efecto hall de núcleo entero, ya que no interrumpe la conexión eléctrica y su precio es menor al de núcleo partido. En la red que poseemos, la corriente continua máxima que se tiene es de 50A. Por ello se eligió el siguiente sensor fabricado por Tamura Corporation que posee las características señaladas en la tabla 5 obtenidas de la hoja de datos del sensor.

Tabla 5. Características del sensor de corriente DC

Modelo	L01Z100S05
Rango de sensor	-100 a 100A
Señal de salida (proporcional)	0 a 5V
Error máximo	1%

La figura 14 muestra el sensor de corriente DC escogido

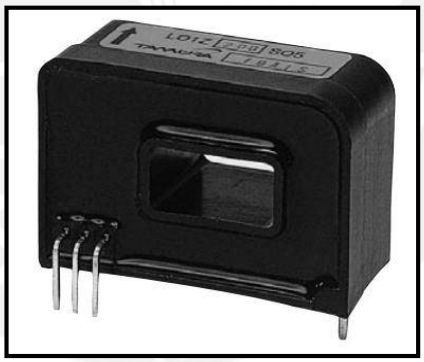


Figura 14. Sensor de corriente DC de núcleo entero L01Z100S05 [19]

- Tensión alterna: Para adquirir los valores de tensión alterna, se empleará un transformador de medida que tiene una relación de transformación de 220:12. El uso del transformador es necesario para separar la tierra del sistema de monitoreo del neutro de la micro-red. A su vez, se empleará un divisor resistivo que reducirá la tensión proveniente del transformador a su décima parte. Debido al consumo del divisor, las resistencias pueden ser de un cuarto de vatio. Las características del divisor mixto se detallan en la tabla 6.

Tabla 6. Características del sensor de tensión AC

Modelo	Transformador + divisor resistivo
Rango de sensor	0 a 260V
Señal de salida (proporcional)	0 a 1.418V
Consumo máximo	15mW

En la figura 15 se muestra el transformador a utilizar y el esquemático del divisor resistivo.

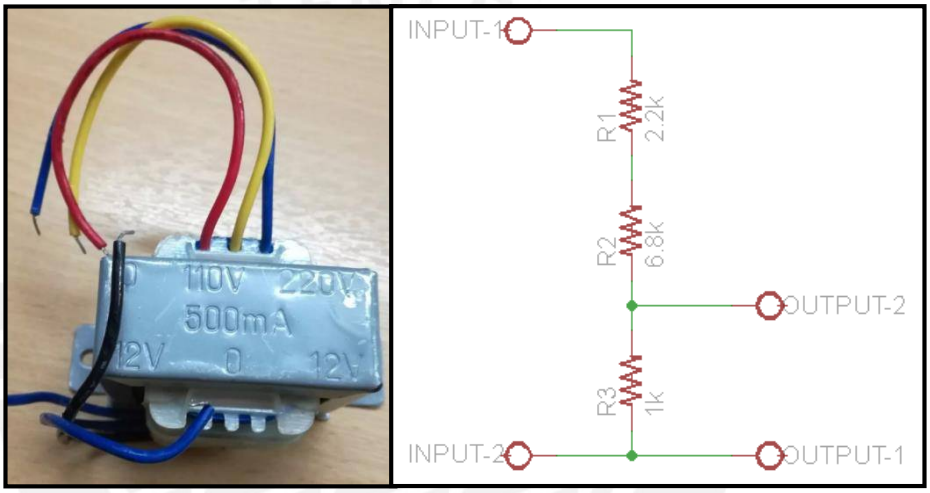


Figura 15. Transformador y divisor resistivo

- Tensión continua: Para la medición de la tensión continua, se usará un divisor resistivo que asegure la linealidad. Las características de este arreglo se detallan en la tabla 7. Este divisor será seguido de un OPAMP en configuración seguidor para evitar la aparición de corrientes de fuga. El OPAMP debía ser de propósito general y poder ser alimentado con 5V, por lo que se escogió el LM324N que satisface las necesidades.

Tabla 7. Características del sensor de tensión DC

Modelo	Divisor resistivo
Rango de sensor	0 a 120V
Señal de salida (proporcional)	0 a 5V
Consumo máximo	60mW

El esquemático del divisor resistivo y OPAMP en configuración seguidor se observan en la figura 16.

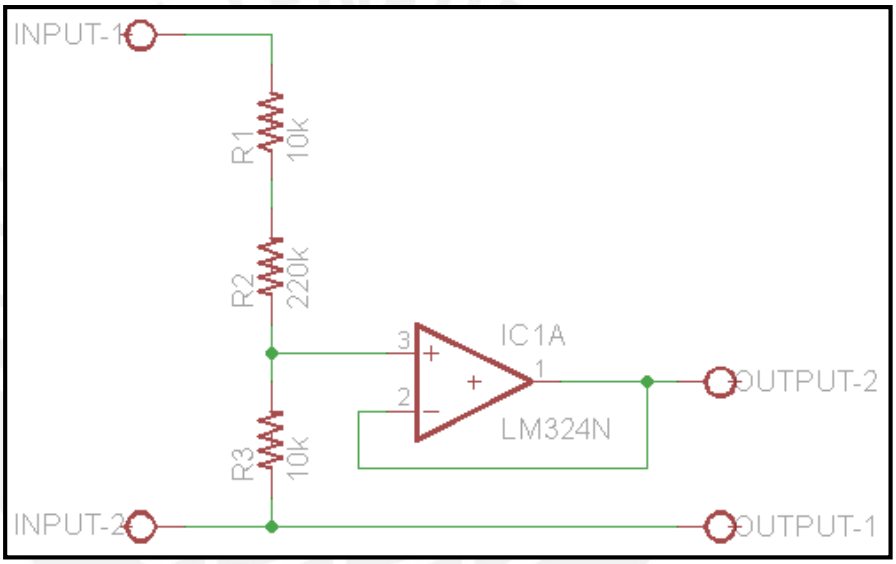


Figura 16. Divisor resistivo y OPAMP seguidor

- Potencia eléctrica: La potencia eléctrica se calculará de forma digital en base a los valores de corriente y tensión obtenidos.

Las señales provenientes de los sensores de corriente y tensión AC son valores más pequeños de tensión AC. Los valores que suelen ser transformados y procesados por los distintos equipos de procesamiento requieren señales DC, por lo que estas señales deben pasar por una etapa previa de acondicionamiento, la cual tendrá como salida valores entre 0 y 3.5Vdc.

Para la etapa de acondicionamiento, se evaluaron tres opciones:

- Rectificador de onda completa mediante puente de diodos: Es el sistema más simple pero a su vez menos preciso. Presenta caídas de tensión debido a los diodos empleados, lo que no lo hace ideal para aplicaciones de medición.

- Rectificador de onda completa mediante OPAMP: Logra convertir la señal AC en DC evitando las caídas de tensión en los diodos. Provee de linealidad al sistema pero se ve limitado por las características del OPAMP, condensadores y resistencias.

- Circuito integrado convertidor de RMS a DC: Es el más preciso de las tres opciones, pero a su vez el más costoso. Convierte el verdadero valor RMS a DC y brinda gran precisión, pero su precio es diez veces el precio de las otras opciones.

Finalmente se optó por la rectificación de onda mediante OPAMP's, ya que evita las caídas de tensión del puente de diodo y no incrementa significativamente el costo del sistema. En la figura 17 se observa el esquemático del circuito rectificador.

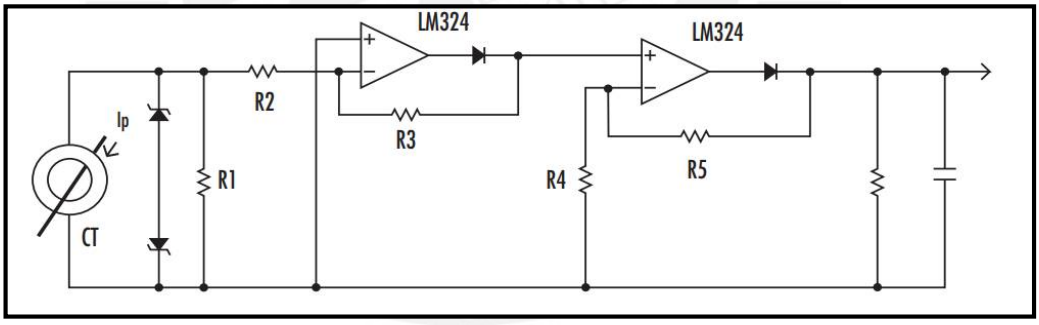


Figura 17. Circuito rectificador de precisión para acondicionamiento de corriente [20]

Para este diseño, se optó por seleccionar R2=R3=10kOhm con el fin de conservar la simetría de la onda rectificada. Luego se busca amplificar la señal obtenida 2 veces. Por lo tanto, según la ecuación 3, seleccionamos R4=R5=10kOhm. Todos los OPAMP's serán LM324N puesto que deben ser de propósito general que puedan ser alimentados con 5V y de bajo consumo (700uA).

$$G = (R4 / R5) + 1 \quad \ldots..(3)$$

3.2.2 Procesamiento de Datos

Durante esta etapa se realiza la digitalización de los datos adquiridos para que puedan ser procesados y posteriormente almacenados y analizados.

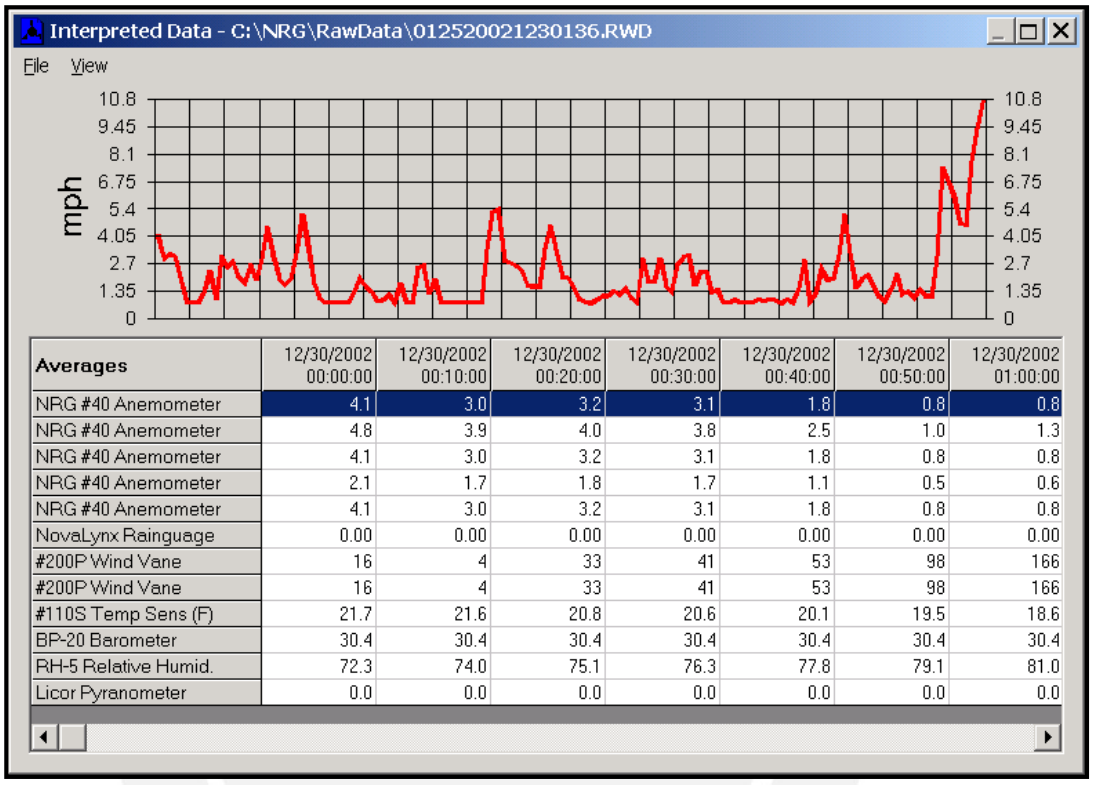
En la micro-red en cuestión se cuenta con el datalogger Symphonie PLUS3 que realiza esta acción de forma eficaz y que muestra los parámetros en tiempo real, así como información referente al estado de las baterías, entre otras opciones.

En la figura 18 se muestra los parámetros correspondientes a las veletas conectadas a los canales 7 y 8 del datalogger. Por otro lado, en la figura 19 se observa el estado de las baterías, fecha y hora del sistema.

Figura 18. Valores de la veleta mostrados en tiempo real por el SymphoniePLUS3

Figura 19. Información del datalogger mostrada en el mismo

Además, el datalogger cuenta con un software que muestra y organiza los datos obtenidos durante un periodo de tiempo, tal como se muestra en la figura 20, el software provee los datos por periodos de tiempo y permite observar su variación.



Averages	12/30/2002 00:00:00	12/30/2002 00:10:00	12/30/2002 00:20:00	12/30/2002 00:30:00	12/30/2002 00:40:00	12/30/2002 00:50:00	12/30/2002 01:00:00
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	4.8	3.9	4.0	3.8	2.5	1.0	1.3
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	2.1	1.7	1.8	1.7	1.1	0.5	0.6
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NovaLynx Rainguage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
#200P Wind Vane	16	4	33	41	53	98	166
#200P Wind Vane	16	4	33	41	53	98	166
#110S Temp Sens (F)	21.7	21.6	20.8	20.6	20.1	19.5	18.6
BP-20 Barometer	30.4	30.4	30.4	30.4	30.4	30.4	30.4
RH-5 Relative Humid.	72.3	74.0	75.1	76.3	77.8	79.1	81.0
Licor Pyranometer	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figura 20. Gráfica de valores históricos mediante *Symphonie Data Retriever* [21]

En primera instancia se propuso emplear el datalogger como medio de procesamiento. Entre las razones para escoger usar el sistema existente está el diseño industrial con el que cuenta, el mismo que le permite una expansión de actividades pero que no son usadas, por ejemplo la transmisión de datos mediante el estándar Sistema Global para las Comunicaciones Móviles (GSM por sus siglas en inglés). Por otro lado, también se consideró importante contar con un software de análisis de datos. Por último, hacer uso del producto ya existente significa un ahorro en el tiempo y presupuesto del proyecto.

Sin embargo, como se mencionó anteriormente, el Symphonie está pre-configurado para medir valores meteorológicos únicamente. Es por esta razón que los parámetros eléctricos deberán ser acondicionados para que el datalogger los interprete como valores meteorológicos. Esto debería ser

posible debido a que el datalogger cuenta con seis canales digitales, seis analógicos y tres que pueden funcionar como digital o analógico dependiendo de cómo se configure.

El funcionamiento de los canales analógicos es similar al de un convertidor ADC, el cual recibe un nivel de tensión analógico y lo transforma a digital para poder ser procesado. El rango de tensiones admitidas lo limita su tensión de alimentación (1.5V). Por lo tanto, el acondicionamiento de señales para este canal se basaría en reductores de tensión para lograr los niveles de tensión deseados.

Por otro lado, el funcionamiento de los canales digitales se basa en señales de frecuencia. Los canales digitales están pre-configurados para sensar anemómetros digitales que funcionan generando señales cuyas frecuencias son lineales a la velocidad de giro de sus aspas.

Para el acondicionamiento de una señal eléctrica, se debe buscar una forma de generar una señal cuya frecuencia esté relacionada a un nivel de tención dado. Sin embargo este procedimiento es muy complejo, espacioso y caro. En un principio se planteó la opción de utilizar un microcontrolador que generase estas señales PWM, pero las frecuencias que este podía generar eran fijas y no lineales.

Se propone entonces usar un microcontrolador que proporcione la cantidad de canales digitales y analógicos necesarios, así como capacidad de procesamiento y memoria requeridos a un precio módico. Se optó por el uso del *Arduino MEGA 2560* que procesará todas las señales de los sensores y las almacenará en un dispositivo de almacenamiento sin hacer uso del datalogger.

En la figura 21 se muestra el Arduino Mega 2596 que se usará como unidad de procesamiento.

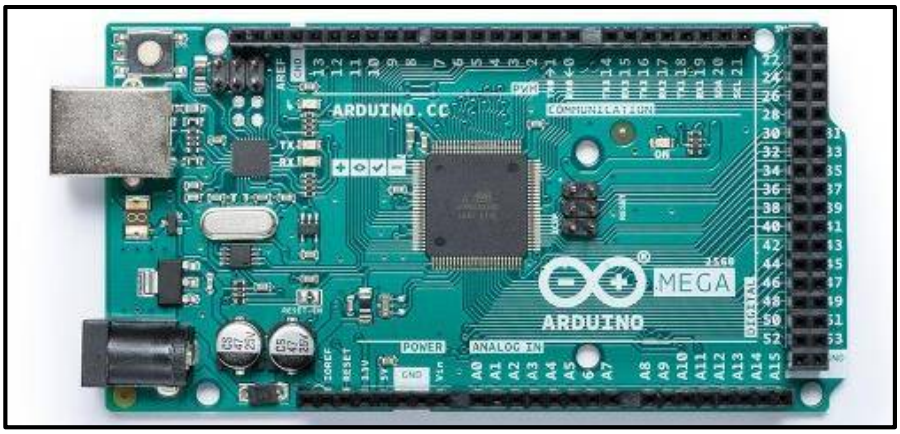


Figura 21. Arduino Mega 2560 [22]

El Arduino Mega cuenta con 16 ADC que permitirán digitalizar las señales de los parámetros eléctricos, así como de la veleta y el piranómetro. Por otro lado, la frecuencia de la señal a la salida del anemómetro puede ser obtenida mediante uno de los canales digitales del microcontrolador. Sus entradas soportan señales de hasta 5V, por lo tanto, se usará el acondicionamiento previamente desarrollado para las señales.

Las señales de los sensores se conectarán según lo indica la tabla:

Tabla 8. Canales de conexión de los sensores

Sensor	Canal	Sensor	Canal
Voltaje Alterno 1	A0	Corriente Continua 4	A9
Corriente Alterna 1	A1	Voltaje Continuo 5	A10
Voltaje Continuo 1	A2	Corriente Continua 5	A11
Corriente Continua1	A3	Voltaje Continuo 6	A12
Voltaje Continuo 2	A4	Corriente Continua 6	A13
Corriente Continua 2	A5	Piranómetro	A14
Voltaje Continuo 3	A6	Veleta	A15
Corriente Continua 3	A7	Anemómetro	D49
Voltaje Continuo 4	A8		

Como se observa en el cuadro, el sistema permitirá conectar catorce sensores de parámetros eléctricos (pre-calibrados para una salida de entre 0 y 5V), un piranómetro (li-cor 200R), una veleta (NRG 200P) y un anemómetros (NRG 40C). En el caso de las veletas, que necesitan una tensión de excitación, serán alimentadas con 5V.

Debido a que el Arduino no cuenta con un sistema de alimentación permanente, la hora y fecha no son fijas en el mismo. Es por esta razón que se usará el módulo *RTC DS1307* que proporciona la fecha y hora en tiempo real. Su alimentación es mediante una pila de reloj de 3V que le otorga una autonomía de entre 5 y 10 años. En la figura 22 se observa el módulo que se conectará al Arduino mediante comunicaciónI2C y haciendo uso de los pines indicados en la tabla 9.

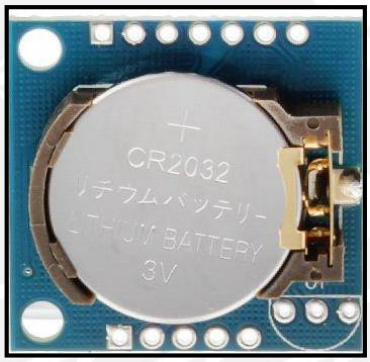


Figura 22. Módulo RTC DS1307 [23]

Tabla 9. Pines de conexión del módulo RTC DS1307

Pin RTC DS1307	Pin Arduino Mega 2560
SCL	D21
SDA	D20
VCC	5V
GND	GND

3.2.3 Almacenamiento y Análisis de Datos:

El almacenamiento de los datos se dará en una tarjeta micro SD. La cual se colocará en el módulo SD-MICRO_PCB de Arduino, mostrado en la figura 23, con el que se comunica de forma serial según la tabla 10.

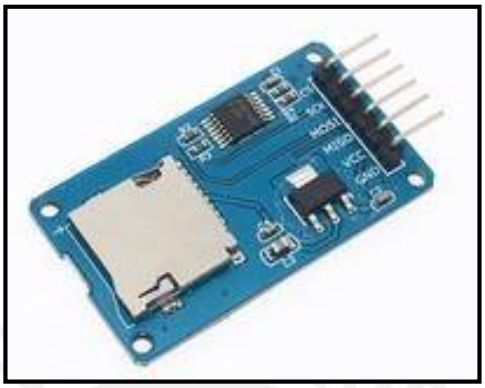
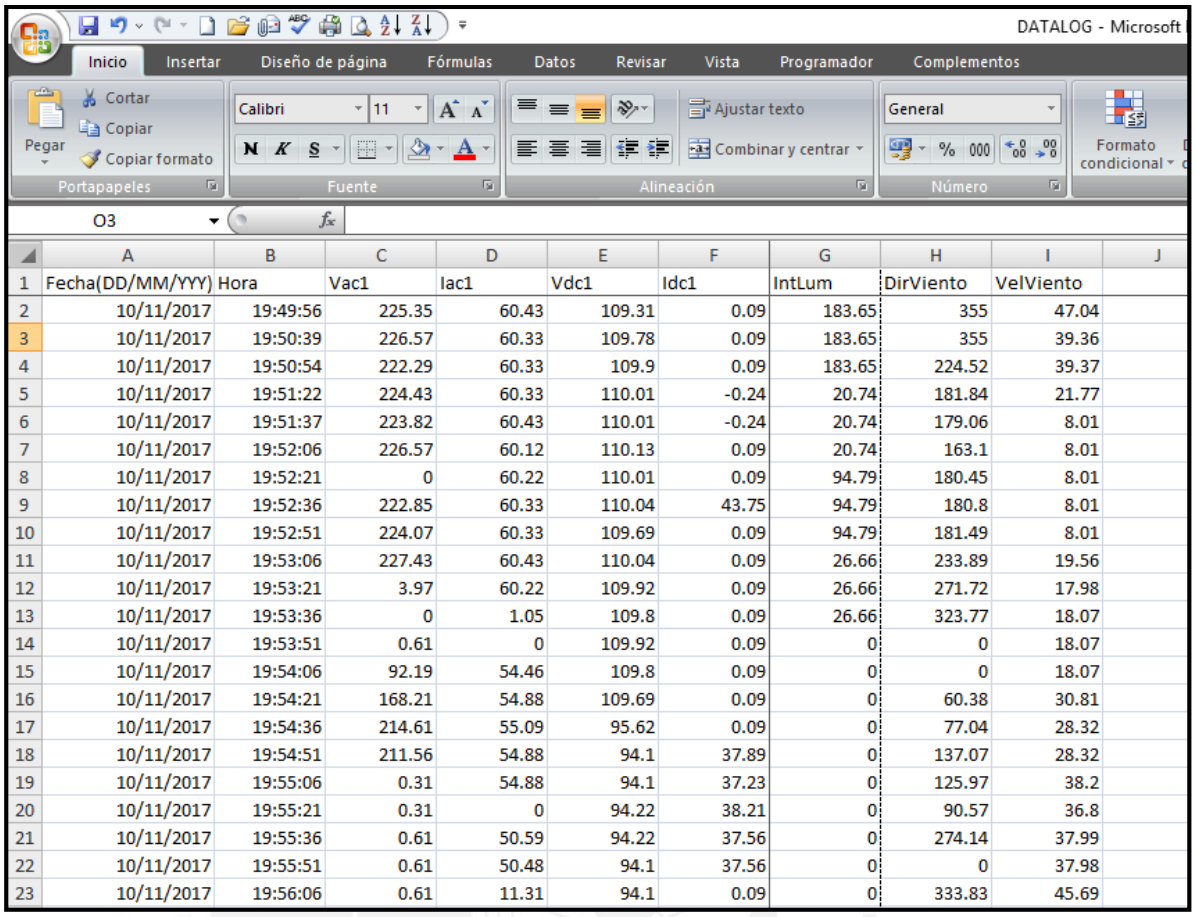


Figura 23. Módulo Arduino Micro SD [24]

Tabla 10. Pines de conexión del módulo SD-MICRO_PCB

Pin Módulo Micro SD	Pin Arduino Mega 2560
CS	D4
SCK	D52
MOSI	D51
MISO	D50
VCC	5V
GND	GND

Los datos serán almacenados en formato CSV (Valores Separados por Coma por sus siglas en inglés) para que luego puedan ser vistos y evaluados usando el software Microsoft Office Excel. En la figura 24 se muestra un ejemplo de datos guardados en este formato y representados en Excel.



	A	B	C	D	E	F	G	H	I	J
1	Fecha(DD/MM/YYY)	Hora	Vac1	Iac1	Vdc1	Idc1	IntLum	DirViento	VelViento	
2	10/11/2017	19:49:56	225.35	60.43	109.31	0.09	183.65	355	47.04	
3	10/11/2017	19:50:39	226.57	60.33	109.78	0.09	183.65	355	39.36	
4	10/11/2017	19:50:54	222.29	60.33	109.9	0.09	183.65	224.52	39.37	
5	10/11/2017	19:51:22	224.43	60.33	110.01	-0.24	20.74	181.84	21.77	
6	10/11/2017	19:51:37	223.82	60.43	110.01	-0.24	20.74	179.06	8.01	
7	10/11/2017	19:52:06	226.57	60.12	110.13	0.09	20.74	163.1	8.01	
8	10/11/2017	19:52:21	0	60.22	110.01	0.09	94.79	180.45	8.01	
9	10/11/2017	19:52:36	222.85	60.33	110.04	43.75	94.79	180.8	8.01	
10	10/11/2017	19:52:51	224.07	60.33	109.69	0.09	94.79	181.49	8.01	
11	10/11/2017	19:53:06	227.43	60.43	110.04	0.09	26.66	233.89	19.56	
12	10/11/2017	19:53:21	3.97	60.22	109.92	0.09	26.66	271.72	17.98	
13	10/11/2017	19:53:36	0	1.05	109.8	0.09	26.66	323.77	18.07	
14	10/11/2017	19:53:51	0.61	0	109.92	0.09	0	0	18.07	
15	10/11/2017	19:54:06	92.19	54.46	109.8	0.09	0	0	18.07	
16	10/11/2017	19:54:21	168.21	54.88	109.69	0.09	0	60.38	30.81	
17	10/11/2017	19:54:36	214.61	55.09	95.62	0.09	0	77.04	28.32	
18	10/11/2017	19:54:51	211.56	54.88	94.1	37.89	0	137.07	28.32	
19	10/11/2017	19:55:06	0.31	54.88	94.1	37.23	0	125.97	38.2	
20	10/11/2017	19:55:21	0.31	0	94.22	38.21	0	90.57	36.8	
21	10/11/2017	19:55:36	0.61	50.59	94.22	37.56	0	274.14	37.99	
22	10/11/2017	19:55:51	0.61	50.48	94.1	37.56	0	0	37.98	
23	10/11/2017	19:56:06	0.61	11.31	94.1	0.09	0	333.83	45.69	

Figura 24. Captura de pantalla de los datos guardados

CAPÍTULO 4: IMPLEMENTACIÓN Y PRUEBAS

4.1 Implementación del Sistema

Para implementar el sistema general, se procedió primero por el diseño y elaboración de las 2 placas de circuito impreso necesarias [Anexo G]. La figura 25 muestra el panel de la Placa Central, mientras que la figura 26, el panel de la Placa de Conexiones.

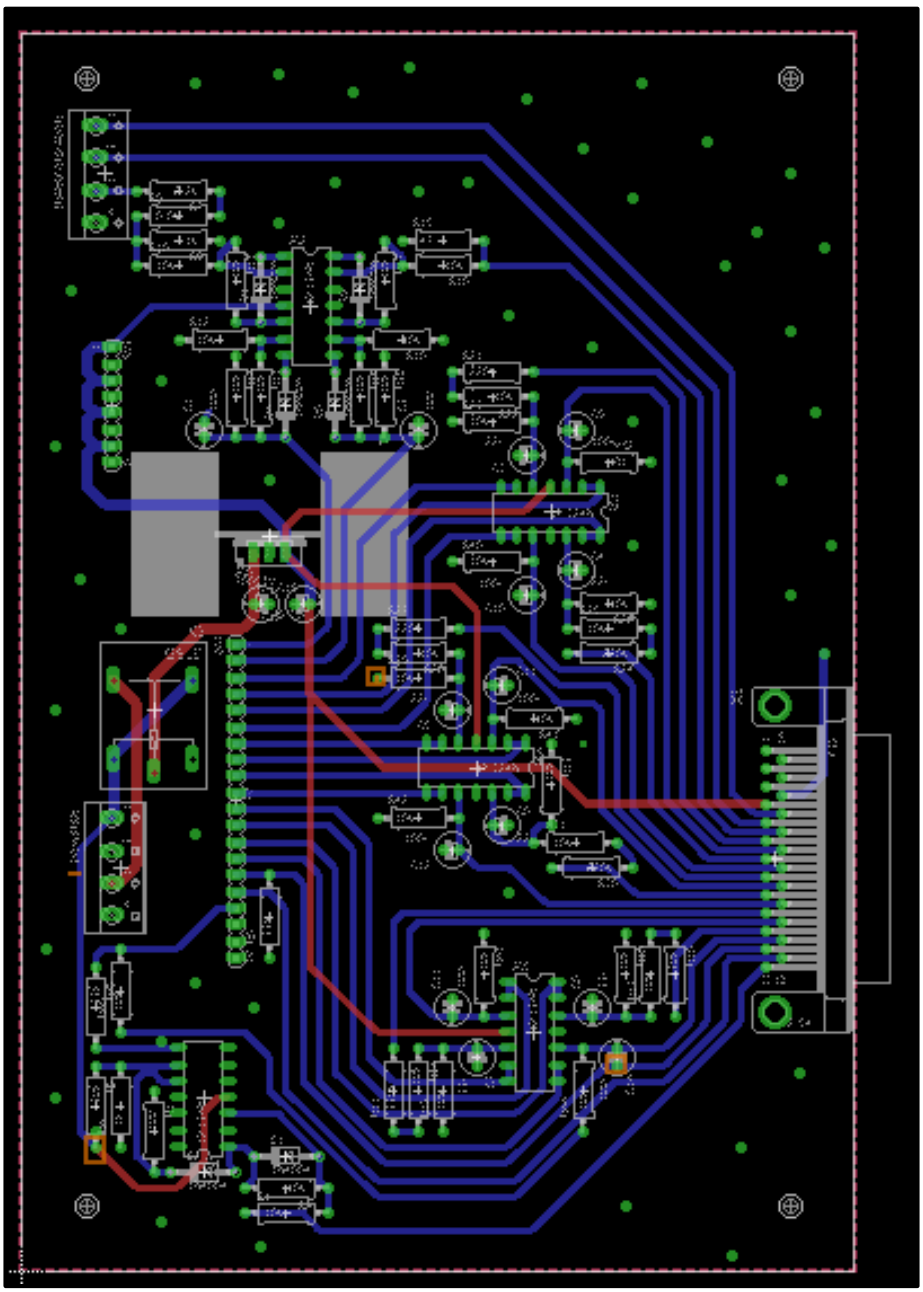


Figura 25. Panel de Placa Central

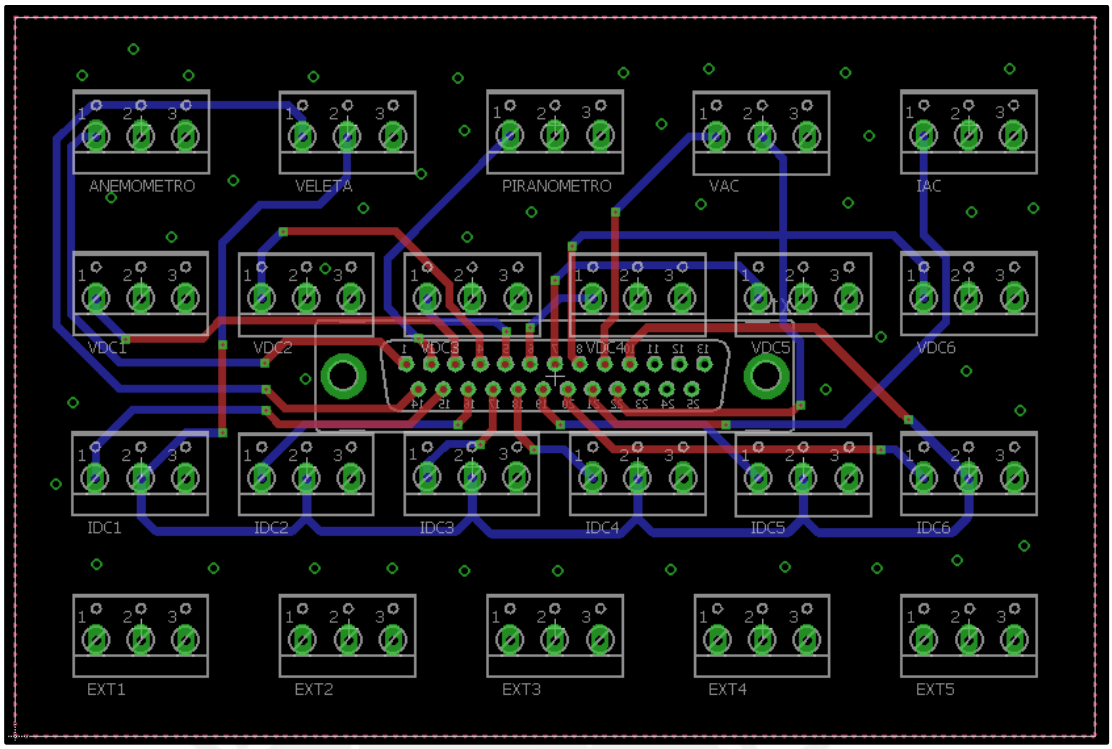


Figura 26. Panel de Placa de Conexiones

La figura 27 muestra la Placa Central que contiene los circuitos de procesamiento de las señales sensadas diseñados en el capítulo anterior, así como los distintos componentes necesarios. Esta placa interactúa con el Arduino Mega mediante un conector Berg de 20 pines. Así mismo, se usará otro conector Berg de 8 pines para brindar alimentación de +5VDC y GND a los distintos periféricos que lo requieran. Una bornera de 4 canales se usará para conectar el transformador necesario en la medición de tensión AC y otra bornera de 4 canales sensará para la alimentación de esta placa. La placa Central trabaja directamente sobre las señales de sensado, las cuales provienen de la Placa de Conexiones mediante un conector DB-25 mostrado en la figura 28.

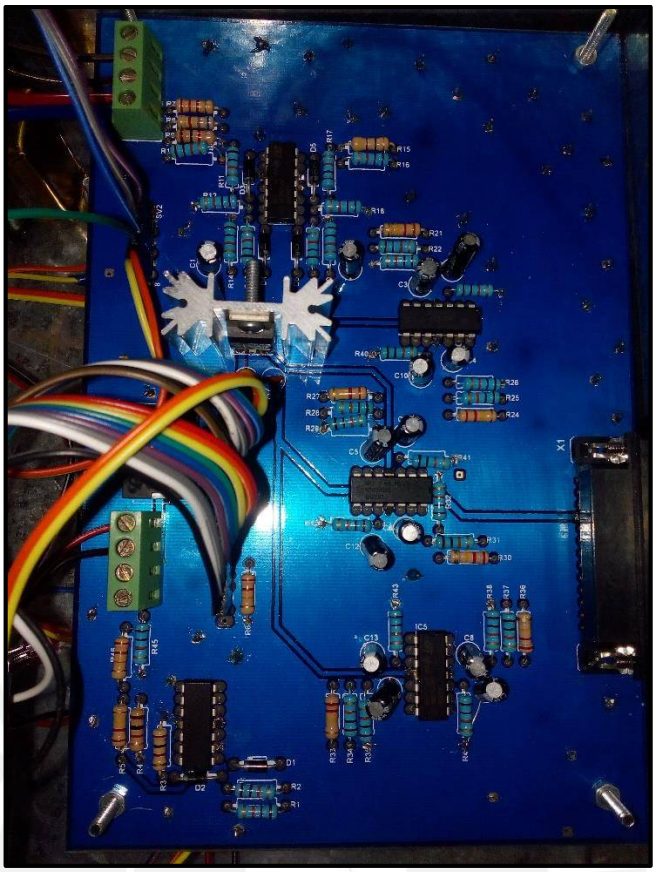


Figura 27. Placa Central del Datalogger

Figura 28. Conector DB-25 [25]

La figura 29 muestra la Placa de Conexiones, la cual se encargará de agrupar todas las señales de sensado y permitirá la interacción de los sensores con las borneras de conexión.

Figura 29. Placa de Conexiones del Datalogger

Una vez completadas las placas de circuito impreso, se procedió a realizar el chasis del dispositivo. El diseño del chasis [Anexo H] estuvo a cargo del tesista, pero la fabricación de estuvo a cargo de la Empresa Waira Energía. El chasis está fabricado en aluminio y no cuenta con ninguna protección IP puesto que es un prototipo inicial.

En la figura 30 se observa el chasis que cuenta con ranuras para los siguientes periféricos:

- Pantalla: Permite al usuario observar en tiempo real las mediciones de los distintos canales.
- Teclado: Posibilita la interacción con el sistema, para escoger la medición a observar.
- Tarjeta micro SD: Permite el ingreso y retiro de la tarjeta micro SD.
- Puerto USB de Arduino Mega: Habilita la comunicación con el ordenador y así la modificación del código fuente.
- Jack de alimentación de +12VDC: Alimentación de todo el sistema.
- Batería de 12VDC: Sistema de respaldo de energía.
- Conector DB-25: Permite la comunicación entre la Placa Central y la Placa de Conexiones.

Figura 30. Chasis del Datalogger

Posterior a la fabricación del chasis, se procedió a ensamblar todo el sistema. Una característica de este sistema es que no cuenta con una conexión a tierra debido a que el conector de alimentación es el mismo que el usado para el Arduino Mega; por ello se procuró aislar cada componente del chasis y así evitar posibles interferencias.

4.2 Pruebas del Sistema

Teniendo listos todos los componentes del sistema, se observa el funcionamiento del sistema, el cual sensa los parámetros requeridos cada segundo y almacenarlos en la tarjeta micro SD externa cada quince.

4.2.1 Adquisición de Datos

Para el momento en que el sistema terminó de ser ensamblado, la mayoría de sensores se encontraban en funcionamiento en otras locaciones, por lo que

la prueba propia en la micro-red fue realizada únicamente con los sensores de tensión y corriente. Lo que se evaluó en esta prueba fue el correcto funcionamiento de los sensores empleados y la interfaz, puesto que anteriormente se realizaron las pruebas con cada uno de los sensores.

La figura 31 muestra la fachada del local comunal donde se encuentra el equipamiento de la micro-red en estudio. En la figura 32 se observa la instalación del datalogger en la micro-red. Mientras que en la figura 33 se muestra la instalación de los sensores.

Figura 31. Fachada de la Micro-red en Laguna Grande

Figura 32. Instalación del Datalogger

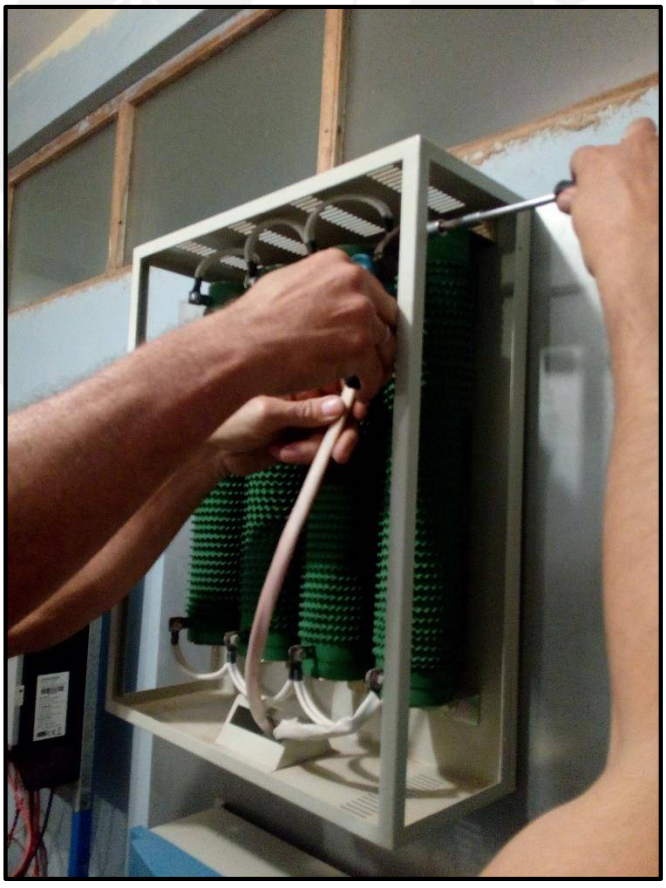


Figura 33. Instalación del Sensores

Para la adquisición de datos, se realizaron experiencias con cada uno de los sensores en la etapa previa al ensamblado.

El anemómetro se simuló con el empleo de señales cuadradas a distintas frecuencias para representar distintas velocidades de viento. La figura 34 muestra la representación de la experiencia.

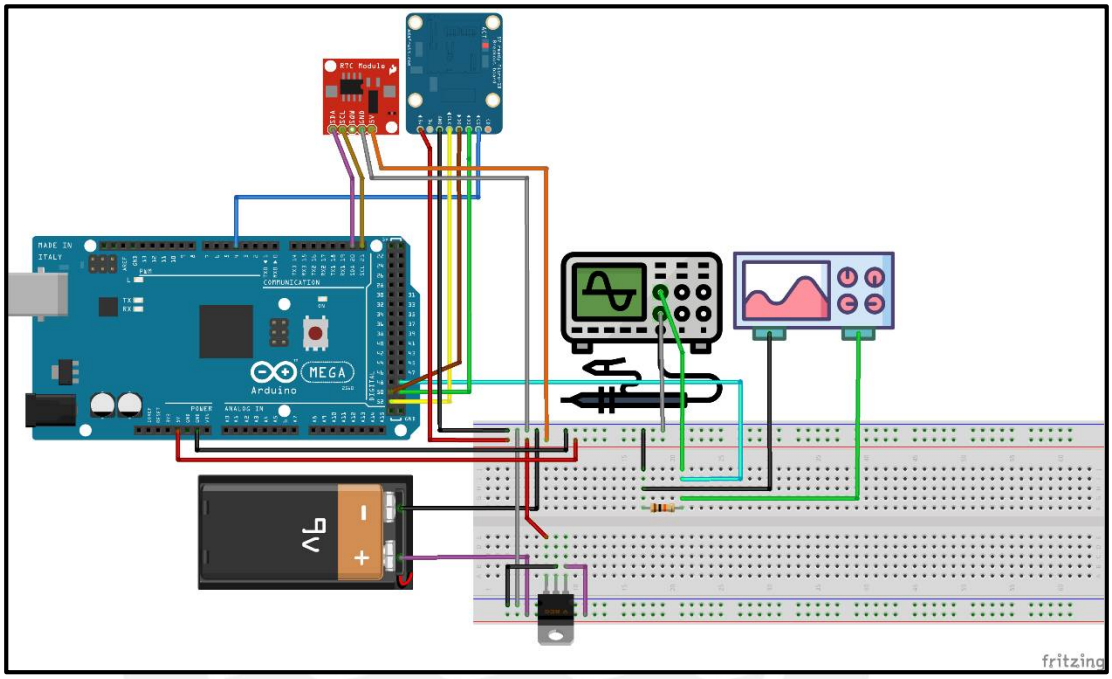


Figura 34. Verificación de sensado de frecuencia

En la figura 35 se observa a la veleta sensando valores de posición angular, para esto se giró la veleta en distintas posiciones para observar su variación.

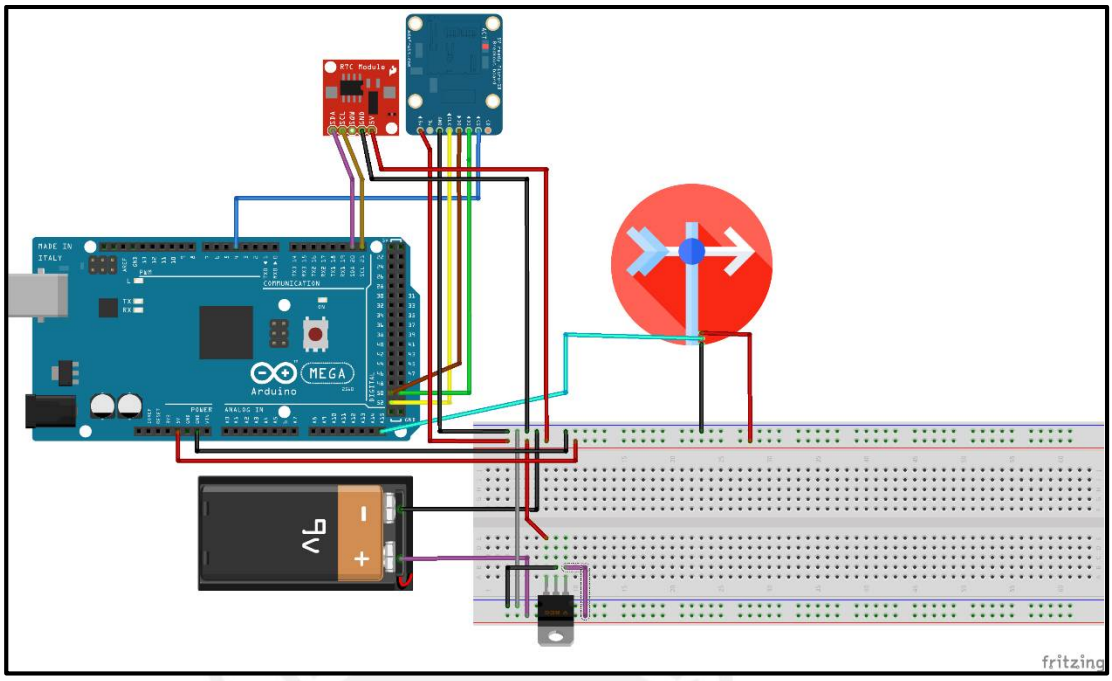


Figura 35. Prueba de sensado con veleta

La figura 36 muestra el piranómetro conectado al Arduino y midiendo la intensidad luminosa presente.

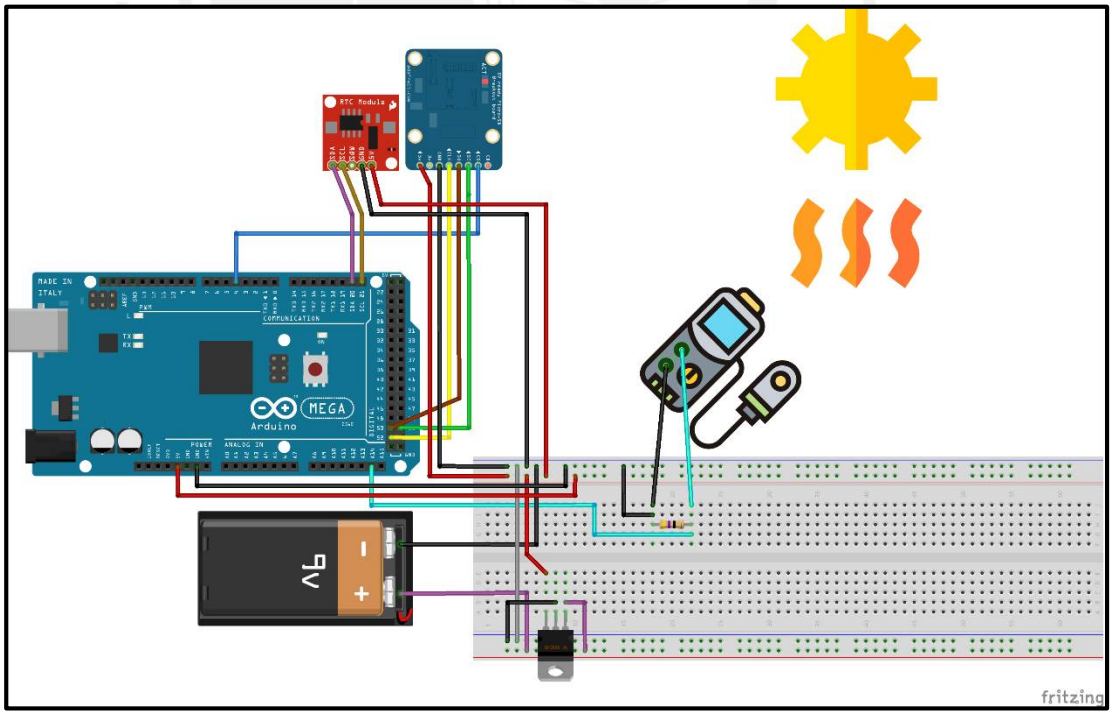


Figura 36. Prueba de sensado con el piranómetro

El sensor de tensión AC se conectó a una fuente de tensión alterna variable tal como se observa en la figura 37.

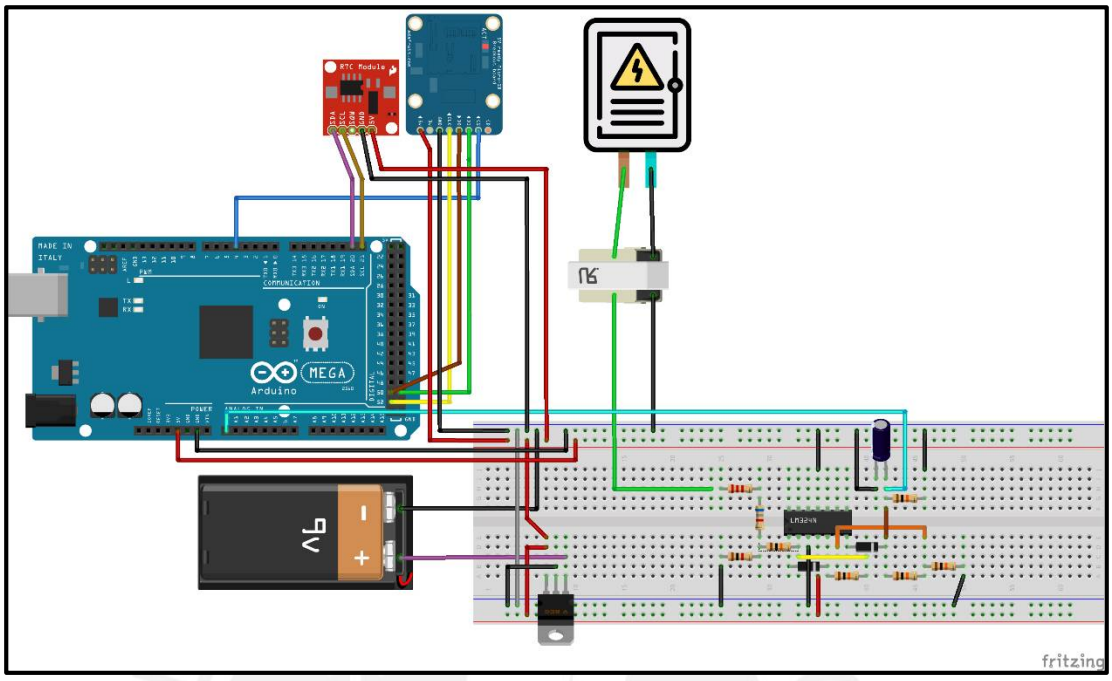


Figura 37. Experiencia de sensado de tensión AC

Por otro lado, los valores de tensión DC fueron obtenidos de una fuente de tención DC variable según se observa en la figura 38.

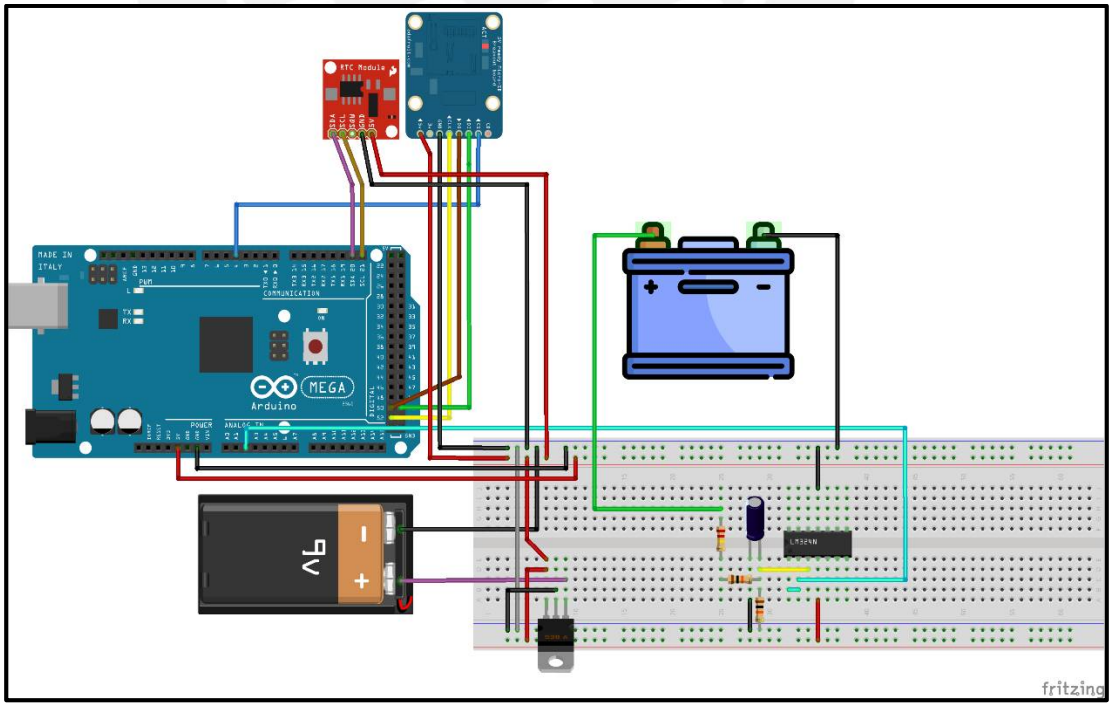


Figura 38. Experiencia de sensado de tensión DC

Para la medición de corriente AC se utilizó una fuente de tensión AC variable conectada a un resistor variable como se muestra en la figura 39.

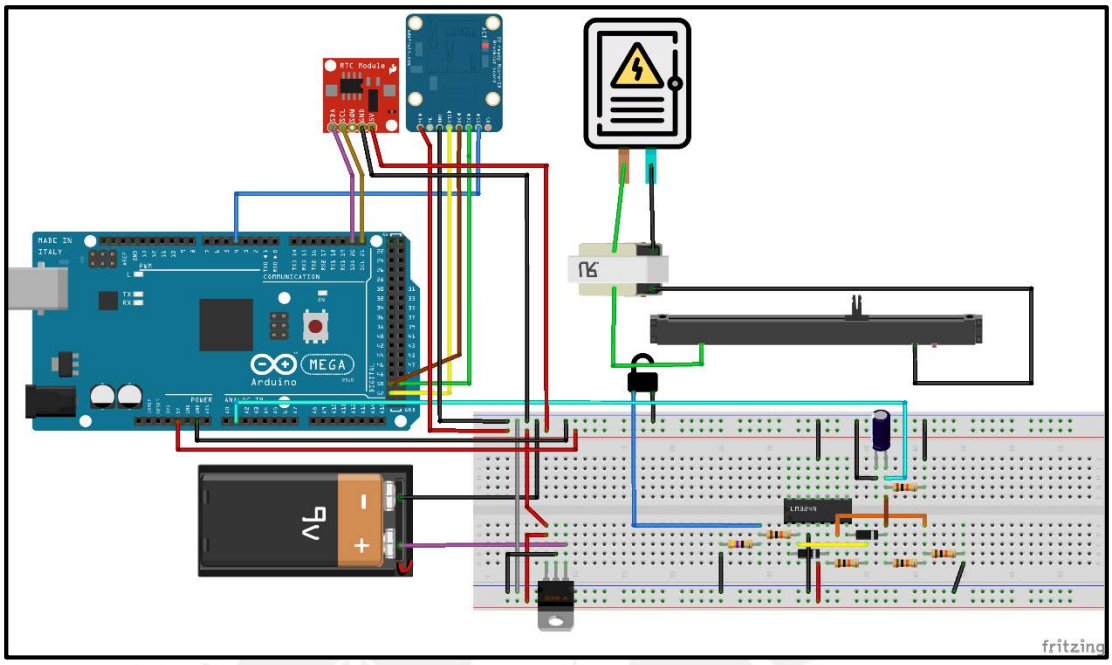


Figura 39. Experiencia de sensado de corriente AC

La figura 40 muestra la experiencia realizada para sensar la corriente DC. Para esta se empleó la fuente de tensión variable DC conectada a una resistencia variable.

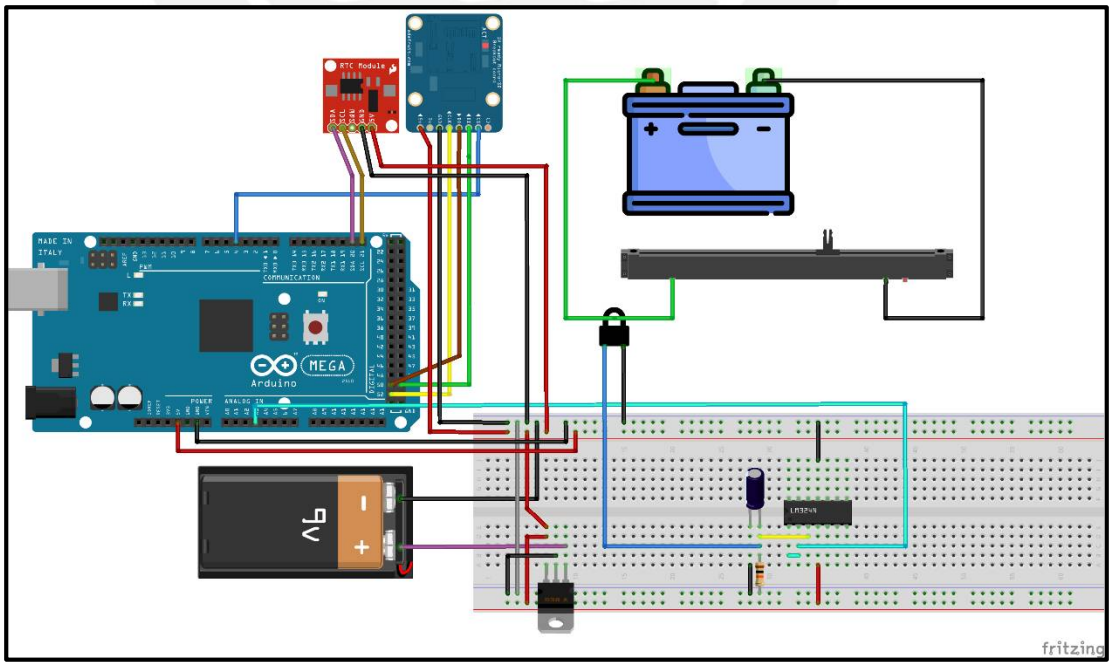


Figura 40. Experiencia de sensado de corriente DC

4.2.2 Procesamiento de Datos

El procesamiento de los datos implica convertir las señales analógicas en digitales y se realiza de forma directa por los convertidores ADC del microcontrolador. Así mismo, parte del procesamiento de estos datos involucra mostrarlos luego de aplicarles un factor de correlación que es definido por la función transferencia del circuito de acondicionamiento.

4.2.3 Almacenamiento de Datos

La experiencia realizada para comprobar el almacenamiento de datos consiste en observar si el monitor serial muestra algún mensaje de error. De no ser así, se retirará la tarjeta micro SD y se insertará en el ordenador, luego se abrirá el archivo creado y se comprobará que los datos hayan sido guardados con relación al formato establecido. La figura 41 muestra el archivo creado por el Arduino en la tarjeta micro SD.

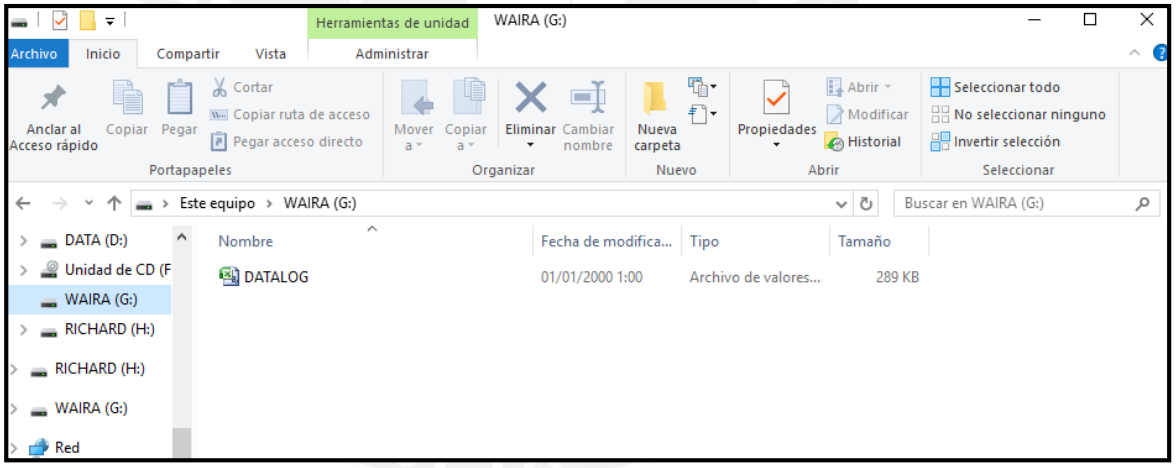


Figura 41. Archivo creado en la tarjeta micro SD

4.3 Análisis de Resultados

Para el análisis de resultados se procedió a adquirir una serie de valores distribuidos a través de su rango para cada sensor con el fin de evaluar la exactitud y linealidad del sistema. Así mismo, para cada valor se tomarán mediciones a fin de calcular la precisión del instrumento.

Las fórmulas utilizadas son las siguientes:

Precisión = DesviaciónEstándar (medida1, medida2, medida3) …..(4)

Exactitud = Error relativo ((medida promedio - referencia)/referencia) …..(5)

La tabla 11 muestra los datos y cálculos de frecuencia realizados para el anemómetro, mientras que la figura 42 ilustra la linealidad de las mediciones para el anemómetro.

Tabla 11. Datos y cálculos de frecuencia

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Osciloscopio Tektronix	Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio			
8.00	8.01	8.01	8.01	8.01	8.00	0.00	0.12
18.00	18.07	18.07	18.07	18.07	18.05	0.00	0.11
28.00	28.32	28.32	28.32	28.32	28.25	0.00	0.25
38.00	37.98	37.98	37.98	37.98	37.88	0.00	0.26
48.00	48.05	48.05	48.05	48.05	48.08	0.00	-0.06
58.00	57.91	57.91	57.91	57.91	58.47	0.00	-0.96
68.00	68.31	68.31	68.31	68.31	68.50	0.00	-0.28
78.00	77.96	77.96	77.96	77.96	77.88	0.00	0.10
88.00	87.44	87.44	87.44	87.44	87.41	0.00	0.03
98.00	96.73	96.73	96.73	96.73	96.71	0.00	0.02
108.00	106.44	106.44	106.44	106.44	106.40	0.00	0.04
118.00	119.14	119.14	119.12	119.13	119.10	0.01	0.03
125.00	126.47	126.49	126.50	126.49	126.60	0.02	-0.09
					PROMEDIO	**0.00**	**-0.03**

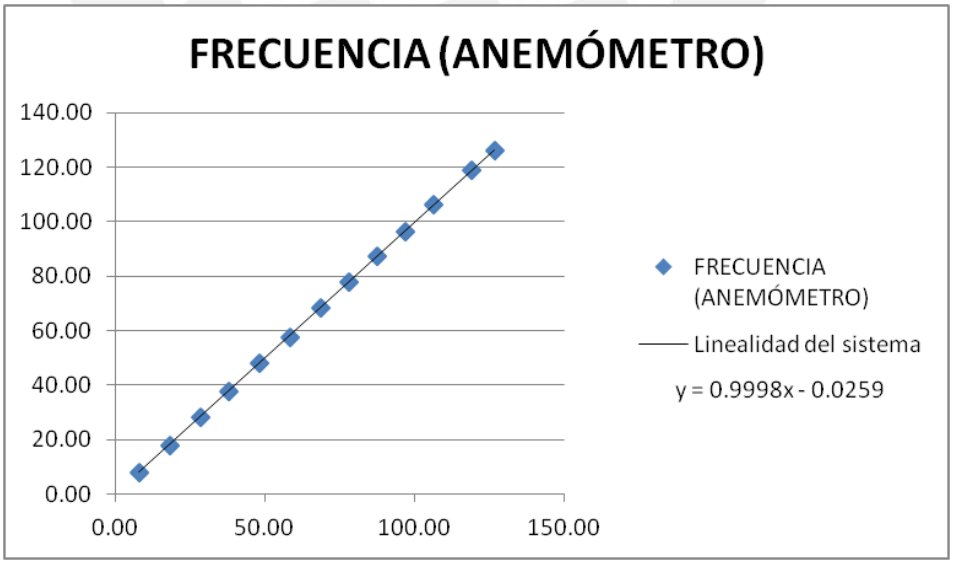


Figura 42. Linealidad del Arduino

La tabla 12 muestra los datos y cálculos realizados para la veleta, mientras que la figura 43 ilustra la linealidad de las mediciones para la veleta.

Tabla 12. Datos y cálculos de ángulo de la veleta

	DATOS				CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio		
0.00	0.69	0.69	0.69	0.69	0.00	-
45.00	39.91	39.91	39.91	39.91	0.00	-11.31
90.00	90.61	90.61	90.61	90.61	0.00	0.68
135.00	136.38	136.38	136.38	136.38	0.00	1.02
180.00	181.14	181.14	181.14	181.14	0.00	0.63
225.00	233.89	233.89	233.89	233.89	0.00	3.95
270.00	272.41	272.41	272.41	272.41	0.00	0.89
315.00	324.46	324.46	324.46	324.46	0.00	3.00
				PROMEDIO	**0.00**	**-0.16**

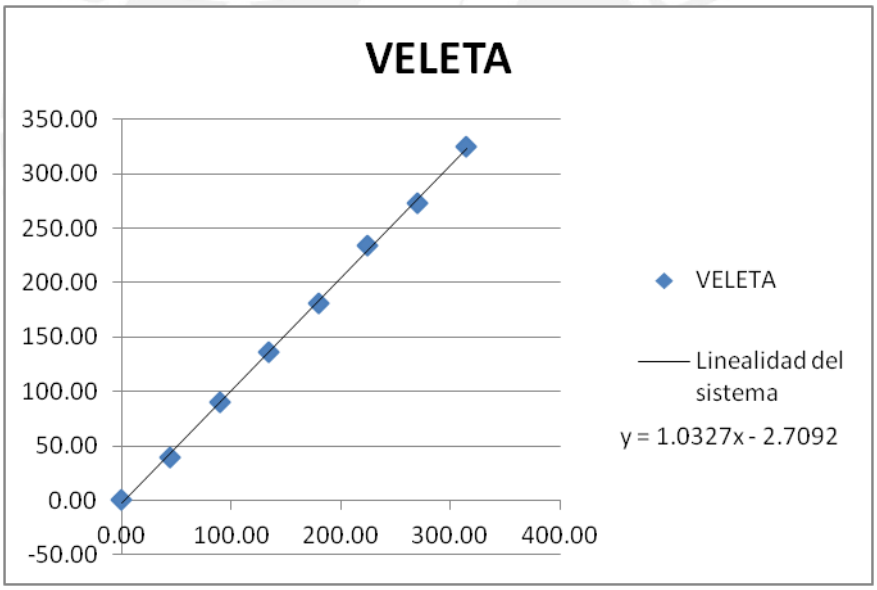


Figura 43. Linealidad del sistema veleta - Arduino

La tabla 13 muestra los datos y cálculos realizados para el sensor de tensión DC, mientras que la figura 44 ilustra la linealidad de las mediciones para el sensor de tensión DC.

Tabla 13. Datos y cálculos del sensor de tensión DC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
15	14.77	14.77	14.77	14.77	15.36	0.00	-3.84
30	29.65	29.65	29.65	29.65	30.33	0.00	-2.24
40	39.61	39.61	39.61	39.61	40.30	0.00	-1.71
50	49.69	49.69	49.69	49.69	50.30	0.00	-1.21
65	64.45	64.45	64.45	64.45	65.00	0.00	-0.85
73	72.42	72.42	72.42	72.42	73.00	0.00	-0.79
80	80.39	80.39	80.39	80.39	80.80	0.00	-0.51
87	87.07	87.07	87.07	87.07	87.40	0.00	-0.38
95	94.22	94.34	94.22	94.26	94.30	0.07	-0.04
100	100.46	100.46	100.46	100.46	100.60	0.00	-0.14
110	109.92	109.80	109.92	109.88	109.90	0.07	-0.02
					PROMEDIO	**0.01**	**-1.07**

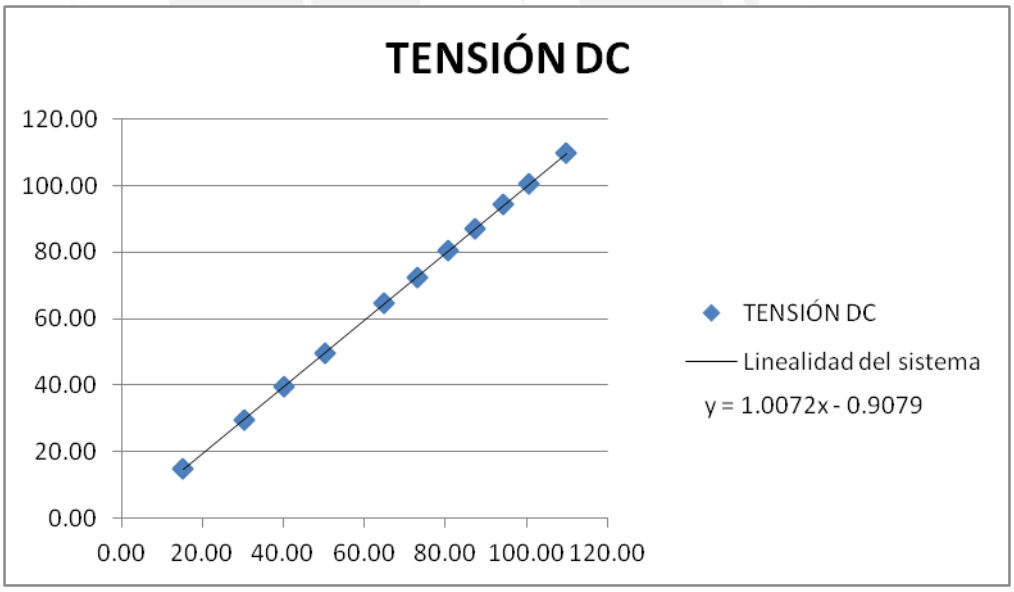


Figura 44. Linealidad del sistema sensor de tensión DC - Arduino

La tabla 14 muestra los datos y cálculos realizados para el sensor de tensión AC, mientras que la figura 45 ilustra la linealidad de las mediciones para el sensor de tensión AC.

Tabla 14. Datos y cálculos del sensor de tensión AC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio			
20	19.54	19.54	19.54	19.54	20.40	0.00	-4.22
40	39.69	39.69	39.77	39.72	40.15	0.05	-1.08
60	59.53	59.53	59.53	59.53	60.40	0.00	-1.44
80	81.20	80.90	80.90	81.00	81.60	0.17	-0.74
100	100.74	100.74	100.44	100.64	100.00	0.17	0.64
120	119.97	119.97	119.97	119.97	120.40	0.00	-0.36
140	140.43	141.65	141.65	141.24	140.50	0.70	0.53
160	161.80	161.49	161.18	161.49	161.00	0.31	0.30
180	181.64	180.72	181.33	181.23	180.70	0.47	0.29
200	202.40	203.01	202.70	202.70	202.00	0.31	0.35
220	227.43	226.21	224.64	226.09	223.60	1.40	1.12
					PROMEDIO	**0.33**	**-0.42**

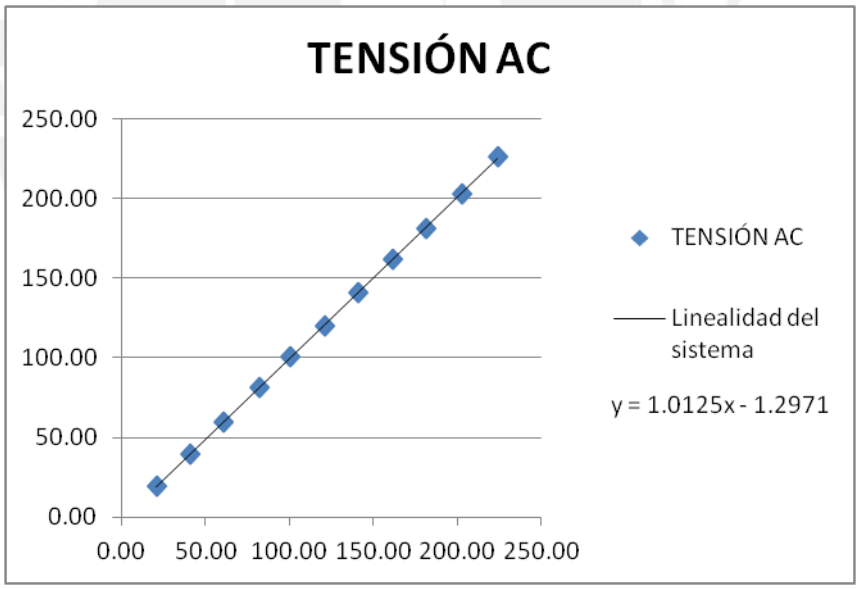


Figura 45. Linealidad del sistema sensor de tensión AC – Arduino

La tabla 15 muestra los datos y cálculos realizados para el sensor de corriente DC, mientras que la figura 46 ilustra la linealidad de las mediciones para el sensor de corriente DC.

Tabla 15. Datos y cálculos del sensor de corriente DC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
6	6.60	6.60	6.60	6.60	6.68	0.00	-1.20
13	13.45	13.45	13.45	13.45	12.96	0.00	3.78
16	16.71	16.71	16.71	16.71	16.47	0.00	1.44
20	19.96	19.96	19.96	19.96	19.95	0.00	0.04
23	23.22	23.22	23.22	23.22	23.22	0.00	0.02
27	27.13	27.13	27.13	27.13	26.48	0.00	2.45
30	30.39	30.39	30.39	30.39	29.90	0.00	1.63
33	33.65	33.65	33.65	33.65	33.28	0.00	1.11
37	37.23	37.23	37.23	37.23	36.64	0.00	1.61
40	40.49	40.49	40.49	40.49	39.96	0.00	1.33
44	44.40	44.40	44.40	44.40	43.18	0.00	2.83
48	48.64	48.64	48.64	48.64	47.41	0.00	2.60
					PROMEDIO	**0.00**	**1.47**

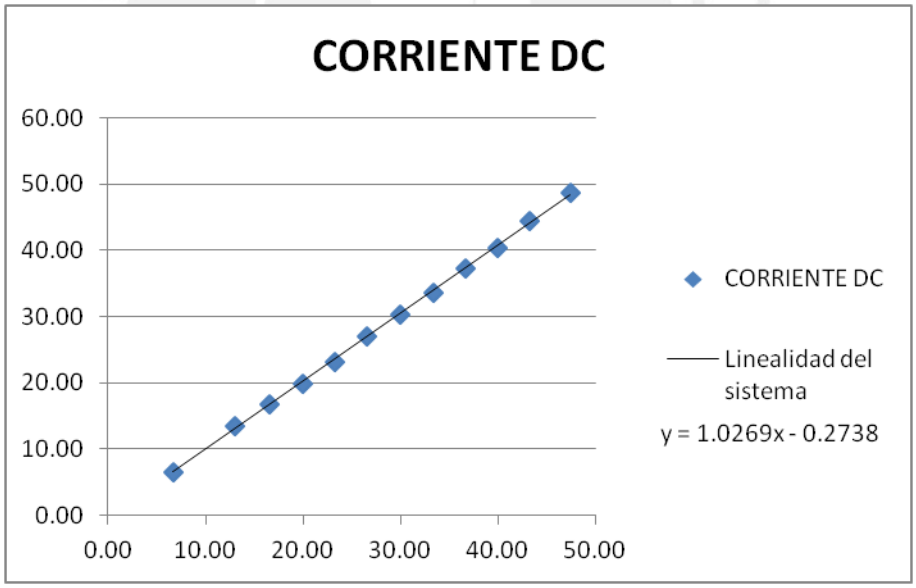


Figura 46. Linealidad del sistema sensor de corriente DC – Arduino

La tabla 16 muestra los datos y cálculos realizados para el sensor de corriente AC, mientras que la figura 47 ilustra la linealidad de las mediciones para el sensor de corriente AC.

Tabla 16. Datos y cálculos del sensor de corriente AC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de pinza amperimétrica	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
9	9.01	8.90	9.01	8.97	8.70	0.06	3.14
20	20.30	20.30	20.30	20.30	19.90	0.00	2.01
20.5	20.63	20.63	20.63	20.63	20.50	0.00	0.63
25	24.93	24.93	24.93	24.93	25.10	0.00	-0.68
30	29.43	29.43	29.43	29.43	29.60	0.00	-0.57
33	33.62	33.73	33.62	33.66	34.50	0.06	-2.44
38	37.70	37.70	37.70	37.70	38.00	0.00	-0.79
42	42.31	42.31	42.21	42.28	42.50	0.06	-0.53
47	46.71	46.71	46.71	46.71	47.00	0.00	-0.62
50	50.48	50.38	50.48	50.45	50.70	0.06	-0.50
55	55.09	55.46	55.41	55.32	55.00	0.20	0.58
60	60.75	60.64	60.64	60.68	60.07	0.06	1.01
					PROMEDIO	**0.04**	**0.10**

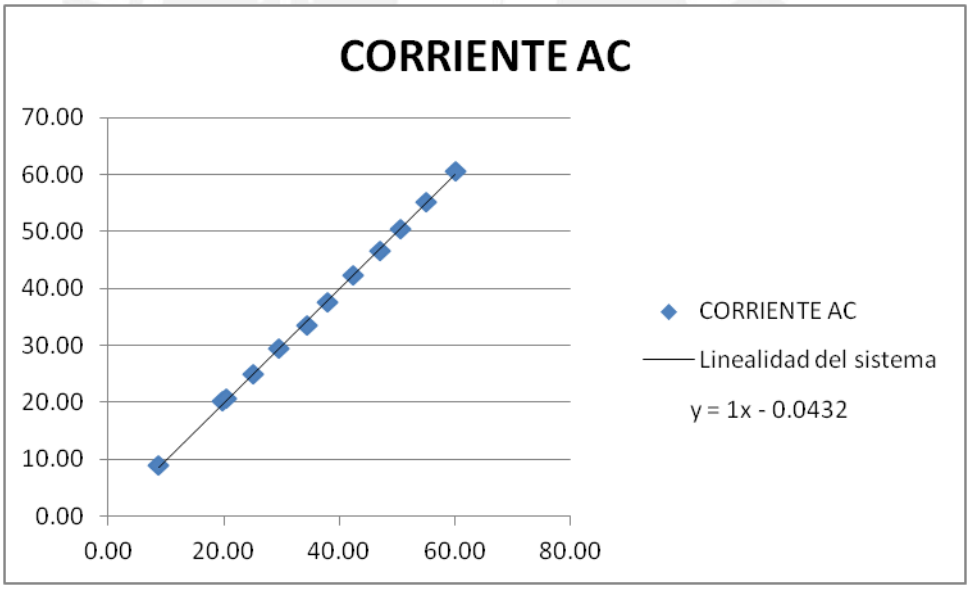


Figura 47. Linealidad del sistema sensor de corriente AC – Arduino

CONCLUSIONES Y OBSERVACIONES

Al finalizar el trabajo de tesis, se obtuvieron las siguientes conclusiones y observaciones:

- Se concluye que el sistema de monitoreo desarrollado, logra recopilar satisfactoriamente los parámetros eléctricos y atmosféricos tal como se muestra en las tablas de resultados presentados en el punto 4.3 Análisis de Resultados.
- El sistema de monitoreo es confiable pues se esperaba un error no mayor al 2%, y este presenta un error de medición menor al 1.5% para los parámetros DC (tensión y corriente) incluso menor al 0.5% para los demás parámetros.
- La precisión del sistema es favorable, siendo menor a 0.04 unidades en todos los parámetros excepto la tensión alterna, donde la precisión es de 0.33V.
- Los componentes utilizados pueden ser conseguidos localmente, con excepción de los sensores; por lo tanto su implementación puede ser replicada fácilmente en universidades.
- Se puede observar que el sistema de monitoreo implementado requiere de una calibración previa al funcionamiento.

RECOMENDACIONES

Para que el sistema de monitoreo desarrollado pueda ser replicado y mejorado se recomienda lo siguiente:

- Los valores de las resistencias deben ser medidos previamente para determinar con exactitud su valor real, y así poder calcular la función de transferencia exacta entre los parámetros de entrada y los valores del microcontrolador.
- La relación de conversión de la señal AC a DC se debe ajustar mediante mediciones a la entrada y salida del convertidor.
- Se debe aplicar tensiones o valores offset a las señales que así lo requieran.
- Debido a que el sistema de referencia de tensión es el mismo para todo el sistema, las señales de tensión DC a sensar deben tener una referencia común (GND) con el fin de evitar cortocircuitos.
- Se recomienda sensar señales DC libres de ruido, por lo tanto usar filtros que posibiliten su medición.
- Se recomienda conectar y desconectar la tarjeta microSD cuando el sistema no se encuentre energizado.
- Se sugiere realizar mayores experimentaciones para validar el funcionamiento del equipo.
- Es recomendable tener un mayor número de valores para evaluar la precisión y exactitud.
- Es necesario calcular la capacidad de datos que se pueden almacenar en una tarjeta microSD de determinada capacidad y periodo.

TRABAJOS FUTUROS

El presente trabajo de tesis fue desarrollado siguiendo unos objetivos establecidos. Sin embargo, este puede añadir ciertas etapas a futuro que ayudarán en su funcionamiento.

Entre los trabajos futuros que se plantean se encuentran:

- Opción de calibración en tiempo real: No cabe duda que la calibración del sistema es esencial para conseguir los valores de precisión esperados. En el actual sistema este debe ser calibrado mediante código y debe realizarse previamente a las mediciones. Por lo que se propone modificar el código en un futuro para que sea capaz de calibrar cada sensor sin necesidad de modificar el código, simplemente usando el teclado para modificar variables de calibración.
- Optimizar el diseño y arreglo del sistema: El prototipo del sistema funciona correctamente, mas es voluminoso y no aprovecha al máximo todo el espacio disponible. Por tanto, se propone mejorar el diseño de las tarjetas y el chasis para hacerlo más compacto y cuente con las Certificaciones de Protección IP para una mayor seguridad.
- Añadir una conexión a tierra al sistema: Una conexión a tierra en el sistema de medición añadiría una mayor robustez al datalogger, lo que prolongaría su expectativa de vida.

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ANEXOS

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ANEXO B: Especificaciones del anemómetro NRG 40C

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ANEXO A:

Manual de usuario del datalogger SymphoniePLUS3

SymphoniePLUS3®

15-channel data logger

Symphonie*PLUS3*® Data Logger and Accessories User's Manual

RENEWABLE NRG SYSTEMS™

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e-mail: sales@renewablenrgsystems.com

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Customer Support

Renewable NRG Systems offers a variety of support options to help you get the most from your Renewable NRG Systems product. If you have questions about your Renewable NRG Systems product, first look in the printed product documentation, the Knowledge Base, or in the Technical Forum in the Tech Support section of the Renewable NRG Systems web site. If you cannot find the answer, contact your salesperson or Renewable NRG Systems Technical Support for assistance using the information below. Customer support is available 8:30 AM to 5:00 PM EST, Monday through Friday.

Renewable NRG Systems
110 Riggs Road
Hinesburg, Vermont
05461 U.S.A.

Telephone: 802-482-2255

FAX: 802-482-2272
Email: support@renewablenrgsystems.com

When you call or email, you should have the appropriate product documentation at hand and be prepared to give the following information:

- Customer name
- Who purchased equipment
- Item number or description
- Serial numbers of logger and iPack
- When equipment was purchased
- Where equipment is installed - terrain conditions
- Description of the problem with some detail
- What events took place leading up to the problem
- What you have tried while attempting to solve the problem

Renewable NRG Systems maintains an extensive website which includes an in-depth customer support area for Renewable NRG Systems customers. If you need assistance at times other than our regular business hours, we suggest visiting our website, **www.renewablenrgsystems.com**.

All instruments, sensors, software and towers manufactured by Renewable NRG Systems are designed to be reliable and easy to use. We welcome your comments and appreciate your help in making Renewable NRG Systems products the best available.

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Introduction

Welcome!

Congratulations on your purchase of the Symphonie*PLUS3* data logger. The revolutionary Symphonie*PLUS3* data logger is part of the world's most advanced Internet enabled data logger system. It gives you all the accuracy and durability of other Renewable NRG Systems loggers, but allows you to collect data without leaving your desk. Symphonie*PLUS3* stores data on a standard SD card. With an optional iPack or iPackGPS, you can send data via your Internet provider over an embedded standard, satellite, or cellular phone. You get an email with an attached data file at any interval you choose.

The Symphonie*PLUS3* is a further evolution of the Symphonie-*PLUS* logger. Built on the proven designs of the Symphonie and SymphoniePLUS, Symphonie*PLUS3* offers 3 "flex" channels compatible with either analog or digital sensors with the addition of an SCM. The universal anemometer inputs of the Symphonie*PLUS3* are compatible with most commonly used anemometers – no SCMs required! Optional plug-in Signal Conditioning Modules (SCMs) are available and pre-configured to work with analog sensors from Renewable NRG Systems or other manufacturers.

The look and feel of Symphonie*PLUS3* as well as the menu structure and user programming tasks remain largely unchanged from Symphonie and SymphoniePLUS. SCM auto-detection allows the logger to display flex channel information according to whatever SCM is inserted in the corresponding channel. A new programming feature in the SDR software allows logger programming using a laptop through the iPack programming port.

If you can program a SymphoniePLUS, you already know how to program a Symphonie*PLUS3*!

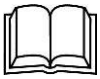
The complete Internet enabled Symphonie*PLUS3* data logger system is comprised of the Symphonie*PLUS3* data logger; optional iPackGPS kit for (2G) CDMA cellular, (2G) GSM cellular, (3G) GSM cellular (HSPA), or satellite communications, plus Symphonie Data Retriever Software. The Ethernet based iPackACCESS is also available and is very well suited for use at reference towers where real time SCADA networks polling for MODBUS data are utilized. Starting in June 2010, all wireless based Symphonie iPacks will ship pre-configured for WindLinx wireless service. WindLinx allows for uniform activation of communications services and features the WindLinx web portal, which allows for remote management and monitoring of wireless account activity.

Using This Manual

The Symphonie*PLUS3* logger User's Manual is an indispensable part of the Symphonie*PLUS3* logger system. Read this manual completely before installing and operating the Symphonie*PLUS3* logger. Follow all instructions and recommendations closely. Several checklists and forms have been included to facilitate preparing for installation and site visits. Avoid jeopardizing the reliability of your data collection system by being prepared with the required information and tools.

This document and the instruments described herein may use the following symbols:

 Earth (Ground)

 Read the Manual

 DC Voltage

Definitions

This type style is used for the general body of this manual and is used for general descriptions and instructions to the

user.

Instructions in **Bold Type** refer to Symphonie Data Retriever Software and require you to press a button on the computer screen, open a file, or select from a program menu. For example: **File>Open**.

Instructions in **[Brackets]** refer to Symphonie*PLUS3* logger keypad navigation and require you to press a series of keys to perform a specific function. For example, pressing the **[Home/Esc]** key will always return the display to the Main Menu.

This type style is used to show actual prompts and messages that appear on the logger display.

This type style is used to warn users of a potential danger, either to themselves or to the equipment or data.

SymphoniePLUS3 Set-up Overview

Symphonie*PLUS3* is a very flexible logging system that can be set up as a stand alone unit or as an Internet enabled logging system. When used as a stand alone unit, data files are retrieved manually through regular site visits. When used in conjunction with a snap-on CDMA, GSM, or satellite communications iPack, data files are delivered to the user as email attachments.

Stand Alone Users (no iPack)

Stand alone Symphonie*PLUS3* configuration is fairly straightforward for those familiar with data loggers. Follow the sections on logger setup carefully. Stand alone users may skip the headings in this manual referring to iPacks and do not need to install the SDR software in order to configure a logger. All software related operations including software installation can be skipped until files need to be processed.

Internet Enabled Users (with iPack or iPackGPS installation)

This manual provides full instructions in a chronological order for Symphonie*PLUS3* / iPack / iPackGPS systems. It is recommended that the manual be followed in chronological order for configuring an iPack or iPackGPS System. The term "iPack" as used throughout this manual refers to either the iPack or iPackGPS except where a difference in programming or features is explicitly noted.

As of June 2010, all iPacks ship pre-configured for WindLinx wireless service. Through WindLinx unified wireless service, iPack and iPackGPS users can set up Internet service provider accounts in addition to cellular or satellite accounts from a single provider. The WindLinx web portal will generate necessary programming parameters for the iPack. Instructions for programming the iPackGPS, released February 2011, are the same as for iPacks except where explicitly noted.

Theory of Operation

The Renewable NRG Systems Symphonie*PLUS3* data logger is an Internet ready, ultra-low power microprocessor-controlled data logging system specifically designed for the wind energy industry. Addition of a wireless based iPack with a small PV panel provides convenient autonomous power (with its built-in 12V battery and charge controller), and allows for Internet transfer of data via email through wireless networks. The Ethernet based iPackACCESS is suitable for windfarm reference towers which require real time and statistical data for SCADA networks.

The Symphonie*PLUS3* logger has a fixed averaging interval of 10 minutes. Each of the 15 channels' averages, standard deviations, and other statistical values are calculated from continuous 1 second data samples. Data intervals are calculated every 10 minutes, time stamped with the beginning time of each interval and written to the SD Card (SD) at the top of each hour.

Symphonie Data Retriever (SDR) software is then used to process raw data files stored on your computer either from an SD Reader or email. Configuration of iPacks is also performed by the SDR software with the use of a programming cable. Sensor scales and offsets programmed into the Symphonie*PLUS3* logger can be edited later with SDR if there is a mistake

or if a sensor is added or changed. The parameters in SDR's Site Information Editor are used to create the tab-delimited text file (ASCII), so there is always an opportunity to make changes to how the raw files will be processed before generating ASCII data files.

Features of the SymphoniePLUS3 Logger System

The Symphonie*PLUS3* logger is a 15 channel data logger optimized for the needs of the wind energy assessment user. It is designed to be easy to install and reliable in any climate. Wherever you need to measure the wind, no matter how demanding the environment, Symphonie*PLUS3* and the "plug and play" iPacks make data collection as easy as reading your email.

- It provides up to 9 counter inputs used for measuring wind speed or other frequency signals such as rain gauges or other totalizer type sensors.
- All counter inputs can accommodate the RNRG Class 1 Anemometer, RNRG 40C Anemometer or other digital anemometers and do not require SCMs. Only flex channels (channels 4, 5, and 6) require SCMs.
- 3 flex channels can be configured for analog or anemometer/counter input signals by inserting an SCM card.
- It provides up to 9 analog channels (6 dedicated analog channels plus 3 flex channels) used for measuring wind direction or a range of other parameters including temperature, barometric pressure, relative humidity and solar energy.
- The Symphonie*PLUS3* logger is wind energy industry specific and pre-configured to industry standards. All features for wind energy assessment are built in. Symphonie*PLUS3* requires no complex configuration.
- Convenient "plug and play" Signal Conditioning Modules (SCMs) are pre-configured for a large variety of additional sensors.
- Configuration of channels 4-6 and 9-12 can be altered at any time for different sensors by simply changing the corresponding SCM. Channels 4 – 6 offer the option of accepting either analog or anemometer/counter SCMs.
- Symphonie*PLUS3* uses standard, non-volatile Secure Digital (SD) Cards (SD) for data storage. Cards are available almost anywhere in the world and provide secure data storage.
- The SD card provides over 2 years of data storage.
- Average, Standard Deviation, Maximum and Minimum values are recorded for all wind speeds and most analog channels at every 10 minute interval. Set up is done for you.
- Free Symphonie Data Retriever Software is included and produces versatile tab-delimited text files. Data files can be used with a wide range of data processing software, including SQL databases, Microsoft Excel and Access, and more. International numeric formats are supported.
- The 4 line x 20 character display is easy to read and provides easy to understand real-time data and configuration information.
- Dedicated navigation buttons (up, down, left, right, home), plus a data entry keypad make the full-text, menu driven display easy to use.
- Separate lithium battery-backed real-time clock provides accurate and reliable time stamping.
- Wiring panel provides additional gas tube electro-static damage (ESD) protection for each input channel.
- Symphonie*PLUS3* runs on two alkaline D-cells (included) for up to one year, depending on sensor configuration.
- iPack kits for CDMA cellular, GSM cellular, and satellite communications provide remote data collection via e-mail.

- Symphonie iPack | Power Only kits provide additional power for higher consumption sensors such as barometric pressure sensors or relative humidity sensors.
- Loggers with iPacks allow remote changes to sensor configuration and communication parameters via email.
- Symphonie Data Retriever Software allows pre-installation programming of iPacks and Symphonie loggers through a programming cable.
- Call Now and antenna test features allow on-site testing of iPack communications.
- iPack battery can be recharged after office testing using a convenient wall charger (available from Renewable NRG Systems).
- Symphonie Data Retriever Software version 7 and later is compatible with data from Symphonie*PLUS3*, Symphonie, Wind Explorers, 9200-*PLUS*, and 9300 series loggers and their readers (DataPlug Reader, EEReader II).
- Improved support for DBCS systems.
- Data filtering in Symphonie Data Retriever Software can exclude icing data and faulty sensor data from reports.
- Support for SMTP authentication for iPacks version 14 and later.
- iPackGPS can have its firmware upgraded via e-mail or on site using SDR and the iPack programming cable.
- POPAuto feature included with Symphonie Data Retriever Software automates extraction of emailed data.
- Convenient access to complete sensor history information in the Site Information Editor screen.
- Customized ASCII export available.
- Integrated Global Positioning System (GPS) in iPackGPS
- More detailed iPackGPS info such as iPackGPS serial number, signal strength, modem identifier, and firmware version available in header of each raw data file.

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Precautions

Notes for First Time Users

It is recommended that you take the time to become familiar with your new logger and its operation before going out in the field. Please read the manual and experiment with all the functions and features of the Symphonie*PLUS3* data logger.

Practice the following in your office before going to the field:

- installing SCM cards
- setting Symphonie*PLUS3* parameters (through the keypad, or through the iPack with the iPack programming cable)
- attaching the sensors to the Symphonie*PLUS3* logger
- using the keypad
- formatting and changing SD cards
- changing batteries
- installing and configuring iPacks (ALWAYS verify successful data transfer before field installation!)
- using Symphonie Data Retriever Software
- transferring data from the SD card to your PC

Grounding

Whenever coming in contact with the SymphoniePLUS3 logger, either in the field or indoors, it is good practice to first grasp a piece of grounded (earthed) metal to avoid a potentially damaging electrostatic discharge (ESD) to the logger.

Meteorological sensors, loggers, and towers will accumulate static charge unless they are properly grounded. Both high wind speeds and low humidity increase the rate of charge accumulation. Static charge can change the electric potential of the logger and sensors by thousands of volts relative to ground. Charge will continue to accumulate until the developed voltage difference causes dielectric breakdown and static discharge.

Electrostatic discharge will damage any scientific instrument, including a Symphonie*PLUS3* logger. It is very important that you ground your logger immediately after mounting and prior to connecting a sensor. If a copper clad ground rod cannot be driven into the ground at the base of the tower, a grounding cable should be buried in the ground for sufficient distance to reduce the resistance between the logger ground stud and the earth. Failure to adequately ground a Symphonie*PLUS3* logger will cause damage to the logger, sensor damage, and loss of data.

Equipment that is not properly grounded is not covered by Renewable NRG Systems' warranty.

Recharging the iPack Battery

Lead acid batteries such as the one used in the Symphonie*PLUS3* iPack need to be kept fully charged. It is very important to recharge the iPack before installing it in the field, especially after programming or communications testing. All lead acid batteries will lose their capacity over time.

The battery must be recharged if an iPack is kept in storage or is unused for any period of time.

An iPack battery charger is available from Renewable NRG Systems (item #3615).

iPack models released after April 2006 have an additional set of terminals for a 12 V external power source (battery bank with charge controller, for example). Please review the following table to make sure you are making the correct connections.

Connection Point	Do	Do NOT	Functional Notes
PV Terminals	Do…connect PV panels, DC power sources between 14 and 28 V DC	Do NOT…connect power sources in excess of 28 V DC, including large PV panels	The PV terminals will charge the iPack's internal battery; the PV terminals will NOT charge an external battery.
External Battery Terminals	Do…connect 12 V battery and/or external charge controller up to 14.3 V DC	Do NOT…connect PV panel or power sources in excess of 14.3 V DC	The external battery terminals are an input only, an external battery will NOT be charged from the iPack through these terminals nor will the internal iPack battery.
Ground Terminal	Do…connect to logger ground stud and trim ground wire to the required length.	Do NOT…leave disconnected or connect other wires such as shields; do NOT coil or roll excess ground wire.	This terminal will help provide protection from electrostatic discharge for the iPack and logger.

If the iPack battery is not fully charged before being installed in the field, the battery may discharge faster than the photovoltaic panel can recharge it. This is more likely when using sensors with greater rates of power consumption such as barometric pressure and relative humidity sensors. Like most lead acid batteries, if the iPack battery remains at low capacity for an extended period of time, the battery will no longer accept or maintain a charge.

Environmental Considerations

- Grounding requirements are site specific; determine soil type before installation.
- Sensor cables become less flexible and are more easily damaged at very low temperatures.
- Make sure that all sensor cables are securely fastened to the tower so they do not flap in the wind.
- Be sure that all connections are tight and securely fastened to ensure reliability in high winds.
- Low temperatures can diminish battery performance. Always use good quality alkaline batteries, and always stay within reasonable limits when establishing your battery replacement schedule. Replace alkaline batteries at least once per year to avoid leakage.
- Make sure that all sensor cables are spiral wrapped (2 wraps every three meters) around the tower to discourage natural frequency vibrations. Use a high quality electrical tape rated for extreme conditions to further secure the cables to the tower.
- Coat terminal connections with anti-corrosive or petroleum jelly to reduce corrosion.

Site Records

Understanding the assignment of site numbers is the single most important step in setting up a wind assessment system.

- The Symphonie*PLUS3* logger system requires that you assign a unique site number to each logger site.
- The assigned site number must stay with the site even if the tower, sensors, and logger are dismantled and moved to another location.
- An abandoned site number is never re-used or assigned to a new location. It remains as a reference to the historical data from the abandoned site.

An accurate description of each site is essential to your wind measurement program. Your SymphoniePLUS3 logger can

be configured to label datasets with the following information:

- Latitude and longitude (programmed automatically when using iPackGPS)
- Site elevation (programmed automatically when using iPackGPS)
- Sensor heights

It is advisable to record additional site information that may help in the analysis of your data:

- Type of terrain (open plain, mountainous forest, etc.)
- Type and height of trees
- Type of climate
- A topographic map of the area

Additional procedures and recommendations for keeping good site records can be found in the American Wind Energy Association's siting standards document*: Standard Procedures for Meteorological Measurements at a Potential Wind Turbine Site.* This document can be found on the AWEA web site, www.awea.org.

Other good resources for site configuration guidelines can be found here:

http://www.nyserda.org/publications/wind_resource_assessment_handbook10_30.pdf
http://www.measnet.com/measnet_siteassessment_v1_0.pdf

In the Appendices, we've provided some blank site data sheets that may be helpful in organizing site information.

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Symphonie*PLUS3* Logger Components (Quick Tour)

Unpacking the SymphoniePLUS3 Logger System

Follow standard precautions for handling electronic components when unpacking the Symphonie*PLUS3* logger. Discharge static electricity from your body by touching a piece of grounded metal or wearing a ground strap.

> *Do not remove the brown desiccant pack from the clear plastic package at this time. During the field installation procedure, you will remove the clear wrapper and place the desiccant pack inside the logger enclosure to keep it dry.*

Confirm that you have received all components by comparing your order to the packing list shown below. Immediately contact Renewable NRG Systems if any of the components are missing.

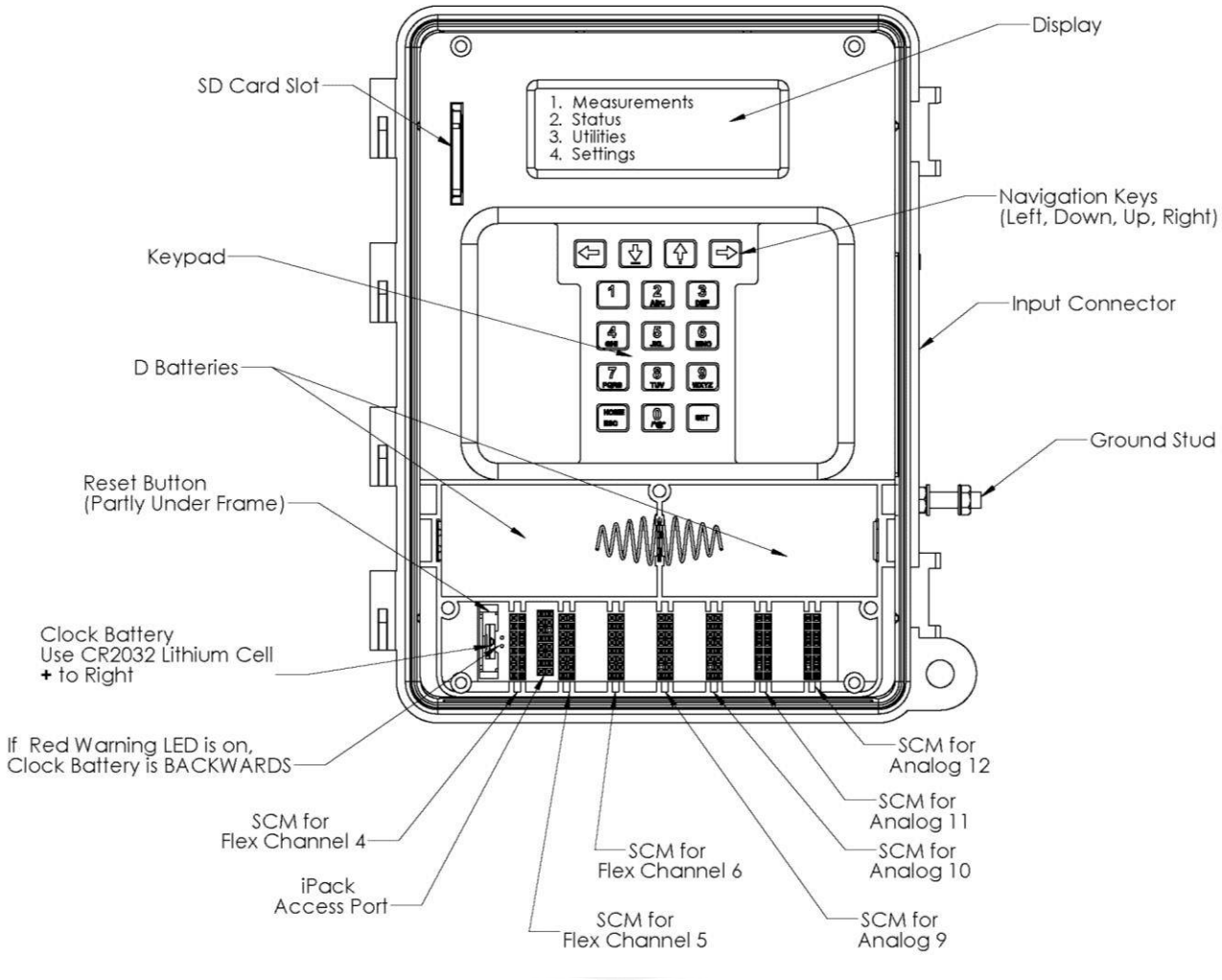
You should find the following standard equipment:

1 – Symphonie*PLUS3* data logger unit
2 – 1.5 volt D-cell alkaline batteries
1 – 3 volt lithium clock battery (installed)
1 – 10 foot (3 meter) 10 Ga. ground cable with connector
2 – 10-32 hex machine nuts
4 – 10-32 x 0.50 inch (13 mm) mounting screws
1 – desiccant pack
1 – Renewable NRG Systems SD card with protective case
1 – field wiring panel
1 – sheet of paper referring users to Renewable NRG Systems' website for downloading the latest version of Symphonie Data Retriever Software and the Symphonie*PLUS3* User's Manual
1 – screwdriver with Renewable NRG Systems logo

Be sure to double-check your order for any optional equipment ordered, such as SCMs, extra SDs, etc.

SymphoniePLUS3 Logger Components Map

Here is an illustration of the logger with the cover open and the battery cover removed.



Keypad

- Two field types are utilized when programming the Symphonie*PLUS3* logger - numeric only and alphanumeric. While in a numeric only field, pushing a numbered key allows direct entry of any numeric value. While in alphanumeric fields, the keys will scroll through each of the assigned characters. For example, push the **[2]** key, and it types the number "2." Push the same key again and it types the letter "A" or "a." Press the same key again, and it types the letter "B" or "b." The navigation keys in the top row are used to toggle between upper and lower case letters (see below).
- In this manner, the digits 0-9, the entire alphabet, as well as special characters, can all be entered utilizing only ten keys.
- The zero **[0]** key can be used to enter a blank space or the characters "*" and "#." Pressing the **[Home/Esc]** key will always return the display to the Main Menu.
- Take some time to experiment with the keypad to become familiar with its operation.

Navigation keys

The keys in the top row are the navigation keys – left, down, up and right. These keys can be used to page forward and backward, move the cursor on data entry screens, and enter decimal points "." or negative "-" characters. Additionally, the up and down keys are used to toggle between capital and lower case letters in alphanumeric fields. The exception to this is that the up and down arrow keys are used for the semi-colon and colon characters while in the Manual Dial screen of the iPackGPS.

Display

- The liquid crystal display is built into the logger to facilitate site visits and is activated by pressing any key on the logger keypad. The user can view present wind conditions and logger parameters without additional equipment.
- As a power saving function, the display will always shut off after one minute without any key inputs. The logger continues to collect data while the display is off.

D-cell Batteries

The logger runs on standard D-cell batteries which are protected by a battery cover. Batteries should be changed one at a time so that logging operations are not disrupted during the battery change.

It is recommended that high quality alkaline batteries are used (such as Energizer or Duracell), and they should be changed at least once per year to avoid leakage and equipment damage.

Input connector

This male DB-62 connector interfaces to the field wiring panel. Sensor wires are connected to the field wiring panel with the supplied Renewable NRG Systems screwdriver.

iPack access port

This port allows connection of the Programming Adapter for iPack and logger programming while the iPack or iPackGPS is connected to the logger.

Ground stud

This 10-32 stud is designed to be connected directly to earth ground with the supplied ground cable. The logger must be grounded!

Clock battery

A lithium battery powers the logger clock even if D-cell batteries are not present. This allows the logger to retain date and time in the event of a reboot. Clock batteries will last many years under normal use.

Clock battery warning LED

This LED illuminates if the clock battery has been installed backwards.

Reset Button

Any time the reset button is pressed, the logger will begin a new data file.

- A reset button is provided in the unlikely event that a nearby lightning strike or ESD event causes the Symphonie*PLUS3* data logger electronics to lock up. It is located between the battery box and the clock battery.
- Should it become necessary to reset the Symphonie*PLUS3* logger, place the Renewable NRG Systems screwdriver (provided) in the upper corner just to the left of the "Channel 4" SCM slot and slide down.
- Resetting the unit will cause up to 10 minutes of data to be lost (depending on how long since data was last written to memory) and will start a new data file.

- Symphonie*PLUS3* loggers with attached iPacks will initiate an automatic call ("cold boot call") 10 minutes after the logger is powered up. If no antenna is attached or the call can't be completed, no attempt will be made to call again until the next scheduled call or a "Call Now" is initiated by the user.
- Collected data already written to memory and all configuration settings will be retained.
- The reset button can also be used during field installation to start a new data file from the point at which all sensors have been connected.

Note that a reset can be also be initiated by the built-in watchdog in response to an ESD (electrostatic discharge) event. When an iPack is connected to a logger with no D-cells, this will also initiate a reset. The iPack provides auxiliary power to the logger and therefore powers it up in the absence of D-cells.

SD Card Slot

The SD memory card installs into this slot with the beveled front corner down.

Channel Description

The Symphonie*PLUS3* Logger has 15 input channels; 6 channels are counters, 6 are analog, and 3 channels can be either counter or analog.

Channels 1 – 3 and 13 – 15 (Counters)

Channels 1 through 3 and 13 through 15 have built-in sensor interfaces for the RNRG Class 1 Anemometer, RNRG 40C Anemometer and other anemometers such as the P2546A WindSensor, Thies First Class, Vector, etc. Flex channels 4 through 6 can be configured for anemometers or analog sensors by plugging an SCM into the corresponding SCM slot for that channel. The SCM provides the electronics to configure the input for the connected sensor. The SCM also sets up the channel as a speed (frequency) or totalizer for sensors such as tipping-bucket rain gauges or kWh meters.

SCM slots for flex channels 4, 5 and 6 (analog or counter / anemometer)

Each slot accepts an analog or counter / anemometer type Signal Conditioning Module (SCM). These are used to configure the logger for additional analog or counter /anemometer channels (in addition to the 6 built-in counter/anemometer channels). When you insert the SCM, the correct type of sensor should be automatically detected by the logger and only show programming options appropriate for that type of sensor.

Channels 7 – 12 (Analogs)

Channels 7 and 8 have built-in sensor interfaces for the RNRG 200P wind vane or other wind vanes with similar output signals. Channels 9 through 12 are configured by plugging an SCM into the corresponding SCM slot for that channel. The SCM provides the electronics to configure the input for the connected sensor. Appropriate SCMs in analog channels 9 through 12 also describe to the logger whether the analog channel is a vane or other type of analog sensor (relative humidity, barometric pressure, temperature, etc.).

SCM slots for analog channels 9, 10, 11 and 12

Each slot accepts an analog type Signal Conditioning Module (SCM). These are used to configure the logger for additional wind vanes (in addition to the 2 built-in vanes channels) or other analog type sensors.

Pre-Installation Setup: Logger Configuration

It is important to follow the instructions in this section in the sequence presented. Logger programming can be done using the logger's keypad, or programming information can be uploaded to the logger using SDR. Uploading from SDR requires an iPack and connection through the logger's iPack access port. The Logger Direct Editor screen is accessed through SDR's Modify iPack Settings screen.

Grounding

Whenever coming in contact with the SymphoniePLUS3 logger, either in the field or indoors, it is good practice to first grasp a piece of grounded (earthed) metal before touching the logger to avoid a potentially damaging electrostatic discharge (ESD) to the logger.

Installing SCMs

If your site configuration requires more than the 6 built-in anemometer / counter channels and 2 built-in vane channels, it will be necessary to install appropriate Signal Conditioning Modules (SCMs) for each additional anemometer / counter sensor (channels 4 through 6) and each additional analog sensor (channels 4 through 6, and channels 9 through 12) to be connected to the Symphonie*PLUS3* logger. Each SCM provides the necessary signal conditioning (filtering, gain, buffering and protection) electronics for the specific sensor type to be connected to the channel.

Additionally, each SCM automatically sets the logging mode for the channel. The logging mode determines how the Symphonie*PLUS3* logger will process data gathered by each channel. For each flex channel 4 through 6, the SCM identifies the logging mode as a vane or analog (other than vane), frequency (speed), or totalizer, and for each analog channel 9 through 12, the SCM identifies the logging mode as vane or analog (other than vane).

Before inserting an SCM in the appropriate slot, be sure to grasp the ground stud on the logger to prevent a potentially harmful static discharge. The SCM has a metal strip on the top edge to facilitate grounding while being handled.

- In order to install an SCM, it is necessary to remove the battery cover by loosening the three thumbscrews. It is preferable that the logger is not powered while installing or removing SCMs, so the D-cells or iPack should not be installed at this time.
- Install the SCM into the appropriate slot with the pins facing downward and the circuit components facing to the right.
- Do not force the SCM.
- The pins and connectors are "keyed" so that a counter SCM cannot be inserted into an analog slot.
- Once the SCMs have been installed, the D-cell batteries can be installed, and the channels can be configured.
- Allow 4 seconds between inserting and removing SCMs as they take a few seconds to be recognized by the logger

Installing D-Cell Batteries

- Open the logger enclosure and remove the battery box cover. If you just installed SCMs, the cover should already be off.
- Insert two fresh D-cell batteries, one at a time, into the battery holders with the positive terminals of the batteries (the end with the bump) oriented towards the sides of the enclosure. When the batteries are first inserted, the display will read:

  NRG Systems, Inc.
  SymphoniePLUS3
  SN: 00000
  Press [HOME]
- Replace the battery box cover.
- As a power saving function, the display will always shut off after one minute without any key inputs.
- The display may also be shut off by pressing **[Home] [3] [3].**
- The logger continues to collect data while the display is off.

SCM cards installed under battery cover

Setting Logger Display Contrast

The Symphonie*PLUS3*'s display contrast is pre-set at the factory but can be adjusted if necessary. Please note that changes in contrast are temporary. When the display is powered up again, the default contrast setting will appear. This is to avoid the screen being accidentally set so that it can't be read (completely black or completely white).

[Home][3][2] = Set Display Contrast

Use up and down keys
to adjust contrast

ESC=Quit Set=Accept

Setting and Verifying Logger Units (Imperial or SI)

Sensor lists are used to configure each channel of the logger. There are two internally stored factory loaded sensor lists,

one with scale factors in Imperial units and one with scale factors in SI (metric) units. Setting the logger units to Imperial will load the sensor list with the scale factors in miles per hour, and the site elevation and sensor height units will default to feet.

Setting the logger units to SI will load the sensor list with the scale factors in m/s, and the site elevation and sensor height units will default to meters.

Note that this will not change the currently stored scale factors for each channel in the logger. You must always confirm the scale factors and units for each logger channel individually.

- Press **[Home][4][3][3]**
- Use the **[UP]** and **[DOWN]** navigation keys to select Imperial or SI.
- Press the **[Set]** key to accept the selected units or press **[ESC]** to quit without changing the units.
- With an iPack connected and using the programming adapter in the logger's iPack access port, you may set the Default Units using SDR's Logger Direct Editor Screen (found in the **File** menu of the Modify iPack Settings screen).

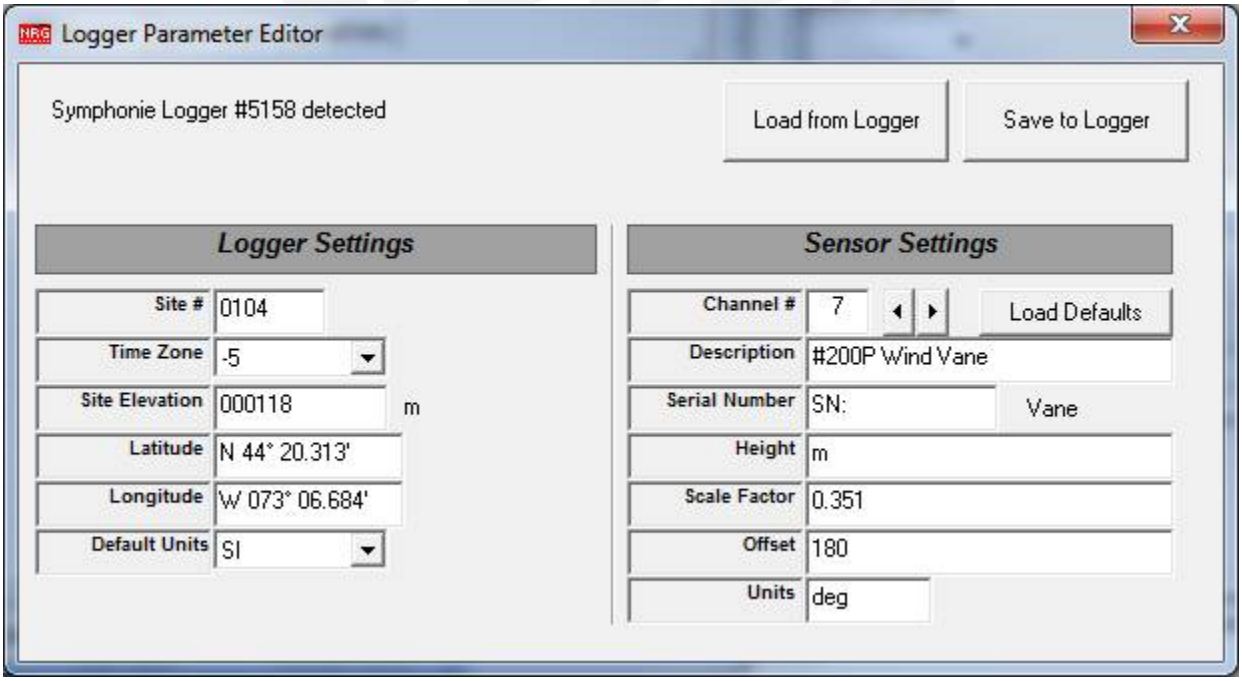
Channel Configuration Sequence – choosing a sensor, setting and verifying each logger channel

It is recommended that the channels are configured only after the logger units have been set to either Imperial or SI as described above. Default sensor configuration values are preprogrammed for Renewable NRG Systems sensors and can typically be used to simplify the configuration process.

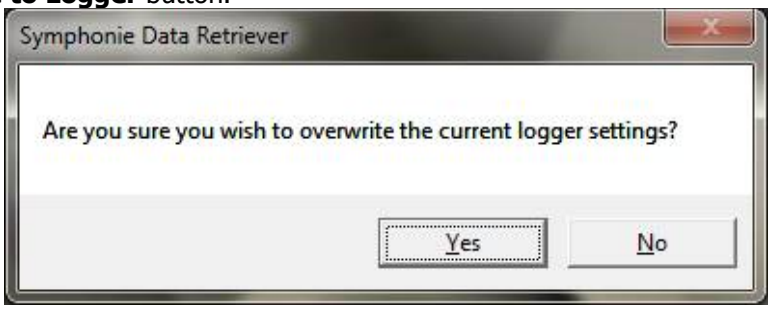
With an iPack connected and using the programming adapter in the logger's iPack access port, you may configure each sensor channel using SDR's Logger Direct Editor Screen (found in the **File** menu of the Modify iPack Settings screen).

Channel Configuration Using SDR's Logger Parameter Editor

To begin the configuration process using SDR, make sure your logger is connected to an iPack and that you have a programming adapter installed in the logger's iPack access port. Connect your computer running SDR to the programming adapter, and choose **Modify iPack Settings** from the **Site** menu. Then choose **Logger Parameter Editor** from the File menu. Click the **Load from Logger** button to see the current settings in the logger.



Use the arrow buttons to scroll through each channel to review current settings and make changes as needed. If a channel isn't listed, it means there is no SCM currently installed for that channel and it is therefore inactive. Once changes are complete, click the **Save to Logger** button.



Click **Yes** to accept the changes or **No** to discard them.

Channel Configuration Using the Logger's Keypad

To begin the configuration process using the logger's keypad, press **[Home][4]**. The following display will appear:

1. Counter Channels
2. Analog Channels
3. Logger Settings

- Pressing **[1]** will display a list of the currently active counter channel descriptions.
- Pressing **[2]** will display a list of the currently active analog channel descriptions.
- Scroll through the list of channels using the **[UP]** and **[DOWN]** arrows. If a channel isn't listed, it means there is no SCM currently installed for that channel and it is therefore inactive.
- Press the corresponding number for the channel you wish to configure [for example, 1, 4 for channel 14]. This will display the currently active channel description.
- You may now edit the currently displayed channel by pressing **[SET],** or you may select a new configuration from the loaded sensor list by pressing the **[Down]** arrow key to scroll until the desired sensor description appears. When you have scrolled to the correct sensor description, press **[SET]** to edit. Any changes will be loaded as a working copy into temporary memory and will be saved and finalized after the configuration process for the channel is completed.
- Note that the currently selected sensor description will be followed by [Set] to Change on the LCD.

Channel 1: Frequency
NRG #40C Anem m/s
[Set] to Change
[Down] for Defaults

Other available sensor description choices will be followed by Up, Down to select and ESC=QUIT SET=ACCEPT.

-> Description (Sensor Model)

Edit the sensor description if desired by using the keypad and navigation keys. Press **[SET]** when the sensor description is correct. The description is now loaded into the temporary memory and will be saved after the configuration process for this channel is completed. The scale factor editing screen will appear next.

-> Scale Factor

Enter the scale factor exactly and be careful to place the decimal point into the correct place. Edit the sensor scale factor if desired by using the keypad and navigation keys. Press **[SET]** when the sensor scale factor is correct. The scale factor is now loaded into the temporary memory and will be saved after the configuration process for this channel is completed. The offset editing screen will appear next.

-> Offset

Edit the sensor offset if desired by using the keypad and navigation keys. Press **[SET]** when the sensor offset is correct. The offset is now loaded into the temporary memory and will be saved after the configuration process for this channel is completed. The units editing screen will appear next.

-> Units

The Symphonie*PLUS3* Logger may be set to use "mixed" units – that is, one can use SI units for some channels and Imperial units for others. Additionally, the units for each channel do not need to match the units that have been set for site elevation (altitude) and sensor height. Edit the sensor units if desired by using the keypad and navigation keys. Press **[SET]** when the sensor units are correct. The units are now loaded into the temporary memory and will be saved after the configuration process for this channel is completed. The height editing screen will appear next.

-> Height

Edit the sensor height if desired by using the keypad and navigation keys. The sensor height may be up to 4 characters. Press **[SET]** when the sensor height is correct. The height is now loaded into the temporary memory and will be saved after the configuration process for this channel is completed. The serial number editing screen will appear next.

-> Serial Number

Edit the sensor Serial Number (SN) if desired by using the keypad and navigation keys. It is an 8 character alphanumeric field. Press **[SET]** when the sensor Serial Number (SN) is correct.

All channel parameters that were loaded into temporary memory during editing are now finalized, and the configuration of this channel is now complete. The Symphonie*PLUS3* data logger will return to the channel selection menu, and the process is repeated for the next channel.

Setting and Verifying Site information, Time Zone, Clock and Data Encryption

Time Zone and Logger Clock (Time and Date)

- Press **[Home] [4] [3] [1]** to display the screen that sets the appropriate time zone (the logger defaults to zone – 5: American Eastern Standard Time).
- Use the **[Up]** or **[Down]** arrows to scroll to the proper zone for your site, then press **[Set]** to accept. The logger will update the time zone and then display the prompt:

  Set Date and Time
  02/15/2003 15:26
  mm/dd/yyyy hh:mm
  ESC=Quit SET=Accept

  Remember to use local standard time (not daylight savings time). Press **[Set]** to accept.

- With an iPack connected and using the programming adapter in the logger's iPack access port, you may set the Time Zone using SDR's Logger Direct Editor screen (found in the **File** menu of the Modify iPack Settings screen).

Site Number

- Press **[Home [4] [3] [2]** to set your unique site number.
- The Site Number field initially defaults to the logger's serial number but can be reset to any four digit number.
- With an iPack connected and using the programming adapter in the logger's iPack access port, you may set the Site Number using SDR's Logger Direct Editor screen (found in the **File** menu of the Modify iPack Settings screen).

Site Altitude (Elevation) (optional)

- Press **[Home] [4] [3] [4]** to set site elevation.

- Site elevations will be expressed using the units (Imperial or SI) previously selected.
- Site elevations below sea level can be set by using a "-" in the first position. The "-" can be found in the navigation keys (the top row of the keypad).
- If an iPackGPS with adequate GPS signal is connected to the logger, this setting will be updated automatically at the end of a successful call.
- With an iPack connected and using the programming adapter in the logger's iPack access port, you set the Site Elevation using SDR's Logger Direct Editor screen (found in the **File** menu of the Modify iPack Settings screen).

Site Latitude and Longitude (optional)

- Press **[Home] [4] [3] [5]** to set site latitude.
- Use the **[Up] [Down]** navigation keys to toggle between north and south ("N" and "S"), and use the keypad to edit the displayed latitude information.
- When the latitude information appears as desired, press **[SET].**
- Use the **[Up] [Down]** navigation keys to toggle between east and west ("E" and "W"), and use the keypad to edit the displayed longitude information.
- When the longitude information appears as desired, press **[SET].**
- Enter latitude and longitude in decimal degrees (rather than degrees, minutes, seconds)
- If an iPackGPS with adequate GPS signal is connected to the logger, this setting will be updated automatically at the end of a successful call.
- With an iPack connected and using the programming adapter in the logger's iPack access port, you may set the Latitude and Longitude using SDR's Logger Direct Editor screen (found in the **File** menu of the Modify iPack Settings screen).

Data Encryption PIN Number (optional)

As a security measure, Symphonie*PLUS3* can encrypt data before storing it on the SD. A Data Encryption PIN Number can be entered into the logger to enable data encryption. Note that this is an optional feature intended only for those for whom data theft is a risk. Data encryption can be disabled by setting the PIN to 0000. The data encryption PIN number is set to 0000 (disabled) at Renewable NRG Systems before shipment. If the data are stored in encrypted format on the SD, the encryption PIN number will also be needed for the SDR software to decrypt the data.

Do not lose the Data Encryption PIN number! You must know the PIN in order to disable or change it.

Keypad Security (optional)

As an added security measure, Symphonie*PLUS3* allows you to set a 6 digit lockout code for the logger's keypad. When a key is pressed, the first screen displayed will be:

NRG Systems, Inc.
SymphoniePLUS3
SN: 00000
Enter Security Key

Failure to enter the correct security key will result in a message:

NRG Systems, Inc.
SymphoniePLUS3
SN: 00000
Locked, 7 tries left

If the correct security key isn't entered during one of the remaining attempts, the keypad will lock out the user for approximately 2 days. Note that this is an optional feature intended only for use by those for whom logger theft is a serious risk. Keypad security can be disabled by setting the security key to 000000. The security key is set to 000000 (disabled) at Renewable NRG Systems before shipment.

Failure to enter the correct security code within 8 attempts will lock the SymphoniePLUS3's keypad for approximately 2 days, and there is no way to defeat the lockout – use caution!

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Symphonie Data Retriever Software and Accessories

Symphonie Data Retriever Software Functions

- Reads binary data files that have been stored on the computer hard disk from an email or SD card reader, or MMC card reader source.
- Stores site information.
- Configures iPacks and Symphonie*PLUS3* loggers through the use of a programming cable.
- Reads files generated by Symphonie*PLUS3*, SymphoniePLUS, Symphonie, 9300, 9200-*PLUS*, and Wind Explorer data loggers, scales them according to a user-defined site file, and converts them to tab-delimited ASCII files readable by Notepad, Excel, etc.
- Imports data into a self-contained Microsoft Access compatible database.
- Exports data as tab-delimited 10 minute, 60 minute .txt files or WASP format for any time range.
- Generates Wind Rose, Frequency Distribution and Summary reports for any time range.

Please be sure to open the "Read Me" file and check for any updates that may not have been included in the printing of this manual.

System Requirements

- Symphonie Data Retriever runs on Windows 95/98/2000, Windows ME, Windows XP Home, Windows XP Professional, Windows 7, and Vista computer operating systems and can be downloaded from www.renewablenrgsystems.com.
- An SD card reader is required to read the SD Card. This may be built into your computer or may be an external reader.
- A standard DB9 COM port is required to program the iPack parameters. Note that in many cases, a USB to serial converter can be used in place of a real COM port.

Related Hardware Accessories

- iPack programming cable
- Optional USB to serial converter cable with driver

Installation

Symphonie Data Retriever Software must be installed in order to program iPacks or read data files. Download the latest version from Renewable NRG Systems' website.

1. Go to the Renewable NRG Systems web site at **http://www.renewablenrgsystems.com**, and go to the **Free Software Downloads** section of the **Tech Support** page.
2. Click on the link for **Symphonie Data Retriever Software** and when asked, choose "**Run from current location**."
3. When the download is complete, the program will start.
4. Select the options you want to install. If you are not sure, leave all the boxes checked. Hit "**Next**."
5. Choose the target directory for your installation. If you are not sure, leave it un-changed and hit "**Next**."
6. When the installation is complete, hit "**Close**." If you are prompted to restart, do so now.

7. You are now ready to program iPacks or Symphonie*PLUS3* loggers or process files.

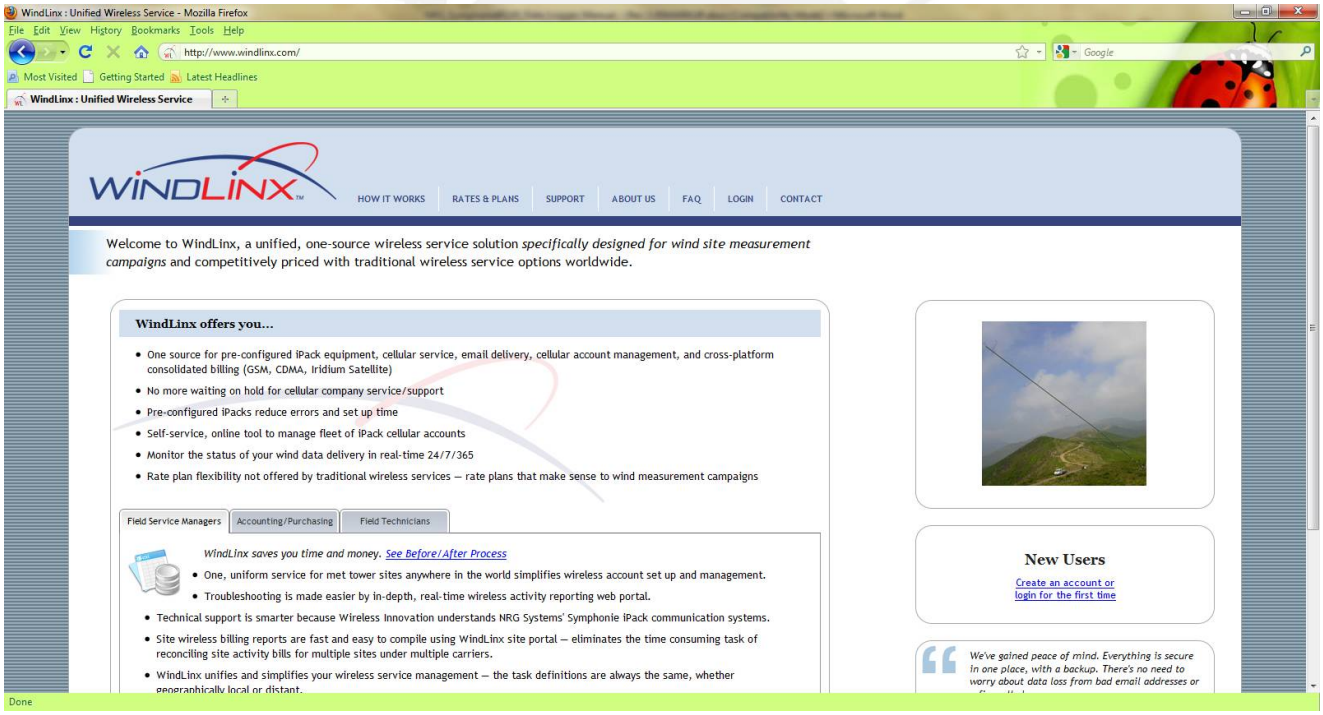
Please note that a default printer driver must be assigned before the software will run. You may use Windows Control Panel to do this. Some versions of Windows do not allow users without administrator access to modify Windows system files. The user must have access privileges to install Symphonie Data Retriever.

Pre-installation Setup: iPack Accounts

WindLinx Wireless Service

iPacks shipped after June 1, 2010 are pre-configured for WindLinx wireless service. WindLinx streamlines the wireless account set-up process and simplifies overall management of met tower data transfer from multiple sites around the world. WindLinx provides satellite, GSM, or CDMA service plus Internet service via the WindLinx web portal, all from a single supplier. A form with instructions for activating and managing WindLinx accounts is included with each iPack.

To activate the WindLinx service, go to the WindLinx web portal at www.windlinx.com and click the link under **New Users**:



During the setup process, the WindLinx web portal will generate necessary programming parameters for the iPack (an *.ipk file), so much of the information provided in this section and the next chapter, Pre-installation Setup: iPack Configuration is not required for WindLinx subscribers.

Customers wishing to work with their own service providers have the option to do so according to the instructions provided below.

GSM Cellular Account

Before installing your GSM iPack, a GSM cellular account must be activated by a cellular service provider. Your GSM service provider will supply you with a SIM card that contains the GSM cellular account programming information.

In August 2014, the GSM 3G iPackGPS (model 7984) became available and is compatible with 3G HSPA networks (as well as 2G GPRS networks). In many locations 2G GSM (GPRS) is still available, and the (2G) GSM iPackGPS (model 4622) can still be utilized. However, in 2014, a growing number of network providers are migrating from 2G to 3G and 4G service (for example, AT&T in North America). Be certain to work with the cell provider in your area to determine which services are available, and obtain an appropriate account and SIM. Circuit Switched Data (CSD) is no longer available in most areas. Please note that GSM iPacks shipped prior to April 2006 (SN:3122xxxx) cannot handle GPRS connections. GSM iPacks shipped after June 1, 2010 include a WindLinx enabled SIM.

The SIM card must be installed into the GSM iPack before the iPack can be installed. Detailed instructions for opening and closing the iPack can be found in the next chapter of this manual. A PIN (Personal Identification Number) number may also be provided and its use is supported by the iPack. Be sure to inform your cellular service provider that you need the account enabled for data service.

Record your GSM iPack cellular parameters using the **GSM iPack Data Sheet** worksheet found in the Appendices of this manual.

CDMA Cellular Account (Verizon)

Before using your CDMA iPack, a data account must be established with Verizon. In order to activate your CDMA account, you will need to provide Verizon with the CDMA iPack's Electronic Serial Number (ESN). The iPack's unique ESN can be found on a label on the CDMA iPack. Once you have given the ESN to the cellular provider and the account has been activated, *you will need to register the phone in a Verizon home area*. This is done through SDR by connecting the iPack directly to your computer, or by accessing the iPack through the logger's iPack access port, or through menus accessed from the logger's keypad. The phone will then download the account information automatically. *It is absolutely essential that a test call is performed prior to installing the CDMA iPack in the field.*

iPackGPS users can use the Manual Dial feature [Home][3][4][5] to switch a CDMA iPackGPS to WindLinx or from WindLinx to Verizon through use of an initialization string (*22899;). Sending this initialization string updates the iPackGPS modem's PRL (Preferred Roaming List). When entering *22899; in the Manual Dial screen, use the up arrow to enter a *, use the right arrow key to enter a semi-colon, and then press the "SET" button on the logger's keypad.

***NOTE**: If opting out of WindLinx service for a CDMA iPackGPS, it is necessary to contact Wireless Innovations with the serial number and ESN before registering with Verizon.*

Satellite Account

Before installing your satellite iPack, an account must be established with a satellite service provider that utilizes the Iridium satellite network. Complete the Windlinx activation form included with the satellite iPack and fax to the satellite service provider as instructed on the form. The satellite phone in the iPack will be active once confirmation is received from the satellite service provider.

Internet Service Provider (ISP) Account (all iPacks)

Before installing your iPack, an Internet Service Provider (ISP) account must be activated. iPacks shipped after June 1, 2010 are pre-configured for WindLinx wireless service, which includes Internet service. If you choose a different ISP, it must be capable of handling dial-up connections, be compatible with either PAP or CHAP authentication methods, be able to recommend Domain Name Service (DNS) servers, and have an SMTP server available for use. The SMTP server can connect over user defined ports (for example ports 25, 587, 465). A POP3 server name, mailbox name and mailbox password are required, and you may use the ones provided by your ISP. POP3 ports are also user definable.

With GPRS service, SMTP server information can sometimes be obtained from the cellular service provider. Remember that SMTP servers are used to send email from the logger. However, you will still need a POP3 mail account (to receive patch files), which will likely not be provided by the cellular carrier. Multiple loggers can share one POP3 account between them, but this account should not be used for anything other than Symphonie*PLUS3*. If you do not already have a POP3 account for your loggers, you can obtain one from an email provider.

The POP3 mailbox MUST remain clear of SPAM and other email. The iPack checks the POP3 mailbox at the end of each successful data transmission. Email other than a patch file residing in this mailbox will increase airtime unnecessarily.

Multiple loggers can share a single ISP account just as multiple users can share one ISP account. Check with your ISP provider to see if more than one user can be logged in to an ISP at any one time.

Renewable NRG Systems recommends having a separate, iPack-only ISP account to make handling your data easier and avoid access conflicts. It is recommended that the assigned iPack ISP account is NOT the same account you use for your personal Internet access. Each ISP account allows access for one user at any given time. This means that your day-to-day office Internet access could obstruct the iPack's Internet access. If the ISP is busy with another user, the iPack will try again later. Repeated attempts to access the Internet should be avoided.

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Pre-installation Setup: iPack Configuration

Items required to configure (program) an iPack

You will need the following items to configure an iPack or iPackGPS. Be sure you have all of these items before continuing:

- Symphonie Data Retriever Software
- Computer - system requirements are specified in the *Symphonie Data Retriever Software and Accessories* section of this manual. You must follow the instructions to install the software before proceeding.
- iPack programming cable (available from Renewable NRG Systems)
- USB to serial converter with driver (if your computer does not have a 9-pin serial port)
- All ISP and phone account information (WindLinx subscribers will be provided this information and an *.ipk file from the WindLinx web portal)

Configuration (Programming) recommendations

iPack configuration should always be done in the office before going to the field. Bringing an "active, ready to go" iPack to the field will insure the installation can be performed as quickly as possible, saving valuable field time and expense. Please note that if your logger revision is 8, 7, 11 or later, you have the ability to program the iPack through the logger's iPack Access Port. However, the iPack Access Port is intended for field use. For pre-installation programming of iPacks in your office, we recommend using the programming cable with PC as described below.

Grounding

Please take care to observe good grounding practices when configuring your iPack. If you are in a dry office environment, make sure to discharge yourself before handling the iPack. The best solution is to place the iPack on a grounded anti-static mat.

Connecting the iPack to the Computer

Connect the iPack using a standard 9-pin female to 25-pin male AT Modem cable to the serial port on your PC. The 9-pin end goes to the PC, and the 25-pin end goes to the iPack. Connect the computer end first, and then connect the iPack end. If your computer doesn't have a 9-pin serial port, you will need to use a USB to serial converter.

Starting Symphonie Data Retriever iPack Configuration Software

Start the Symphonie Data Retriever Software from the Windows **Start** menu. The program is usually found here: **C:\NRG\SymDR\SDR.exe**.

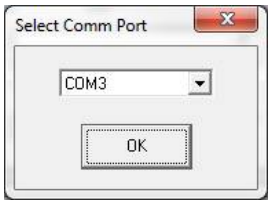
Establishing communication between the computer and iPack

From the main SDR Window, select **Site>Modify iPack Settings**. Check the lower left hand corner of the Modify iPack Settings window for a message.

If you receive no message or "iPack Communication Failed," it is likely that the COMM port on your computer is not configured properly. You must disable any programs such as Palm HotSync that might be trying to access the COMM port.

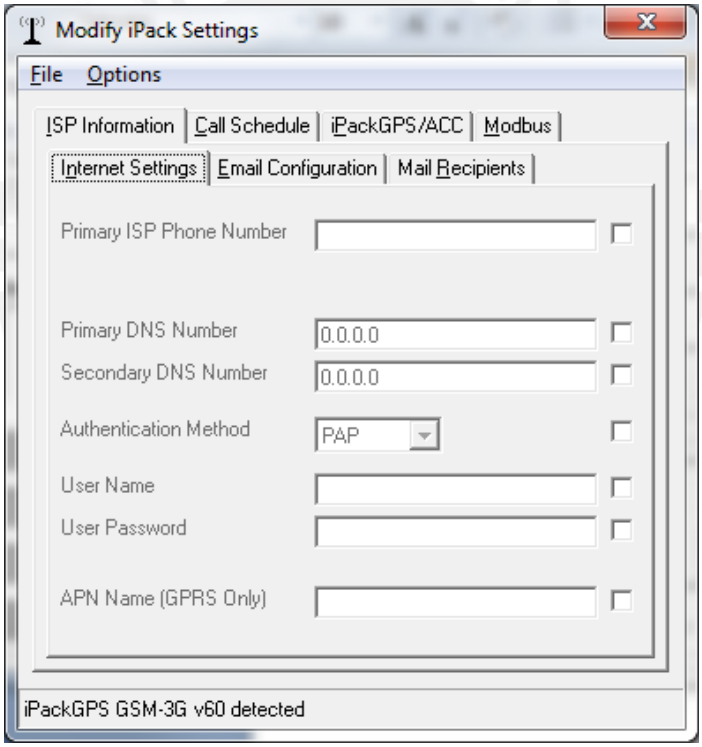
Select **Options>Comm Port** from the menu, and select the communication port you will be using to connect to the

iPack. The COMM port setting will be restored the next time you use the program and only needs to be entered the first time you use the program or following a reinstallation of SDR software.



Note: If none of the COMM ports in the Select Comm Port window can be selected, you will need to use Windows Control Panel's Device Manager to change the available COMM port number to 1, 2, 3, or 4. Please note that iPackGPS users may choose COMM ports 1 through 16.

If the port is properly configured, you should see the message "Verifying iPack Connection" and then "iPack detected" at the bottom of the window. iPackGPS users will see a tab labeled "iPackGPS/ACC" displayed. The "iPackGPS/ACC" tab (shown in many of the following screen shots) will not be visible if an older iPack is detected.



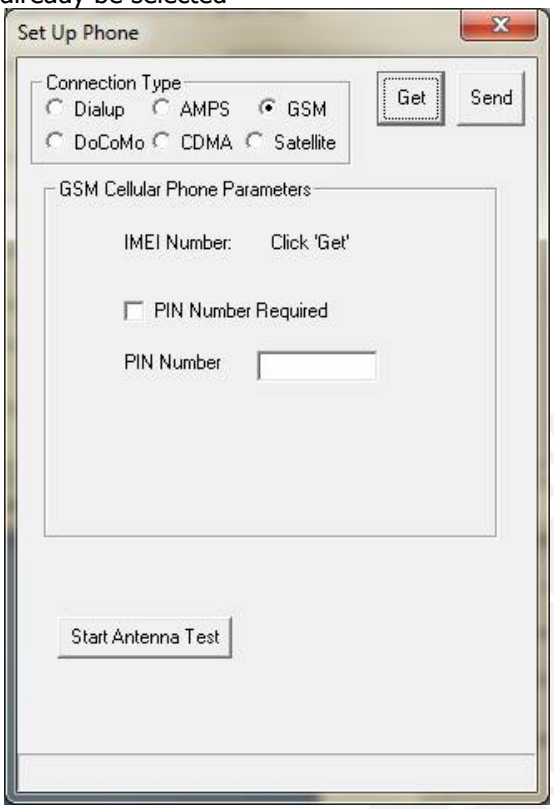
Phone Programming & Initialization Overview - Set Up Phone

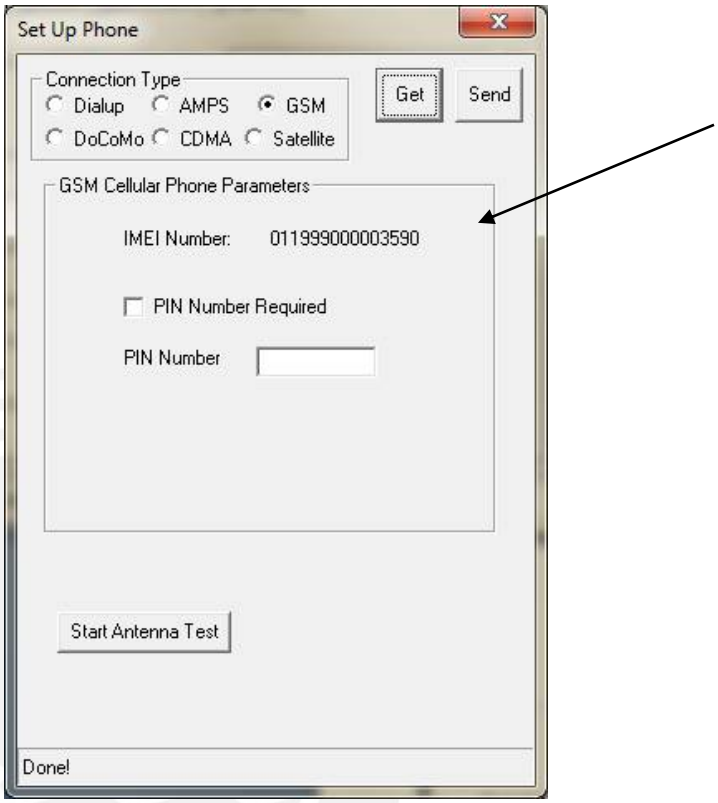
You will want to take extra care during this section. ***It is strongly recommended that you get the iPack working before bringing it to the field for installation!***

At this point, you have established communication between the iPack and your computer. The embedded GSM phone will need to be programmed through SDR with the account information provided by your cellular service provider.

iPacks with WindLinx are pre-initialized at the factory; non-WindLinx CDMA and Satellite iPacks require initialization.

Note that you may select **Options>Set up Phone**, and then use the **Get** button to retrieve the IMEI Number or ESN Number from the iPack's phone modem. The appropriate type of phone (GSM, CDMA, Satellite, etc.) button should already be selected





Other options available on this screen are the ability to set a PIN Number using the **Send** button or perform an antenna test without a logger attached to the iPack using the **Start Antenna Test** button.

Phone Programming - GSM cellular

The GSM phone programming functions are performed through the GSM SIM (Subscriber Identity Module, a smart card containing the telephone number of the subscriber, encoded network identification details, the PIN and other user data such as the phone book). Your GSM provider will supply you with a SIM that you will install into the phone. In August 2014, the GSM 3G iPackGPS (model 7984) became available and is compatible with 3G HSPA networks (as well as 2G GPRS networks). In many locations 2G GSM (GPRS) is still available, and the (2G) GSM iPackGPS (model 4622) can still be utilized. However, in 2014, a growing number of network providers are migrating from 2G to 3G and 4G service (for example, AT&T in North America). Be certain to work with the cell provider in your area to determine which services are available, and obtain an appropriate account and SIM. Circuit Switched Data (CSD) is no longer available in most areas. Please note that GSM iPacks shipped prior to April 2006 (SN:3122xxxx) cannot handle GPRS connections. GSM iPacks shipped after June 1, 2010 include a WindLinx enabled SIM.

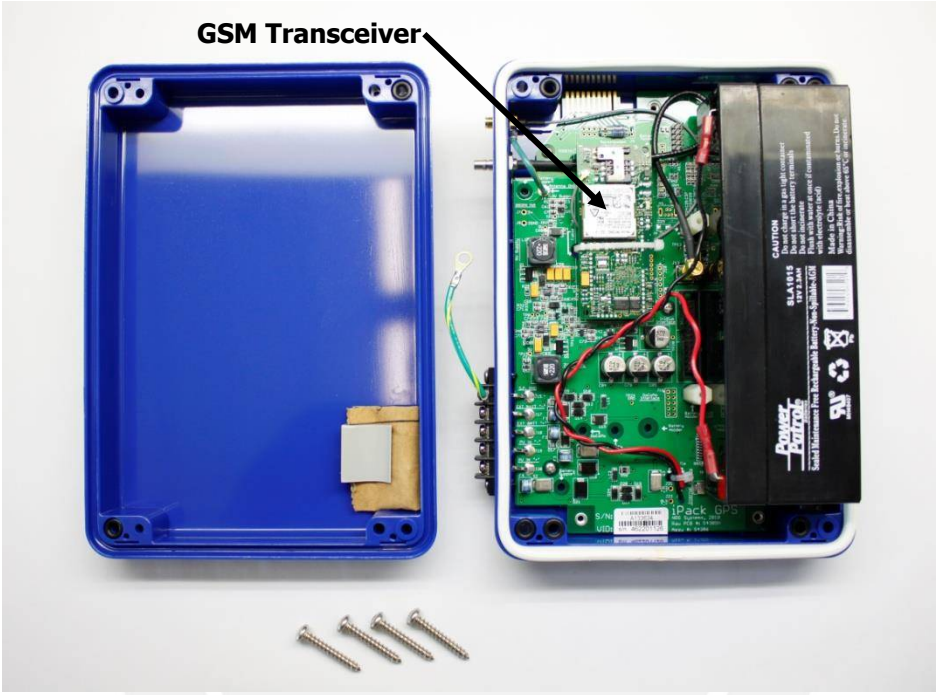
Installing a SIM card into a GSM iPack

WindLinx subscribers do not need to open the iPack as the WindLinx SIM is already installed. However, other GSM users will need to open the iPack and install a SIM card into the GSM Data Modem.

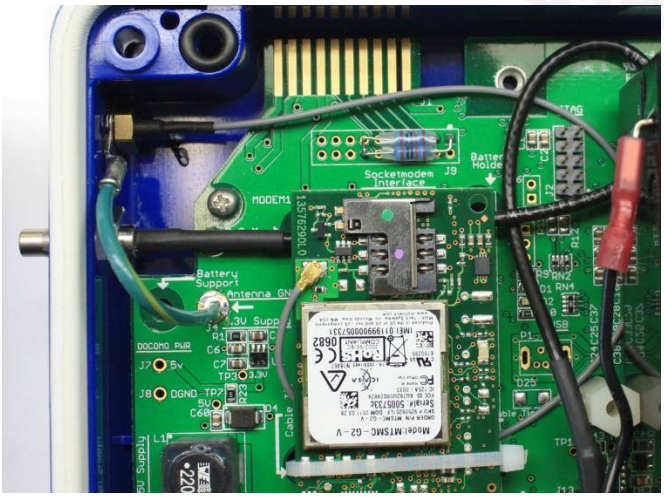
Opening the iPack

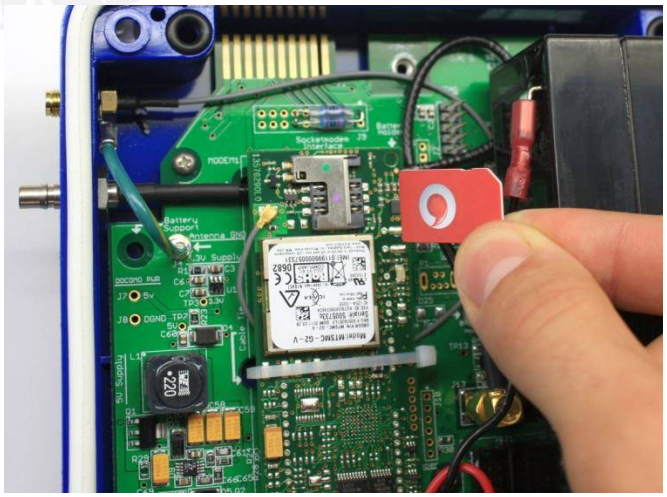
Be sure to touch the metal shell of the DB25 connector on the iPack before opening the enclosure in order to safely discharge any static electricity.

The iPack enclosure consists of two halves secured together by four recessed screws, two from each side of the enclosure. A gasket in between the two halves and 8 o-rings provide an environmental seal for the iPack protecting the internal electronics from the elements.

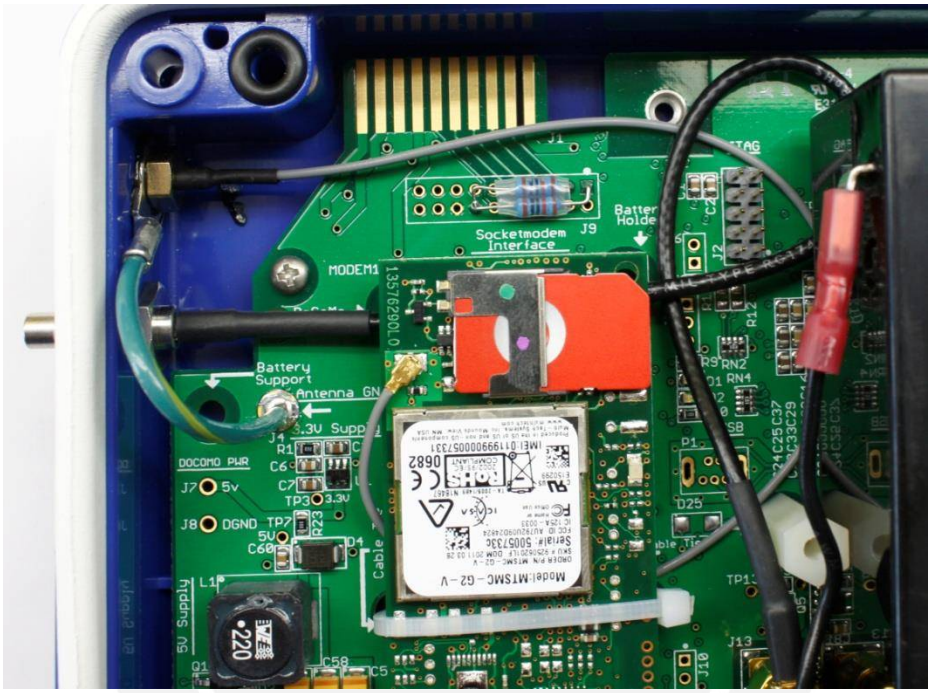


Remove the four recessed screws, and the iPack will separate into two halves. For older iPack models a short cable will connect the two halves. One half contains the iPack electronics, and the other half contains the rectangular battery which is secured by Velcro. Newer GSM iPacks will have the battery and electronics on the same half. The GSM transceiver is located to the left of the battery. *Try not to lose any of the o-rings, and be careful not to rip or tear the gasket if it should come loose.*





Once the iPack cover is off, find the GSM transceiver. Install the SIM in the GSM Data Modem by gently sliding it in. Older GSM Data Modems will have an outline of the correct SIM orientation. Be sure to install the SIM so that the gold contacts are facing down and the SIM card's notched corner is aligned to the top right, as seen in the picture above. First-generation GSM Data Modems will have a hatch that needs to be opened before the SIM can be inserted. Secure the hatch (if applicable), and then reassemble the iPack.



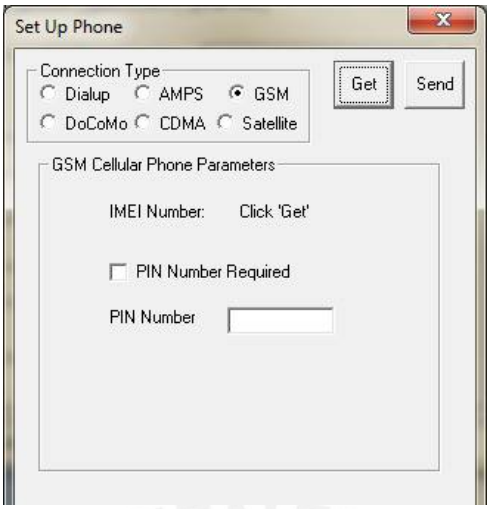
Closing the iPack

- Insert the (4) 2-½ inch mounting screws up through the half of the enclosure that contains the iPack electronics.
- Set the gasket into the groove of the shell.
- Slide the cover (the half with the battery) over screws being careful not to pinch the battery cable.
- Make sure the gasket is not pinched, and then install the screws. It is a good idea to make sure the screws fall back into the existing threads in the iPack enclosure. An easy way to do this is to gently turn the screw counterclockwise one turn – it will fall into the existing threads in the iPack enclosure.

PIN Number

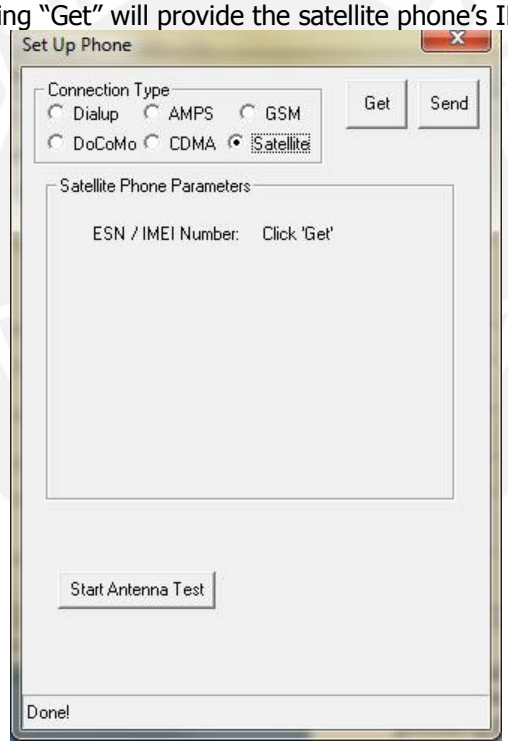
Setup parameters for GSM phones are stored on the user-installed SIM card. Some SIM cards, however, require an un-locking PIN number to be entered every time the phone is used. The iPack uses this PIN number to initiate a call. The PIN should be a 4 to 8 character string and must be entered in the Set Up Phone screen shown below.

Press **Send** to send the PIN number into the modem. *If your iPack does not require a PIN, do not press Send, and make sure the PIN Number Required box is un-checked and no characters appear in the PIN Number field*. Return to the Modify iPack Settings window by closing the Set Up Phone window when done.



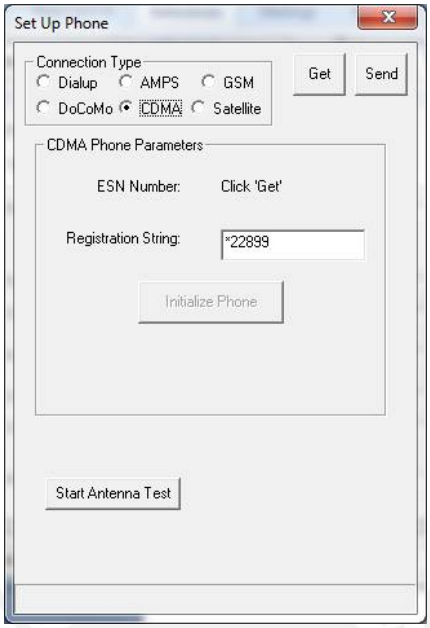
Phone Programming – Satellite

The satellite phone in the iPack will be active once confirmation is received from the satellite service provider. There are no phone parameters to program. Clicking "Get" will provide the satellite phone's IMEI number.



Phone Programming – CDMA (Verizon)

The CDMA phone in the iPack will be active once confirmation is received from Verizon. Clicking "Get" will provide the CDMA phone's electronic serial number. The CDMA phone must be initialized on Verizon's network by clicking the "Initialize Phone" button. The CDMA iPack will configure the same way as a wireless card on Verizon's network (using an initialization string of *22899). The phone can also be initialized through the logger's keypad by pressing **[Home][3][4][4]**.



For iPackGPS, the initialization is done through the Manual Dial screen, **[Home][3][4][5]**. When entering ***22899;** in the Manual Dial screen, use the up arrow to enter a *, use the right arrow key to enter a semi-colon, and then press the "**SET**" button on the logger's keypad.

In order for the iPack to work, the CDMA phone must be initialized (registered) on Verizon's home network!

The cellular provider that Verizon is partnering with in the "extended coverage area" must support the CDMA IS95 call protocol and also provide a "modem pool" for the CDMA iPack. To insure a successful installation, we recommend that you determine who the Verizon partner is in the extended coverage area and contact them to see if they support IS95 and have a modem pool available. As a result, placing a call from a Verizon handheld phone is not a complete test of a site's compatibility with a CDMA iPack.

Note that you ALWAYS need to activate the CDMA iPack in a Verizon "home" area network and then bring the unit to the site. When setting up service with Verizon, find out which system (A or B) the phone will register on for your intended installation site. When performing an antenna test, if your iPack accesses the other system, your site is likely in an "extended coverage area." A manual initialization process may sometimes resolve the issue (contact Renewable NRG Systems for assistance).

CDMA iPacks with WindLinx are pre-initialized at the factory and therefore do not require this step.

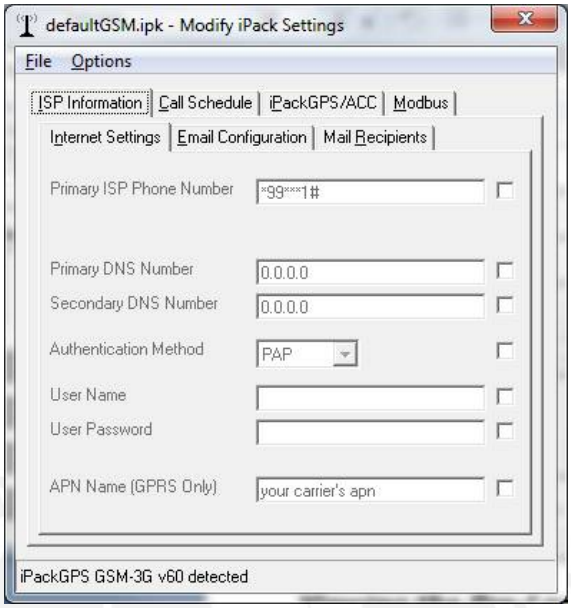
ISP Programming Overview (All iPack types)

You are now ready to enter all of your ISP settings. WindLinx subscribers will be provided this information through the WindLinx web portal. For non-WindLinx iPacks, the process for programming ISP information is the same for every type of iPack. You must have all of your ISP information (obtained from your Internet service provider) to program the iPack and connect to the Internet. The process is much the same as if you were configuring a PC to connect to the Internet. You may want to ask your company's IT department for assistance if they regularly configure your computer systems for Internet access. The programming has been organized into a familiar folder-tab system. The programming will be discussed tab by tab.

You will want to take extra care during this section. Even a minor typographical error will prevent the iPack from connecting to the Internet. It is strongly recommended that you get the iPack working before bringing it to the field for installation!

Viewing the Pre-Loaded iPack Settings

From SDR's Modify iPack Settings window, select **File>Load from iPack** from the menu. The status line on the bottom of the screen should show the message "Transferring >>>>>>" followed by the message "Done!" You will now see the fields populated with information that is currently programmed into your iPack.

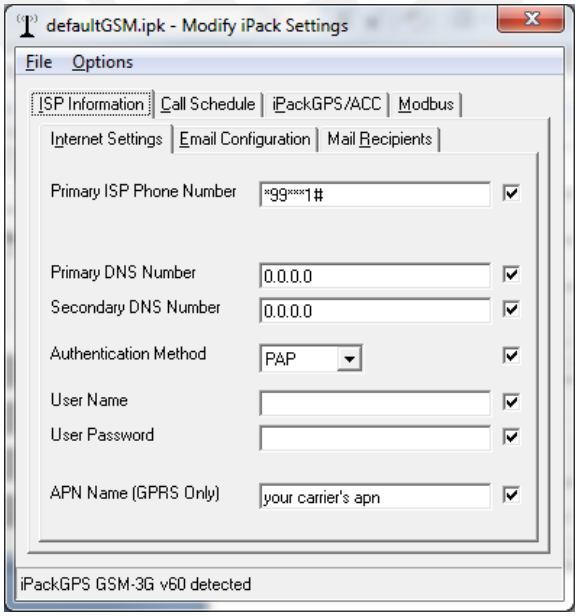


ISP Programming – ISP Access Tab

You may edit the pre-loaded iPack configuration (*.ipk file) that is currently being viewed with the information you have obtained from your ISP by selecting the checkbox to the right of each setting.

Note: The maximum number of characters for each field is 22 for iPacks with firmware version 60 or earlier.

To select all the checkboxes, select **Options>Check All**.



All the checkboxes will be checked, and you may now edit each setting. General information regarding each setting is provided below.

Primary ISP Phone Number

This is the number the iPack will use to dial and access the Internet Service Provider (ISP).

- Enter the number with no spaces or dashes.
- GSM iPack users with GPRS service will set the ISP phone number to: *99***1#
- CDMA iPack users will set the ISP phone number to #777
- Satellite iPack users will use the ISP phone number in the default satellite *.ipk file
- Check that there are no leading or trailing spaces in your entry.
- If you are using a satellite iPack, two leading zeroes are required for the ISP phone number (0088160000603, for example). This is standard Iridium satellite dialing protocol.

Primary DNS Number and Secondary DNS Number

These are the Domain Name Server entries that the ISP uses.

- GPRS, CDMA, and satellite iPack and iPackGPS users will enter primary and secondary DNS numbers of: 0.0.0.0
- Enter the numbers with no spaces.
- Be sure to enter the decimal points between numbers.
- Check that there are no leading or trailing spaces in your entries.

Authentication Method

Symphonie*PLUS3* supports both PAP and CHAP authentication methods. Select the authentication method provided by your ISP.

User Name

This is the account level user name your phone service provider gives you or you select when you sign up for an account.

- Satellite iPack users will typically enter: michmail
- GSM iPack users with WindLinx accounts will typically enter: web
- GSM iPack users with non-WindLinx accounts will typically enter something like:

  ISP@CINGULARGPRS.COM
  Web
  Internet
  movistar
  Or something else provided by your GSM service provider.

- CDMA iPack users with WindLinx accounts will typically enter: web
- CDMA iPack users with Verizon accounts will typically enter the 10 digit Verizon phone number followed by @vzw3g.com Example: 1111111111@vzw3g.com
- Enter it exactly as provided, and do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

User Password

- This is the account level password your phone service provider gave you or you selected.
- Enter it exactly as it is provided to you.
- Satellite iPack users utilizing the michmail service will leave the User Password field blank.

- GSM iPack users with WindLinx accounts will typically enter: web
- GSM iPack users with non-WindLinx accounts will need to enter the user password provided by their GSM service provider.
- CDMA iPack users with WindLinx accounts will typically enter: web
- CDMA iPack users with Verizon accounts will typically enter: vzw
- When you enter your password, it will be displayed as asterisks (*) so it will be secure if someone else reads the information from the iPack.
- When you read the parameters from the iPack and then save them to the iPack, all parameters, including the password, are returned unchanged unless the user changes them and then **chooses File>Save to iPack**.
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

APN Name (GSM and 3G iPackGPS)

- GSM and 3G iPackGPS users will need to set the APN Name to whatever the provider gives you.
- GSM iPack users with WindLinx accounts will use an APN of: nrg.windlinx.com
- The format may be something like "apn.provider.com."
- **An APN is NOT required for CDMA or Satellite iPacks (leave APN blank).**

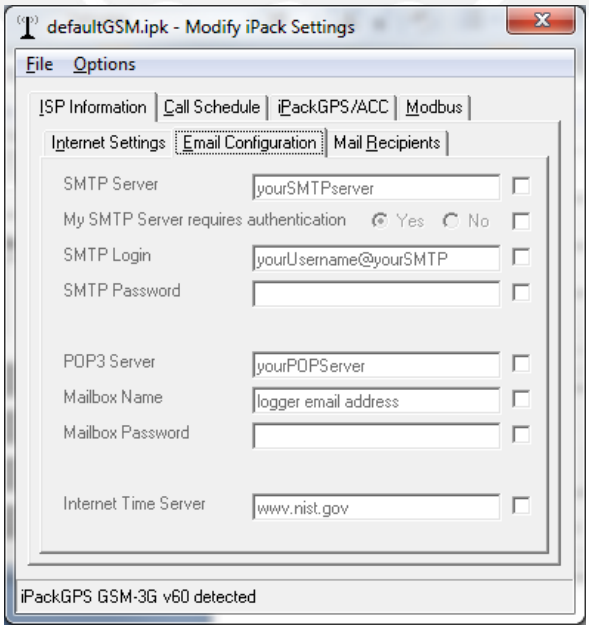
Once the information on this tab has been edited and double checked, move to the Mail Access tab. More details regarding programming requirements for specific service providers can be found in the Knowledge Base section of the Renewable NRG Systems web site.

ISP Programming – Email Configuration

All the checkboxes should still be checked, and you may edit each Mail Access setting. General information regarding each setting is provided below. Note that the SMTP server setting is used to send the email from the logger and should not be confused with the POP3 server, which is used to access patch files addressed to the logger and iPack and firmware updates addressed to the iPackGPS.

Note: The maximum number of characters for each field is 22 for iPacks with firmware version 60 or earlier.

GSM iPack users with GPRS accounts may obtain the SMTP server setting from their GSM service provider but will need to obtain access to a POP3 server through another provider.



SMTP Server Name

This is the SMTP server name that your ISP will provide and/or you can find on your ISP's web site. It is used to send mail from the logger. GSM iPack users with GPRS service will need to get the SMTP server name from the cellular service provider rather than from an ISP. CDMA iPack users utilizing packet switched connections (1xRTT) will need to make sure that the SMTP server is authenticated.

- Enter it exactly as your ISP provided.
- WindLinx users will use an SMTP server name of: smtp.packet-mail.net
- Do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- Non-WindLinx users will enter an SMTP Server name that looks something like:
  smtp.myisp.com
  smtpauth.myisp.net
- The SMTP port can be configured on the "iPackGPS/ACC tab".
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

My SMTP Server requires authentication

Some SMTP servers require a login and password before allowing you to send mail. If the SMTP server does not require authentication, select "No." If your ISP requires SMTP server authentication, select "Yes" and enter the SMTP login and password. WindLinx requires SMTP Server authentication. The formats are often identical to those of the mailbox name and password. However, check with your ISP if you are unsure. Please note that CDMA iPack users will need to use an authenticated SMTP server.

POP3 Server Name

This is the name of the POP3 server that your ISP will provide and/or you can find on your ISP's web site.

- Enter it exactly as your ISP provided, and do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- WindLinx users will use a POP3 server name of: pop3.packet-mail.net
- Non-WindLinx users will enter a POP3 Server name that looks something like:
  pop.myisp.com
  mail.myisp.net
- The POP3 port can be configured on the "iPackGPS/ACC tab".
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Mailbox Name

This is the mailbox account name your ISP provided or you selected when you set up your email account for the iPack.

- This is the mailbox account name on the POP3 server that the logger points to in order to retrieve mail (patch files, for example).
- Enter it exactly as your ISP provided.
- Do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- It should be something like:
  Logger
  7345552555
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Mailbox Password

This is the mailbox password your ISP provided or you selected that allows access to your mailbox.

- Enter it exactly as it is provided to you.

- When you enter your password, it will be displayed as asterisks (*) so it will be secure if someone else reads the information from the iPack.
- When you read the parameters from the iPack and then save them to the iPack, all parameters, including the mailbox password, are returned unchanged unless the user changes them and then chooses **File>Save to iPack**.
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Internet Time Server Name

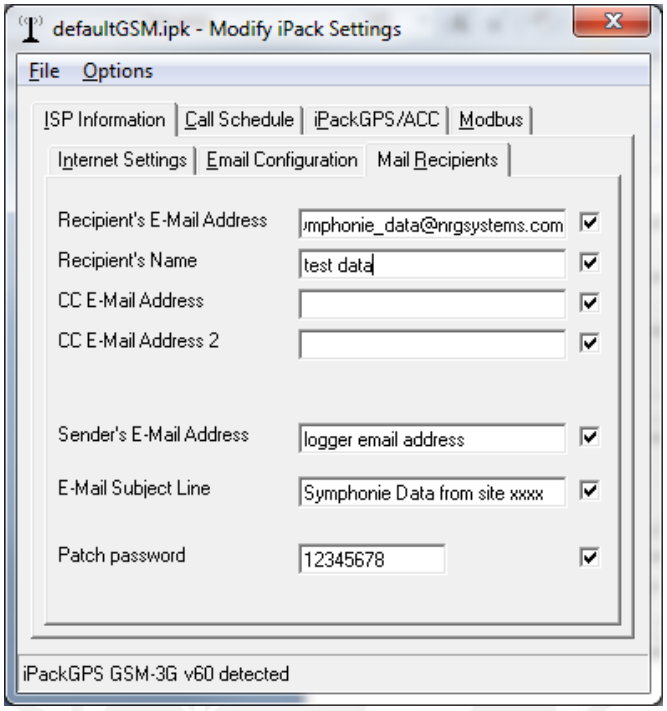
- As part of the iPack's calling routine, it gets the current time (in UTC) from the Internet and updates the Symphonie*PLUS3*'s clock.
- The user must enter a local time server for the iPack to use.
    - NOTE: for standard iPacks (rev 40 and older) the local time server must be compliant with RFC 868 time servers that respond to requests on port 37. There are many on the Internet, and your ISP may be able to suggest one that is RFC 868 compliant. The iPackGPS (rev 50 and newer) uses SNTP protocol on port 123
    - Enter the time server name exactly as provided, and do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- Be sure to include the decimal points in the name.
- WindLinx users will use an Internet Time Server Name of: time.packet-mail.net
- For non-WindLinx users, this entry should look something like one of the following:
  wwv.nist.gov
  nist1-atl.ustiming.org
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Once the information on this tab has been edited and double checked, move to the E-Mail Info tab.

ISP Programming – Mail Recipients

All the checkboxes should still be checked, and you may edit each Email Info setting. General information regarding each setting is provided below.

Note: The maximum number of characters for each field is 22 for iPacks with firmware version 60 or earlier.



Recipient's E-Mail Address

This is the primary e-mail address where the Symphonie*PLUS3*'s iPack is going to send the data.

- This can be your e-mail at work.
- Enter it exactly as your ISP provided.
- Do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- It should look something like:
  jsmith@mycompany.com
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Recipient's Name

This field is the text portion of the e-mail address.

- If you look at an e-mail in your in-box, it will have the "To" item as something like, "John Smith" <jsmith@mycompany.com>.
- This entry is the "John Smith" portion of the recipient's e-mail address.
- This field is optional but is useful if someone has to sort through incoming emails.
- It could look something like:
  John Smith
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

CC E-Mail Address

This is an additional e-mail address where the Symphonie*PLUS3*'s iPack is going to send the data. For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

CC E-Mail Address 2

This is also an additional e-mail address where the Symphonie*PLUS3*'s iPack is going to send the data. For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Sender's E-Mail Address

This is the e-mail address that will appear in the "from" of the emails being sent to the recipient's email address from the iPack. It is often identical to the Mailbox Name plus the "@myisp.com" part of the email address. *However, the Sender's E-Mail Address is NOT necessarily the address to which patch files should be sent.*

- Do not enter any extra spaces or quotation marks.
- Check that there are no leading or trailing spaces in your entry.
- It should look something like:
  logger@mycompany.com
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

E-Mail Subject Line

This entry will become the subject line of the e-mail that you receive from the iPack and may contain letters, numbers and other symbols.

- It is typically a description of the logger that will be calling.
- It should look something like:
  Site 1234 – Derry Mountain
- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Patch Password

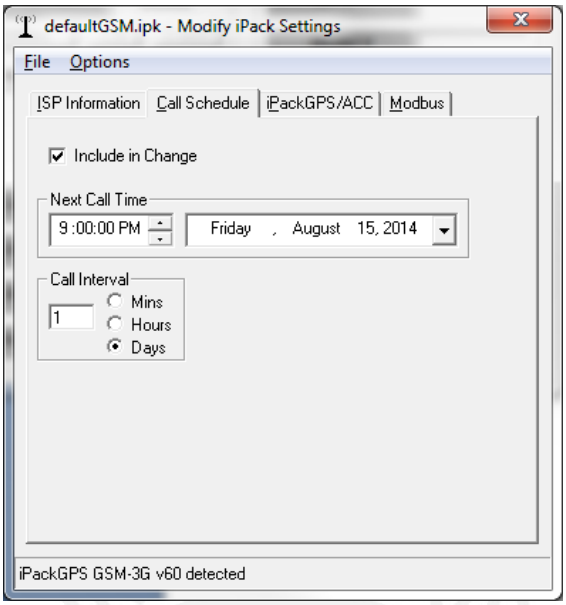
The patch password is a security measure that protects your data logger from unwanted or accidental patching.

- Enter a patch password – do not leave blank.

Once the information on this tab has been edited and double checked, move to the Call Schedule tab.

- For iPacks with firmware version 60 or earlier, the maximum number of characters for this field is 22.

Call Schedule Programming – Call Schedule Tab



Next Call Time and Call Interval

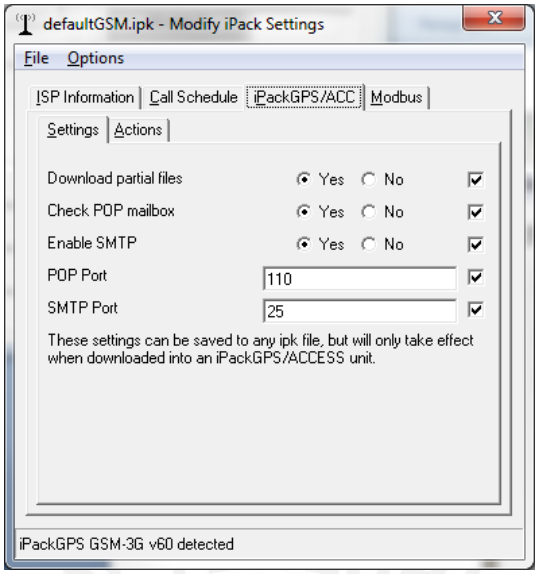
These entries give the iPack a first time to call and how often to call thereafter.

- The Next Call Time entry can actually be in the past, but the logger will initiate its call schedule calculations using this entry as a starting time. Using the Next Call Time and date entered in this screen, the logger calculates the next possible time to call.
- This combination is used to force iPacks to call at specific times during the day or week.
- If you want an iPack to call daily at 6:45am, set the next call time to any day at 6:45am and the call interval to 1 day.
- If you want an iPack to call every 2 days at 7:30pm starting tomorrow, then set the next call time and date to tomorrow at 7:30pm and the call interval to 2 days.
- If you set the next call time to a week from now and set the call interval to 1 day, the iPack will not wait until next week to call but will immediately start calling daily at the time specified in the next call time field.
- You can determine when the iPack will make the first call by taking the difference between the scheduled call time and the current time, dividing the total time by the call interval and work your way backwards (or forwards) from the "next scheduled call time" by subtracting (or adding) the call interval from the "next scheduled call time." Notice that if the call interval is less than the amount of time between the current time and the "next scheduled call time", the iPack will call before the next scheduled call time.
- iPack GPS users can enter a 10-minute call interval; more frequent call intervals are not supported.

Due to increased phone power requirements and potential problems with overlapping phone calls, use caution when choosing a multiple daily call schedule.

Setting iPack Preferences – iPackGPS/ACC Tab (iPackGPS only)

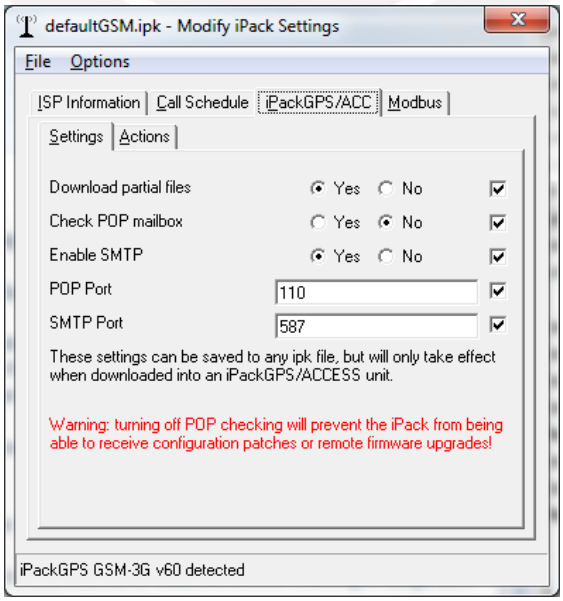
This screen provides access to new features of the iPackGPS unavailable in previous iPack versions, such as the ability to set SMTP and POP3 ports.



Settings (SMTP, POP3 ports, etc.)

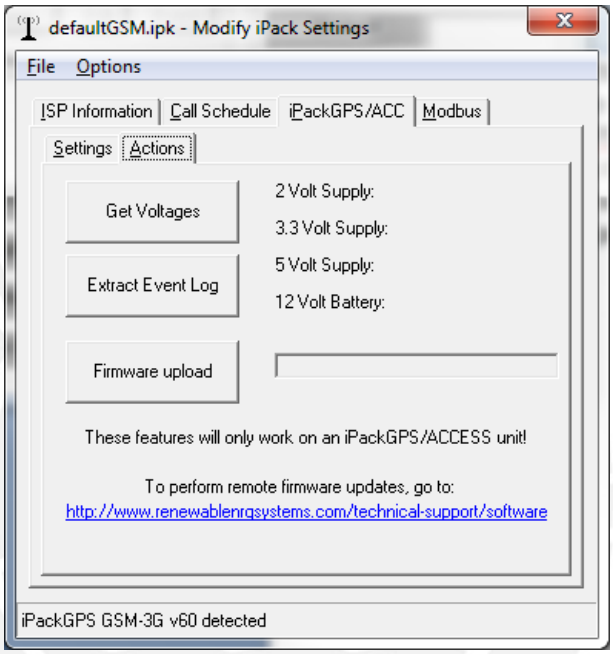
Like all other screens in the Modify iPack Settings window, once you have made a change, you must go to **File** and choose **Save to iPack**.

- SMTP and POP3 port settings allow a user to select specific ports when communicating with these servers. For example, some SMTP servers are no longer responding to port 25 (Brazil), and port 587 should be used instead (be certain to ask your provider).
- The "Download partial files" setting allows the user to toggle on and off downloading of partial files.
- A "partial file" refers to a file that includes less than 24 hours of data, typically from midnight up until the iPack's scheduled call time.
- Disabling the downloading of partial files and checking of POP3 can reduce air time. However, this is generally not recommended for remote sites.
- If POP3 checking is disabled, the iPack will not be able to receive patches or firmware updates until the setting is changed via a direct connection to SDR.



Actions (firmware updates, extract events, etc.)

- iPack battery voltage and voltages from various locations on the iPack's circuit board are displayed here when the **Get Voltages** button is clicked.
- iPackGPS firmware version can be updated via SDR and the iPack programming cable using the **Firmware Upload** button.
- A link to the site used for remote firmware updates is also displayed on this screen.
- The iPackGPS event log will show "UPDATE_DOWNLOAD_EVT" and "UPDATE_APPLY_EVT" to help track the installation of the new firmware.
- Remote firmware updates for some iPackGPS types (satellite) will be completed over the course of several calls.
- Firmware updates via SDR and the iPack programming cable are completed in a few seconds.

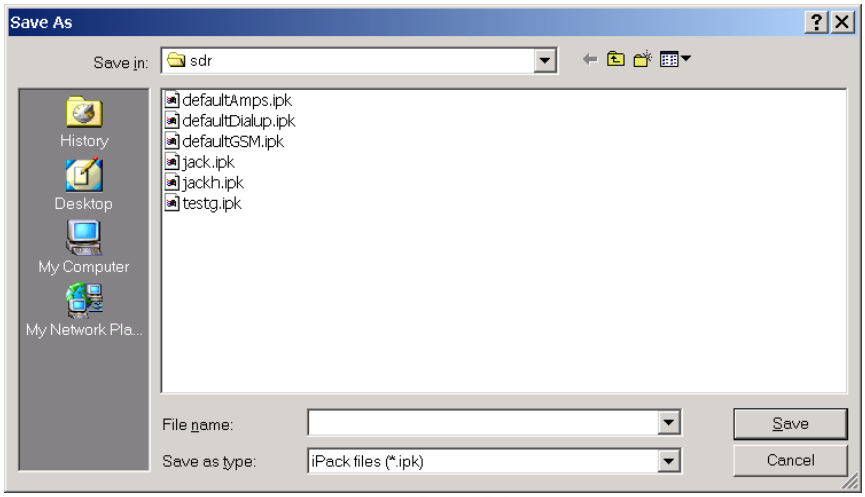


Saving the iPack Displayed Setup to the connected iPack

After editing the parameters on the screen, save the changed parameters to the iPack by selecting **File>Save to iPack**. This will download all of the checked settings to the attached iPack. On the lower left of the Modify iPack Settings window you should see the message "Transferring>>>>>>" and then "Done!" You've now completed programming the iPack.

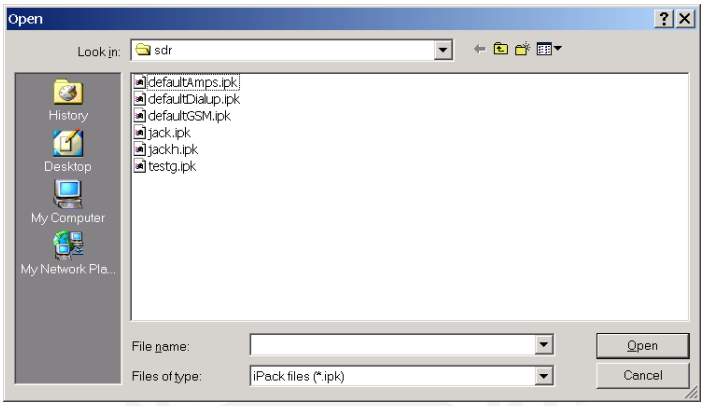
Saving a copy of the iPack File (.ipk) to your computer

Save a copy of the iPack settings by selecting **File>Load from iPack**. This will load the current iPack configuration to your computer screen. Then choose **File>Save iPack File.** This will save a copy of the iPack configuration (*.ipk file) to your computer. Remember to send a copy of the iPack file to your site management team – it is important to keep the *.ipk file safe!


Save As
Save in:
sdr
defaultAmps.ipk
defaultDialup.ipk
defaultGSM.ipk
jack.ipk
jackh.ipk
testg.ipk
History
Desktop
My Computer
My Network Pla...
File name:
Save as type:
iPack files (*.ipk)
Save
Cancel

Opening a Saved iPack File (.ipk)

From the Modify iPack Settings Window, select **File>Open iPack File.** In the future, you may want to open a saved iPack file, edit the settings and then send it back to the iPack. You can also do this to check the saved iPack file.



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Office Testing

Why It's Important

Office testing your Symphonie*PLUS3* system prior to installation in the field will save you time and money. Internet access capabilities rely on perfect coordination between iPack, cellular phone, and ISP settings – if these are not set up correctly, the system will not work. Troubleshooting is much easier in the comfort of your office than in the field, in foul weather, with a crackling, intermittent handheld cellular phone connection as your only lifeline to civilization. It is likely that if you experience communication problems, you will need to contact your cellular account representative or your ISP to resolve the problem.

During office testing, be sure to fill out Data Sheet forms (found in Appendices) with setup parameters. A copy of these forms should be made for field personnel so setup parameters are readily available.

What You'll Need

If you haven't done so already, read the rest of this manual, paying particular attention to the chapter covering *SymphoniePLUS3 Start-up.* If you are ready to begin office testing your Symphonie*PLUS3* system, you should have already completed the tasks found in the chapters *Pre-Installation Setup: Logger Configuration, Pre-Installation Setup: iPack Accounts,* and *Pre-Installation Setup: iPack Configuration*. You'll also need a few test sensors with cables, the field wiring panel and related hardware, an SD card, the antenna(s) included with your iPack or iPackGPS, a Phillips head (+) screwdriver, and a computer running the latest version of Symphonie Data Retriever Software.

Installing the iPack to the Logger (iPack users only)

Connect the antenna to the iPack. GSM iPackGPS and CDMA iPackGPS users will also connect the GPS antenna. Carefully set the iPack (connector facing up) flat on a table, preferably on an anti-static mat. Connect an earth ground to the logger's ground lug. Place the logger (connector facing down) over the iPack and mate the two units together, and connect the iPack's ground wire to the logger's ground lug. While mated, handle the units with care. While performing office tests, it is recommended that you connect a 15 V DC **regulated and fused** adapter to the iPack PV input to prevent draining the batteries during testing. However, this is necessary only if initiating more than 5 calls.

Note that a cold boot call can be triggered when an iPack is initially connected to the logger. During a call, the Call Now, Antenna Test, and iPack programming features are unavailable, but all other logger programming functions are available. The iPackGPS allows further navigation to iPackGPS menus and logger menus while a call is in progress. If no D-cells are installed in the logger and then the logger is plugged onto the iPack, the iPack provides auxiliary power to the logger and therefore powers it up regardless of the lack of D-cells. The iPack will then dial the ISP to transfer data, and the iPack status screen will indicate that a call is being made ("iPack busy or not present", or in the case of iPackGPS, a sequence of status screens such as "checking for file", "detecting GSM band", "connecting modem", etc.). However, if you have already completed the logger programming in the *Pre-installation Setup: Logger Configuration* chapter, the logger batteries are already installed, so attachment of the iPack will not initiate the automatic call.

Pre-Installation Testing

To test before installing in the field, do the following:

1) If using an iPack or iPackGPS, connect it to the logger as described above.

2) Check logger status (battery voltage, date, time, internal temperature, revision numbers).
3) Connect the wiring panel according to instructions in the *Field Installation* chapter.
4) Connect the test sensor(s) and verify logger programming of each input channel.
5) Install and format SD card.
6) Check SD status (logging, files stored, days left).
7) Check iPack status (if present), noting the iPack battery voltage.
8) Verify cellular signal strength with the antenna test.
9) Verify iPack communications by performing a Call Now.
10) Verify that the *.rwd files are successfully received by the intended recipient(s).

For detailed instructions on performing these tests, refer to the chapter on *SymphoniePLUS3 Start-Up.*

Recharging the iPack Battery

Under normal use, the iPack battery will stay charged through an installed 15 Watt 12 V photovoltaic (PV) panel. However, the iPack battery must be fully charged before field installation. Connect a **regulated and fused** 15 V DC source to the PV input of the iPack. The iPack's charging circuit will draw a maximum of 750 mA (earlier iPacks will draw a maximum of 500 mA). A completely discharged battery can be recharged in about 6 hours with such an adapter. An iPack charger is available from Renewable NRG Systems (item #3615).

After completing tests, you may want to pre-assemble the logger and iPack in the logger's shelter box. This can simplify the transport of the equipment and save time. See the *Field Installation* chapter for detailed instructions.

The iPack has two sets of terminals. When recharging the iPack battery, you MUST use the PV terminals; do not use the 12 V external battery terminals. For more information about these terminals, see the following sections regarding connecting a PV panel to the iPack.

Field Installation

Tools Required

- diagonal wire cutters to trim sensor wire leads
- wire strippers to strip sensor cables if necessary
- 7/16 inch nut driver or wrench for installing optional yagi antenna
- 5/16 inch nut driver for hose clamps, mounting screws (PV and logger)
- ½ inch crescent wrench to tighten ground acorn nut
- ¼ inch nut driver for sensor terminals
- 3/8 inch nut driver or wrench for ground stud nut
- electrical tape
- small flat blade RNRG screwdriver (included with logger) for sensor wires
- Phillips head screw driver for PV terminals
- 5/16 inch open end wrench
- drill to tighten hose clamps - optional
- tin snips to cut excess hose clamp - optional

Site Grounding Recommendations

For many sites, the Renewable NRG Systems Grounding Kit provides all the needed parts to earth ground your TallTower™ and instrumentation. The Grounding Kit includes a copper-clad lightning spike, copper ground wire, and two copper-clad ground rods. It is recommended that you determine the soil type of your site and classify its resistivity.

The lower the resistivity, the better the earth ground is.

Soil Type Average	Soil Resistivity per cm (Ohms/cm)
1. ashes, cinders, brine, waste	2370
2. Clay, shale, gumbo, loam	4060
3. Same, with varying proportions of sand and gravel	15800
4. Gravel, sand, stones with little clay or loam	94000

The Renewable NRG Systems Grounding Kit will perform adequately in type 1 and 2 soils. For other soil types, or for sites with a high incidence of lightning, you will need to augment the earth grounding system.

The best approach to grounding will depend on the soil type in your area. Soil resistivity is directly related to moisture content AND temperature. The colder it gets, the higher the resistivity will be for a specific moisture content. Any moisture content below 20% quickly increases ground resistivity exponentially to dangerous levels. In most climates, moisture content and soil temperature change seasonally. During times of the year when the soil is very dry or very cold, soil resistivity is at its highest, and getting a good ground is more difficult. Keep this in mind when evaluating your site - it's better to put in too much grounding than not enough.

You may want to consult a local utility regarding grounding techniques they've successfully used in the site area.

- Use longer ground rods, and/or install additional rods.
- Cut the logger's ground wire to the required length; do not roll or coil any excess length of ground wire.
- Additional contact surface helps, and soil conductivity improves with depth. If multiple rods are used, they must be installed far enough away from each other [at least 2 meters (6 feet)] so that each rod's effective resistance

area does not overlap.
- Use high compression fittings at all conductor/rod connections.
- Ensure that the single strand, bare copper conductor is 10 gauge.
- Ensure that the grounding rod(s) is free from non-conducting coatings such as paint or enamel.
- Wire all grounding rods together to provide electrical continuity.
- Where rock is encountered, drive the ground rod at a 45 degree angle, or bury it in a trench at least 0.6 m (2 feet) deep (deeper is better; the key is to maximize the soil contact area).
- Protect the above-soil end of the rod and its electrical conductor attachment against damage. Where the soil can become frozen, drive grounding rods below the frost line.
- Apply an anti-oxidation agent to all grounding connections.

Installing a Stand Alone SymphoniePLUS3 Logger

To install a stand alone Symphonie*PLUS3* logger (no iPack), insert 10-32 x ½ inch mounting bolts through the mounting holes in the back of the shelter box, and then align with the threaded mounting holes in the back of the logger and tighten. You may now skip the instructions related to iPack installation and proceed to the instructions for *Mounting the Shelter Box to the Tower.*

Mounting the iPack and Logger to the Shelter Box

Prior to mounting to a Renewable NRG Systems TallTower, the Symphonie*PLUS3* logger and iPack should first be installed in a shelter box to protect the unit from the elements. You may find it easier to remove the cover of the shelter box prior to attaching the logger, iPack, or PV panel.

Removing protective sticker from Logger

When ready to install the iPack to the logger, remove the protective water resistant sticker from the back of the logger.

Inserting Screws into Shelter Box

Continue installation of the shelter box according to the following instructions. Mounting holes are pre-drilled in the optional Symphonie*PLUS3* shelter box. To install a Symphonie*PLUS3* with an iPack, insert four 10-32 x 2 ½ inches mounting bolts through the mounting holes in the back of the shelter box, through the iPack, and then align with the threaded mounting holes in the back of the logger and tighten.

Mounting inside the Shelter Box

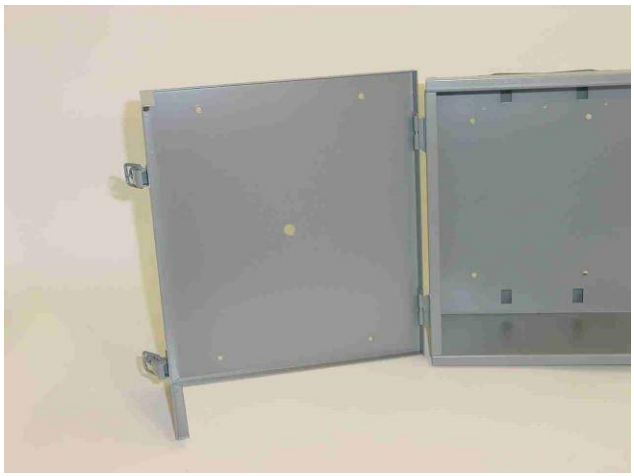
If your shelter box has keyhole slots, insert the mounting bolts through the iPack and logger assembly and screw them in until they are about 1 cm away from the back of the iPack. The Symphonie*PLUS3* and iPack can be hung in the shelter box by inserting the mounting screws in the keyhole slots. The mounting screws can then be tightened from the back of the shelter box.

Connecting the iPack Ground Wire to the Logger

If you haven't done so already, connect the iPack's green/yellow striped ground wire to the logger's ground stud. To do this, remove the nut and lock washer from the logger ground stud, place the ground wire lug from the iPack over the logger ground stud, replace the lock washer and nut; tighten the nut.

Installing the optional PV panel (iPack users only)

Inside the PV panel carton you will find a PV panel and four screws. Remove the five plastic plugs from the Symphonie*PLUS3* shelter box door.

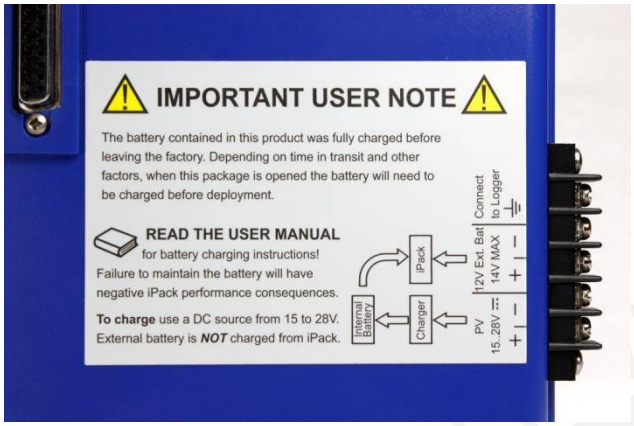


Read the back of the PV panel and note the polarity of the wires. Feed the PV panel wire through the center hole in the shelter box door, and then secure the PV to the shelter box door with the four mounting screws.

Feed any excess PV wire back into the hole behind the PV panel. Connect the PV wires with the polarity that you noted to the iPack PV input screw terminals located on the right side of the iPack. Shade the PV panel from direct sunlight while wires are being connected to avoid sparks.

Connecting the PV Panel and/or External Battery Wires

The iPack has an extra set of terminals that allow for connection of an external 12 V DC power source such as a battery in addition to the PV panel. There are some basic rules for these terminals as described below.



Connection Point	Do	Do NOT	Functional Notes
PV Terminals	Do…connect PV panels, DC power sources between 14 and 28 V DC	Do NOT…connect power sources in excess of 28 V DC, including large PV panels	The PV terminals will charge the iPack's internal battery; The PV terminals will NOT charge an external battery.
External Battery Terminals	Do…connect 12 V battery and/or external charge controller up to 14.3 V DC	Do NOT…connect PV panel or power sources in excess of 14.3 V DC	The external battery terminals are an input only, an external battery will NOT be charged from the iPack through these terminals nor will the internal iPack battery.
Ground Terminal	Do…connect to logger ground stud and trim ground wire to the required length.	Do NOT…leave disconnected or connect other wires such as shields; do NOT coil or roll excess ground wire.	This terminal will help provide protection from electrostatic discharge for the iPack and logger.

Mounting the Shelter Box to the Tower

The Symphonie*PLUS3* shelter box is mounted to the tower 1.5 to 2.0 meters (5 to 6 feet) above the ground (or above the maximum height of the annual snowfall) using the two stainless steel hose clamps (provided).

Trimming the Hose Clamps

The hose clamps are long enough to mount the shelter box to towers up 10 inches (25 cm) diameter. If your tower is a smaller diameter, it will speed up the installation to trial fit the clamps to your tower and trim them to length. Place your hand between the tower and the clamp to allow for the logger. Trim off the excess hose clamp material using a pair of tin snips. Be careful not to cut off too much. Note that if you have a drill on site, it may not be necessary to trim the hose clamps.

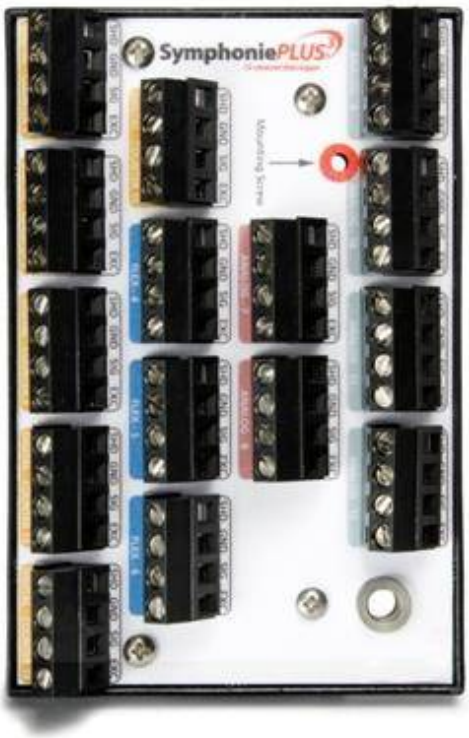
Mounting Technique

Mount the logger and shelter box to the tower using the hose clamps. Thread the hose clamps through the slots in the

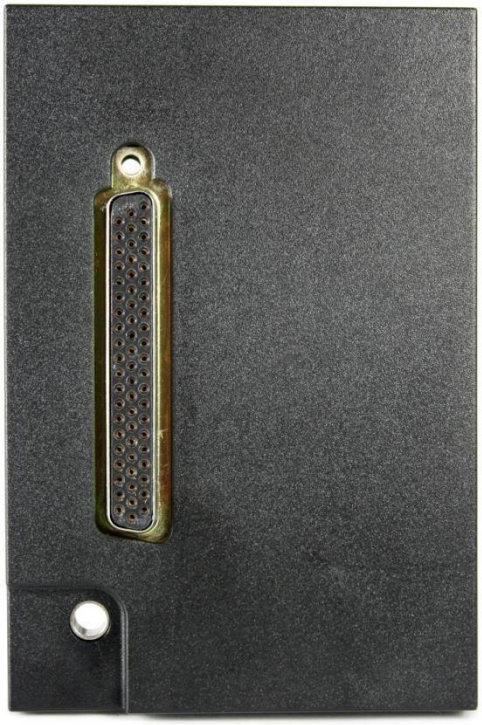
back of the shelter box from the inside. It is best to pass the end of the hose clamp through the right slot first (as viewed from inside the enclosure), then around the tower, and back through the left slot, since this will provide easier access when tightening the hose clamp. Connect the logger ground wire to the ground rod at the base of the tower, passing the ground wire into the shelter box through either the lower wire slot or through one of the upper wire knockouts. Trim the logger ground wire to the required length; do not coil or roll excess ground wire.

Field Wiring Panel

All sensor wires connect to the field wiring panel. *Please note that the SymphoniePLUS3, SymphoniePLUS, and Symphonie wiring panels are NOT interchangeable.*



Front of Wiring Panel



Back of Wiring Panel

The field wiring panel connects to the 62 pin connector on the side of the logger and is held in place by the ground nut and a mounting screw. If you haven't done so already, connect the logger ground wire to earth ground.

Connect the logger ground wire to the earth ground rod before connecting any sensors!

To install the field wiring panel, remove the warning label from the logger's ground stud. Then touch the ground wire to the wiring panel's ground lug and the logger's ground stud. This will safely discharge any electrostatic build-up that could damage your logger. Slide the ground wire over the logger's ground stud. Connect the wiring panel by gently pushing it securely onto the logger's 62-pin connector. Finally, secure the ground wire with the washer and nut on the ground stud (as shown below) and tightening the wiring panel's mounting screw until the wiring panel and ground wire are secure.

Note that the field wiring panel mounts over the grounding stud and can be removed from the logger without having to disconnect the sensor wires. This is particularly useful in the event a logger needs to be swapped out for service.

Sensor Connection

Make sure that the logger ground wire is connected to the earth ground rod before connecting sensor wires!

Pass sensor wires into the shelter box, either through the lower wire slot or through one of the upper wire knockouts.

All wires coming down the tower and into the shelter box should be secured to the tower below the shelter-box and then brought back up, to form a drip-loop, before entering the shelter-box.

Sensor wires should be stripped to expose only 5 mm (1/4 inch) of bare wire. Stripping off more insulation could allow the wires to touch and cause an electrical short. If using standard Renewable NRG Systems sensor cables, you may need to trim off some of the exposed wire.

NOTE*:* The nuts on the wiring terminals of the #200P and #40C sensors should only be tightened until secure. Over tightening will snap the terminals off of the sensors and will not be covered under warranty.

Wiring Sequence

Make sure that the logger ground wire is connected to the earth ground rod before connecting sensor wires!

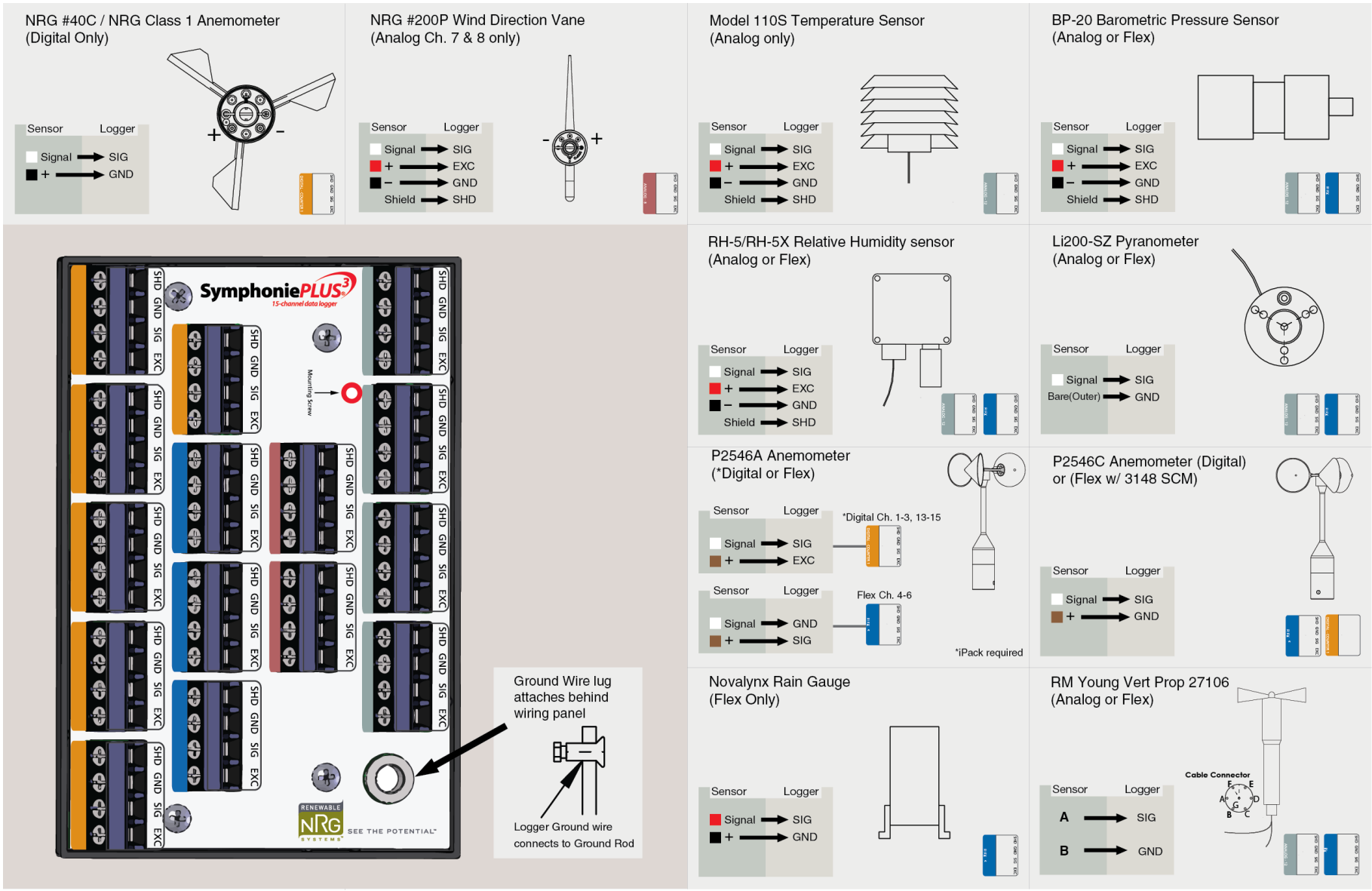
NOTE: Connecting sensors to the back terminals first may be easier in terms of installation. Sequence: (9-12, 7-8, 15, 4-6, 1-3, 13-14).

Connect sensor wires to the field wiring panel according to the *Sensor Connections* diagram (see below) using the following sequence:

1. Touch the shield wire to the ground stud, and then connect it to the SHD (shield) terminal.
2. Connect the black wire of the sensor to the “GND” terminal of the appropriate channel’s input.
3. Connect the signal (white or clear) wire to the “SIG” (signal input) terminal.
4. For three terminal devices ONLY (such as vanes or anemometers requiring 12 V power), connect the red wire (excitation/power) to the “EXC” terminal.
5. Confirm correct wiring by reviewing each sensor channel on the logger’s display.

6. Coat the wiring panel's terminal screws with an anti-corrosive product (such as PreserveIT P100L from Caig Labs or Vaseline petroleum jelly).
7. Systems that include an iPack will be on as soon as the iPack is connected and supplying power to the logger. For systems without an iPack, install the D-cells now as described in the Logger Setup section of this manual.

Sensor Connections

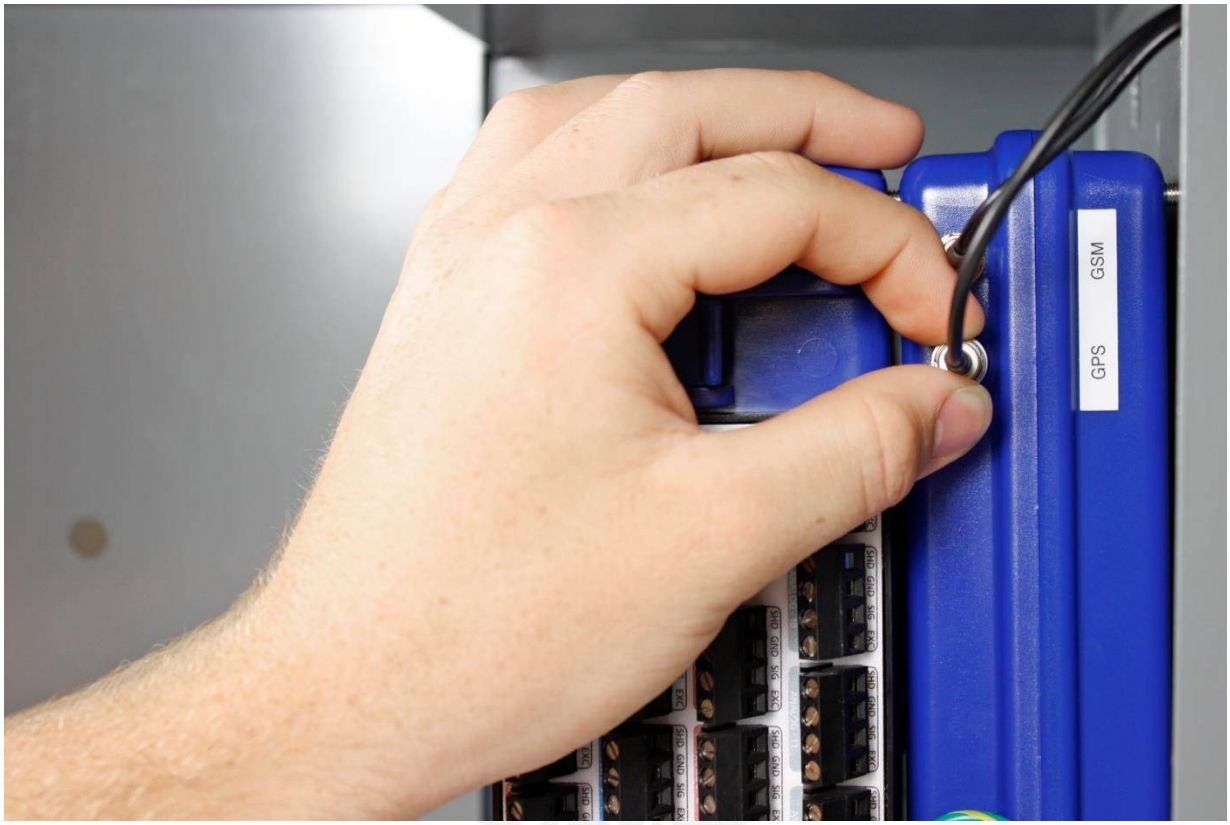


Antenna Connection

After connecting sensors to the field wiring panel, connect the iPack antenna and GPS antenna (for iPackGPS). Mount the GPS antenna to the top of the shelter box (outside).

Satellite iPacks S/N: 35333300 and above have an SMA type antenna connector; older satellite iPacks have a TNC type antenna connector, so if you need to replace the older antenna or iPack, you will need an adapter.

Be sure to form a drip-loop with the antenna cables to protect the iPack from water that may get inside the cable jacket.



You may now proceed to the next chapter, *SymphoniePLUS3 Start-up*, to complete the installation process.

Symphonie*PLUS3* Start-up

At this point, you should have already completed the tasks described in the *Pre-Installation Setup: Logger Configuration* chapter (all users). If using an iPack, you will also need to have completed the tasks in *Pre-Installation Setup: iPack Accounts* and *Pre-Installation Setup: iPack Configuration*.

Pressing any key will activate the logger display.

NRG Systems, Inc.
SymphoniePLUS3
SN: 00000
Press [HOME]

Pressing the **[Home]** key at any time will always bring you back to the home menu of SymphoniePLUS3.

1. Measurements
2. Status
3. Utilities
4. Settings

It is recommended that the user check the logger functions in the order presented in this section.

Checking logger status (battery, date and time, internal temperature, revision)

[Home][2] = Status Menu

1. Logger Status
2. Mem Card Status
3. iPack Status
4. Event Log

The Status menu allows the user to check current operating status of the SymphoniePLUS3 data logger system.

[Home][2][1] = Logger Status Screen

14 Apr 2002 14:02:50
Batt 1.19V REPLACE
Site:0150 Temp -10 C
Revision: 26, 27, 53

The message Waiting for update should display for a few seconds. The logger status screen displays current date and time in Standard Time (remember that this may appear one hour off during daylight savings time). It also displays current logger battery voltage and condition (Good, Fair, or Replace) as well as the firmware revision levels of the logger and iPack.

Checking logger measurements (all 15 channels)

Press **[Home][1]**, then scroll using **[Down]** to see each sensor's current readings. Readings that vary widely with expected norms may indicate a sensor malfunction, incorrect channel configuration, or incorrect wiring. If a channel number displays no information, it means there is no SCM currently installed for that channel and it is therefore inactive.

Installing the SD Card

Place a new SD card in the SD card slot with the beveled front corner down. Note that the card cannot be inserted backwards. If the SD was not the last SD formatted by this logger the following message will display:

Initializing SD Card
Please wait…

Formatting the SD Card

Formatting the SD card may take up to 60 seconds and will beep every few seconds, after which a Format complete message will briefly display before changing to the Home menu.

If an SD does not format after the first attempt, it could indicate a damaged or corrupted SD card. Always have spare cards available.

When the logger writes data to the SD card, it beeps to warn you that the card is active.

To be sure that all the data files have been transferred, do not remove the card until five seconds have passed since the last beep.

Since the logger is always storing data to its internal non-volatile memory, there will be several data files created during installation. These files will be written to the card as soon as formatting is complete. The logger's internal memory stores the most recent 1.5 days.

The data files created during installation may have incorrect readings because sensors were being connected during these intervals. As part of your site data, note the date and time of the start of logging with your completed connections and settings.

[Home][3][1] = Erase RWD Files, are you sure?

All RWD Data Files will be erased!
Are you sure ??
Press [9] to Erase

[Home] aborts the formatting function and returns home. *Data will not be recorded onto an unformatted SD.*

Checking SD status (logging, files stored, days left)

[Home][2][2] = Memory Card Status Screen

Card In,	or	Card Out
Card Inserted Logging 3 Files Stored 665 Days Left		Please Insert another card

Memory card status displays the number of files stored on the SD card, as well as the number of days remaining until the card is full. The Symphonie*PLUS3* data logger emits a beep when it writes to the SD card. *The process of writing to the*

card takes about two seconds, so should the unit beep just as the card is about to be changed, wait until five seconds have passed before pulling the card.

Checking iPack status (if present)

[Home][2][3] = iPack Status Screen

1. Call Now
2. Modem Status
3. GPS Status
4. iPack Event Log *

If an iPack is attached to the Symphonie*PLUS3*, the status screen will display the above menu.
If an iPackGPS is not connected, then "No iPack present" will be displayed. The + symbol will alternate with the * symbol during an antenna test to indicate the iPackGPS is on. [Home][3][4][2] will show the iPackGPS's live Modem Status page which displays the model of iPack in use, the revision level, the next scheduled call, and the status of the last operation performed.

iPackGPS v50 GSM
Registered Roaming
Sched: 8 Feb 15:15
Batt: 12.8 Ant: 79% +

Checking iPack Battery Voltage from the logger

You can check the voltage of the iPack internal 12 V battery from the logger. Go to **[Home][3][4][2]** for iPackGPS or **[Home][3][4]** for older iPacks. If you want to continuously monitor iPack voltage, there is an SCM available (Item #3585) specifically for this purpose. When installed in one of the logger's analog or flex channels, the iPack voltage SCM will provide an iPack voltage reading for each 10-minute averaging interval.

Verifying Signal Strength and Connection Status

A connection status function has been built in to determine received signal strength and connection quality while on site.

Alternatively, the signal strength can be performed by directly connecting the iPack to a computer and running the "Antenna Test" from the SDR software. Older GSM iPack antenna tests using SDR will give a Signal Strength value between 0 and 31, followed by a Bit Error Rate value between 0 and 7. GSM iPackGPS, CDMA iPacks and satellite iPacks will all display Signal Strength as a percentage.

Note that signal strength found on a fair weather day is optimistic, and local conditions can dramatically affect connection reliability. Cell radio signals are weakened by local cellular traffic, rain, and even high humidity in the signal path.
To check signal and connection status, press **[Home][3][4].** Wait for the menu to change while the iPack powers up. Then press **[2].** A message will tell you if service is available and will display the strength of the signal as a percentage. In this screen, additional detail such as cellular band and carrier are also available.

To view:

IP address, press **[1]**
DNS1, press **[2]**
DNS2, press **[3]**
Cellular Band, press **[7]**
Cellular Carrier, press **[8]**

For example, pressing **[Home][3][4], wait, [2], [8]** on an iPackGPS will bring up the screen:

iPackGPS v60 3G
Registered Roaming
AT&T
Batt: 12.8 Ant: 75% +

Older iPacks (pre-GPS model) do not have the additional detail available and will display:

iPack/GSM Cellular
Rev 9
RSSI: 24 BER: 2
REGISTERED (HOME)

GSM iPacks (s/n 38607905 and earlier):

RSSI (RECEIVED SIGNAL STRENGTH INDICATOR):	**Status**
24 to 31 (75% to 100%)	Good (31 is best).
9 to 23 (30% to 75%)	On the edge. It may miss calls, especially on foul weather days.
0 to 8 (less than 30%)	May not even get service.
99 (0%)	No signal.
BER (BIT ERROR RATE):	**Status**
0 to 2	Good (0 is best).
3 to 7	May not even get service.
99	No signal.
Service availability message	**Status**
Not searching	Not registered and not searching
Registered (Home)	Registered on the home network
Searching	Not registered, searching
Registration denied	Recognized but service denied – call provider.
Unknown	Call provider.
Registered (Roaming)	Registered on different provider's network.

Satellite iPack:

The satellite iPack antenna test will provide results ranging from 0 to 100% in increments of 20%. A result of 100% indicates optimal signal strength, and a result of 50% indicates only fair signal strength.

An antenna mounting boom is included with each satellite iPack. However, the satellite antenna easily mounts to any boom with a terminal end of ¾" IPT. The threaded ¾" IPT socket of the antenna will screw onto the end of the boom. Installation considerations include:

- The antenna MUST have a clear view to the satellite at ALL TIMES.
- Any obstructions can cause an interruption between the communications of the iPack and the satellite and could cause the data call to be terminated before complete.
- The antenna must be upright/facing the sky to ensure maximum exposure.
- The antenna must be located so that it has a good view of the sky, ideally horizon-to-horizon coverage.
- The antenna should be mounted so that it is away from structures by a distance of at least 0.5 meters. The Renewable NRG Systems mounting boom meets this requirement.
- The satellites fly in a South-to-North orbit; the antenna must be mounted such that no obstructions occur in this plane. We suggest orienting the antenna South in the northern hemisphere, and North in the southern hemisphere.

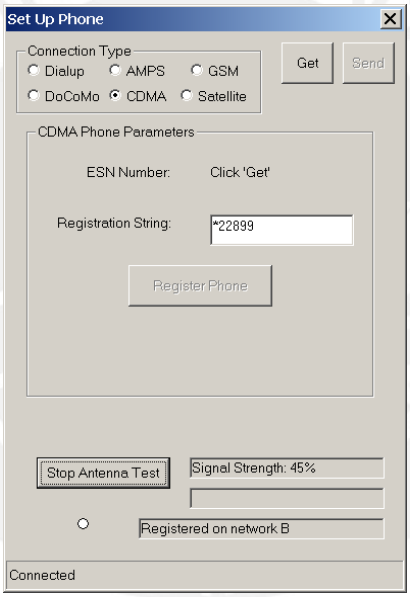
An antenna test should be performed on the satellite iPack once it is attached to the logger. Go to iPack Utilities from the Symphonie*PLUS3* logger main menu to perform this function (iPackGPS users will choose [2] Modem Status to perform an antenna test). Signal strength is reported from 0% to 100% and may fluctuate depending on site conditions. If a value other than 0% is returned, the user can try to establish a call. A value of 0% indicates that no direct connection has been established between the antenna and the satellite. Try mounting the antenna in a different location.

CDMA iPack:

The CDMA iPack antenna test will provide results ranging from 0 to 100%. A result of 100% indicates optimal signal strength, and a result of 50% indicates only fair signal strength. Powering up phone is displayed briefly, followed by Contacting Carrier, and then a screen similar to this appears:

iPack/CDMA
rv21d 10-26
Signal Strength: 45%
Carrier: B SID: 300

The screen below shows the same results when the antenna test is done using SDR software (from the Modify iPack Settings screen, choose **Options**, and then **Set Up Phone**).



Verifying iPack data transfer to ISP (Call Now)

Once you have verified that the logger is functioning and that the iPack is present by pressing **[Home][2][3]**, you will want to perform a Call Now to verify communications with your ISP. During a call, the Call Now and Antenna Test features are unavailable, but all other logger programming functions are available. The iPackGPS's Call Now screen displays the antenna signal strength and allows the user to navigate other menus while a Call Now is in progress.

Press **[Home][3][4] or [Home][2][3]**, and wait for the menu to change while the iPack powers up. Then press **[1]** to initiate a "Call Now". The logger will display the series of messages shown below as it performs the call. Please note that loggers with an iPackGPS will display slightly different progress messages as follows: Checking for file, getting next file, starting modem, detecting modem, detecting GSM band (GSM iPackGPS only), registering modem, initializing modem, connecting modem, connecting Internet, Internet connected, getting time info., starting email send, starting email recv, email in progress, disconnecting, checking GPS.

Call Now Requested
iPack displays this message when a Call Now is requested.

Battery OK for Call
iPack checks internal gel cell battery voltage and displays this message if it is above 10.5 V.

Initializing
iPack retrieves necessary settings from non-volatile memory.

Detecting GSM band
(GSM Only) iPack automatically detects bandwidth of cellular network.

Programming Modem
iPack loads retrieved settings into the Internet processor, modem, and cellular transceiver (GSM iPacks).

Getting SD File or Retrying Last File
iPack retrieves a copy of the file from the SD and loads the entire file into a non-volatile memory location (or if a file is already loaded in the iPack's non-volatile memory, it will retry to send that file). Retries can occur if data transmission is interrupted during a call.

Emailing Data
iPack begins to move data from non-volatile memory to the Internet processor.

Waiting for Internet
This message is displayed while the phone is powered, dials the ISP, and the iPack logs onto the Internet. The message could be displayed up to 3 minutes. If the logger can't log on to the Internet within 3 minutes, a retry will occur automatically in 10 minutes.

While logging onto the Internet, the iPack checks for successful completion of the authentication process, confirms availability of DNS service, locates the SMTP server, and confirms that service is available. During communications, the iPack status screen **[Home] [2] [3]** will indicate that a call is being made ("iPack busy or not present" or a series of status messages for iPackGPS).

Percent Sent %
iPack data transfer progress of the file currently being sent is displayed as a percentage.

File was Sent
A file was successfully transferred to the ISP, and the iPack checks the SD for another unsent file. If another unsent file is found, the logger returns to the step of the process where the SD file is retrieved. The logger will keep returning to that step in the process in a loop type fashion until all files have been sent, data transmission has been cut off, or the iPack times out after a 20 minute on-air period.

Note: Under normal use, an iPack should never need to exceed 20 minutes of on-air time. In fact, each daily call should take under 2 minutes to transfer data. The 20 minute on-air time out protects both your battery from running down and your phone account bill from running up should something go wrong.

Getting Time
Once all the files from the SD have been sent, the iPack gets the time from the defined time server. Note that the iPack is compliant with RFC 868 time servers which respond to requests on port 37. Your ISP can recommend a time server that is RFC 868 compliant.

Checking Mail
The iPack logs onto the POP3 server (with the proper Mailbox Name and Mailbox Password settings) and searches each

email header for a patch file that is addressed to the logger. If the logger finds a patch email, it downloads it and updates the iPack programming parameters or sensor configuration settings in non-volatile memory based on the patch file.

Tip: Keep the mailbox clean and regularly delete SPAM to reduce air time and save money on phone bills. Also, any changes in your account status may result in the ISP sending an email to this mailbox. It is a good idea to log on (through a web-mail type interface such as mail2web.com) and check for important mail from your ISP regarding your account status.

Patch Applied
If the iPack finds a patch file, the logger will briefly display this message.

Shutting Down
This is always the last message of the series after checking mail or patch applied.

Success or Internet Error XXX

This is the same message as would be found in the iPack status screen. The call is properly terminated by the iPack with all data transfer a success, or an error has occurred. Note the error code number and look up the error on the iPack Error Code Chart in the Troubleshooting chapter of this manual or in the Tech Support area of the Renewable NRG Systems website.

Checking the iPack's Modem Status – Modem Status Screen (iPackGPS only)

The Modem Status screen **[Home][3][4][2]** displays the iPack firmware version battery voltage along with the registration state (Home, Roaming, Searching, Not Registered), the next scheduled call time, and the antenna signal strength. From this menu, the back arrow button can be used to return to the iPack menu.

Checking the iPack's GPS Status – GPS Status Screen (iPackGPS only)

The GPS Status screen **[Home][3][4][3]** displays the iPackGPS's version number and type (CDMA, GPS, or Satellite), along with the latitude, longitude, altitude, and number of acquired GPS satellites. The latitude and longitude are shown in degrees and decimal minutes (rather than in degrees, minutes, and seconds).

Checking the iPack Event Log – iPack Event Log Screen (iPackGPS only)

The iPack Event Log **[Home][3][4][4]** allows the user to scroll through numbered events by pressing the up and down arrow keys. The most recent events are displayed first. Using the numeric keypad, the user can enter a number jump to a particular event.

Using the Manual Dial feature – Manual Dial Screen (iPackGPS only)

The Manual Dial feature **[Home][3][4][5]** allows a CDMA iPackGPS to be switched from Verizon to WindLinx or from WindLinx to Verizon through use of an initialization string (*22899;). Sending this initialization string updates the iPackGPS modem's PRL (Preferred Roaming List).

When entering *22899; in the Manual Dial screen, use the up arrow to enter a *, use the right arrow key to enter a semi-colon, and then press the "SET" button on the logger's keypad. If you are unsure about how to use this feature, please contact Renewable NRG Systems Technical Support for assistance.

Verifying iPack settings with your computer at the site using the iPack Access Port

Sometimes it is necessary to check the current iPack ISP and phone settings while on site. The programming adapter along with the DB9 field programming cable will allow you to do this by connecting a portable computer equipped with a COM port to the logger's iPack access port (see Symphonie*PLUS3* Logger Components Map).

The front panel iPack access port works exactly the same way as the DB25 port but allows the user to access the iPack

while the logger is connected to the iPack. Note that if the logger is controlling the iPack at the moment you plug it in, the computer will not be able to communicate with the iPack until the logger commands are finished. The iPack can only communicate with one device (logger or computer) at a time.

With the iPack connected to the computer through the access port, you may perform all the same functions as found in the *Pre-Installation Setup: iPack Configuration* section.

Installing the programming adapter

On one side of the adapter you should see symbols for a headphone and microphone. Renewable NRG Systems supplies the DB9 cable with the adapter. Plug the DB9 cable into the adapter. To install the adapter, remove the logger battery cover and very carefully insert the programming adapter with the 1/8 inch phone jacks pointing down.

Be careful not to bump the SCMs! Electrical damage could result! Do not force the adapter! Make sure you are inserting the adapter into the correct port!

Once installed, the headset and microphone symbols should be on the right side of the adapter.

Before Leaving the Site

1. Check sensor readings to assess sensor condition. Readings that vary widely with expected norms may indicate a faulty connection. Press **[Home][1]**, then **[Up]** or **[Down]** to scroll through the sensors.
2. Check all sensor cables, making sure they are firmly attached to the tower.
3. Check the batteries and clock. Note battery condition. Press **[Home][2][1]**.
4. Confirm that the SD has been installed and formatted.
5. Review the time and date settings, and the next call scheduled (remember the clock is set to Standard time).
6. Remove the desiccant pack from its plastic bag, and clip it under the gray clip in the logger's door.
7. Install the battery cover to securely hold the D-cells and the SCMs. Tighten the thumbscrews by hand only (do not over-tighten or use tools).
8. Close the logger's door, and secure both latches.
9. Check that the wiring panel is secured to the logger.
10. Close, latch and lock the shelter box.

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Site Visits

Recommended Tools and Supplies

- diagonal wire cutters to trim sensor wire leads
- wire strippers to strip sensor cables if necessary
- 7/16 inch nut driver or wrench for installing yagi antenna
- 5/16 inch nut driver for hose clamps, mounting screws (PV and logger)
- ½ inch crescent wrench to tighten ground acorn nut
- ¼ inch nut driver for sensor terminals
- 3/8 inch nut driver or wrench for ground stud nut
- electrical tape
- small flat blade RNRG screwdriver (included with logger) for sensor wires
- Phillips head screw driver for PV terminals & attaching iPack to logger
- drill to tighten hose clamps - optional
- tin snips to cut excess hose clamp – optional
- extra desiccant pack

Changing SD and Routine Site Visit Check List

A routine site visit should include the following activities:

1. Check sensor readings to assess sensor condition. Readings that vary widely with expected norms may indicate a sensor malfunction. Press **[Home][1]**, then **[Up]** or **[Down]** to scroll through the sensors.
2. Check the batteries and clock. Note battery condition. Press **[Home][2][1]**.
3. Pull SD and label it with the date and site number. The SD can be pulled at any time.
4. If battery status was "Replace", replace batteries now, one at a time. Use only alkaline D-cells, IEC type LR20.
5. Correct the clock, if needed (remember the clock is set to Standard time).
6. Insert and format a new SD card.
7. Check SD status.
8. If any condensation is noticed inside the enclosure, replace the desiccant pack with a fresh one from a sealed package.

Cleaning

If it should become necessary to clean the Symphonie*PLUS3* data logger, use a cloth slightly dampened with water and wipe clean. Do not use solvents. Never submerge the unit.

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Symphonie Data Retriever Software: Data Processing

Backing up data files

It is very important that your data is backed up at regular intervals. It is a good idea to back up and archive all your raw data files (.rwd) as well as the SDR site database (.nsd). A simple backup method is to copy/burn your entire Renewable NRG Systems directory to an external drive or CD after every successful data processing session. Always consult with your IT professional if unsure how to copy or back up files.

Make sure to back up your data!

Transferring Raw Data Files onto your computer hard drive

Using an SD Reader and Windows Explorer to copy Raw Data Files to your Raw Files working directory

Once you have successfully installed the SD Reader and have a drive mapped to it, you may use standard commands in Windows Explorer to copy the raw files from the SD to the Raw Files working directory (see Options) on your computer system. Many computers have a built-in SD card reader. It is important to remember that when viewing the raw data files (*.rwd) on the SD Reader, they only exist in the SD Card and do not exist on your computer until you copy them to your system hard disk. It is very important that the drive to which the raw data files are copied is backed up at regular intervals. Consult with your IT professional if unsure how to copy or backup files.

Saving Raw Data Files received as email attachments from your email program to your Raw Files working directory (iPack users only)

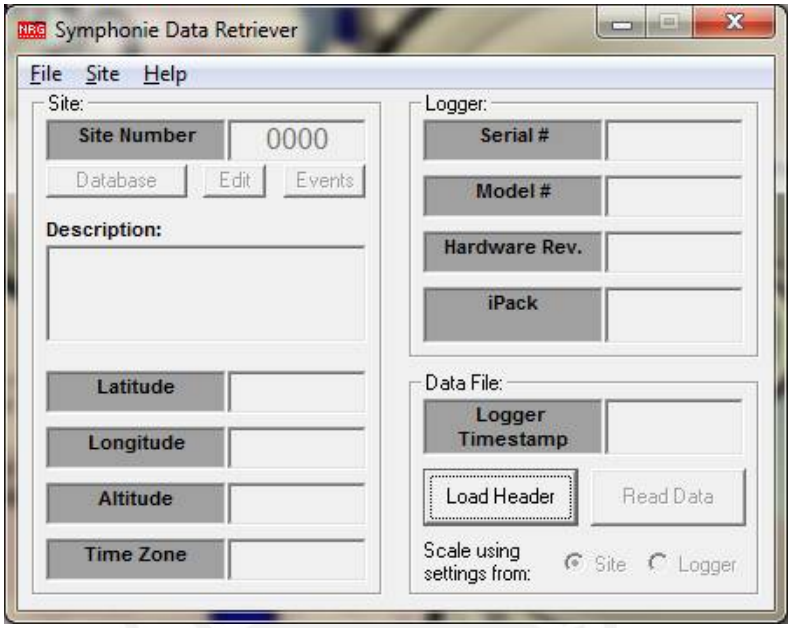
Once you have successfully received a raw data file as an email attachment, use standard commands in your email program to save the raw data files (*.rwd) to the Raw Files working directory (see **Options** under SDR's **File** menu). It is very important that the drive to which the raw data files are copied is backed up at regular intervals. Ask your IT professional if unsure how to save or backup files.

Data Processing Utilities

SDR installs utilities on your computer that assist in data handling. PopAuto.exe can be used to automate the extraction of Symphonie*PLUS3* data from emails. Application notes that explain how to use PopAuto.exe can be found in the Tech Support section of the Renewable NRG Systems web site.

Opening the SDR software

From the Windows **Start** menu, go to **Programs>NRG>Symphonie Data Retriever**. The SDR main window will open.



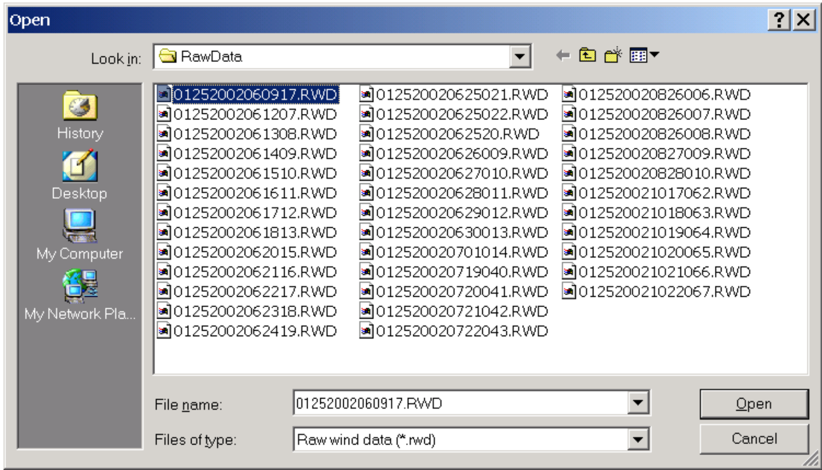
Checking what version of SDR is installed

From time to time it is necessary to check which version of SDR is installed on your computer so you may check for an update or submit a technical support inquiry. Go to the **Help>About** menu to check the version number. *Be sure to check the Renewable NRG Systems website for updates!*

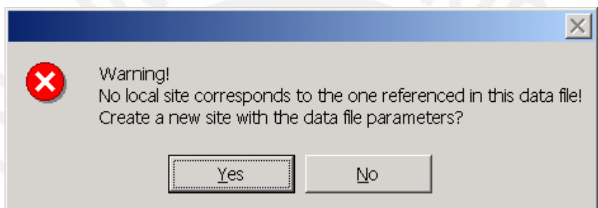
Viewing Data Header

The data header contains basic site and logger information such as site number, site description, latitude, longitude, altitude, time zone, logger serial number, model number, hardware revision, iPack, and logger time stamp for the data file. This information should always be checked before reading a data file. If anything is corrupt in the header information, take note and proceed with caution.

Press the "**Load Header**" button to view the header information.

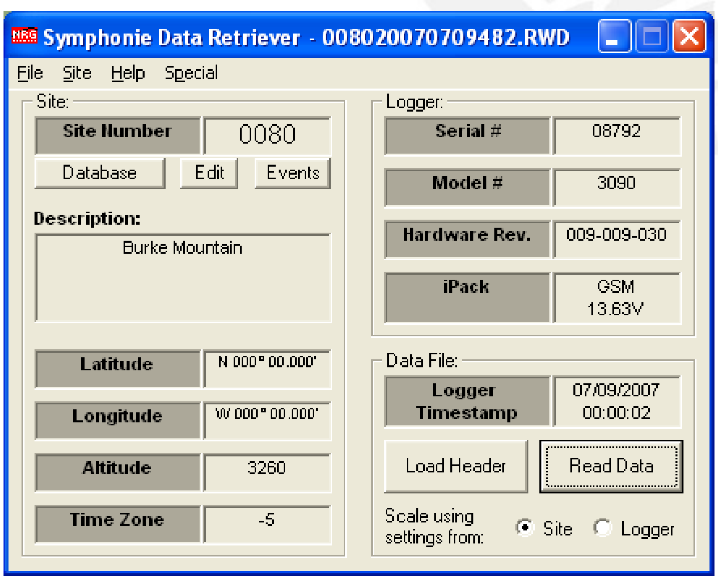


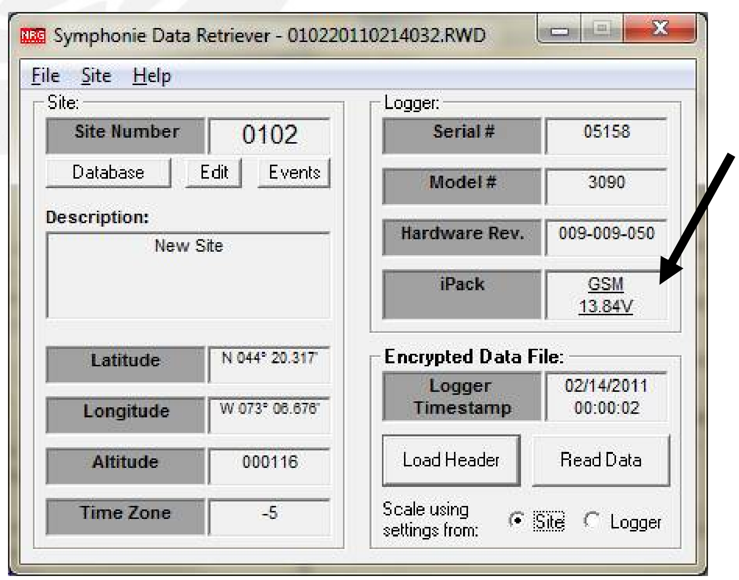
Select a file and press "**Open**." If files are not *.rwd, choose the correct type of file from the "Files of type" drop-down menu at the bottom of the window. If a site for this file does not exist, you should see the following message:



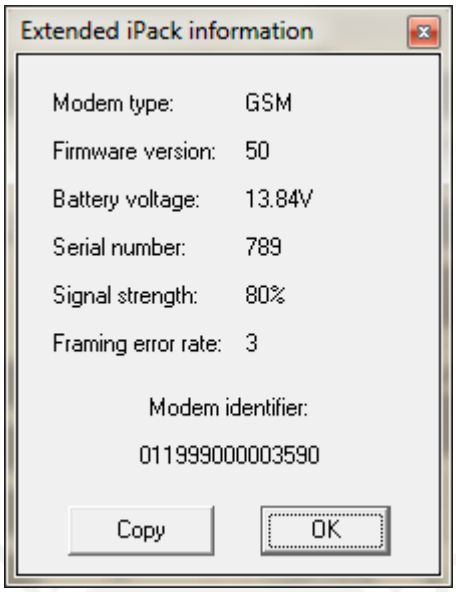
Note that if a site file does not exist, SDR will prompt you to create one at this point. See the section called "Creating a New Site" found in the chapter called "Data Retriever Site Information" if you choose to create a site file at this point. You will want to have the site commissioning data at this point to be able to successfully create the site.

To view the file header without creating the site, choose **No**. You should see the following window with the file header information:



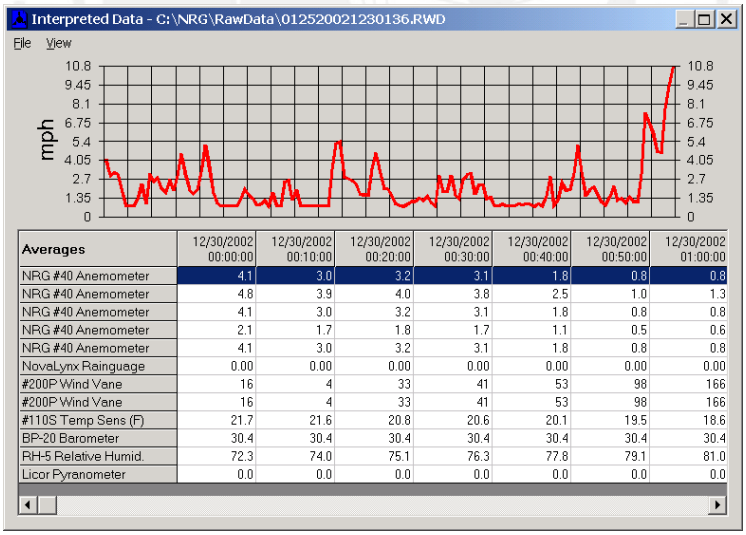


iPackGPS users can click on the iPack link shown above to access more detailed iPackGPS information such as iPackGPS serial number, modem identifier, battery voltage, and antenna signal strength at the time of the call:



Reading Data to the Data Viewer with settings from data file

Once you have loaded the header of a raw data file, you may **"Read"** the data into the graphical data viewer. If you wish to use the settings that are included in the data file (the settings that were programmed into the logger), select "**Scale using settings from: Logger."** The interpreted data in the data viewer will be based on the logger settings as they were configured by field personnel.

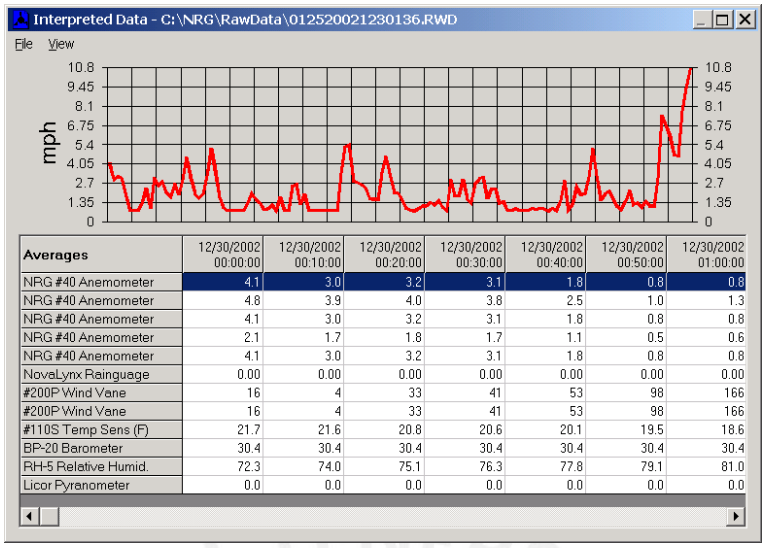


Averages	12/30/2002 00:00:00	12/30/2002 00:10:00	12/30/2002 00:20:00	12/30/2002 00:30:00	12/30/2002 00:40:00	12/30/2002 00:50:00	12/30/2002 01:00:00
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	4.8	3.9	4.0	3.8	2.5	1.0	1.3
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	2.1	1.7	1.8	1.7	1.1	0.5	0.6
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NovaLynx Rainguage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
#200P Wind Vane	16	4	33	41	53	98	166
#200P Wind Vane	16	4	33	41	53	98	166
#110S Temp Sens (F)	21.7	21.6	20.8	20.6	20.1	19.5	18.6
BP-20 Barometer	30.4	30.4	30.4	30.4	30.4	30.4	30.4
RH-5 Relative Humid.	72.3	74.0	75.1	76.3	77.8	79.1	81.0
Licor Pyranometer	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Reading Data to the Data Viewer with settings from site file

Once you have loaded the header of a raw data file, you may **"Read"** the data into the graphical data viewer. If you wish to use the settings that are included in the Site Information Editor window, select **"scale using settings from: Site."**

The interpreted data in the data viewer will be based on the site information as it was configured with the SDR software.



Averages	12/30/2002 00:00:00	12/30/2002 00:10:00	12/30/2002 00:20:00	12/30/2002 00:30:00	12/30/2002 00:40:00	12/30/2002 00:50:00	12/30/2002 01:00:00
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	4.8	3.9	4.0	3.8	2.5	1.0	1.3
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NRG #40 Anemometer	2.1	1.7	1.8	1.7	1.1	0.5	0.6
NRG #40 Anemometer	4.1	3.0	3.2	3.1	1.8	0.8	0.8
NovaLynx Rainguage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
#200P Wind Vane	16	4	33	41	53	98	166
#200P Wind Vane	16	4	33	41	53	98	166
#110S Temp Sens (F)	21.7	21.6	20.8	20.6	20.1	19.5	18.6
BP-20 Barometer	30.4	30.4	30.4	30.4	30.4	30.4	30.4
RH-5 Relative Humid.	72.3	74.0	75.1	76.3	77.8	79.1	81.0
Licor Pyranometer	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Logger Channels and Graph

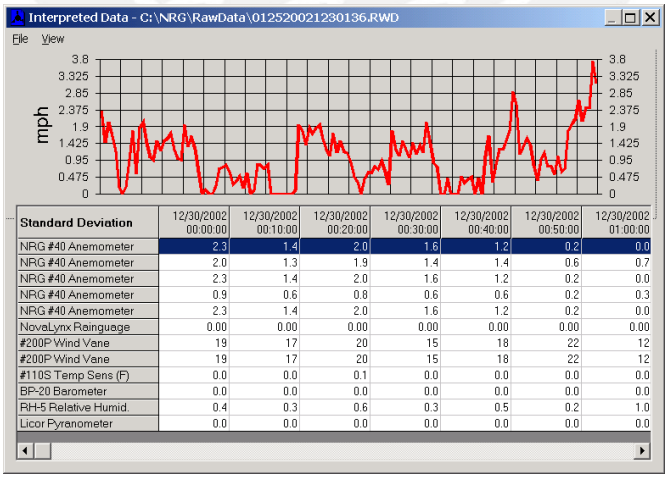
The data viewer allows users to graphically view each channel or even multiple adjacent channels simultaneously in the graph located at the top of the screen. The channel descriptions run down the left side of the screen.

Choosing logger channel to view in graph

To select a channel to view in the graph, click on the channel with your mouse. You may select multiple adjacent channels simultaneously by holding down the shift key and clicking on the channels with your mouse. Each channel will be represented by a different color on the graph, and a key is included to the right.

Choosing parameters from selected logger channel to view in graph

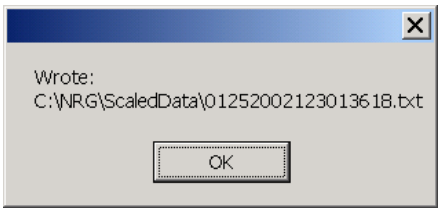
Once you have selected channels to view in the graph, you may change the parameter you are viewing for the channel by selecting from the **View** menu. For example, to view the standard deviation instead of 10 minute averages, select **View>Standard Deviation.**



Standard Deviation	12/30/2002 00:00:00	12/30/2002 00:10:00	12/30/2002 00:20:00	12/30/2002 00:30:00	12/30/2002 00:40:00	12/30/2002 00:50:00	12/30/2002 01:00:00
NRG #40 Anemometer	2.3	1.4	2.0	1.6	1.2	0.2	0.0
NRG #40 Anemometer	2.0	1.3	1.9	1.4	1.4	0.6	0.7
NRG #40 Anemometer	2.3	1.4	2.0	1.6	1.2	0.2	0.0
NRG #40 Anemometer	0.9	0.6	0.8	0.6	0.6	0.2	0.3
NRG #40 Anemometer	2.3	1.4	2.0	1.6	1.2	0.2	0.0
NovaLynx Rainguage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
#200P Wind Vane	19	17	20	15	18	22	12
#200P Wind Vane	19	17	20	15	18	22	12
#110S Temp Sens (F)	0.0	0.0	0.1	0.0	0.0	0.0	0.0
BP-20 Barometer	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RH-5 Relative Humid.	0.4	0.3	0.6	0.3	0.5	0.2	1.0
Licor Pyranometer	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Saving Data from the Data Viewer to a TXT file

Once you have viewed the data and wish to create an ASCII (.txt) file for further data processing, choose **File>Save TXT File**. SDR will save a tab delimited ASCII file with the .txt extension into the scaled data working directory (see **Options** under SDR's **File** menu).



Note: When creating an ASCII file from data scaled from settings from the logger, scale factors from the logger will applied rather than scale factors from the Site Information Editor window.

Importing the data into the site database (when viewing with settings from Site only)

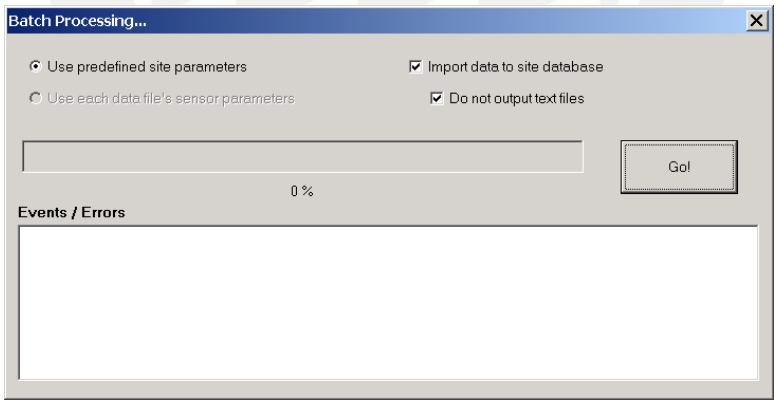
Once you have viewed the data using the settings from the site and wish to import the data into the SDR site database, choose **File>Import to database**. SDR will import the data into the corresponding site database file (.nsd) where the data can be accumulated over time.

Closing the Data Viewer

Select **File>Close** from the Interpreted Data Window to close the Data Viewer. The SDR Main menu will appear once the Data Viewer has been closed.

Batch Processing data files (Converting a group of raw data files to .txt files and importing into the database)

If you wish to convert many raw data files into scaled ASCII data files and/or import many raw files into the database together in a single process, you may do so using the batch processing feature. Select **File>Batch Process**. SDR allows you to choose if the scaling information will come from the site file and if this data will also be imported into the database with or without generating corresponding daily .txt files. SDR also allows import using the settings from each raw file – in this case the data cannot be imported into the site database. If selected, text files will be written to your scaled data folder. If a file cannot be processed, filename.log will be written in the scaled data folder.



Options

Disabling Descriptive Headers from Output Files

Certain data processing tasks require that the header information is not included in each saved ASCII (.txt) file. Go to **File>Options** and check the **"skip descriptive headers"** box if descriptive headers are unwanted in the file output. Additionally, if the **"skip descriptive headers"** box is checked, the option to skip column headers is also available by checking the "**skip column headers"** box.

Output Hourly Averages

Check the **"Output Hourly Averages"** box if you wish the daily .txt file format to contain data with hourly averages instead of 10 minute averages.

Delimit with commas instead of tabs

Check the **"Delimit with commas instead of tabs"** box if you wish the daily .txt file format to use commas as a delimiter instead of tabs. *This is not recommended for users outside of the USA!*

Setting the working directory for Raw files (where Raw files from the SD or email program should be saved so SDR can find them)

Go to the **File>Options** menu to change the working directory for raw data files. This is the directory that SDR will point to for reading raw data files. You will see the working directory path and can either edit the path or browse to a new location by clicking on the box with three dots to the right of the Raw Data path.

Setting the working directory for Saved TXT files (where scaled data files are stored)

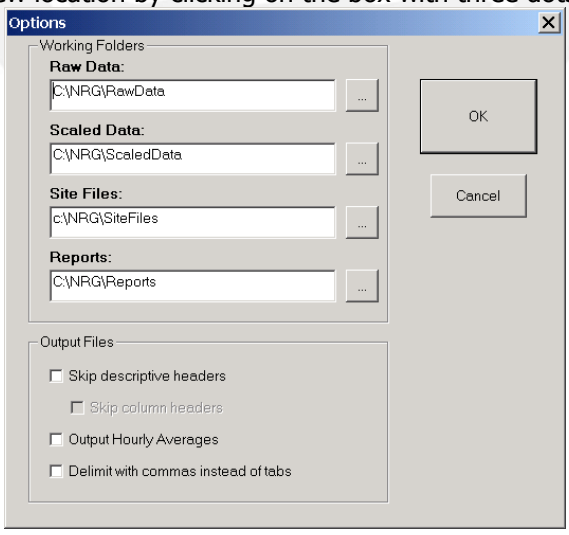
Go to the **File>Options** menu to change this working directory. This is the directory that SDR will point to for saving scaled data files. You will see the working directory path and can either edit the path or browse to a new location by clicking on the box with three dots to the right of the Scaled Data path.

Setting the working directory for Site files (where site information used to scale data is stored)

Go to the **File>Options** menu to change this working directory. This is the directory that SDR will point to for saving site files. It is also the directory that SDR will point to when utilizing a site file to process raw data. You will see the working directory path and can either edit the path or browse to a new location by clicking on the box with three dots to the right of the Site Files path.

Setting the working directory for Reports (.wmf file format)

Go to the **File>Options** menu to change this working directory. This is the directory that SDR will point to for saving reports. Each time you run reports in SDR, they will be saved to this directory. The .wmf report files easily import into MicroSoft office documents and can be easily exchanged through email. You will see the working directory path and can either edit the path or browse to a new location by clicking on the box with three dots to the right of the Site Files path.

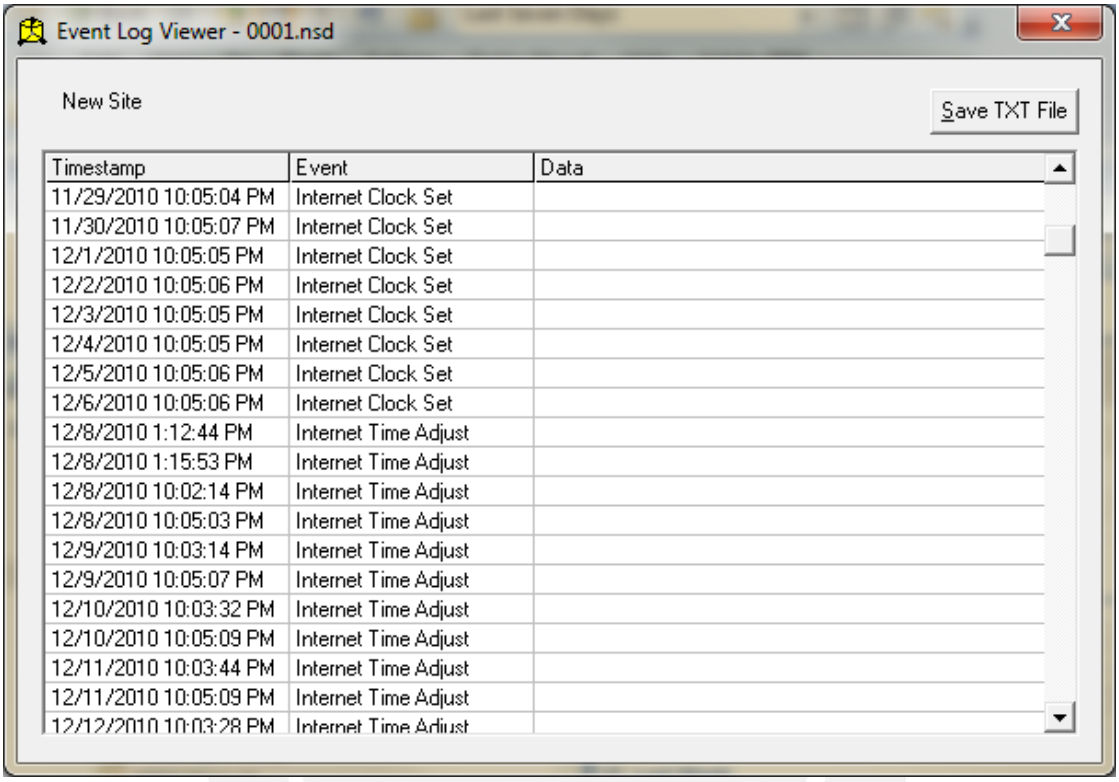


SDR Event Log

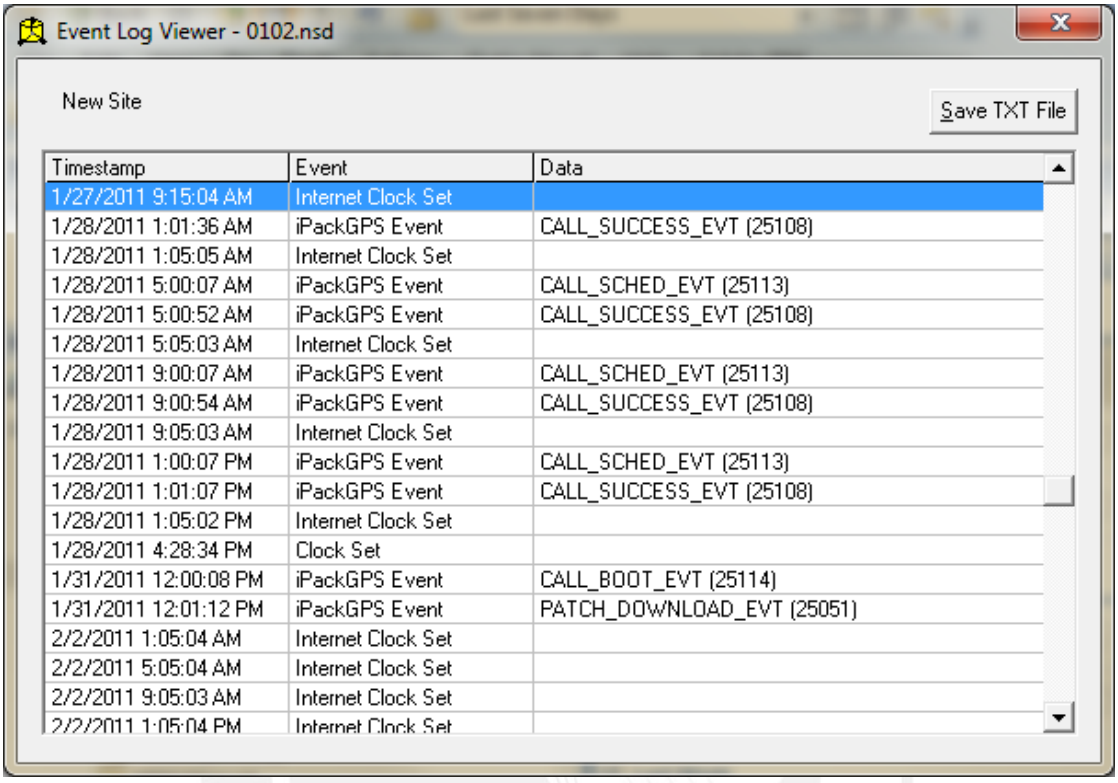
The Symphonie*PLUS3* logger stores internal events into a log viewable from the logger display. The event log is transferred into the Data File header whenever a new file is created for any reason. The SDR software imports these

events into the SDR "Event Log" which is viewable from SDR (from SDR's main menu, choose **Site>View Event Log**, choose the site number from the list, and click OK).

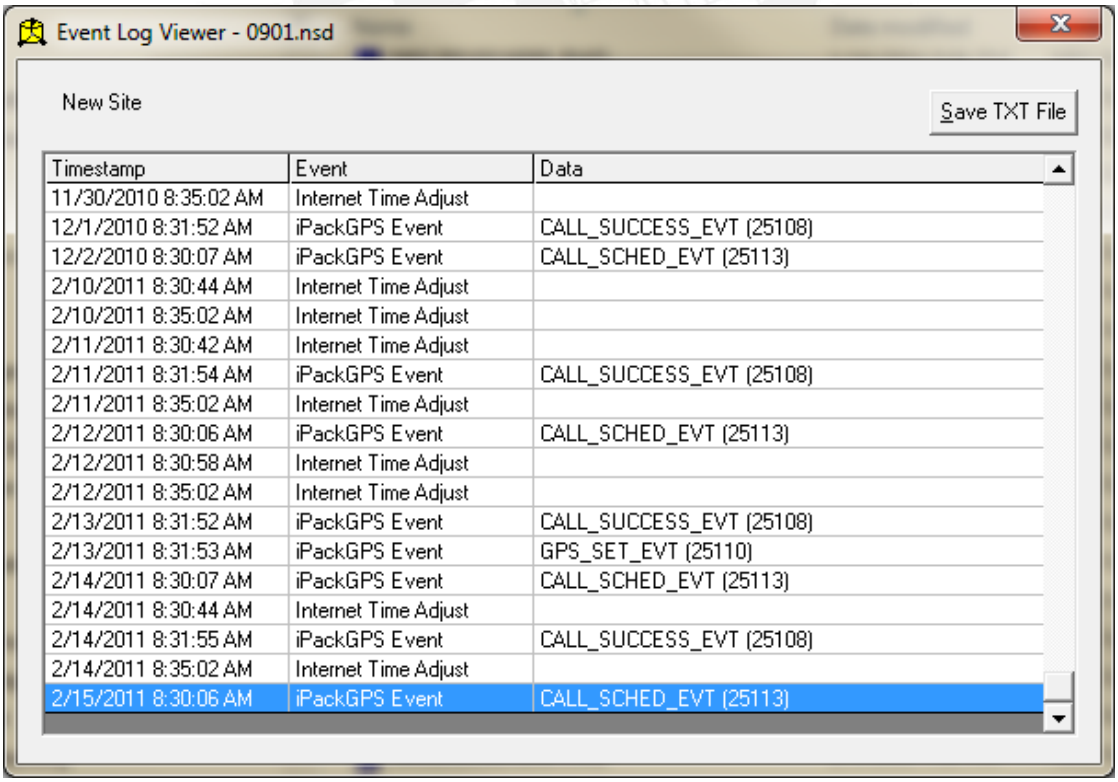
A typical Event Log looks like this:



In addition to logger events, iPackGPS users can also view events generated by the iPackGPS. If an iPackGPS is connected to the logger, you will see iPack events like these:

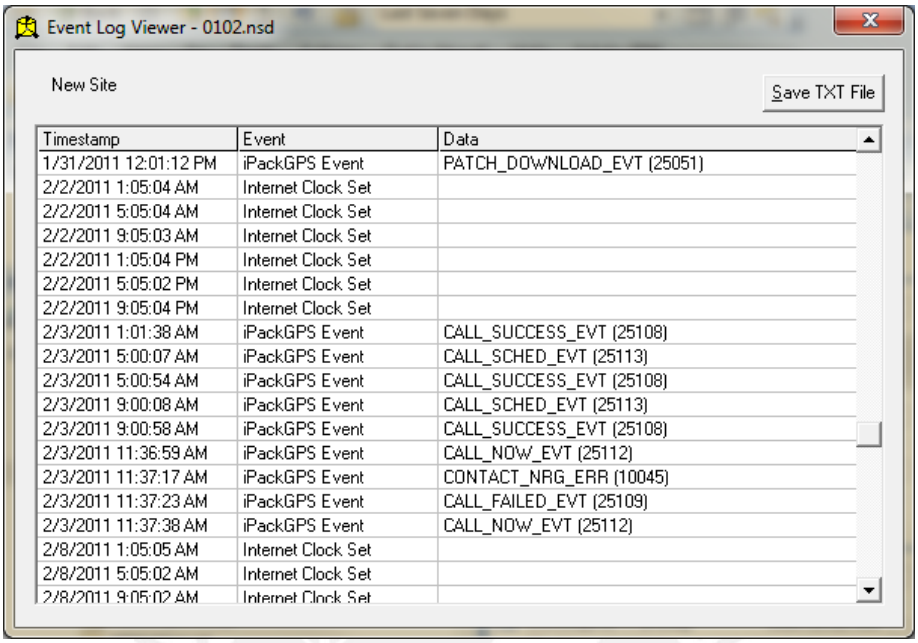


Timestamp	Event	Data
1/27/2011 9:15:04 AM	Internet Clock Set	
1/28/2011 1:01:36 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
1/28/2011 1:05:05 AM	Internet Clock Set	
1/28/2011 5:00:07 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
1/28/2011 5:00:52 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
1/28/2011 5:05:03 AM	Internet Clock Set	
1/28/2011 9:00:07 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
1/28/2011 9:00:54 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
1/28/2011 9:05:03 AM	Internet Clock Set	
1/28/2011 1:00:07 PM	iPackGPS Event	CALL_SCHED_EVT (25113)
1/28/2011 1:01:07 PM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
1/28/2011 1:05:02 PM	Internet Clock Set	
1/28/2011 4:28:34 PM	Clock Set	
1/31/2011 12:00:08 PM	iPackGPS Event	CALL_BOOT_EVT (25114)
1/31/2011 12:01:12 PM	iPackGPS Event	PATCH_DOWNLOAD_EVT (25051)
2/2/2011 1:05:04 AM	Internet Clock Set	
2/2/2011 5:05:04 AM	Internet Clock Set	
2/2/2011 9:05:03 AM	Internet Clock Set	
2/2/2011 1:05:04 PM	Internet Clock Set	



Timestamp	Event	Data
11/30/2010 8:35:02 AM	Internet Time Adjust	
12/1/2010 8:31:52 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
12/2/2010 8:30:07 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
2/10/2011 8:30:44 AM	Internet Time Adjust	
2/10/2011 8:35:02 AM	Internet Time Adjust	
2/11/2011 8:30:42 AM	Internet Time Adjust	
2/11/2011 8:31:54 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/11/2011 8:35:02 AM	Internet Time Adjust	
2/12/2011 8:30:06 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
2/12/2011 8:30:58 AM	Internet Time Adjust	
2/12/2011 8:35:02 AM	Internet Time Adjust	
2/13/2011 8:31:52 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/13/2011 8:31:53 AM	iPackGPS Event	GPS_SET_EVT (25110)
2/14/2011 8:30:07 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
2/14/2011 8:30:44 AM	Internet Time Adjust	
2/14/2011 8:31:55 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/14/2011 8:35:02 AM	Internet Time Adjust	
2/15/2011 8:30:06 AM	iPackGPS Event	CALL_SCHED_EVT (25113)

The screen below shows events generated by a failed call:

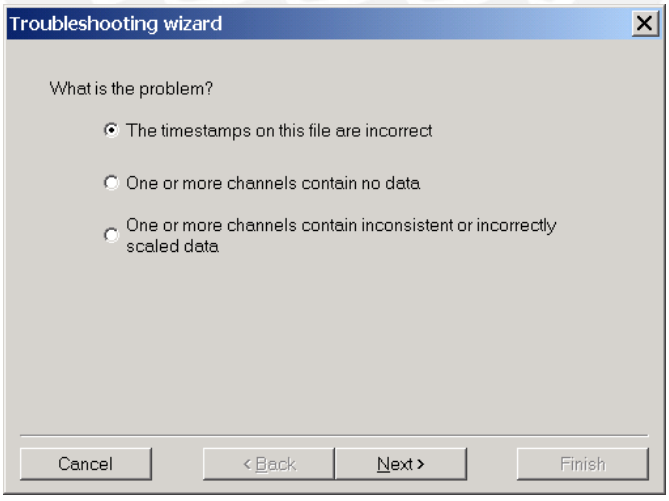


Timestamp	Event	Data
1/31/2011 12:01:12 PM	iPackGPS Event	PATCH_DOWNLOAD_EVT (25051)
2/2/2011 1:05:04 AM	Internet Clock Set	
2/2/2011 5:05:04 AM	Internet Clock Set	
2/2/2011 9:05:03 AM	Internet Clock Set	
2/2/2011 1:05:04 PM	Internet Clock Set	
2/2/2011 5:05:02 PM	Internet Clock Set	
2/2/2011 9:05:04 PM	Internet Clock Set	
2/3/2011 1:01:38 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/3/2011 5:00:07 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
2/3/2011 5:00:54 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/3/2011 9:00:08 AM	iPackGPS Event	CALL_SCHED_EVT (25113)
2/3/2011 9:00:58 AM	iPackGPS Event	CALL_SUCCESS_EVT (25108)
2/3/2011 11:36:59 AM	iPackGPS Event	CALL_NOW_EVT (25112)
2/3/2011 11:37:17 AM	iPackGPS Event	CONTACT_NRG_ERR (10045)
2/3/2011 11:37:23 AM	iPackGPS Event	CALL_FAILED_EVT (25109)
2/3/2011 11:37:38 AM	iPackGPS Event	CALL_NOW_EVT (25112)
2/8/2011 1:05:05 AM	Internet Clock Set	
2/8/2011 5:05:02 AM	Internet Clock Set	
2/8/2011 9:05:02 AM	Internet Clock Set	

A comprehensive list of Symphonie logger events and iPackGPS events and their definitions can be found in the Troubleshooting section of this manual.

SDR Troubleshooting Wizard

The troubleshooting wizard can assist in solving problems with data files in the unlikely event data corruption has occurred. The wizard will step you through the process by first asking "What is the problem?" To open the troubleshooting wizard, select **File>Troubleshooting** from the Interpreted Data window.



Fixing Timestamps

Selecting this wizard makes it possible to fix timestamps (see Time Offset History Window). More details on fixing timestamp issues can be found in the Renewable NRG Systems Technical Support Forum at www.renewablenrgsystems.com.

Sensor Connections

Selecting this wizard makes it possible to see if sensors are disconnected or have no SCM installed.

Sensor History

Selecting this wizard makes it possible to see if an incorrect sensor history entry is skewing data.

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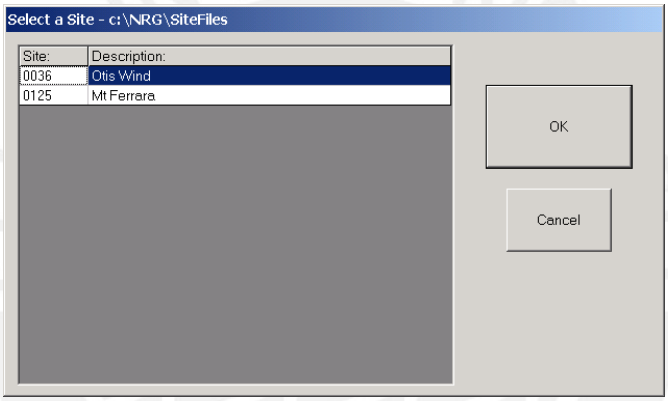
SDR Database and Reporting Functions

SDR includes a self-contained MicroSoft Access compatible database to store imported Symphonie*PLUS3* data. Symphonie*PLUS3* raw files (.rwd) and ASCII files (.txt) can be imported, and all data are stored, after scale factors from the site information settings have been applied for each sensor. This section will provide an overview of the most useful features of the database.

Selecting a site to open (View database)

Go to **Site>View Database,** and you will see the following window:



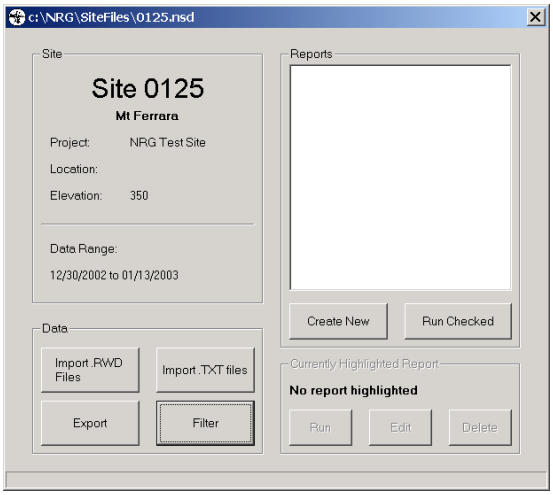
Choose the site you wish to work with and click OK.

Database main window displayed settings:

- Site Number - based on Site Information window
- Site Description - based on Site Information window
- Location - based on Site Information window
- Elevation - based on Site Information window
- Data Range – shows date range of data files that have been imported into the selected database
- Reports –shows the reports that have been configured for the selected database

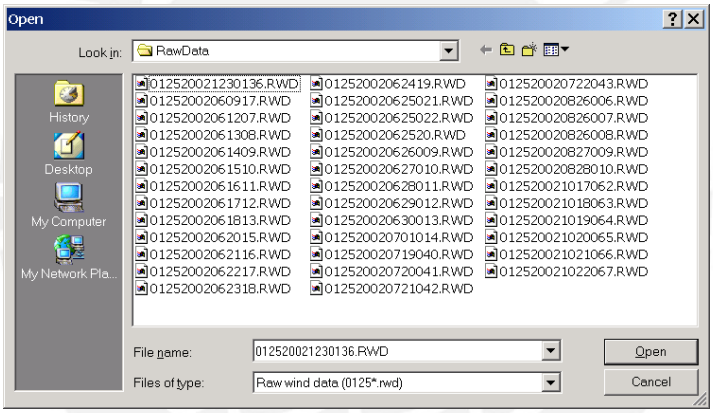
Importing Data from the Database main window

You should see the Main Database window with the information from the selected site database you have opened.



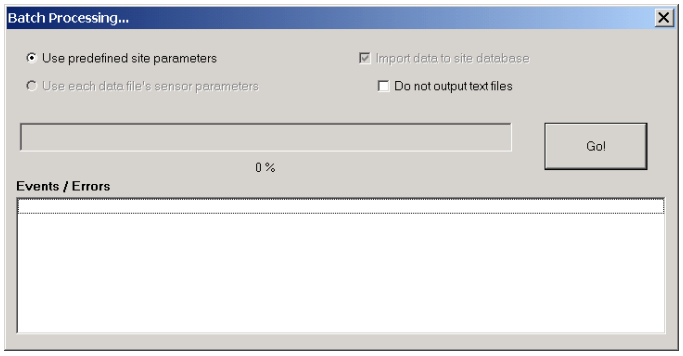
Importing raw (.rwd) files

To import raw Symphonie*PLUS3* data files (.rwd), click on "Import RWD Files." A Windows "File Open" box should appear pointing to the raw files directory you have previously configured under the **File>Options** menu.

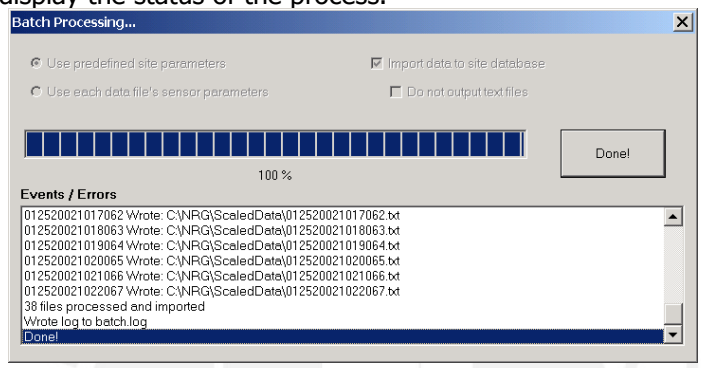


Select the files you wish to import, and click "Open." Notice the "Files of type" entry contains a filter for only the site with which you are currently working.

The "Batch Processing" window should appear. Uncheck the "Do not output text files" box only if you want daily text files to be placed into the "scaled data" folder. Most users prefer to use SDR's export function rather than scaling individual daily text files. The "scaled data" folder has previously been configured under the **File>Options** menu. Press "Go" to import the data into the database. Note that this is the exact same function as choosing "batch processing" mentioned earlier in the "Data Processing" section.



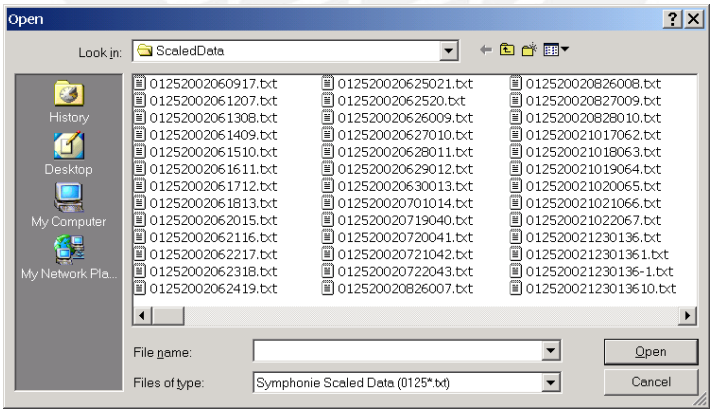
The Events / Errors viewer will display the status of the process.



Click "Done." Once data files are imported, you may export or create and generate reports.

Importing scaled ASCII (.txt) files

Symphonie Data Retriever Software provides an ASCII import feature for use in the unfortunate event that the original raw files have been lost. To import Symphonie*PLUS3* scaled ASCII data files (.txt), click on "Import .TXT Files." A Windows "File Open" box should appear pointing to the scaled files directory you have previously configured under the **File>Options** menu.



Select the files you wish to import and click "Open." Notice the "Files of type" entry contains a filter for only the site with which you are currently working.

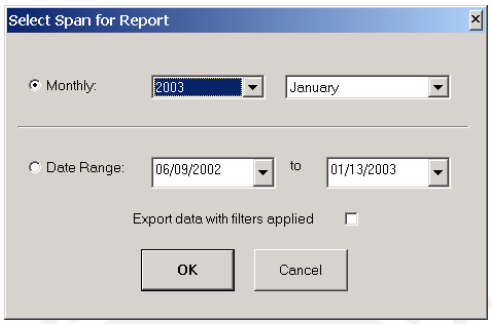
A standard status bar will appear showing the progress of the .txt import.

Warning: Import .txt files only if they are standard SymphoniePLUS3 converted ASCII files. Files converted with header

modifications or alternate delimiters will not import correctly. This feature should only be used when the original raw files have been lost.

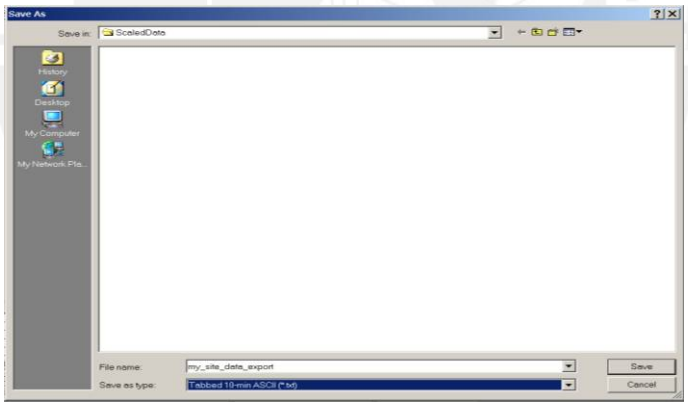
Exporting Data as 10 minute, 60 minute or WAsP

SDR's export feature allows you to export data for a particular month or date range for use with a spreadsheet or other software program that accepts .txt format. Click "Export." The "Select Span for Report" window should appear. You may select a monthly or comprehensive date range for the data export. Also, if you wish to export only data that has had bad data removed, select the "Export data with filters applied" check box. See the section on removing data if you are interested in filtering the data for export.



Select a range and click "OK." A standard Windows "File Save" box should appear pointing to the scaled data folder. Enter a file name for the exported file and choose the file Save as type; here is where you may choose 10 minute, 60 minute or WAsP data.

Click "Save."



A standard status bar will appear showing the progress of the export.

Database Export File Formats

Data can be exported from the database in the following formats:

- tab delimited 10 minute data (.txt)
- tab delimited 60 minute data (.txt)
- WAsP data

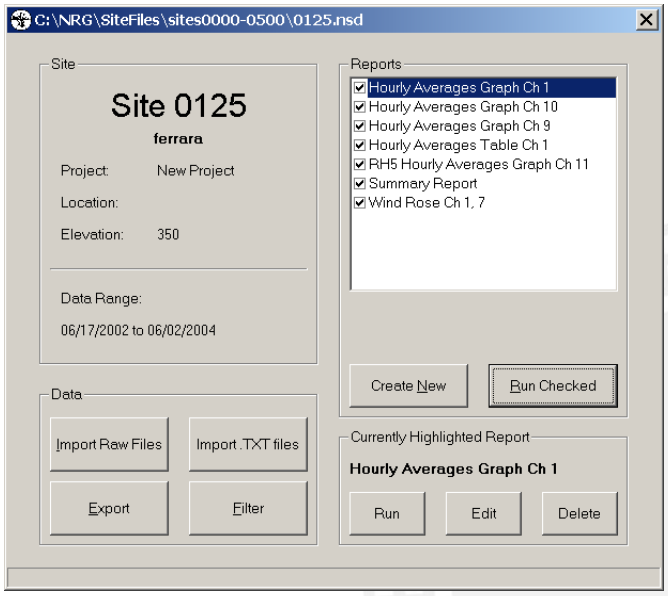
Remember that the exported data has been scaled according to the site information stored in the transferable user defined site file (.nsd).

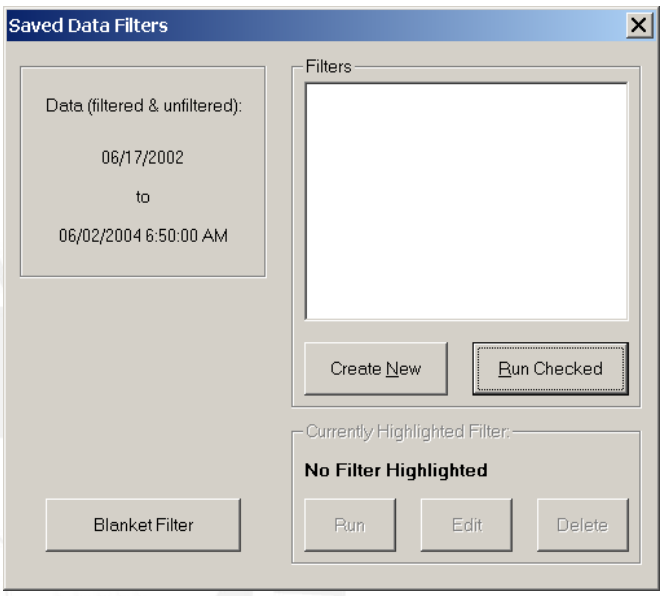
Data Filtering

SDR has the ability to filter data through user-configurable filters. Data filters can be created and saved for each site. Saved filters can then be run on each site periodically.

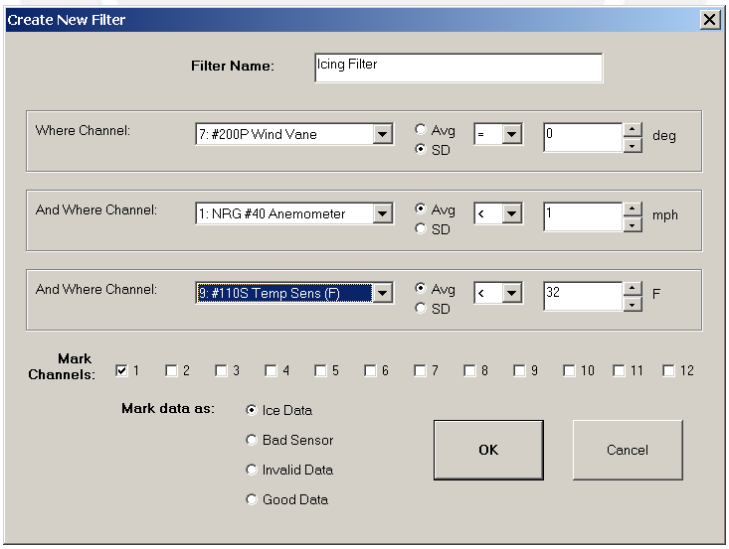
Creating a Data Filter

Go to **Site>View Database** and select the site database for which you wish to create filters. From the Site Database window, click "Filter."





This brings up the "Saved Data Filters" Window. Click "Create New" which brings up the "Create New Filter" window.

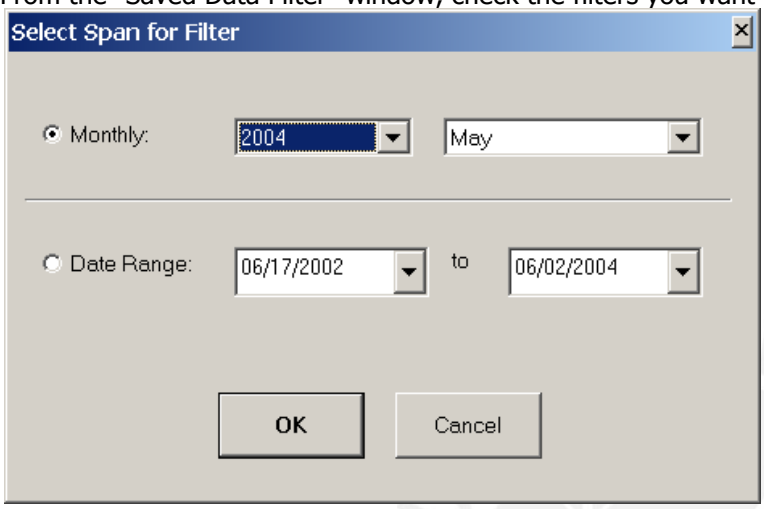


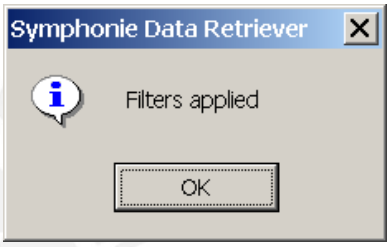
Here you can assign your filter a name and choose the logical definition for your filter based on the data of up to 3 different channels. The "Mark Channels" checkboxes allow you to identify which channels to mark if the filter conditions are all found to apply. The "Mark Data as Type" boxes allow you select the code with which the data will be marked in the SDR database. Click "OK" to save your filter.

Note: Data marked by a filter are not deleted from the database. However, SDR will know to not include those records in report calculations. When exporting, you will have the option to export the data with or without applying filters.

Running a Data Filter

From the "Saved Data Filter" window, check the filters you want to run and select the time span for the filter.

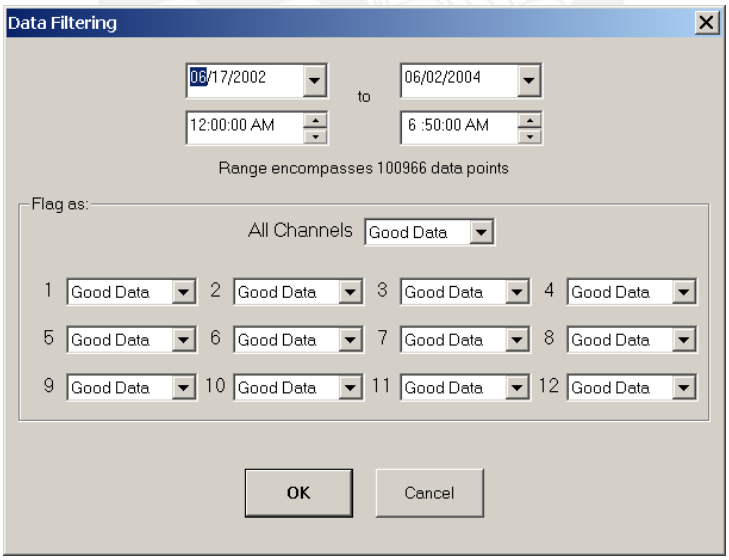




Click "OK" to run the filter. SDR will return the "Filters applied" message when done.

Blanket Filtering / Unmarking all data in database

From the "Saved Data Filters" window, click on "Blanket Filter." You should see the "Data Filtering" window.



This window allows you to filter based on time range and channel and is handy when you may want to remove all marked data from the database.

Data Flag types

You can choose from the following flags to mark data:

- Good Data – applies no filter

- Ice Data – marks data so it can be filtered
- Bad Sensor – marks data so it can be filtered
- Invalid Data – marks data so it can be filtered

The flags "Ice Data", "Bad Sensor", and "Invalid Data" all exclude the data selected from calculations and graphs. SDR does not identify the data flag types on the reports.

If you wish to include all data, make sure that the "Good Data" flag is selected for all 12 channels for the entire time range.

Filtering all channels

Select the desired data range and make your flag selection from the "All Channels" drop down box. You should see the 12 channel flags change when doing this. Click "OK."

Filtering any channel individually

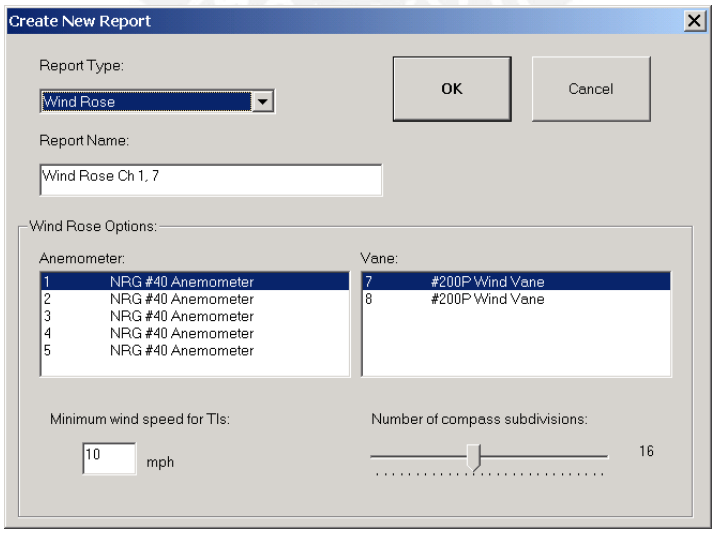
Select a date range and adjust the flags for each channel. Note that only the "Good Data" flag being selected for a channel for a given time range will be included in reports or exports (exports have a checkbox option to include filtered data or not).

Unfiltering (Unmarking) all data for all channels

Select the entire date range. Select "Good Data" from the "All Channels" drop down box. You should see the 12 channel flags change to "Good Data" when doing this. Click "OK."

Creating (Configuring) Reports

From the Main database window, click "Create New" in the Reports section. You should see the "Create New Report" window.



Selecting the report type

Select the desired report from the "Report Type" pull down menu
Report types include the following:

- Wind Rose
- Frequency Distribution
- Hourly Averages Table
- Hourly Averages Graph
- Summary Report

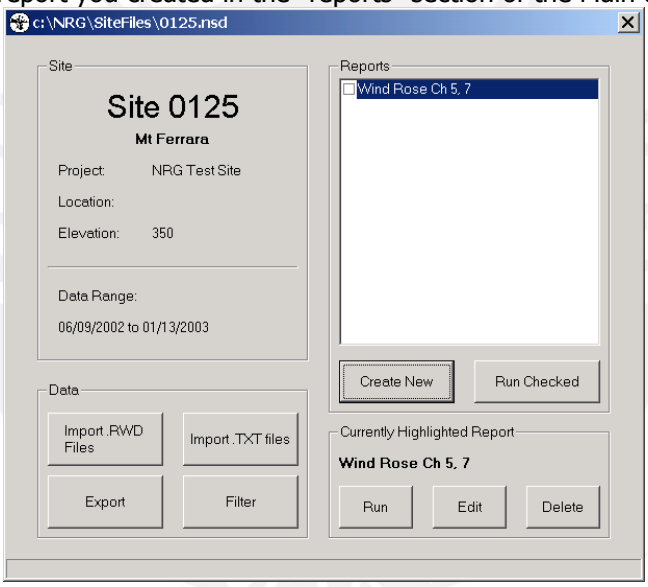
Note that certain options will appear based on the report type selected. You may create as many report types as you want for each site.

Selecting the sensors to be included in the report (Configuring your report)

Click on the sensors you wish to include in the report. The report name will be generated from these selections. A good example is choosing the top level and top level vane to generate the Wind Rose as shown above.

Saving the configured report type for this site

Click "OK." You will now see the report you created in the "reports" section of the Main database window.

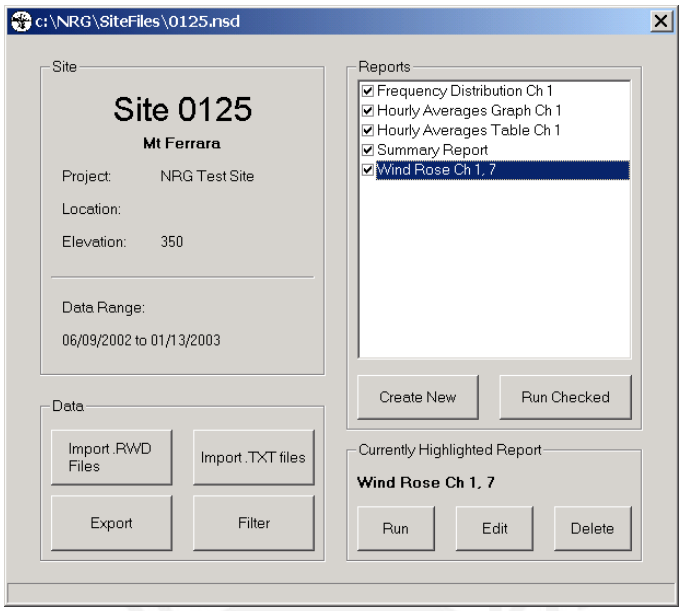


Generating (Running) Reports

Each time you run reports in SDR, they will be saved to the "Reports" directory previously configured under the **File>Options** menu of SDR. The .wmf report files can be imported into MicroSoft Office documents and can be easily exchanged through email. You can also print these reports directly from SDR.

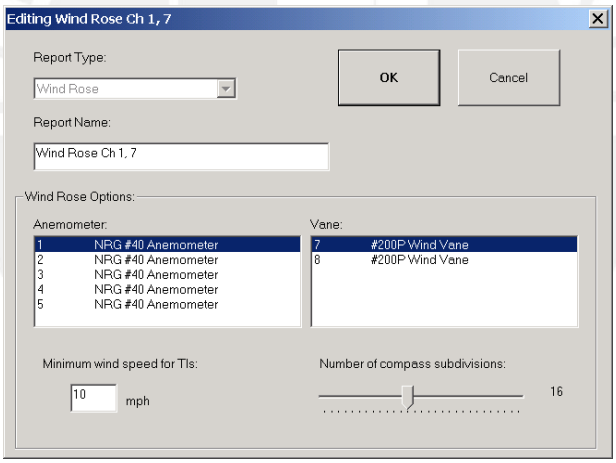
Selecting reports to be generated from the list

Click on the checkbox to the left of each report you wish to run.



Editing and Deleting selected reports

If you wish to edit a report before running, highlight the report by clicking on it, and then click the "Edit" button. You should see an "Editing report…" window. Make your changes and click "OK."



Running and printing the selected reports

Once you have selected all the reports you wish to run in the Main database window, click on "Run Checked." You should see the "Select Span for Report" window. Select the desired month or date range, check the "preview before printing" box, and then click "OK." SDR will then show standard status bars as each report is generated.

Click "Print Setup" and make sure your printer selection is correct. Exit the print setup, and click "Print and Next" to print the currently displayed report and then display the next report that has been generated. Note that all these reports also now exist on your computer's hard drive in the "Reports" folder that SDR has set up.

Always make sure your site's sensor scale factors are correct before generating reports!

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Data Retriever Software: Site Information & Site History

Creating a New Site

The Site File

A site file contains all the information necessary to successfully process raw data files from each individual site. The site file also contains all the scaled data that has been imported into the SDR database. The site files are of the format:

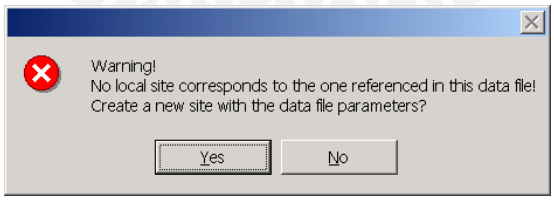
SSSS.nsd
where SSSS = the site number.
For example, 0125.nsd is the site file for site 0125.

Remember, the site file contains scaled data, so if you change the scale factors for old data, you will need to re-import that old data to apply the new scale factors.

When you create a new site, a new site file is created and stored in the SDR subdirectory (as set in the SDR Main Window **File>Options** menu). The site file contains information about the site location, description, what sensors are connected, and how SDR will scale the data from each of the 12 logger channels. It is very important to get the site file set up correctly. You will want to have the site data sheet when creating a new site. All of the specific parameters that are included in each site file are described in this section.

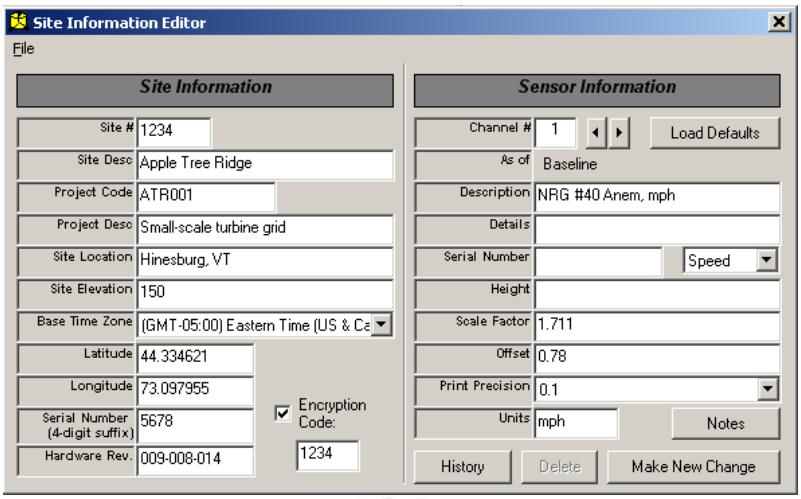
Creating a Site File From Data File (Recommended)

The recommended way to create a new site file is to load the header for a data file from a new site. At that point, a warning message will appear on your screen informing you that "No local site corresponds to the one referenced in this data file! Create a new site with the data file parameters?"



Click **Yes** when prompted at the warning message.

This will bring you into the Site Information Editor window. The site fields will be populated with the information passed from the logger as programmed by the field personnel. At this point, you will be able to edit all the fields and then save the site file. You will want to have the site data sheet when creating the new site. The site data sheet will include the information you need to enter into the site editor if field personnel did not program the logger completely. Once the site file is saved, any raw data files (.rwd) from the corresponding site that are converted based on this site file will use the settings stored in the site file to create the ASCII (.txt) file. For this reason, it is essential that the information in the site file is correct.



Creating a Site File Manually

To manually create a site, select **Site>New Site** from the SDR main window**.** This will bring you into the Site Information Editor Window. The site fields will appear empty. At this point, you will be able to populate all the fields and then save the site file. You will want to have the site data sheet when creating the new site. The site data sheet will include the information you need to enter into the site editor if the field personnel did not program the logger completely. Once the site file is saved, any raw data files from the corresponding site that are converted based on this site file will use the settings stored in the site file to create the ASCII (.txt) file.

Note that you cannot return to the SDR main window until you **close** the Site Information Editor window. Subsequent changes to the site can be made by choosing **Edit Site** from the **Site** menu. This will bring you into the Site Information Editor window. You cannot return to SDR's main window until you close the Site Information Editor window.

Site Information Editor - Site Information Parameters

These parameters are found on the left side of the Site Information Editor window.

Site

The site number is reported as a four-digit number.

Site Desc (Site Description)

A site description of up to 80 characters can be entered here.

Project Code

A six-character parameter used to code sites within a project can be entered here.

Project Desc (Project Description)

An 80-character project description can be entered here.

Site Location

An 80-character site location can be entered here.

Site Elevation (Altitude)

A six-character field reporting the Site Elevation as referenced from sea level can be entered here. Units are not stored. For site elevations below sea level, include a "-" sign before the number.

Base Time Zone (the time zone the logger is located in)

A pull down menu that determines how your data's timestamps (in UTC) are adjusted to match the local time. Make sure it is set to the logger local time zone. Time settings should always be in Standard Time (NOT Daylight Savings Time).

Latitude

Enter latitude data in this field. Note that WAsP export only allows the latitude degrees, minutes, and seconds (North or South) or decimal formats to be exported.

Longitude

Enter longitude data in this field. Note that WAsP export only allows the longitude degrees, minutes, and seconds (East or West) or decimal formats to be exported.

Logger Serial Number (5-digit suffix)

The logger serial number appearing in this field should be the last five digits of the logger serial number.

Hardware Rev. (Logger Hardware Revision)

The hardware revision is reported as a masked three number sequence signifying the current revisions of the logger core, logger SD controller, and the iPack firmware revision number.

Site Information Editor - Baseline Sensor Information Parameters

These parameters are found on the right side of the Site Information Editor window.

Channel

Reports the logger channel for which the sensor information is being displayed. Use the up and down arrows to scroll to the desired channel.

Load Defaults

To the right of the Channel # field, the **Load Defaults** button can be used to load a default scale factor and offset for the type of sensor shown in the Sensor Type field (see below). Note that you will see transfer functions (scale factors) in both SI and Imperial units, allowing the user to specify which units are used for individual channels.

Description

Enter up to a 20-character sensor description. For Renewable NRG Systems sensors, this is the same as the sensor model.

Details

Enter up to 80 characters in this field for reporting any sensor details.

Serial Number

A sensor serial number of up to 8 characters can be entered here.

Sensor Type

The sensor type and therefore the logging mode of the logger for this channel can be chosen using a pull-down menu to the right of the Serial Number field. For a counter channel, the sensor type can be either frequency (Speed), totalizer

(Total), or Unknown. For flex channels, the sensor type can be defined as either Unknown, Speed, Total, Vane, or Analog. For analog channels, the sensor type can be defined as either Unknown, Vane, or Analog.

Height

Enter the sensor height in this field.

Scale Factor

A numerical sensor scale factor up to 8 characters is entered here.

Offset

A numerical sensor offset up to 8 characters is entered here.

Print Precision

The Print Precision field has a pull down menu that reports how many decimals and leading zeros the scaled data will have.

Units (Imperial or SI)

This five-character field reports appropriate SI or Imperial units for the sensor selected. Note that you may choose SI units for some sensors and Imperial units for others (wind speeds in m/s but barometric pressure in inches of Hg, for example).

Notes

Clicking the **Notes** button opens a text field in which site notes can be entered. The **Notes** button will be in bold if any notes are contained. The notes are not output in the ASCII (.txt) files.

Saving the Site File

When all the site information is entered and has been confirmed as correct, it is time to save the site file. From the Site Information Editor window, select **File>Save Site.**

Site History Entries

The Site Information Editor contains a powerful site history tool that can be used when a sensor at a particular site is changed. History entries will mark the point in time the change is made and then patch in the new sensor information from that point forward. Since many projects last several years, it is not uncommon to have sensor changes. For example, you may want to replace an unheated anemometer with a heated anemometer and document this change in your database.

Selecting the Site and Sensor

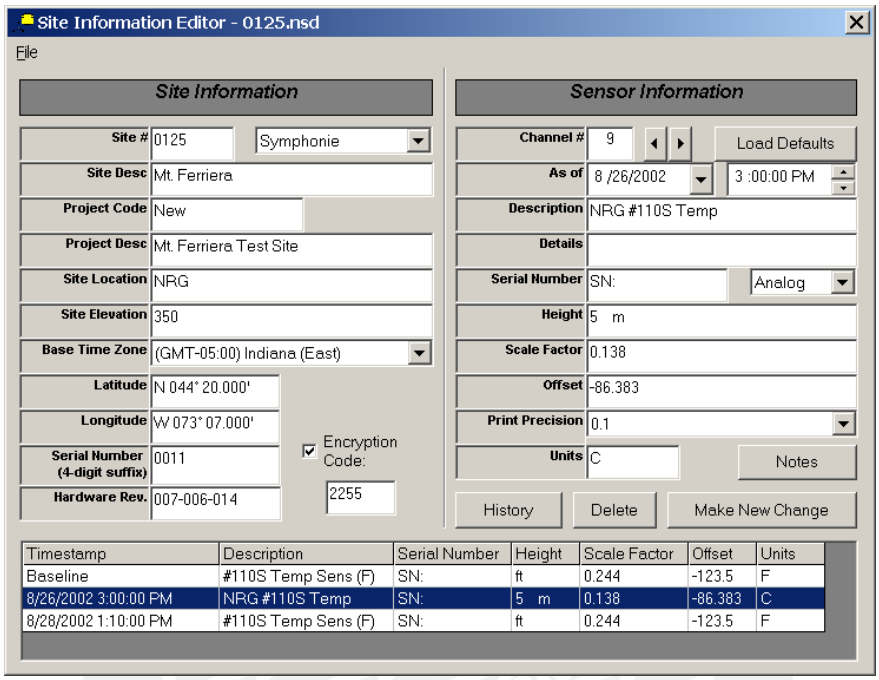
Select **Site>Edit Site** from SDR's main screen. Choose the site from the "Select a Site" screen and click "**OK**."
In the Site Information Editor screen, click the "**History**" button to display the sensor history table. The table displayed will show the history for the sensor channel selected under "Sensor Information." If you scroll through the sensor channels, you will see the history for each channel.

Make New Change

To make a sensor history change, click the "**Make New Change**" button. The sensor information fields are now "live" and will be applied to this entry when the site file is saved.

Site History Concepts

There are several important concepts to understand regarding the history editor. First, whatever row in the history table is selected will be affected by whatever changes are made in the "Sensor Information" fields. For example, in the screen shown below, changing the height from 5 m to 50 m would change the row highlighted in the table. To change the height, put your cursor in the field to the right of "Height," type in the new height, and press Tab. In the table below, you would see the new height displayed in the highlighted row.



The next important concept to understand is that the "Make New Change" button adds a row to the history table. The new row can then be edited by entering new values in the Sensor Information fields above.

Once the entries look good on the screen, the site file must be saved. Don't forget to save your changes! Select **File>Save Site.**

The most important concept is that whatever information appears in each row of the history table is applied until the date of the next entry. For example, if a logger was originally installed with an RNRG Class 1 Anemometer which was replaced 3 months later with an IceFree anemometer, the Baseline entry would show a description and scaling information for the RNRG Class 1 Anemometer for the first 3 months, and then the next history entry would show the time and date the IceFree anemometer was installed and its scaling information.

If you are making a change in your database, you will typically need to re-import any files from the time period after the change occurred. For example, if your field crew installed a new sensor in August, and it's now October, and you have just made a history entry that shows the new sensor, you will need to re-import all raw data from August through October.

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Data Retriever Software: Changing iPack and Sensor Settings from a Remote Location by Creating a Patch File

Cautions

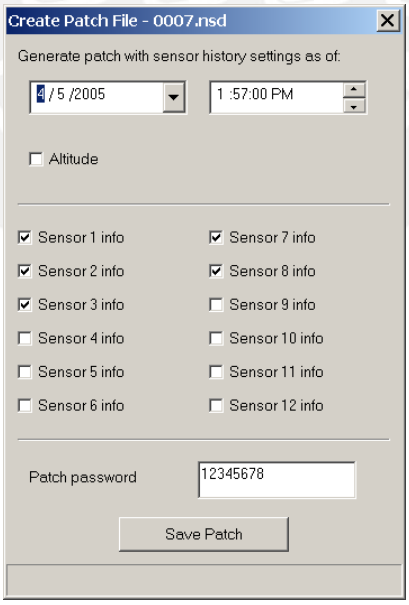
Extreme care must be taken when patching ISP parameters. If you make a mistake (specifying the wrong ISP phone number, for example), you risk cutting communication with the logger, and a site visit will be required.

Creating the Patch File

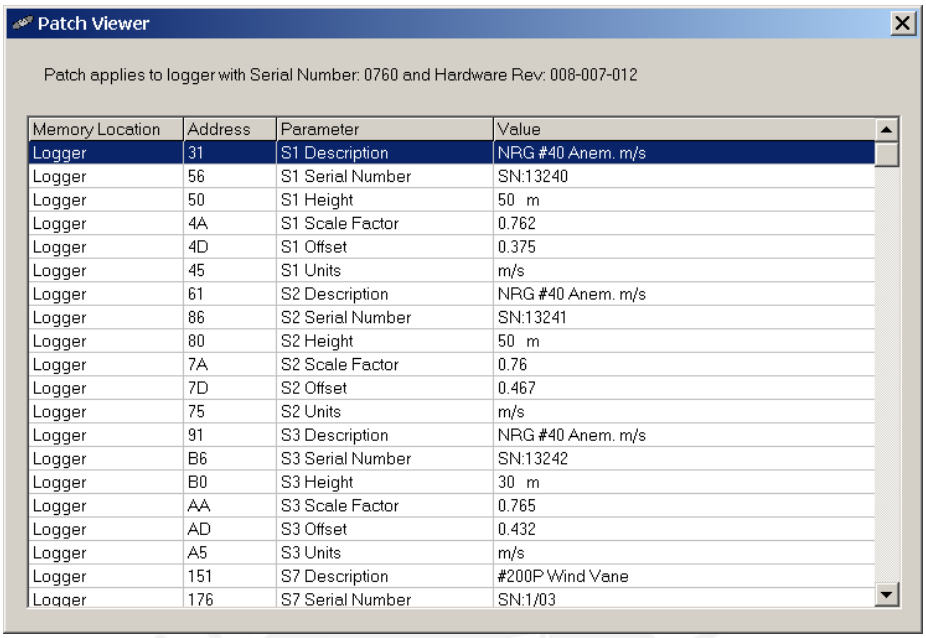
A "patch" is a change to the iPack or logger configuration information. Patch files are generated by SDR and manually sent to the iPack's mailbox by the user. The iPackGPS event log will show "PATCH_DOWNLOAD_EVT" and "PATCH_APPLY_EVT" to help track the installation of the patch.

Sensor Patch

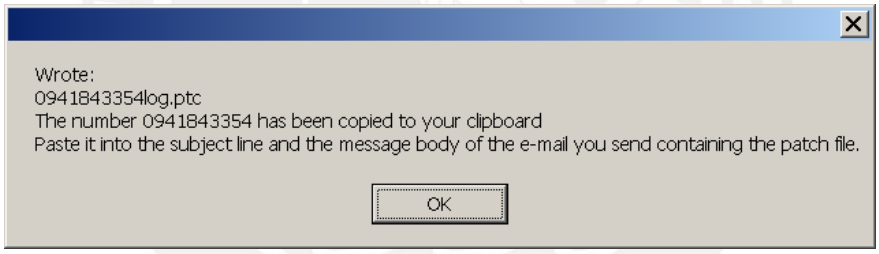
If you need to add or change a sensor, go to the "Site Information Editor" window. Select the sensor entry that you wish to change, make changes, and then select **File>Save Site** to save changes (or create a new entry by following instructions in *"Creating a New Site History Entry"*). Close the Site Editor window and go to **Site>Create Sensor Patch.** Select the site, and click **"OK."** In the "Create Patch File" window, enter the time and date at which the change occurred, and check the boxes corresponding to the sensor channels affected by the change.



Then enter your patch password, click "Save Patch," and then "Save" in the Windows dialog box.
The Patch Viewer will then show the entry for each field as it will be patched to the logger. Check the changes you made to be sure they are correct. Confirm that the logger serial number and logger hardware revision number are correct. These numbers must be correct for the patch to be applied.



When you are satisfied that the patch information is correct, click the **X** in the upper right corner of the window to exit the Patch Viewer window. SDR will now display a message notifying you that the Patch File has been written and the file name has been copied to your Windows clipboard:



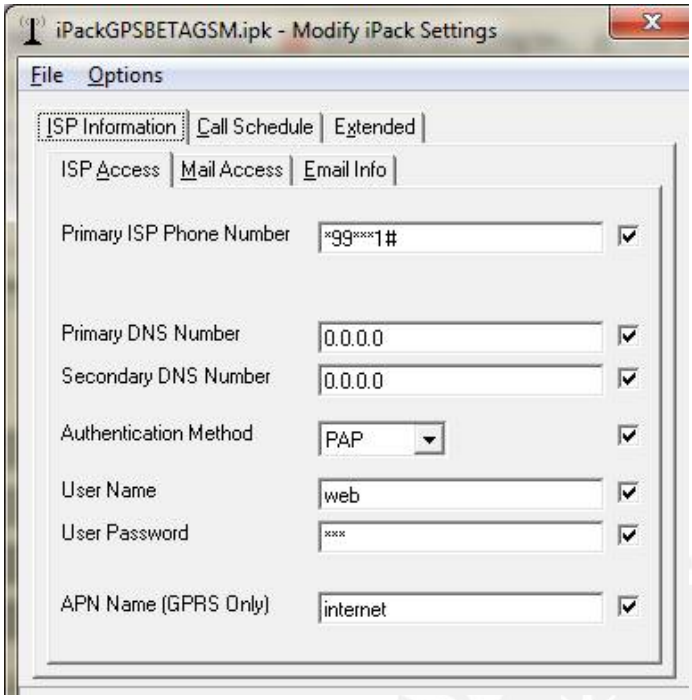
The file name will be used as the subject line of the outgoing email to which the Patch File will be attached.
Open your email program, and address an email message to the iPack (usually addressed to the email address in the Mailbox Name field of the *.ipk file). Paste the Patch File name from your Windows clipboard into the subject field of your email and into the body of the email message.

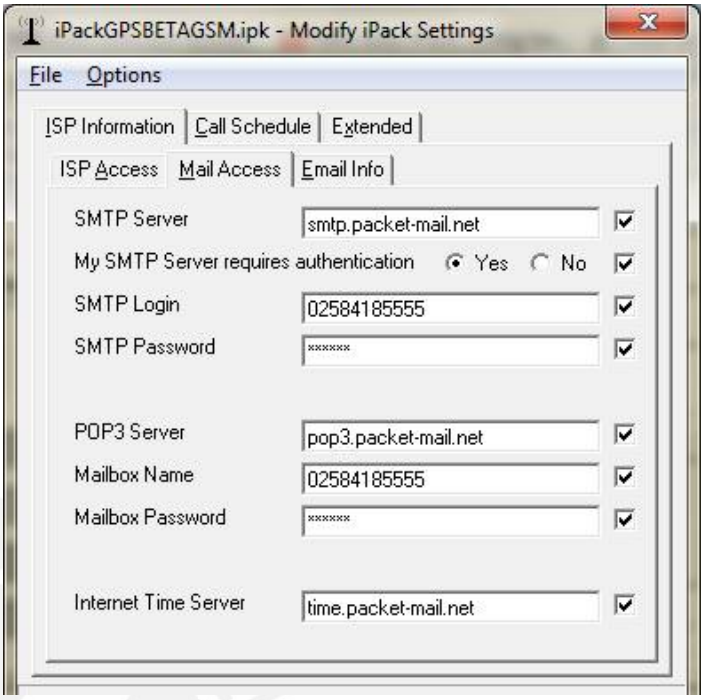
Failure to paste the patch file name into the body of the email message may cause some email clients (such as Outlook, Pegasus, Eudora, etc.) to incorrectly attach the patch file. Also note that patch emails need to be in Plain Text format, not HTML. In Outlook, you can switch your outgoing message to Plain Text format in the Options menu.

Attach the Patch File and send the message.

Configuration Patch

From the SDR Main Window, select **Site>Modify iPack Settings.** This will bring up the Modify iPack Settings window. From here, select **File>Open iPack File**. Browse and select the iPack file you wish to modify. Once you have selected the file, you will notice check boxes on the right side of the window. Be sure to uncheck any parameter that you wish to keep the same. Parameters you wish to edit should remain checked.





Review the *Pre-Installation Set-up: iPack Configuration* section of this manual for an explanation of all parameters. Enter new parameter information in checked boxes. Once you've confirmed the settings are correct, it is time to save the Patch File.

Saving the Patch File

Select **File>Save To Patch File**. This will bring up the Select A Site window. With your mouse, select the site you wish to patch, and then click **OK**.

This will bring up the Save As dialog box. SDR will generate an appropriate file name under which this patch file will be saved. *Do not change it.* Select **Save**.

This will bring up the Patch Viewer window. Confirm that the logger serial number and logger hardware revision number are correct. These numbers must be correct (match the hardware revision number of the equipment in the field) for the patch to be applied. Click the **X** in the upper right corner of the window to exit the Patch Viewer window.

SDR will now display a message notifying you that the Patch File has been written and the file name has been copied to your Windows clipboard. The file name will be used as the subject line of the outgoing email to which the Patch File will be attached.

Sending the Patch File to the iPack via email

Open your email program, and address an email message to the iPack (usually addressed to the email address in the Mailbox Name field of the *.ipk file). The address you choose must be one that will get the mail delivered into the mailbox on the pop3 server that the iPack will check for email.

This is typically of the format: mailboxname@myisp.com.

Do not send the patch email as a response to a logger email! The "from" field from incoming data emails is user configurable; be sure to use the email address assigned to your account by your ISP.

Paste the Patch File name from your Windows clipboard into the subject field of your email and into the body of the email message. Attach the Patch File and send the message.

Failure to paste the patch file name into the body of the email message may cause some email clients (such as Outlook, Pegasus, Eudora, etc.) to incorrectly attach the patch file. Also note that patch emails need to be in Plain Text format, not HTML. In Outlook, you can switch your outgoing message to Plain Text format in the Options menu.

Confirming the change

Depending on when the Patch File is delivered and the iPack's call interval, changes may not be immediately visible in the next received data file. Subsequent files, however, should reflect the changes. The iPackGPS event log will show "PATCH_DOWNLOAD_EVT" and "PATCH_APPLY_EVT" to help track the installation of the patch. If the patch file is successfully retrieved, the email will be deleted from the Internet server by the iPack. If the email is not deleted from the Internet server, the patch was unsuccessful and must be tried again after identifying the problem.

Once the logger has received a new patch, if it is unable to download data or connect with a POP3 server within 12 attempts (within 2 scheduled calls), the iPack will revert to the previous configuration. This ensures that communication can be restored if faulty patch information is uploaded and disrupts the logger's ability to successfully download data (a patch with an incorrect ISP phone number, for example). Communication will eventually resume on the third scheduled call. *An incorrect entry in any parameter field can result in a bad patch*. The only exception to this is the time server field – an incorrect entry in this field alone will not prevent the iPack from calling.

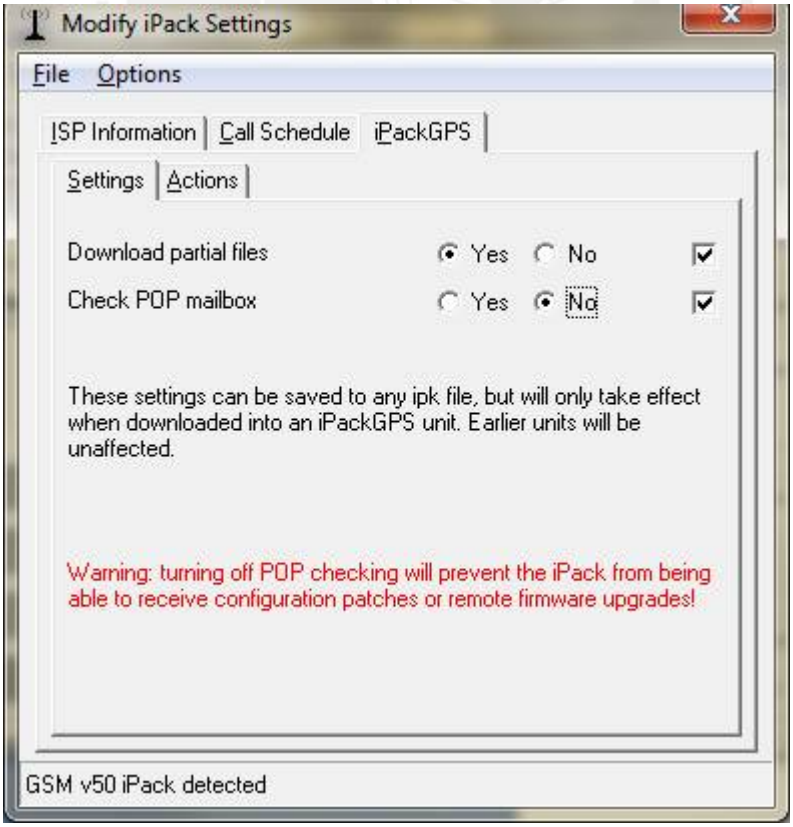
Data Retriever Software: iPackGPS Features

The "iPackGPS" tab's Settings and Actions screens provide access to new features of the iPackGPS unavailable in previous iPack versions.

Settings

In the Settings window, the "Download partial files" and "Check POP mailbox" features can be turned on and off here once the boxes to the right are checked. Like all other screens in the Modify iPack Settings window, once you have made a change, you must go to File and choose Save to iPack.

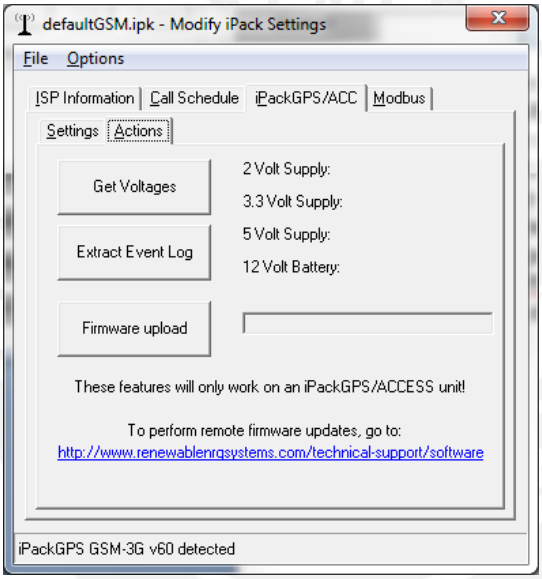
- The "Download partial files" setting allows the user to toggle on and off downloading of partial files.
- Disabling the downloading of partial files and checking of POP3 can reduce air time. However, this is generally not recommended for remote sites.
- If POP3 checking is disabled, the iPack will not be able to receive patches or firmware updates until the setting is changed via a direct connection to SDR.



Actions

The iPackGPS can have its firmware upgraded via email using the link in the Actions window seen below or on site using SDR's Firmware upload button and the iPack programming cable.

- iPack battery voltage and voltages from various locations on the iPack's circuit board are displayed here when the **Get Voltages** button is clicked.
- iPackGPS firmware version can be updated via SDR and the iPack programming cable using the **Firmware upload** button.
- A link to the site used for remote firmware updates is also displayed on this screen.
- Remote firmware updates for some iPackGPS types (satellite) will be completed over the course of several calls.
- Firmware updates via SDR and the iPack programming cable are completed in a few seconds.
- The iPackGPS event log will show "UPDATE_DOWNLOAD_EVT" and "UPDATE_APPLY_EVT" to help track the installation of the new firmware.



Data Retriever Software: Processing Data from 9200-*PLUS*, Wind Explorer and 9300 Loggers

In addition to processing data from Symphonie*PLUS3* loggers, Symphonie Data Retriever can import and process data from Symphonie, 9200-*PLUS*, Wind Explorer, and 9300 loggers. This provides users with older Renewable NRG Systems loggers an upgrade path to Symphonie*PLUS3*. Each Renewable NRG Systems logger had some different features, and to maintain uniformity in the database, there are a few things to pay attention to when using SDR to process data from these loggers.

Leave Time Zone set to 0

The 9200-*PLUS*, Wind Explorer and 9300 logger systems all record data in "logger local time." This is different from the Symphonie, SymphoniePLUS, and Symphonie*PLUS3* loggers, which record data with time and date stamps relative to UTC. Because of this difference in time zone configuration, leave the time zone setting at "0 UTC" for all loggers except Symphonie*PLUS3*, SymphoniePLUS, or Symphonie Renewable NRG Systems loggers.

Importing and Processing Data

Importing and processing data should otherwise be the same for these loggers as for Symphonie*PLUS3*; please refer to the sections on processing Symphonie*PLUS3* raw data files in this manual.

Introduction to SDR ChipReader

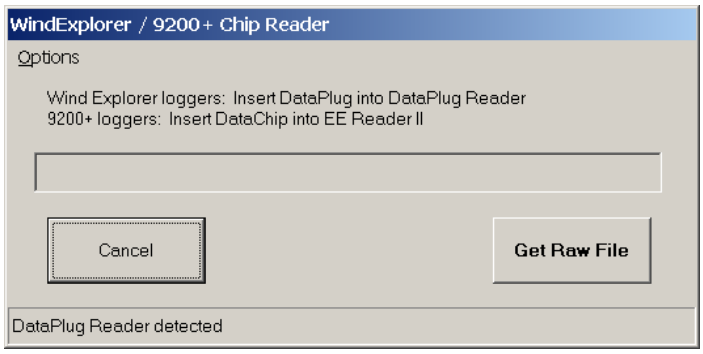
Versions 5 and higher of the SDR software includes a built in "Chip Reader" utility that is capable of reading 9200-*PLUS* DataChips and WindExplorer DataPlugs. SDR is not compatible with the TermReader and will not read 9300 DataCards.

In order to read a DataPlug you will need a DataPlug Reader complete with the supplied null modem cable. To read a DataChip, you will need an EEReader complete with the phone cable and its RS-232 connector. Your computer will need a serial COM port or a USB port with a reliable USB to serial converter. The EEReader should be installed on COM 1 or COM 2.

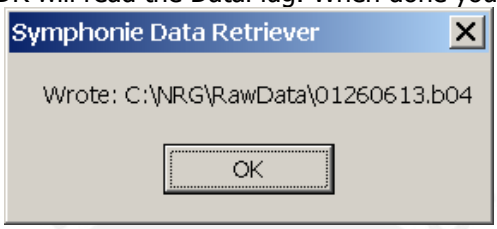
Reading a DataPlug from a WindExplorer

Connect the DataPlug Reader to your computer with the null-modem cable and place the DataPlug into the Reader.

Go to File>Chip Reader (WE/9200+). You should see the following screen:



Press the "**Get Raw File**" button and SDR will read the DataPlug. When done you will see the following message:

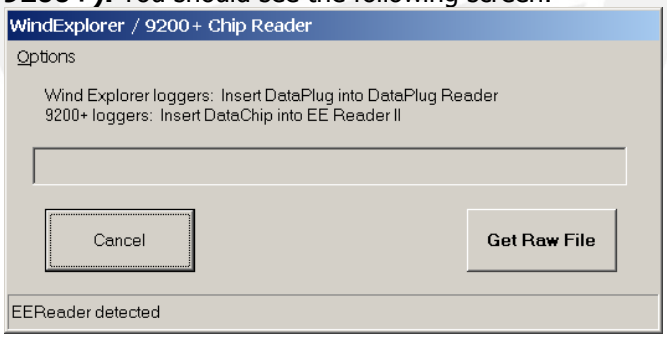


You may press **OK**. The reading process is done; a raw file now exists in the specified directory and this data can be imported and processed with SDR.

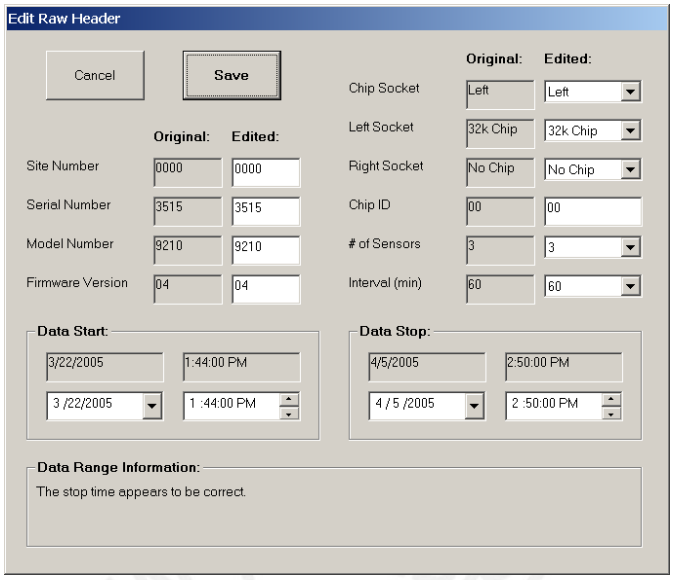
Reading a DataChip from a 9200-Plus

Connect the EE Reader to your computer with the phone cable and RS232 connector and place a DataChip into the EE Reader. Please remember that the EE Reader can only read one DataChip at a time.

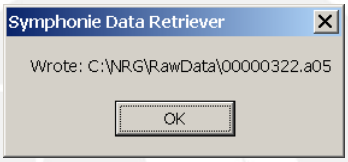
Go to File>Chip Reader (WE/9200+). You should see the following screen:



Press the "**Get Raw File**" button, and SDR will read the DataChip and display the following:



Confirm everything looks Ok and press the "**Save**" button. You will see the following:



You may press **OK**. The reading process is done; a raw file now exists in the specified directory and this data can be imported and processed with SDR.

*If you receive an error message that the EEReader is not found, click the right mouse button, choose "**Options**" and then set the COM port to 1 or 2.*

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Troubleshooting Guide

Be sure to visit the support section of the Renewable NRG Systems website at: http://www.renewablenrgsystems.com/TechSupport.aspx for the most up to date troubleshooting information.

Communication Problems

Although the Symphonie*PLUS3* system was designed to be as robust and simple as possible, it relies on phone service and the Internet to perform its functions. From time to time, things do not go as smoothly as anticipated. If you have stopped receiving or have never received emails from your Symphonie*PLUS3* logger and iPack, check the following before visiting the site:

GSM iPacks

Phone Service

- Request a copy of the installation crew field notes.
- What did the antenna test results show?
- What error message appeared when a "Call Now" was attempted? iPackGPS users can use the Event Log Viewer **[Home][3][4][4]** to see all errors that occurred during the call.
- Did you remember to send an APN to the phone modem?
- Obtain a copy of the .ipk file that was programmed into the iPack.
- Call your GSM cell provider and make sure that the account is active. Is the SIM active? Have you tried the SIM in another phone or in another iPack?
- Has the SIM been properly activated for data transfer, and has the SIM been installed into the iPack?
- Get the cell account records and check the duration and frequency of the activity. Do you see cellular activity around the time a scheduled call is supposed to occur? Do you see re-tries every 10 minutes (up to six total)?
- Give the cell provider the exact coordinates of where the logger is installed AND the ISP phone number it is dialing.
- Ask them if the number is being dialed correctly. Most GSM iPacks should dial *99***1#.
- To check signal and connection status, press **[Home][3][4].** Wait for the menu to change while the iPack powers up. Then press **[2].** A message will tell you if service is available and will display the strength of the signal as a percentage. In this screen, additional detail such as cellular band and carrier are also available.

To view:

IP address, press **[1]**
DNS1, press **[2]**
DNS2, press **[3]**
Cellular Band, press **[7]**
Cellular Carrier, press **[8]**

ISP Service

- Get the ISP account records and check the duration and frequency of the activity. Do you see activity around the time

a scheduled call is supposed to occur? Do you see re-tries every 10 minutes (up to six total)?
- Use www.mail2web.com or a similar website used to check email remotely, and try to log in to the account using ISP settings that are in the .ipk file. If you are unable to login to the ISP from a computer, you will need to review all the ISP settings with your provider. Renewable NRG Systems has seen ISPs that have unexpectedly changed the user name on an account. If you are having a particularly difficult time, you may send the .ipk file to Renewable NRG Systems as an email attachment. We may be able to check (but not necessarily test) the settings for you.

At the site

- Perform an antenna test and record the result.
- Try dialing the ISP phone number from a personal handheld cell phone at the site. You should hear modem tones on the other end. If you hear a "fast busy," there may be compatibility issues between the cell system and the ISP modem bank it is dialing into. Contact your ISP provider and ask if there are any restrictions or problems associated with cellular phones calling into the modem bank.
- Perform the "Call Now" function on the logger and note the resulting message. If the message "Internet error" appears, record the error number (and text decription if using iPackGPS). iPackGPS users can use the Event Log Viewer **[Home][3][4][4]** to see all errors that occurred during the call.
- Is the SIM active? Have you tried the SIM in another phone?
- Has the SIM been properly activated for data transfer, and has the SIM been installed into the iPack? Be sure that the SIM card is activated for transparent data mode.

General GSM System Information

When a GSM phone is powered, it registers with the cellular system, and when it powers down, it de-registers with the system. The GSM iPack follows this protocol closely.

Using GSM in marginal signal areas can cause registration problems. The iPack de-registers when powering down. However, if signal is lost, the de-registration is never seen by the cell. The next time the GSM phone in the iPack is powered up, it will try to register with the system and will be blocked out because the system thinks it is already registered.

The only solution is to have the central GSM office perform a de-registration and then bring the account back up. We learned this information by talking with Vodafone and a customer in Europe who encountered this issue.

CDMA iPacks

Phone Service

- Request a copy of the installation crew field notes.
- What did the antenna test results show?
- What error message appeared when a "Call Now" was attempted? iPackGPS users can use the Event Log Viewer to see all errors that occurred during the call.
- What were the results of the phone initialization process?
- Verizon users only: Are you certain that you were in a home area during the phone initialization process?
- Obtain a copy of the .ipk file that was programmed into the iPack.
- Call your CDMA service provider and make sure that the MIN and ESN pair are active on your account.
- Get the cell account records and check the duration and frequency of the activity. Do you see activity around the time a scheduled call is supposed to occur? Do you see re-tries every 10 minutes (up to six total)?
- Give the CDMA provider the exact coordinates of where the logger is installed AND the ISP phone number it is dialing. Most CDMA users will use #777 as the Primary ISP Phone Number. Renewable NRG Systems has already seen situations where the provider unexpectedly changed the dialing requirements for a given area as well as a provider accidentally shutting off a customer's account ESN.

ISP Service

- Get the ISP account records and check the duration and frequency of the activity. Do you see activity around the time a scheduled call is supposed to occur? Do you see re-tries every 10 minutes (up to six total)?
- Use www.mail2web.com or a similar website used to check email remotely, and try to log in to the account using ISP settings that are in the .ipk file. If you are unable to login to the ISP from a computer, you will need to review all the ISP settings with your provider. Renewable NRG Systems has seen ISPs that have unexpectedly changed the user name on an account. If you are having a particularly difficult time, you may send the .ipk file to Renewable NRG Systems as an email attachment. We may be able to check (but not necessarily test) the settings for you.

At the site

- Perform an antenna test and record the result.
- Verizon users only: Try dialing *228 from a handheld CDMA cell phone at the site. Do you receive a "welcome to Verizon" message or a message from another carrier?
- Try dialing the ISP phone number (usually #777) from a personal handheld CDMA cell phone at the site. You should hear modem tones on the other end. If you hear a "fast busy," there may be compatibility issues between the cell system and the ISP modem bank it is dialing into. Contact your ISP and ask if there are any restrictions or problems associated with cellular phones calling into the modem bank.
- Perform the "Call Now" function on the logger and note the resulting message. If the message "Internet error" appears, record the error number. iPackGPS users can use the Event Log Viewer **[Home][3][4][4]** to see all errors that occurred during the call.
- Re-register the phone in home area.

Satellite iPacks

Phone Service

Instructions are included with each Satellite iPack to turn on the phone service. This includes a registration form that needs to be filled out and faxed to the provider.

Satellite System

The Satellite iPacks use Wireless Innovation as the satellite service provider. The Iridium satellites circle the earth once every100 minutes traveling in a roughly South to North direction and depend on "line of sight" signals from the iPack transceiver. Every region on the globe is covered by at least one satellite at all times.

Each (daily) call should take around 3 minutes per day and probably not more than 4 minutes. This may be slightly longer than other iPacks. The variables in the call length are login, UTC timeserver check, and POP mail check. These events happen each call regardless of the number of files sent and can be considered "overhead." Using Wireless Innovation's email service (which is included with air time minutes) can reduce connection times.

Installation

Obstructions such as a tower or trees can cause an interruption between the communications of the modem to the Iridium satellite and therefore can cause untimely termination of the data call.

Installations must therefore take into account the following:

- The antenna must be upright/facing the sky to ensure maximum exposure for the satellite.
- The antenna must be located so that it has a good view of the sky, ideally horizon to horizon coverage.
- The antenna should be mounted offset from the mast by a distance of at least 0.5 meters, with no other obstructions in the line of sight view.

- The satellites fly in a South-North orbit so the antenna must be mounted such that no obstructions will occur in this plane. In the northern hemisphere, the antenna mast should point south, and in the southern hemisphere, the antenna should point north.

At the site

- Perform an antenna test and record the result.
- Perform the "Call Now" function on the logger and note the resulting message. If the message "Internet error" appears, record the error number. iPackGPS users can use the Event Log Viewer **[Home][3][4][4]** to see all errors that occurred during the call.

Internet Error Codes as Displayed by SymphoniePLUS3 Logger

Rev 009 iPacks and higher are capable of reporting numeric Internet error codes on the logger display. The iPackGPS offers enhanced descriptive text error codes as shown in the table below.

The error code is the last message displayed if data transmission is unsuccessful. The user can also review the iPack status screen to see the error code. The error codes are useful tools in determining the source of a transmission problem. These error codes are trapped by the Internet processor inside the iPack. The error codes do not necessarily give a specific resolution to a particular issue. However, they will point you to the set of settings most likely causing the problem and give you an indication of the phase of the calling process in which the problem was encountered. If you receive an error code not listed below, please contact Renewable NRG Systems for assistance.

iPackGPS Event Codes

DISPLAYED MESSAGE	DISPLAYED NUMBER	RECOMMENDED ACTION/EVENT DETAILS
CONTACT_NRG_ERR		Contact Renewable NRG Systems for assistance.
DNS_ERR	2102	DNS server not responding.
INVALID_IPSTRING_ERR	2103	Incorrect format of server name.
SNTP_ERR	2104	Incorrect Time Server Name or Time Server not responding.
PPP_ERR	2105	Incorrect User Name or User Password.
MODEM_ACTIVE_ERR	2106	Internet service is active and modem already in use.
PPP_OPEN_ERR	2108	Unable to open PPP session; bad or missing APN, User Name, or User Password.
PPP_CONNECT_ERR	2112	PPP connection lost, inadequate antenna signal strength or antenna unplugged.
PPP_AUTHFAIL_ERR	2113	Incorrect User Name and/or User Password.
PPP_PROTOCOL_ERR	2114	Bad or missing APN, User Name, or User Password.
PPP_CLOSED_ERR	2115	PPP session closed.
NOT_SUPPORTED_ERR	2116	No Ethernet connection available.
MAIL_IN_PROGRESS_ERR	2121	Email transmission already in progress.
KEY_MATCH_ERR	2122	Patch password email subject field incorrect.
SMTP_CONNECT_ERR	2123	iPack unable to establish connection with SMTP server.
SMTP_SERVER_ERR	2124	Mailbox Name or Mailbox Password incorrect; authentication setting is incorrect.
SMTP_TIMEOUT_ERR	2125	SMTP server not responding.
SMTP_CLOSED_ERR	2126	SMTP server shuts down prematurely. Try again.
SMTP_NO_NAME_ERR	2132	SMTP server name left blank.
SMTP_NO_CTX_ERR	2133	Inadequate memory to send email.

SMTP_TCPCONN_ERR	2134	iPack is unable to connect to the SMTP server. Could be invalid SMTP name or mail server is down.
POP3_CONNECT_ERR	2138	iPack unable to establish connection with POP3 server. Server could be down.
POP3_SERVER_ERR	2139	Mailbox Name or Mailbox Password incorrect.
POP3_TIMEOUT_ERR	2140	POP3 server not responding.
POP3_CLOSED_ERR	2141	POP3 server shuts down prematurely. Try again.
IPACK_ERR	2142	POP3 header bigger than 2 KB; send patch file or firmware patch in plain text format instead of HTML.
POP3_NO_USER_ERR	2147	Mailbox name is missing.
POP3_NO_PASS_ERR	2148	Mailbox password is missing.
POP3_NO_NAME_ERR	2150	POP3 server name left blank.
POP3_TCTCONN_ERR	2151	iPack is unable to connect to the POP3 server. Could be invalid POP3 name or mail server is down.
SYNC_FAILED_ERR	10047	Modem failure. Contact Renewable NRG Systems for assistance.
UNKNOWN_MODEM_ERR	10048	Modem failure. Contact Renewable NRG Systems for assistance.
UNKNOWN_RSSI_ERR	10049	No antenna connected or damaged antenna or antenna cable.
NOT_DIRECT_ERR	10051	Modem not found by iPack.
IPACK_ERR	10052	Suspension not removed upon account activation by service provider and data function blocked.
INVALID_APN_ERR	10055	Missing or invalid Access Point Name.
INVALID_PIN_ERR	10056	Assigned PIN is incorrect.
NO_SIM_ERR	10057	No SIM card installed in GSM modem.
NOT_REGISTERED_ERR	10059	Phone account not set up; CDMA phone not properly provisioned.
LOCKED_SIM_ERR	10060	Need to enter SIM PIN in SDR's GSM Set Up Phone screen.
NO_SIGNAL_ERR	10061	No antenna signal strength. GSM phone configured on wrong band; damaged antenna cable.
CONNECT_TIMEOUT_ERR	10063	Communication network (satellite, GSM, CDMA) connection failure.
REGISTRATION_RST_EVT	10069	Indicates a retry after failure of G2 modem registration.
NO_CARRIER_ERR	10112	When iPack modem can't detect modem on the other end.
SOCKET_ERR	2401	MODBUS initialization failure.
INVALID_REG_ERR	2402	MODBUS register is invalid.
INVALID_FUNC_ERR	2403	Requested MODBUS function is not supported.
INVALID_BANK_ERR	2404	Indicates an attempt to access a register group that is out of range.
ACCEPT_SOCKET_ERR	2405	MODBUS socket connection error.
INDEX_RANGE_ERR	2406	Contact Renewable NRG Systems for assistance.
CLIENT_LIST_FULL_ERR	2407	Client list already has 4 (maximum) active MODBUS connections.
INVALID_CLIENT_ERR	2408	Client attempting to connect is not in secure IP list.
INVALID_NUM_REG_ERR	2409	More than the available registers has been requested.
SOCKET_CLOSE_ERR	2410	MODBUS disconnection error.
LOGR_IPACK_COMM_FAIL	25026	Logger is no longer communicating with the iPack.
LOGR_IPACK_CONN_FAIL	25028	Unable to establish communication with the logger due to bent pin or corrosion on connector.
NO_RAWDATA_ERR	25030	Contact Renewable NRG Systems for assistance.
INVALID_STRING_ERR	25041	Invalid field in *.IPK file.

PRIMARY_ISP_ERR	25042	Primary ISP phone number missing or incorrect.
TIME_SERVER_ERR	25043	Internet Time Server name is missing or incorrect.
SMTP_SERVER_NAME_ERR	25044	SMTP Server name is missing or incorrect.
SENDER_EMAIL_ADD_ERR	24045	Sender's Email Address is missing or incorrect.
RECIP_EMAIL_ADD_ERR	25046	Recipient Email address is missing or incorrect.
POP3_SERV_NAME_ERR	25047	POP3 Server name is missing or incorrect.
MAILBOX_NAME_ERR	25048	Mailbox Name is missing or incorrect.
MAILBOX_PASS_ERR	25049	Mailbox Password is missing or incorrect.
PATCH_DOWNLOAD_EVT	25051	iPack has initiated patch file download from the POP3 server.
UPDATE_DOWNLOAD_EVT	25052	iPack has initiated firmware download from the POP3 server.
CALL_ACTIVE_ERR	25101	Call in progress while "Call Now" is requested.
DIAL_FAILED_ERR	25102	Modem can't connect to network. Satellite down and therefore unavailable; incorrect ISP phone number programmed into iPack; inadequate antenna signal strength.
PATCH_NOT_APPL_ERR	25103	Data in patch file could not be validated and therefore patch was not applied.
IPACK_LOW_BAT_ERR	25104	iPack 12V batteries below 10.5 volts; iPack will not attempt call under this condition.
PATCH_APPLY_EVT	25105	iPack has successfully applied a sensor patch or iPack configuration patch at indicated date and time.
UPDATE_APPLY_EVT	25106	iPack has successfully applied a firmware update at indicated date and time.
START_CALL_EVT	25107	iPack has initiated a call.
CALL_SUCCESS_EVT	25108	Normal successful call (you will see one of these events per day on daily call schedule).
CALL_FAILED_EVT	25109	Call failed due to lack of antenna signal strength, proper phone account setup, modem registration problem, etc. Other event(s) in Event Log just prior to this message will indicate failure source.
GPS_SET_EVT	25110	Adequate satellites acquired to update GPS coordinates in the logger (you will see one of these events per day on daily call schedule).
IPACK_DEAD_BAT_ERR	25111	iPack 12V batteries below 9.6 volts; iPack will not power up modem or attempt call under this condition. "IPack busy or not present" message will be displayed soon after this event is logged.
CALL_NOW_EVT	25112	Operator initiated a "Call Now" from the logger's keypad.
CALL_SCHED_EVT	25113	Normal scheduled call (you will see one of these events per day on daily call schedule).
CALL_BOOT_EVT	25114	Call was initiated following a complete power loss by the logger.
PATCH_NOT_APPL_ERR	25115	Patch file contents (attachment) do not appear to be a patch file.
BOOT_EVT	25117	iPackACCESS rebooted.
NO_LINK_ERR	25118	iPackACCESS Ethernet cable unplugged.

Other iPack Error Codes

Problem: Internet error 001: iPack timeout error

This message is received when the iPack processor sends a command to the iPack's Internet processor to initiate data transfer and does not receive any message from the iPack's Internet processor for three minutes.

Possible cause(s): No cellular service; interference, or poor signal strength.

Possible solution: Perform antenna test to confirm signal strength and check for service. Contact your service provider and make sure the account is active.

Problem: at + ixfh error:

The "at+ixfh error" comes up when the Internet processor is busy trying to talk to the cellular modem and cannot process commands from the iPack's main microprocessor.

Possible cause(s): Bad iPack phone; cellular account is improperly configured and confusing the modem.

Possible solution: Disassemble the iPack and remove the iPack battery for several minutes to re-boot; contact Renewable NRG Systems for return authorization number and return iPack for repair.

Problem: Internet errors 41 – 52:

Error messages 41 through 52 indicate an incorrect format was entered in an iPack programming field in SDR.

Possible cause(s): Typographical error; incorrect format (for example, the DNS field must contain only numbers).

Possible solution: Check the format of each entry; consult ISP for assistance.

Problem: Internet error 57: Error when trying to establish PPP

This error indicates a problem with an ISP setting.

Possible cause(s): Incorrect DNS, username, password, or authentication method.

Possible solution: Check all ISP settings; consult ISP for assistance.

Problem: Internet error 58: Error when trying to establish SMTP

This error is received when SMTP authorization (authentication) is required by the ISP but the iPack's SMTP authentication setting is "No."

Possible cause(s): SMTP authentication setting is incorrect; SMTP authorization username (SMPT login) or password (SMTP password) is incorrect.

Possible solution: Change iPack's SMTP authentication setting to "Yes" and enter the correct username and password (usually the same as the Mailbox Name and Mailbox Password); consult ISP for assistance.

Problem: Internet error 59: Error when trying to establish POP3

This error indicates a problem with the POP3 setting.

Possible cause(s): Incorrect POP3 server name.

Possible solution: Check POP3 setting; consult ISP for assistance.

Problem: Internet error 60: Single session body for MIME exceeds the maximum allowed

This error indicates that the file size exceeds that allowed by the ISP.

Possible cause(s): The ISP has limited the size of email messages to less than 20 KB.

Possible solution: Contact ISP for assistance.

Problem: Internet error 61: Internal memory failure

Contact Renewable NRG Systems for assistance.

Problem: Internet error 69: Timeout on host communication

iPack timeout error similar to Internet error 001. This message is received when the iPack processor sends a command to the ISP to initiate data transfer and does not receive any message from the ISP for three minutes.

Possible cause(s): Lost Internet connection due to lack of cellular service, interference, or poor signal strength.

Possible solution: Perform antenna test to confirm signal strength and check for service.

Problem: Internet error 70: Modem failed to respond

The iPack's Internet processor sent ATDT (dial) command to cellular modem and did not receive a response before timeout (about 2 minutes).

Possible cause(s): Bad iPack phone; inactive account (wrong ESN or ESN not active) in an area where service is available. The phone dials but at that point, an operator voice message or special series of tones comes on the line from the service provider with instructions.

Possible solution: Confirm that ESN is active; contact Renewable NRG Systems for assistance.

Problem: Internet error 71: No dial tone response.

This error message indicates a problem with the cellular service.

Possible cause(s): No cellular service; incorrect system setting; interference or poor signal strength.

Possible solution: Perform antenna test to confirm signal strength and check for service; change system setting and try again; contact cellular service provider for assistance.

Problem: Internet error 72: No carrier modem response

This error message is received when the phone dials a phone number that does not have a modem answer (may not be an ISP phone number).

Possible cause(s): Incorrect ISP phone number; ISP has changed their phone number or the area code has changed. For satellite iPacks, a missing or incorrect Sender's Email Address. For CDMA iPacks, a wrong ESN or incorrect MIN configuration by Verizon can also produce this error message; CDMA network incompatible with CDMA iPack.

Possible solution: Correct ISP phone number, enter correct Sender's Email Address (satellite iPacks); initialize CDMA iPack in Verizon Home area, see information below.

The cellular provider that Verizon is partnering with in the "extended coverage area" must support the CDMA IS95 call protocol and also provide a "modem pool" for the CDMA iPack. To insure a successful installation, we recommend that you determine who the Verizon partner is in the extended coverage area and contact them to see if they support IS95 and have a modem pool available. As a result, placing a call from a Verizon handheld phone is not a complete test of a site's compatibility with a CDMA iPack.

Note that you ALWAYS need to activate the CDMA iPack in a Verizon "home" area network and then bring the unit to the site. When setting up service with Verizon, find out which system (A or B) the phone will register on for your intended installation site. When performing an antenna test, if your iPack accesses the other system, your site is likely in an "extended coverage area." A manual initialization process may sometimes resolve the issue (contact Renewable NRG Systems for assistance).

Problem: Internet error 73: Dial failed

Similar to Internet error 71; indicates a problem with the cellular service.

Possible cause(s): No cellular service; incorrect system setting; interference or poor signal strength

Possible solution: Perform antenna test to confirm signal strength and check for service; change system setting and try again; contact cellular service provider for assistance.

Problem: Internet error 74: Connection with ISP lost

Possible cause(s): Poor audio quality on phone line / weak cell signal.

Possible solution: Perform antenna test to confirm signal strength and check for service.

Problem: Internet error 75: Access denied to ISP server

Possible cause(s): Wrong ISP phone number; incorrect authentication method, incorrect username and/or user password; missing APN (GSM iPacks); Modem is locked to incorrect frequency band (GSM iPacks).

Possible solution: Confirm that entries for ISP phone number, authentication method, username, and password are correct. Confirm that APN was sent to GSM iPack's modem (Set Up Phone screen in SDR).

Problem: Internet error 76: Unable to locate POP3 server

Possible cause(s): Wrong POP3 server name.

Possible solution: Confirm that POP3 server name is correct.

Problem: Internet error 77: POP3 server timed out.

Possible cause: POP3 server is down.

Possible solution: Try again later; contact your ISP.

Problem: Internet error 78: Access denied to POP3 server.

Possible cause(s): Password is wrong; mailbox name is wrong or needs to be changed to include ISP name.

Possible solution: Correct password; try changing mailbox name to mailboxname@myisp.com

Problem: Internet error 79: POP3 failed

Possible cause(s): Wrong POP3 server name.

Possible solution: Confirm that POP3 server name is correct; confirm that the POP3 server is your ISP's POP3 server (i.e. don't try to use another ISP's POP3 server).

Problem: Internet error 81: Unable to locate SMTP Server

Possible cause(s): Wrong SMTP server name, SMTP server temporarily down.

Possible solution: Confirm SMTP server name is correct (not entered as "STMP", for example), contact ISP and check that SMTP server is up and running.

Problem: Internet error 82: SMTP server timed out

This message is received when the iPack sends a command to the SMTP server to initiate mail transfer and does not receive any message from the SMTP server for three minutes.

Possible cause(s): Unavailable for overloaded SMTP server; cellular signal drop; SMTP server name programmed into

iPack does not connect over the defined port (for example 25, 587, 465).

Possible solution: Perform antenna test to confirm signal strength and check for service; try different SMTP server; contact ISP for assistance.

Problem: Internet error 83: SMTP failed

Possible cause(s): SMTP server is down or overloaded; GSM units need to have "data mode" enabled on SIM; no cellular service; interference or poor signal strength.

Possible solution: Try again later; confirm that GSM iPack SIM has "data mode" enabled; perform antenna test to confirm signal strength and check for service.

Problem: Internet errors 101 through 109: Parameter not defined

Possible cause: An iPack setting has been left blank.

Possible solution: Enter all required iPack settings in SDR.

Problem: Internet error 110: No SMTP defined.

Possible cause: SMTP server field left empty.
Possible solution: Add SMTP server name to field.

SymphoniePLUS3 Data Retriever and iPack Programming

Problem: "iPack communication failed"

When opening the "Modify iPack Settings" window, the message: "Verifying iPack connection" appears in the lower status bar, but then the message "iPack communication failed" appears.

Possible causes(s): The iPack utilizes a sense line on the COM port in order to initiate communications and expects standardized states for the COM port on and off conditions. On certain models of computer and operating system combinations, the COM port default off state does not return to the expected off state, and the iPack gets "hung" in a state where handshaking cannot take place.

Solution:
- unplug the DB25 cable from the iPack.
- close the "Modify iPack" window.
- reconnect the DB25 cable to the iPack.
- reopen the "Modify iPack" window.

You should now be connected to the iPack and be able to load a file from the iPack.

Note: When the "Modify iPack Settings" window is opened, a request is made by SDR to open the configured COM port. Conversely, when the "Modify iPack Settings" window is closed, a request to close the COM port is made.

A dead iPack battery can also produce this error message, so if the above solution doesn't resolve the problem, try replacing the iPack's battery.

SDR installation

Problem: SDR software can't find serial port.

Possible cause(s): Computer hardware compatibility problem.

Solution: Use USB to serial converter, install manually to COM2.

SymphoniePLUS3 Logger Problems

Problem: SD is blank but should contain data.

Possible cause: SD was never formatted (can't save data); while attempting to read the SD, data files were cut and pasted instead of copied and pasted. SD was formatted after it was read, and files are present but hidden.

Solution: Format SD. Contact Renewable NRG Systems.

Problem: Received error message "One or more CRCs do not match: possible bad data" when trying to read data file in SDR software

Possible cause(s): Data encryption PIN number in Symphonie*PLUS3* logger settings doesn't match PIN number enabled in Symphonie Data Retriever Software's Site Information Editor window.

Solution: Change data encryption PIN number in Symphonie Data Retriever Software's Site Information Editor window to match PIN number in Symphonie*PLUS3* logger settings.

Problem: Receiving message "iPack Not Present."

Possible cause(s): iPack battery is dead; iPack is plugged into SDR; iPack is busy trying to make a call.

Solution: Recharge iPack battery; wait for iPack to stop its communication with SDR software; wait for iPack to complete call. As a failsafe, the logger will check at noon every day to see if an iPack has been connected. To force detection of the iPack, remove the logger's D-cell batteries and then connect the iPack.

Data / SD

Problem: SD Card does not format correctly first time.

Possible cause(s): SD card has damaged memory locations.

Solution: Identify SD markings and notify Renewable NRG Systems with all details. Renewable NRG Systems runs qualification tests on SD Cards we ship. Obtain SD Card from Renewable NRG Systems.

Logger Error Log / SDR Event Log

The Symphonie*PLUS3* logger stores internal events into a log viewable from the logger display. The event log is transferred into the Data File header whenever a new file is created for any reason. The SDR software imports these events into the SDR "Event Log" which is viewable from SDR (from SDR's main menu, choose **Site>View Event Log**, choose the site number from the list, and click OK). iPackGPS users will also be able to view events generated by the iPackGPS.

Event/Error	Meaning
0	Internet Time Adjust. Time of event is the new time after adjustment has been applied. Clock was adjusted by less than 2 minutes by an Internet time update from the iPack. Note: a < 2 minute time correction will not cause a new file. The clock correction will be applied in the middle of the first interval after the call completes. Loggers with firmware version 10 or lower will automatically begin a new file if a correction of more than 2 minutes is required, but nothing will be noted in the Event Log.
1	EEPROM initialized. This event is recorded when the logger is restarted and the internal non-volatile memory was reset.

2	Reboot. This event is recorded when the logger is restarted following a power loss or electrostatic event.
3	Reserved for future use
4	Clock set. This event is recorded when the keys of the logger's keypad are pressed (for updating the logger clock, for example). Note: In loggers with firmware rev 10 and older, event 4 is logged for any completed request from the user. These include manual clock set, a manual call ("call now"), or entering the Utilities, iPack menu **[Home][3][4]**.
5	Reserved for future use
6	I2C error. This event is recorded if the logger encounters an internal data transfer error.
7	SD Failure. This event is recorded if the logger could not write to SD card due to a damaged SD microprocessor, damaged SD, or bad sector on the SD. Try a different SD card.
8	Reserved for future use
9	Reserved for future use
10	Reserved for future use
11	Bad Command. Invalid command request to logger from user or iPack.
12	Internet clock set. For loggers with firmware revision 11 and higher, this event is recorded each time the iPack successfully accesses an Internet time server and adjusts the time by more than two minutes. Time of event is the new time after adjustment has been applied. This time change will cause a new file, with this event, right after call ends. Since there was more than 2 minutes time discrepancy, this event usually implies that there was a real time clock problem, or it has been a long time since the last successful Internet time update. Internet Clock Set in the event log for loggers with firmware revision 10 or lower indicates that the iPack successfully accessed the Internet time server and adjusted the logger's clock by less than 2 minutes.
13	User Activated iPack. Logged whenever a manual call ("Call Now") is requested, or when entering the Utilities, iPack menu **[Home][3][4].**

Battery messages

Note that when an iPack is connected to the logger the logger is powered from the iPack 2 volt regulator. Fresh D Cell batteries can output a voltage as high as 1.6 volts. Always use high quality Alkaline D-Cell batteries in your loggers! Lithium D-Cells should be used when the logger will be left unattended for an extended period of time extreme in cold environments.

Logger Only (no iPack)

1.25 V or better	Good
1.15 V to 1.25 V	Fair
below 1.15 V	Replace

Logger with iPack Connected

1.90 V or higher	Good
1.15 V to 1.89 V	Danger! Logger is not being powered by the iPack battery. iPack battery is likely depleted and logger is being powered by D-Cells only.

If the battery needs to be changed, refer to instructions for "Opening & Closing the iPack" and change the battery as follows:

- Pull the battery loose from the Velcro and gently unclip the battery.
- Clip on the new battery. Be sure the clip fully engages the locking tab.
- Install the new battery into the iPack by fixing it to the Velcro. Use a slight "rubbing" motion to make sure the Velcro sticks.

Carefully close the iPack according to instructions.

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Appendices

Opening & Closing the iPack

Installing or changing a GSM SIM card or iPack battery requires opening the iPack. It is important that this is done carefully to avoid damaging internal wiring or the iPack's weatherproof seal.

Opening the iPack

Be sure to touch the metal shell of the DB25 connector on the iPack before opening the enclosure in order to safely discharge any static electricity.

The iPack enclosure consists of two halves secured together by four recessed screws, two from each side of the enclosure. A gasket in between the two halves and 8 o-rings provide an environmental seal for the iPack and protect the internal electronics from the elements.

Remove the four recessed screws, and the iPack will separate into two halves connected by a short cable. One half contains the iPack electronics and the other half contains the rectangular battery, which is secured by Velcro. *Try not to lose any of the o-rings, and be careful not to rip or tear the gasket if it should come loose.*

Closing the iPack

- Insert the (4) 2-½ inch mounting screws up through the half of the enclosure that contains the iPack electronics.
- Slide the (4) o-rings over the screws.
- Set the gasket into the groove of the shell.
- Slide the cover (the half with the battery) over screws, being careful not to pinch the battery cable.
- Make sure the gasket is not pinched and then install the screws. It is a good idea to make sure the screws fall back into the existing threads in the iPack enclosure. An easy way to do this is to gently turn the screw counterclockwise one turn – it will fall into the existing threads in the iPack enclosure.

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Technical Specifications

Description	Instrument type	15 channel Internet-enabled micropower wind energy data logger
	Applications	• Wind resource assessment • Turbine power performance verification
	Sensor compatibility - counter channels	• RNRG 40C anemometer or compatible • RNRG Class 1 anemometer • Opto anemometer • Reed switch anemometer
	Sensor compatibility - analog channels	• RNRG 200P direction vane • RNRG 110S temperature sensor • Li-Cor 200SZ pyranometer • RNRG BP-20 absolute pressure (requires optional iPack power) • NRG RH-5X relative humidity (requires optional iPack power)
Data Collection	Counter channels	Channels 1-3 and 13-15 are always counter inputs supporting: • RNRG 40C anemometer or compatible • RNRG Class 1 anemometer • Opto anemometer • Reed switch anemometer Maximum counter input frequency is 2500 Hz
	Analog channels	Channels 7-12 are always analog inputs: • Channels 7 and 8 dedicated RNRG 200P direction vane • Channels 9-12 use analog Signal Conditioning Modules (SCMs) to configure each channel for a particular sensor
	Flex channels	Channels 4-6 are 'Flex' Channels • Analog or Counter • Accept Signal Conditioning Modules (SCMs) to configure the channel for a particular sensor type
	Sampling interval	1 second
	Averaging interval	10 minute fixed
	Real time clock	Internal battery-backed with leap year correction, 2000 to 2099
	Storage medium	128MB Renewable NRG Systems formatted SD Card, non-volatile FLASH
	Maximum data storage	672 files
	Parameters recorded for each channel	• Each data interval is time-stamped • Average • Standard deviation • Min* • Max* * Min and Max not used for wind direction vanes
	File format	• Windows compatible • One (1) 14KB binary file per day

		• Header includes site, serial number, and sensor information
	Software	Symphonie Data Retriever (SDR) for Windows • Scales raw data • Creates measurement database for each site • Creates basic reports • Maintains site and sensor information • Configures iPacks
	Reader	Windows compatible SD Card reader
	Data delivery	• SD Cards • Internet email via GSM, CDMA, or Iridium Satellite with optional iPack
Resolution	Analog measurement resolution	0.1% of full scale (1024 counts)
	Counter average stored resolution	0.1% of the value stored
	Analog average stored resolution	0.1% of the value stored
	Min / Max stored resolution	0.4% of the value stored
	Standard deviation stored resolution	4% of the value stored
Configuration	User interface	• Liquid Crystal Display (LCD) 4 x 20 characters • 16 key pad (6 navigation keys plus numeric/phone pad) with audible feedback
	Configurable parameters	• Clock • Time zone • Site number • Display scaling (defaults are provided for each channel based on the channel type)
	iPack options	• iPack configured via serial port connection to your PC • Serial connection direct to iPack or through logger's iPack access port • Symphonie Data Retriever for Windows integrates iPack settings
Connections	Sensor wiring	• Sensors connected to field wiring panel • Field wiring panel plugs into logger • Ground stud connects to earth ground with included ground cable
	Expansion slots	• Three (3) SCM slots accept analog or counter SCMs • Four (4) SCM slots accept only analog SCMs
	Communication ports	• Male DB25 interfaces to one optional iPack communications module • iPack access port provides a connection to the iPack programming port without dismounting the iPack or logger
Power requirements	Batteries	Two (2) 1.5 Volt D-Cell Batteries (included) • Nominal voltage: 1.5 Volts • Minimum voltage: 0.9 Volts • Battery life approximately one year, depending on configuration
	External power input	Provided by any iPack
	External solar input	Provided by any iPack
	Other	Optional iPacks provide 12V power required by some sensors. The Symphonie iPack | Power Only kit provides power to sensors and logger for stand alone

		configurations.
Installation	Mounting	• Mounts with 4 bolts (included) to keyed slots inside of metal shelter box • Shelter box attaches to tower with hose clamps
	Tools required	• Screwdriver for input terminals (included) • 8 mm (5/16 inch) wrench or nut driver for logger mounting screws and logger ground nuts
Environmental	Operating temperature range	-40 °C to 65 °C (-40 °F to 149 °F) Note: display readable -30 °C to 55 °C (-22 °F to 130 °F)
	Operating humidity range	0 to 100% RH non-condensing
	Lifespan	10 years +
Physical	Weight	1.3 kg (2.6 pounds), including batteries
	Dimensions	(Including Field Wiring Panel) 22.2 cm height, 18.8 cm width, 7.7 cm depth (8.7 x 7.4 x 3.0 in.)
Materials	Faceplate	Injection molded black ABS
	Buttons	White elastomer dome keypad
	Wiring panel	Fiberglass-epoxy terminal board, sealed gold plated pins, zinc plated screws and terminals
	Enclosure	Weatherproof polycarbonate

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Glossary

"A carrier"	A non-wireline or "cellular only" phone company.
alphanumeric	Any string of characters that contains letters and numbers in combination. The Symphonie*PLUS3* display is capable of alphanumeric strings.
analog channel	An input channel that accepts a voltage or current type sensor such as a 200P Wind Direction Vane, 110S Temperature Sensor, Relative Humidity Sensor, or Pyranometer.
AMPS cellular	Advanced Mobile Telephone System. AMPS is the cellular phone system that was widely deployed in North America, parts of South America, Australia, and New Zealand. It is now often referred to as "analog" cellular to distinguish it from the various digital systems that use the same channels.
anemometer	A sensing device that is used to measure wind velocity. The Symphonie*PLUS3* logger collects data from anemometers and other measurement sensors. The RNRG Class 1 Anemometer and RNRG 40C Anemometer are 3-cup anemometers.
ASCII file format	American Standard code for Computer Information Interchange. ASCII files are "common currency" in the computer world. The code contains characters including numbers, letters, and standard punctuation. Symphonie*PLUS3* converts raw binary data to ASCII format files.
averaging interval	The time period over which the logger collects data for averaging. The averaging interval for the Symphonie*PLUS3* Logger is fixed at 10 minutes.
"B" carrier	A wireline or "regular" telephone company that also provides cellular service.
cellular carrier	A cellular phone company.
counter channel	An input channel that is designed to accept frequency or totalizer type sensors such as anemometers and rain gauges.
GSM cellular	Global System for Mobile telecommunications. GSM is the digital cellular phone system widely deployed in Europe and elsewhere to replace the various analog systems that were in use before GSM was adopted.
GPS	Global Positioning System
non-volatile	Computer storage that is not affected by a loss of power. The Symphonie*PLUS3* logger uses non-volatile data storage and therefore does not require a battery to retain information in its memory.

offset	Also known as intercept. The offset is the measured value for zero output from a sensor. Symphonie*PLUS3* includes an offset field that can be used for sensors that have non-zero offsets or to correct for wind direction sensors that are referenced to directions other than true north. The number that you enter in the offset field is added to the value that is recorded by Symphonie*PLUS3*. For example, the RNRG 110S Temperature Sensor outputs 0 volts at -86.39 °C. The offset you would enter for the 110S sensor is –86.39.
POP3	Post Office Protocol is a protocol used to retrieve email from a specified server. POP3 is a newer version of the POP protocol.
print precision	Print precision is the number of decimal places you specify in scaled data numbers. For wind assessment studies, specifying two decimal places is appropriate. For example, print precision of (###.##) yields a number up to 999.99.
PV panel	Photovoltaic panel. A 15 watt PV panel is an available option for the Symphonie*PLUS3* logger. The PV panel attaches to the outside of the Symphonie*PLUS3* shelter box and uses solar energy to charge the logger's batteries.
pyranometer	A sensor that is used to measure total solar radiation. The #LI-200SA Li-Cor Pyranometer is a dependable and low-cost pyranometer that can be used for energy studies, site evaluation, passive solar system analysis, or irrigation scheduling.
roaming	Switching from your cellular carrier to another in order to transmit a call. An example of when roaming is necessary is when a car with a cellular phone travels beyond the area covered by the primary cellular carrier.
RS-232 serial port	A standard interface that allows communication between a computer and other devices. On PC's, the port is often referred to as a "Comm Port." Serial ports typically use a 9-pin D shaped connector.
sampling interval	The time period between samples of the input sensors. The Symphonie*PLUS3* logger samples data once every second. At the end of the averaging interval, the Symphonie*PLUS3* Logger calculates and stores an average and standard deviation of these samples.
scale factor	A number that is used as a multiplier to convert raw data from the Symphonie*PLUS3* logger to useful units of measure (such as °F, or m/s). The scale factor is often called the "slope" or "transfer function". For example, the scale factor for the RNRG 40C Anemometer is 0.765 m/s per Hz.
shelter box	The lockable steel enclosure that mounts to a tower or structure and protects a logger from weather and vandalism.

SCM	Signal Conditioning Module. An optional plug in module that provides the electronics to configure the input on channels 4-6 and 9-12 on the Symphonie*PLUS3* logger for a particular sensor. The SCM also tells the logger whether the sensor is a counter (frequency output), totalizer, vane or linear signal.
site	The installation location of the Symphonie*PLUS3* logger, TallTower, and sensors. A site is a unique and permanent location. Symphonie*PLUS3* loggers store a site number you assign to identify the site.
standard deviation	A measure of the central tendency of a collection of data. A small standard deviation means the data do not vary widely. A large standard deviation means the data vary more widely. Standard deviation is calculated as the square root of the variance, where variance is the average of the squared deviations about the mean.
storage intervals	The period of time that data are gathered before being stored to non-volatile memory. In Symphonie*PLUS3* loggers, the storage interval is always 10 minutes.
Symphonie*PLUS3* Data Retriever	Software supplied by Renewable NRG Systems used to produce versatile tab-delimited text Data Retriever files from raw data files collected by the Symphonie*PLUS3* logger. Text files can be used with a wide range of data processing software, including SQL databases, Microsoft Excel, Microsoft Access, and more. Supports international numeric formats.
TallTower	Renewable NRG Systems TallTowers are the original tilt-up tubular steel meteorological tower. TallTowers are delivered in complete kits, assembled on the ground and then tilted up and secured with guy wires.
text editor	A simple utility program that can be used to view or edit text files.
text file	A computer file containing only text in ASCII format.
time stamp	The time and date that identifies when a record was recorded. All Symphonie*PLUS3* logger data files are time stamped with the beginning time of the interval.
turbulence intensity (TI)	A measure of the irregularity of air flow over a site. TI is related to wind speed and terrain and is defined as the ratio of the standard deviation of the wind speed to the mean of the wind speed. Average turbulence intensity is the arithmetic mean of the valid TI values for the reporting period.
UTC	Coordinated Universal Time (UTC) is the international time standard. It is the current term for what was commonly referred to as Greenwich Meridian Time (GMT). Zero (0) hours UTC is midnight in Greenwich, England, which lies on the zero longitudinal

	meridian. Universal time is based on a 24 hour clock. Afternoon hours such as 5 pm UTC are expressed as 17:00 UTC (seven*teen hours, zero minutes*).
wind direction	The compass direction, as compass points (NE, NNE, etc.) or degrees (0 to 360°) from which the wind is blowing.
wind shear	The stress that occurs when adjacent wind layers move at different speeds or in different directions. Wind shear is measured as the change in wind speed from a measured anemometer to a reference anemometer. The measured anemometer is normally the anemometer at the top of the tower. The reference anemometer is the lowest anemometer on the tower.

Two Year Limited Warranty

Renewable NRG Systems warrants its products for a period of two years from date of original purchase solely for the benefit of the original consumer purchaser. If this Renewable NRG Systems product is determined to be defective in materials or workmanship, Renewable NRG Systems will, at Renewable NRG Systems' option, repair or replace this product without charge. This warranty does not cover damage due to improper installation or use, accident or misuse, lightning or damages due to any unauthorized service. This warranty also will not apply if any seal on any instrument or sensor is broken, if any cable has been severed, or the equipment was not adequately grounded.

To return a defective product, call Renewable NRG Systems at the telephone number listed below for a RMA return authorization number. You must also have available when you call the serial number of the item as well as date of purchase. No products will be accepted for warranty work without a RMA number. The product must be returned, postage prepaid, to RNRG with a brief description of the problem, RMA number and a return address with phone number.

The foregoing limited warranty is given in lieu of all other warranties, express or implied. Renewable NRG Systems specifically disclaims all implied warranties including, but not limited to, any implied warranties of merchantability and fitness for a particular purpose.

The above limited warranty expressly excludes, and RNRG shall not be liable for, any incidental or consequential damages caused by or related to the use of, inability to use or malfunction of this product.

Prompt disposition: RNRG will make a good faith effort for prompt correction or other adjustment with respect to any product which proves to be defective within the warranty period. First, contact RNRG or the representative from whom the product was purchased and ask for a RMA number.

RNRG will also make a good faith effort for prompt service after the warranty period of a product has expired. Please contact RNRG with the nature of the problem and serial number to obtain a RMA number.

Inspect your shipments for damage to packages or missing packages immediately upon receipt. Record any such exceptions on the freight receipt of the delivery agent. If any contents are damaged or missing, report this in writing to the freight carrier and send RNRG a copy of the damage report. If you insured the shipment yourself, report any damages to your insurance carrier.

Sending Repair Items to Renewable NRG Systems

INTERNATIONAL CUSTOMERS

1. **Contact Renewable NRG Systems to obtain an RMA number** (Return Material Authorization). Write the RMA number clearly on all shipping cartons.

2. **Send your item to Renewable NRG Systems "Delivery Duty Paid"** to the address below using a door-to-door courier service such as UPS, FedEx, or DHL. If the repair is not urgent, please send your package by Airmail. (Courier services deliver the package directly to us, customs cleared.)
   - **Renewable NRG Systems *will not accept packages shipped Freight Collect or with Collect charges.***
     If Renewable NRG Systems refuses the shipment, the courier service will charge your account return freight charges.
   - ***DO NOT send return items by direct or consolidated air freight service with an airline.***
     The cost for air freight may seem lower than the courier service, but air freight costs do not include customs clearance, airport handling, break bulk fees, and inland delivery to Renewable NRG Systems.

3. **Attach a Commercial Invoice** to the carton. The Commercial Invoice should include the following information:
   - Name and address of the shipper.
   - Renewable NRG Systems ' complete address and telephone number as the consignee.
   - Description of the items being returned.
   - Quantity of each item being returned.
   - Value for customs / insurance (purchase price or replacement cost).
   - Number of cartons with respective weights and dimensions.
   - Please include the following statement to avoid paying US import duties:

     "These items are being returned to their U.S. manufacturer. Country of manufacture and origin is USA,
     HTS CODE 9801.00.1012."

4. **Pack your repair item in a sturdy packing carton.** Tag each item with a brief description of the problem.

5. **Insure your shipment** against damage or loss in transit. Be sure to check the appropriate box and enter a "Value for Carriage" (insurance) on your air waybill. The value is the purchase price of the equipment or what it would cost to replace the equipment if the shipment were lost. Keep a record of the tracking number.

Once your item arrives, we will assess the item and notify you of the repair cost. Any repair charges and freight costs, if applicable, are payable before Renewable NRG Systems will return the repaired item to you via door-to-door courier service. Renewable NRG Systems will send you a shipment advisement when the repaired item is shipped.

International Customers:
Before sending the repair item to Renewable NRG Systems, check with your local customs authorities about provisions in your country for exporting and re-importing repair items. Some countries treat repair shipments like new shipments and charge import duties and taxes again upon re-importation. Other countries have specific steps to follow or specific forms to complete which help reduce the import duties upon re-import of the item.

US CUSTOMERS

Please see items 1, 4, and 5 above. Send your item(s) to Renewable NRG Systems "Freight Prepaid and Insured."
Shipments sent freight collect will not be accepted by Renewable NRG Systems.

Renewable NRG Systems, Inc.

Attn: RMA- _____
110 Riggs Road
Hinesburg VT 05461 USA

GSM iPack Data Sheet

GSM Cellular Account Information:

PARAMETER	ORIGIN	
Symphonie Serial Number	Found on inside front cover of Symphonie logger	
GSM Service Provider	Name of company providing GSM service	
PIN	Provided by user, found on iPack label	

Programming the iPack for internet connection:

PARAMETER	ORIGIN	
Internet Service Provider (ISP)	Name of company providing internet service	Earthlink.com
Primary ISP Phone Number	Provided by ISP	*99***1#
Primary DNS Number	Provided by ISP, found on ISP's web page	0.0.0.0.
Secondary DNS Number	Provided by ISP, found on ISP's web page	0.0.0.0
Authentication Method	Provided by ISP	PAP
User Name	Provided/approved by ISP	ISP@CINGULARGPRS.COM
User Password	Provided/approved by ISP	CINGULAR1
Internet Time Server Name	Provided by user	Time-a.nist.gov
Mailbox Name	Provided/approved by ISP	logger
Mailbox Password	Provided/approved by ISP	Boat6873
POP3 Server Name	Provided by ISP	Pop.myisp.com
SMTP Server Name	Provided/approved by ISP	Cwmx.com
Patch Password	Provided by user	8J5!*66
SMTP Login	Provided by ISP	logger@myisp.com
SMTP Password	Provided by ISP	Boat6873
Recipient's E-mail Address	Provided by user	jsmith@mycompany.com
Recipient's Name	Provided by user	John Smith
Sender's E-mail Address	Provided/approved by ISP	logger@myisp.com
E-mail Subject Line	Provided by user	Site 1234 – Derry Mountain
Next Call Time	Provided by user	20:45
Call Interval	Provided by user	1 day

iPack Data Sheet

Account Information:

PARAMETER	ORIGIN	
Symphonie*PLUS3* Serial Number	Found on inside front cover of Symphonie*PLUS3* logger	
Cellular / Satellite Service Provider	Name of company providing wireless service	
PIN	Usually provided by wireless service provider	

Programming the iPack for Internet connection:

PARAMETER	ORIGIN	
Internet Service Provider (ISP)	Name of company providing Internet service	
Primary ISP Phone Number	Provided by ISP	
Primary DNS Number	Provided by ISP, found on ISP's web page	
Secondary DNS Number	Provided by ISP, found on ISP's web page	
Authentication Method	Provided by ISP	
User Name	Provided/approved by wireless service provider	
User Password	Provided/approved by wireless service provider	
APN Name	Provided by GPRS service provider (GSM only)	
SMTP Server Name	Provided/approved by ISP or wireless service provider	
SMTP Login	Provided by ISP	
SMTP Password	Provided by ISP	
POP3 Server Name	Provided by ISP	
Internet Time Server Name	Provided by user	
Mailbox Name	Provided/approved by ISP	
Mailbox Password	Provided/approved by ISP	
Internet Time Server	Provided by user	
Recipient's E-mail Address	Provided by user	
Recipient's Name	Provided by user	
CC Email Address	Provided by user	
CC Email Address 2	Provided by user	
Sender's E-mail Address	Provided/approved by ISP	
E-mail Subject Line	Provided by user	
Patch Password	Provided by user	
Next Call Time	Provided by user	
Call Interval	Provided by user	

Site Data Sheet

Site Number		Project Number	
Site Name		Project Name	
Site Location			
Latitude		Time Zone	
Longitude		Magnetic Declination	
Elevation		Prevailing Winds	
Installation Crew		Phone Numbers: (hotel, cell phone, etc.)	
Site description (tree types, hills, etc.)			
Terrain Features (obstructions, distances from tower)			
Soil Type			

Installation Date	
Removal Date	

Field Contact Information

Company	
Contact Person	
Address	
Phone Number	
Fax Number	
e-mail Address	

Sensors

Anemometers – Attach calibration sheets for any calibrated anemometers

	Anemometer 1	Anemometer 2	Anemometer 3	Anemometer 4	Anemometer 5	Anemometer 6
Monitoring height						
Serial Number						
Primary or Redundant?						
Mounting Orientation (degrees – magnetic)						
Boom length						
Calibration Date						
Slope						
Offset						
Logger Channel Number:						
Comments:						

	Anemometer 7	Anemometer 8	Anemometer 9
Monitoring height			
Serial Number			
Primary or Redundant?			
Mounting Orientation (degrees – magnetic)			
Boom length			
Calibration Date			
Slope			
Offset			
Logger Channel Number:			
Comments:			

Wind Vanes

	Wind Vane1	Wind Vane 2	Wind Vane 3	Wind Vane 4	Wind Vane 5	Wind Vane 6
Monitoring Height						
Serial Number						
Mounting Orientation (degrees – magnetic)						
Boom Length						
Deadband Orientation (degrees)						
Logger Channel Number						
Comments						

Other Sensors

	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Sensor 7
Sensor Type							
Monitoring Height							
Serial Number							
Mounting Orientation (degrees – magnetic)							
Slope							
Offset							
Logger Channel Number							
Comment							

Tower

Tower Type	
Height	
Diameter	
Comments	

Site Photographs

Take pictures in 8 directions at tower base and several pictures showing the surrounding terrain.

_____ **North**
_____ **Northeast**
_____ **East**
_____ **Southeast**
_____ **South**
_____ **Southwest**
_____ **West**

____ Northwest
____ Site & surrounding area

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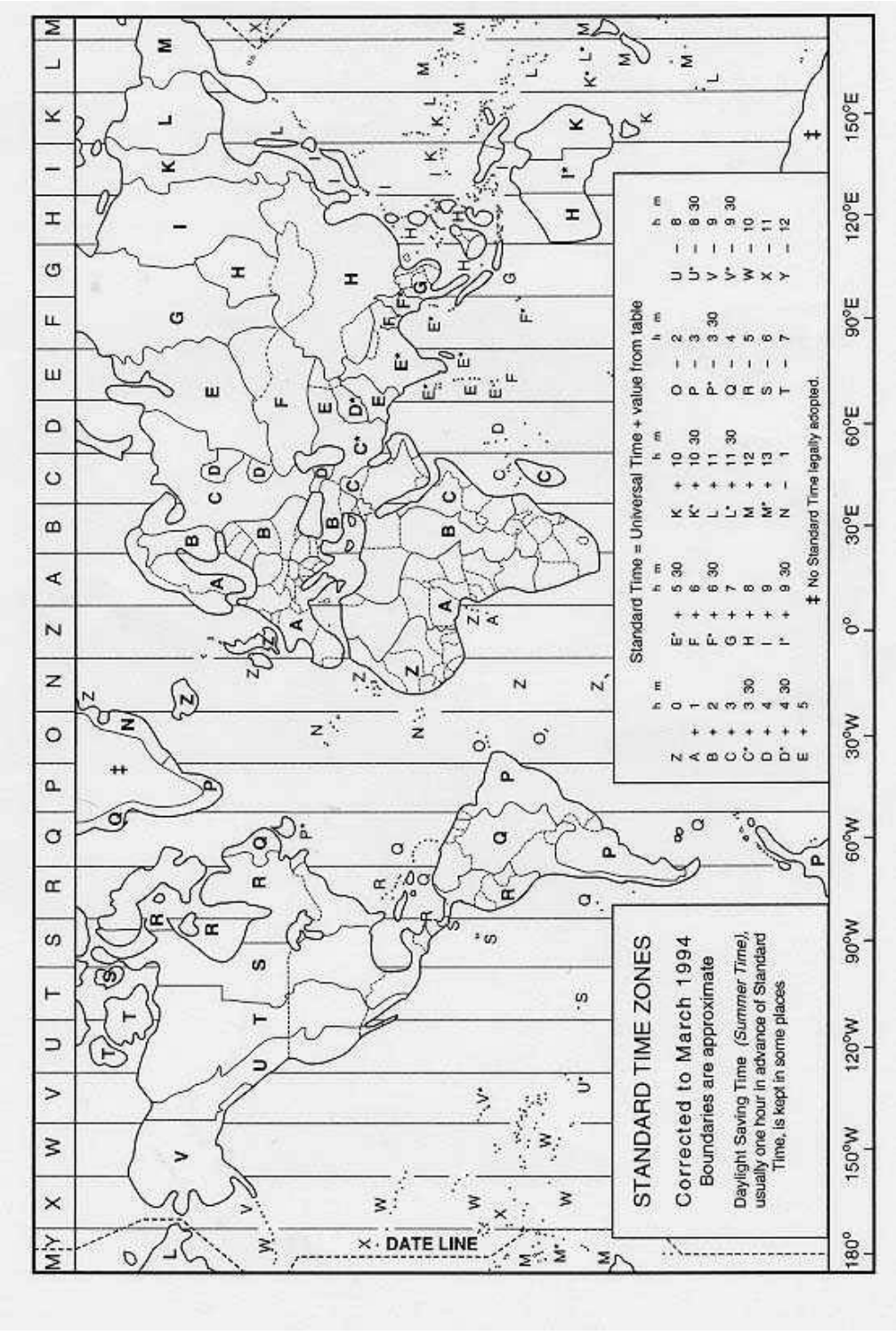
Time Zones


STANDARD TIME ZONES
Corrected to March 1994
Boundaries are approximate
Daylight Saving Time (Summer Time), usually one hour in advance of Standard Time, is kept in some places
DATE LINE
Standard Time = Universal Time + value from table
‡ No Standard Time legally adopted.

EU Declaration of Conformity

RENEWABLE NRG SYSTEMS

110 Riggs Road
Hinesburg, VT 05461 USA

t 802 482-2255
f 802 482-2272

www.renewableNRGsystems.com
info@renewableNRGsystems.com

Declaration of Conformity

(in accordance with ISO/IEC 17050-1:2004)

Supplier: **Renewable NRG Systems**

Supplier Address: 110 Riggs Road, Hinesburg, VT 05461, USA
Telephone: 802 482 2255, Fax: 802 482 2272
Email: sales@rnrgsystems.com

Declares that the Product: Symphonie*PLUS3* Logger System, including:

Logger-Symphonie*PLUS3*, with accessories	**Item 4941**
SCM Cards	**Items 3075, 3070, 3988, 3673, 3077, 3253, 3252, 3073, 3583, 3076, 3071, 3072, 3078, 3742, 3743, 3074, 6925, 6946, 6646**
Symphonie iPacks	**Items 3860, 3533, 4222, 3531, 3146, 3861, 4620, 4621, 4622, 4623, 7169, 7984**

is in conformity with the requirements of the following documents:

EN61326-1 Class A "Electrical Equipment for Measurement, Control, and Laboratory Use—EMC Requirements", in accordance with: **CISPR 11; EN 61000-4-2; EN 61000-4-3; EN 61000-4-8; EN 61000-4-4; EN 61000-4-20; 61000-4-6**

IEC 61010-1 "Safety requirements for electrical equipment for measurement, control, and laboratory use"

Additional Information:

This product complies with the requirements of the applicable directives **2006/95/EC, 2004/108/EC**; and standard **EN 61010-1** and therefore, the product is CE marked in accordance with **93/68/EEC**.

FCC compliance is demonstrated with compliant CISPR data.

The design documentation, test reports, and assessment laboratory accreditation are under document control in NRG Engineering.

Issued at Hinesburg, VT, USA

30 Jul 2014

Phil Pouech

RA Engineering Manager

SEE THE POTENTIAL

References

Some of our products incorporate software that is available in the open source community, including www.freertos.org (version 6.00) and www.savannah.nongnu.org. The information that follows is provided to comply with the terms of use.

www.freertos.org
FreeRTOS is a real time operating system available in the open source community and utilized in the iPackGPS. Source code is available from Renewable tems upon request.

www.savannah.nongnu.org
We are using the lwIP lightweight TCP/IP stack in the iPackGPS.

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ANEXO B:

Especificaciones del anemómetro NRG 40C

NRG 40C ANEMOMETER

The 40C Anemometer offers field-proven measurement accuracy at an economical price.

	NRG 40C Anemometer	MEASNET Calibrated (#1900)	NRG 40C Anemometer	CPH MEASNET Calibrated (#4350)
DESCRIPTION				
Sensor type	3 Cup Anemometer		3 Cup Anemometer	
Applications	• Wind resource assessment • Meteorological studies • Environmental monitoring		• Wind resource assessment • Meteorological studies • Environmental monitoring	
Sensor range	1 m/s to 96 m/s (2.2 mph to 215 mph) (highest recorded)		1 m/s to 96 m/s (2.2 mph to 215 mph) (highest recorded)	
Instrument compatibility	All RNRG loggers		All RNRG loggers	
OUTPUT SIGNAL				
Signal type	Low level AC sine wave, frequency linearly proportional to wind speed		Low level AC sine wave, frequency linearly proportional to wind speed	
Anemometer Transfer Function	• **Consensus Transfer Function:** **Scale Factor (Slope): 0.765 m/s/Hz (1.711 mph/Hz)** **Offset: 0.35 m/s (0.78 mph)** • **Refer to the white paper "The Maximum Type 40 Anemometer Calibration Project" for more information on the consensus transfer function** • **All RNRG 40C Anemometers are calibrated per IEC 61400-12-1, Annex F**		**See individual calibration report**	
Output voltage at threshold	**80 mV (peak-to-peak) minimum**		**80 mV (peak to peak) minimum**	
Output voltage at 60Hz	• **12 V (peak-to-peak) typical** • **Output amplitude NOT proportional to wind speed**		• **12 V (peak-to-peak) typical** • **output amplitude NOT proportional to wind speed**	
Calibration	Each anemometer individually calibrated, calibration reports provided via electronic download		Each anemometer individually calibrated, calibration reports provided via electronic download	
Output signal range	0 Hz to 125 Hz (at 96m/s, highest recorded)		0 Hz to 125 Hz (at 96m/s, highest recorded)	
Uncertainty	**Accuwind (Riso-R-1556) Classification:** • **Class 2.4A** • **Class 7.7B** **IEC 61400-12-1 operational standard uncertainty:** • **± 0.14 m/s at 10 m/s for Class A** • **± 0.45 m/s at 10 m/s for Class B** • **Refer to calibration sheet for information on calibration uncertainty** • **Refer to application note "#40C Anemometer Uncertainty" for definitions and more information**		**Accuwind (Riso-R-1556) Classification:** • **Class 2.4A** • **Class 7.7B** **IEC 61400-12-1 operational standard uncertainty:** • **± 0.14 m/s at 10 m/s for Class A** • **± 0.45 m/s at 10 m/s for Class B** • **refer to calibration sheet for information on calibration uncertainty** • **refer to application note "#40C Anemometer Uncertainty" for definitions and more information**	
RESPONSE CHARACTERISTICS				

	NRG 40C Anemometer	MEASNET Calibrated (#1900)	NRG 40C Anemometer	CPH MEASNET Calibrated (#4350)
Distance constant (63% recovery)	• 2.55 m (8.37 feet) at 5m/s per ASTM D 5096-02 • 2.56 m (8.40 feet) at 10m/s per ASTM D 5096-02		• 2.55 m (8.37 feet) at 5m/s per ASTM D 5096-02 • 2.56 m (8.40 feet) at 10m/s per ASTM D 5096-02	
Moment of inertia	• 1.01 x 10^{-4} kg-m^2 • 74.5 x 10^{-6} S-ft^2		• 1.01 x 10^{-4} kg-m^2 • 74.5 x 10^{-6} S-ft^2	
Swept diameter of rotor	190 mm (7.5 inches)		190 mm (7.5 inches)	
INSTALLATION				
Mounting	Onto a 13 mm (0.5") diameter mast with cotter pin and set screw		Onto a 13 mm (0.5") diameter mast with cotter pin and set screw	
Tools required	0.25 inch nut driver, petroleum jelly, electrical tape		0.25 inch nut driver, petroleum jelly, electrical tape	
ENVIRONMENTAL				
Operating temperature range	-55 °C to 60 °C (-67 °F to 140 °F)		-55 °C to 60 °C (-67 °F to 140 °F)	
Operating humidity range	0 to 100% RH		0 to 100% RH	
PHYSICAL				
Connections	4-40 brass hex nut/post terminals		4-40 brass hex nut/post terminals	
Weight	0.14 kg (0.3 lbs)		0.14 kg (0.3 lbs)	
Dimensions	• 3 cups of conical cross-section, 51 mm (2") dia. • 81 mm (3.2") overall assembly height		• 3 cups of conical cross-section, 51 mm (2") dia. • 81 mm (3.2") overall assembly height	
MATERIALS				
Cups	One piece injection-molded black polycarbonate		One piece injection-molded black polycarbonate	
Body	Housing is black ABS plastic		Housing is black ABS plastic	
Shaft	Beryllium copper, fully hardened		Beryllium copper, fully hardened	
Bearing	Modified Teflon, self-lubricating		Modified Teflon, self-lubricating	
Magnet	Indox 1, 25 mm (1 inch) diameter, 13 mm (0.5 inch) long, 4 poles		Indox 1, 25 mm (1 inch) diameter, 13 mm (0.5 inch) long, 4 poles	
Coil	Single coil, bobbin wound, 4100 turns of #40 wire, shielded for ESD protection		Single coil, bobbin wound, 4100 turns of #40 wire, shielded for ESD protection	
Boot	Protective PVC sensor terminal boot included		Protective PVC sensor terminal boot included	
Terminals	Brass		Brass	

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ANEXO C:

Especificaciones de la veleta NRG 200P

NRG 200P WIND VANE

The 200P Wind Vane is one of the most widely used wind direction sensors in wind, solar, and meteorological applications worldwide.

	200P Wind Direction Vane (#1904)	200P Wind Direction Vane	Calibrated (#2274)
DESCRIPTION			
Sensor type	Continuous rotation potentiometric wind direction vane	Continuous rotation potentiometric wind direction vane	
Applications	• Wind resource assessment • Meteorological studies • Environmental monitoring	• Wind resource assessment • Meteorological studies • Environmental monitoring	
Sensor range	360° mechanical, continuous rotation	360° mechanical, continuous rotation	
Instrument compatibility	All Symphonie Data Loggers	All Symphonie Data Loggers	
OUTPUT SIGNAL			
Signal type	Analog DC voltage from conductive plastic potentiometer, 10K ohms	Analog DC voltage from conductive plastic potentiometer, 10K ohms	
Transfer function	Output signal is a ratiometric voltage	Output signal is a ratiometric voltage	
Accuracy	Potentiometer linearity within 1%	Potentiometer linearity within 1%	
Dead band	8° Maximum, 4° Typical	8° Maximum, 4° Typical	
Output signal range	0 V to excitation voltage (excluding deadband)	0 V to excitation voltage (excluding deadband)	
RESPONSE CHARACTERISTICS			
Threshold	1 m/s (2.2 mph)	1 m/s (2.2 mph)	
POWER REQUIREMENTS			
Supply voltage	Regulated potentiometer excitation of 1 V to 15 V DC	Regulated potentiometer excitation of 1 V to 15 V DC	
INSTALLATION			
Mounting	Onto a 13 mm (0.5 inch) diameter mast with cotter pin and set screw	Onto a 13 mm (0.5 inch) diameter mast with cotter pin and set screw	
Tools required	0.25 inch nut driver, petroleum jelly, electrical tape	0.25 inch nut driver, petroleum jelly, electrical tape	
ENVIRONMENTAL			
Operating temperature range	-55 °C to 60 °C (-67 °F to 140 °F)	-55 °C to 60 °C (-67 °F to 140 °F)	
Operating humidity range	0 to 100% RH	0 to 100% RH	
Lifespan	50 million revolutions (2 to 6 years normal operation)	50 million revolutions (2 to 6 years normal operation)	
PHYSICAL			
Connections	4-40 brass hex nut/post terminals	4-40 brass hex nut/post terminals	
Weight	0.14 kg (0.3 pounds)	0.14 kg (0.3 pounds)	
Dimensions	• 21 cm (8.3 inches) length x 12 cm (4.3 inches) height • 27 cm (10.5 inches) swept diameter	• 21 cm (8.3 inches) length x 12 cm (4.3 inches) height • 27 cm (10.5 inches) swept diameter	

	200P Wind Direction Vane (#1904)	200P Wind Direction Vane	Calibrated (#2274)
MATERIALS			
Wing	Black UV stabilized injection molded plastic	Black UV stabilized injection molded plastic	
Body	Black UV stabilized static-dissipating plastic	Black UV stabilized static-dissipating plastic	
Shaft	Stainless steel	Stainless steel	
Bearing	Stainless steel	Stainless steel	
Boot	Protective PVC sensor terminal boot included	Protective PVC sensor terminal boot included	
Terminals	Brass	Brass	

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ANEXO D:

Folleto de instrumentos de medición solar LI-COR

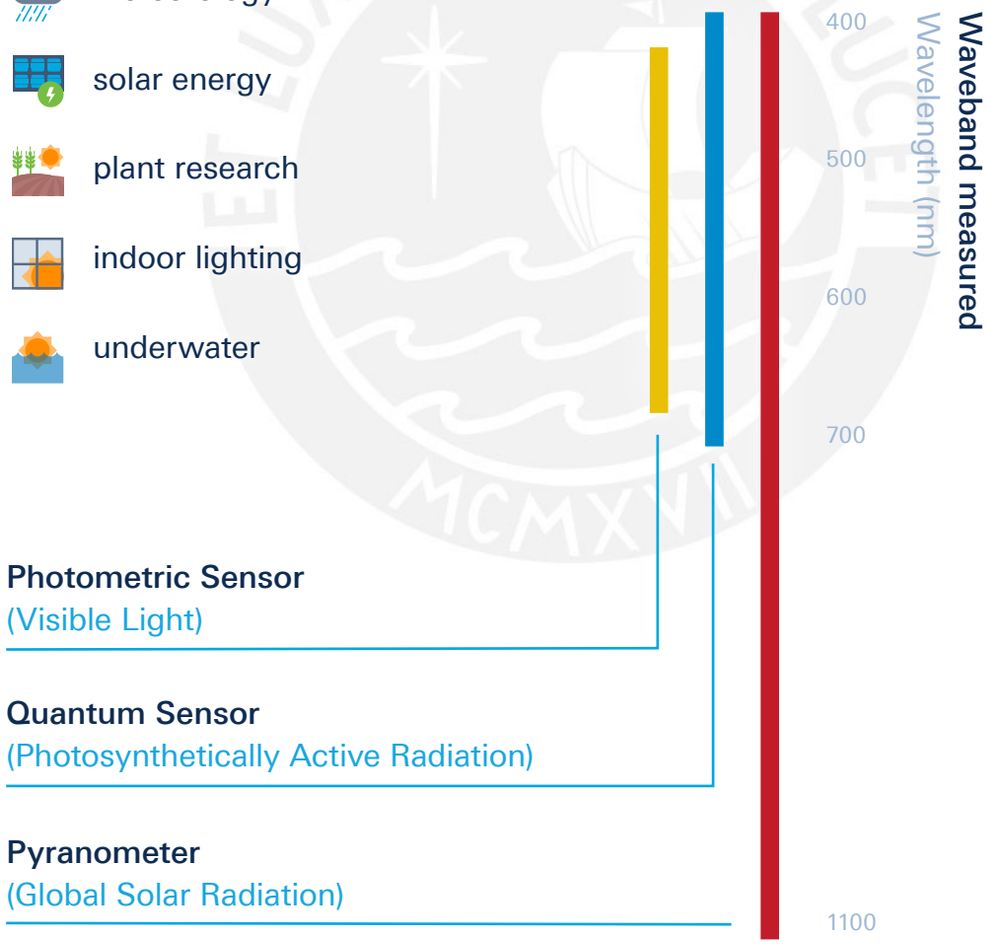
Light Measurement

The Standard for over 40 Years

Introduction

LI-COR radiation sensors measure the flux of radiant energy—the energy that drives plant growth, warms the earth, and lights our world. The properties of radiant flux depend on the wavelength of the radiation. Pyranometers are sensitive to the broadest waveband. Photometric sensors measure visible radiation (light). Quantum sensors measure Photosynthetically Active Radiation (PAR)—the radiant energy used in photosynthesis. These three sensor types cover a wide range of applications:

- ecology
- meteorology
- solar energy
- plant research
- indoor lighting
- underwater



The Sensors

LI-COR sensors are weather resistant, low maintenance, and cosine corrected. From the shape of the crown to the photodiodes and optical filter glass, every aspect is the result of scientific inquiry.

The sensor design features a large drain to shed water, and a more robust housing to help prevent water ingress, increasing the lifespan of the sensors and reducing measurement drift. A detachable sensor head allows for replacement and factory recalibration without removing the cable from the mounting structure.

LI-200R Pyranometer

The LI-200R Pyranometer is meant to be used outdoors under unobstructed natural daylight conditions. It measures global solar radiation—the combination of direct and diffuse solar radiation—in the 400 to 1100 nm range. Measurement units are in watts per square meter (W m^{-2}).

Ideal for agricultural, meteorological, solar energy, and environmental research, the LI-200R is available with a variety of cable lengths and output signals for compatibility with most data loggers.

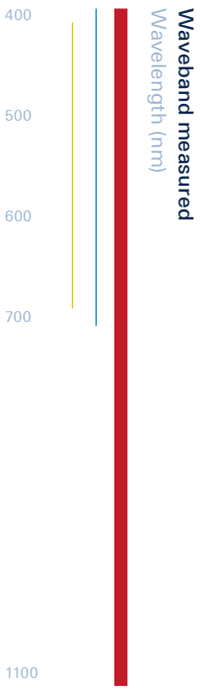
Why choose the LI-200R?

- Weather resistant and durable in long-term outdoor deployments
- Measures global solar radiation under unobstructed natural daylight conditions
- Uniform sensitivity up to 82° incident angle
- Detachable sensor simplifies installation and removal, making it ideal for platforms with complex cabling

How does it work?

The LI-200R measures global solar radiation with an unfiltered silicon photodiode. Its measurements correspond closely to first-class thermopiles when used outdoors under unobstructed natural daylight conditions.

The crown of the sensor rapidly sheds water, and also physically blocks light from outside the hemisphere of sensitivity, providing a precise cosine response.



LI-200R Specifications

- Absolute Calibration: Calibrated against an Eppley Precision Spectral Pyranometer (PSP) under natural daylight conditions. Calibration uncertainty under these conditions is estimated as ± 3% typical, within ± 60° angle of incidence.*
- Sensitivity: Typically 75 µA per 1,000 W m^{-2}
- Linearity: Maximum deviation of 1% up to 3,000 W m^{-2}
- Response Time: Less than 1 µs (2 m cable terminated into a 147 Ohm load)
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Cosine corrected up to 82° angle of incidence
- Azimuth: < ± 1% error over 360° at 45° elevation
- Tilt: No error induced from orientation
- Operating Temperature Range: –40 °C to 65 °C
- Relative Humidity Range: 0% to 95% RH, Non-Condensing
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum body with acrylic diffuser and stainless steel hardware; O-ring seal on the sensor base
- Size: 2.36 cm diameter x 3.63 cm (0.93" x 1.43")
- Weight: 24 g head; 60 g base and cable (2 m) with screws
- Cable Length: 2 m, 5 m, 15 m, 50 m (6.5', 16.4', 49.2', 164')

Specifications subject to change without notice.

*Preliminary specification

LI-190R Quantum Sensor

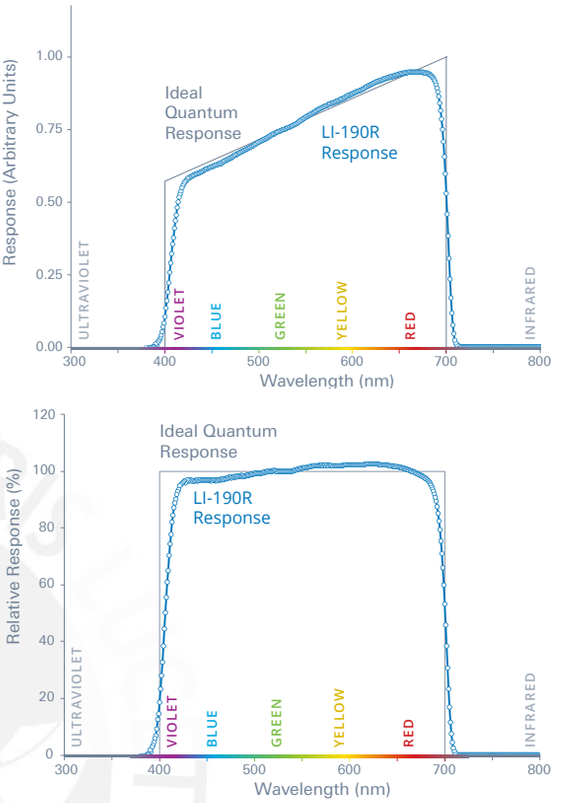
The LI-190R measures Photosynthetically Active Radiation (PAR, in µmol of photons m^{-2} s^{-1}). It provides accurate measurements—in the open, in greenhouses, under plant canopies, or in growth chambers—for most broad-spectrum light sources, including natural sunlight, artificial, or mixed sources.

Plants use light in the wavelength range from about 400 to 700 nm to drive photosynthesis. The efficiency with which plants use light varies somewhat across this range, but McCree[1] showed that measuring PAR provided a consistent way to predict plant photosynthetic response regardless of the spectrum of the light source.[2]

1. McCree, K.J., 1972. The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. Agric. Meteorol. 9: 191-216.
2. McCree, K.J., 1972. Test of current definitions of photosynthetically active radiation against leaf photosynthesis data. Agric. Meteorol. 10: 443-453.

Why choose the LI-190R?

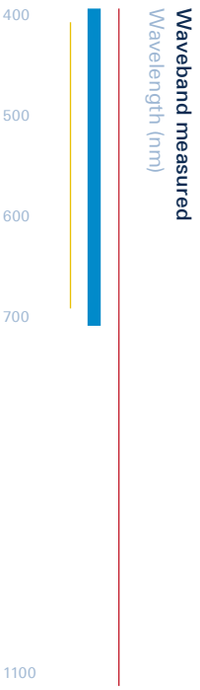
- Uniform sensitivity across the PAR waveband for accurate measurements outdoors, under vegetation, or in artificial lighting without changing the calibration
- Newly designed optical filter tailors the spectral response to an unprecedented performance standard
- Weather resistant and durable in high-temperature, high-humidity, long-term deployments
- Cosine correction is accurate even when the light source is not directly overhead
- Sensor heads are detachable and interchangeable for simplified installation, removal, and recalibration



The LI-190R quantum response and the ideal quantum response curve in energy units (top) and photon units (bottom).

How does it work?

A high-quality silicon photodiode is matched with a specially designed glass optical filter to create nearly uniform sensitivity to all the wavelengths within the PAR waveband (400 to 700 nm). This ensures accurate measurements irrespective of the light source. The glass filter excludes light with wavelengths outside the PAR waveband. Exclusion of wavelengths beyond 700 nm is critical for measurements under vegetation.



LI-190R Specifications

- Absolute Calibration: ± 5% traceable to the U.S. National Institute of Standards and Technology (NIST)
- Sensitivity: Typically 5 µA to 10 µA per 1,000 µmol s^{-1} m^{-2}
- Linearity: Maximum deviation of 1% up to 10,000 µmol s^{-1} m^{-2}
- Response Time: Less than 1 µs (2 m cable terminated into a 604 Ohm load)
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Cosine corrected up to 82° angle of incidence
- Azimuth: < ± 1% error over 360° at a 45° elevation
- Tilt: No error induced from orientation
- Operating Temperature Range: –40 °C to 65 °C
- Relative Humidity Range: 0% to 95% RH, Non-Condensing
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum body with acrylic diffuser and stainless steel hardware; O-ring seal on the sensor base
- Size: 2.36 cm diameter x 3.63 cm (0.93" x 1.43")
- Weight: 24 g head; 60 g base and cable assembly (2 m) with screws
- Cable Length: 2 m, 5 m, 15 m, 50 m (6.5', 16.4', 49.2', 164')

Specifications subject to change without notice.

LI-210R Photometric Sensor

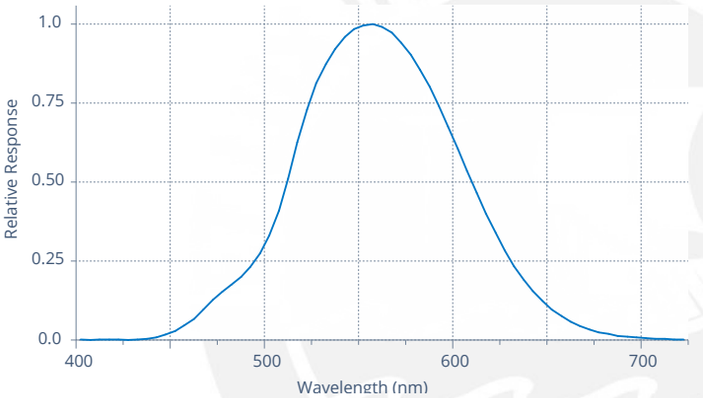
The LI-210R Photometric Sensor measures light with the same sensitivity as a typical human eye. The photometric sensor is ideal for evaluating illumination in work areas, exhibits, interior lighting, and in public spaces. Measurement units are lux or klux.

Why choose the LI-210R?

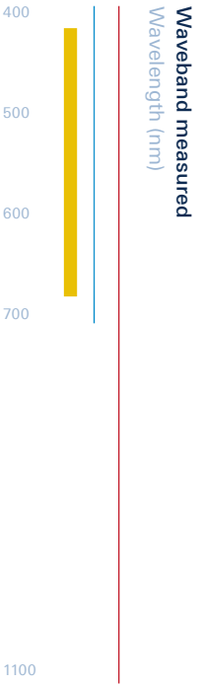
- Spectral response closely matches the CIE Standard Observer Curve
- Excellent cosine response—sensitive to light from all directions up to an 82˚ angle of incidence
- Detachable sensor simplifies installation and removal, making it ideal for platforms with complex cabling

How does it work?

The LI-210R measures light with a precision filtered silicon photodiode that is sensitive to light in the visible spectrum.



Typical spectral response of the LI-210R Photometric Sensor.



LI-210R Specifications

- Absolute Calibration: ± 5% traceable to the U.S. National Institute of Standards and Technology (NIST)
- Sensitivity: Typically 30 µA per 100 klux
- Linearity: Maximum deviation of 1% up to 100 klux
- Stability: < ± 2% change over a 1 year period
- Response Time: Less than 1 µs (2 m cable terminated into a 604 Ohm load)
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Cosine corrected up to 82° angle of incidence
- Azimuth: < ± 1% error over 360° at 45° elevation
- Tilt: No error induced from orientation
- Operating Temperature Range: –40 °C to 65 °C
- Relative Humidity Range: 0% to 95% RH, Non-Condensing
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum housing with acrylic diffuser and stainless steel hardware; O-ring seal on the sensor base
- Size: 2.36 cm diameter x 3.63 cm (0.93" x 1.43")
- Weight: 24 g head; 60 g base and cable assembly (2 m) with screws
- Cable Length: 2 m, 5 m, 15 m, 50 m (6.5', 16.4', 49.2', 164')

Specifications subject to change without notice

LI-191R Line Quantum Sensor

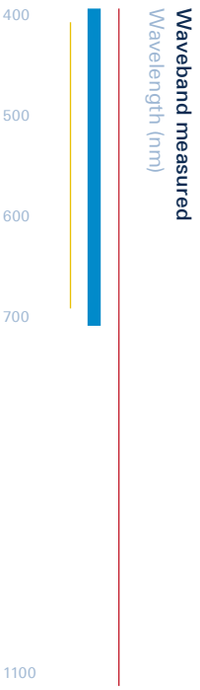
The LI-191R Line Quantum Sensor measures PAR integrated over its 1-meter length. It is used to measure sunlight under a plant canopy, where the light field is non-uniform. The LI-191R makes it easy to measure under-canopy light in many plots quickly and consistently. It measures light in units of Photosynthetic Photon Flux Density (PPFD), which is expressed as µmol s^{-1} m^{-2}.

Why choose the LI-191R?

- Improved water resistance for long-term outdoor deployment
- Integrated measurements using a single detector prevents variance found in sensors that use multiple detectors
- Selected by the National Ecological Observatory Network (NEON®) for integrated PAR measurements

How does it work?

The LI-191R uses a 1-meter long quartz rod under a diffuser to direct light to a single filtered silicon photodiode. The entire LI-191R diffuser is sensitive to light over its 1-meter length. Since the diffuser is one continuous piece, the LI-191R essentially integrates an infinite number of points over its surface into a single value that represents light from the entire 1-meter length. Optical filters block radiation with wavelengths beyond 700 nm, which is critical for under-canopy measurements, where the ratio of infrared to visible light may be high. The unique design of the LI-191R provides an excellent quantum response that is close to the ideal quantum response.



LI-191R Line Quantum Sensor Specifications

- Absolute Calibration: ± 10% traceable to National Institute of Science and Technology (NIST). The LI-191R is calibrated via transfer calibration using a reference LI-190R Quantum Sensor. Transfer error is ± 5% (included in the ± 10%)
- Sensitivity: Typically 7 µA per 1,000 µmol s^{-1} m^{-2}
- Linearity: Maximum deviation of 1% up to 10,000 µmol s^{-1} m^{-2}
- Response Time: 10 µs
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Acrylic diffuser
- Azimuth: < ± 2% error over 360° at 45° elevation
- Operating Temperature Range: –40 °C to 65 °C
- Relative Humidity Range: 0% to 95% RH, Non-Condensing
- Sensitivity Variation over Length: ± 7% maximum using a 2.54 cm (1") wide beam from an incandescent light source.
- Sensing Area: 1 m x 12.7 mm (39.4" x 0.50")
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum housing with acrylic diffuser and stainless steel hardware.
- Size: 121.3 L x 2.54 W x 2.54 cm D (47.7" x 1.0" x 1.0")
- Weight: 1.4 kg (3.0 lbs.)
- Cable Length: 2 m, 5 m (6.5', 16.4')

Specifications subject to change without notice.

LI-192 Underwater Quantum Sensor

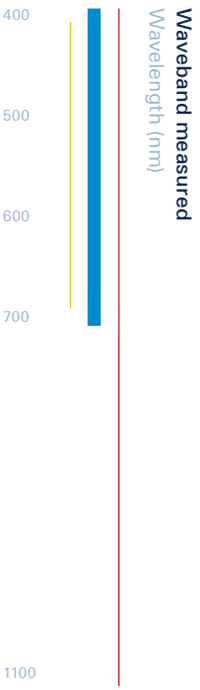
The LI-192 Underwater Quantum Sensor measures PAR from all angles in one hemisphere. The LI-192 works in air or underwater at depths up to 560 meters. The measurements are cosine corrected and typically expressed as Photosynthetic Photon Flux Density (PPFD). For simultaneous measurements of downwelling and upwelling PAR, two sensors can be mounted on the 2009S Lowering Frame.

Why choose the LI-192?

- Designed for immersion
- Rugged, corrosion-resistant sensors for use in fresh and saltwater environments
- Ideal for oceanography, limnology, turbidity, and vertical profiling
- Suitable for submerged and out-of-water measurements

How does it work?

The LI-192 uses a silicon photodiode and a glass optical filter to create nearly uniform sensitivity to light between 400 and 700 nm, which closely corresponds to light used by most terrestrial and aquatic plants and algae. A precision optical filter blocks light with wavelengths beyond 700 nm, which is critical for measurements in a water column, where the ratio of infrared to visible light may be high.



LI-192 Specifications

- Absolute Calibration: ± 5% in air traceable to NIST
- Sensitivity: Typically 4 µA per 1,000 µmol s^{-1} m^{-2} in water
- Linearity: Maximum deviation of 1% up to 10,000 µmol s^{-1} m^{-2}
- Response Time: 10 µs
- Temperature Dependence: ± 0.15% per °C maximum
- Cosine Correction: Optimized for underwater and atmospheric use
- Azimuth: < ± 1% error over 360° at 45° elevation
- Operating Temperature Range: –40 °C to 65 °C
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Corrosion resistant metal with acrylic diffuser for both saltwater and freshwater applications. Waterproof to withstand approximately 5500 kPa (800 psi), 560 meters.
- Size: 3.18 cm diameter × 4.62 cm height (1.25" × 1.81")
- Weight: 227 g (0.5 lbs.)
- Mounting: Three 6-32 holes are tapped into the base for use with the 2009S Lowering Frame or other mounting devices
- Cable: Requires 2222UWB Underwater Cable (available in 3, 10, 30, 50, 100 meter lengths)

Specifications subject to change without notice.

LI-193 Spherical Quantum Sensor

The LI-193 Spherical Quantum Sensor measures PAR in air or underwater from all directions at depths up to 350 meters. This sensor is useful for studies of phytoplankton, which uses radiation from all directions. The measurement is referred to as Photosynthetic Photon Flux Fluence Rate (PPFFR) or Quantum Scalar Irradiance.

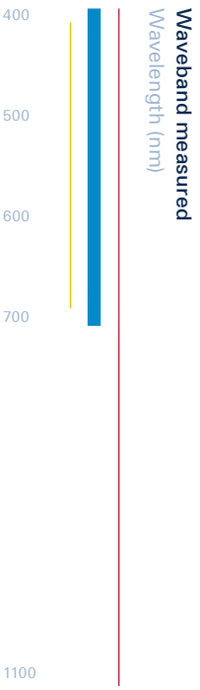
Why choose the LI-193?

- Designed for immersion
- Measures PAR from all directions
- Ideal for oceanography, limnology, turbidity, and vertical profiling

How does it work?

The LI-193 uses a diffusive sphere to direct light through glass optical filters to the silicon photodiode. The filters create nearly uniform sensitivity to light between 400 and 700 nm, which closely corresponds to light used by most terrestrial and aquatic plants and algae. The angular response of a typical LI-193 is slightly lower in the direction of the cable connection. When mounted, the low response is usually not significant due to the small proportion of upwelling radiation compared to the total.

Typical angular response of the LI-193.



LI-193 Specifications

- Absolute Calibration: ± 5% in air traceable to NIST
- Sensitivity: Typically 7 µA per 1,000 µmol s^{-1} m^{-2} in water
- Linearity: Maximum deviation of 1% up to 10,000 µmol s^{-1} m^{-2}
- Stability: < ± 2% change over a 1 year period
- Response Time: 10 µs
- Temperature Dependence: ± 0.15% per °C maximum
- Angular Response: < ± 4% error up to ± 90° from normal axis (see Angular Response chart)
- Azimuth: < ± 3% error over 360° at 90° from normal axis
- Operating Temperature Range: –40 °C to 65 °C
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Corrosion resistant metal for both saltwater and freshwater applications with an injection molded, impact resistant, acrylic diffuser. Units have been tested to 3,400 kPa (500 psi), 350 meters.
- Size:
  - Globe: 6.1 cm diameter (2.4")
  - Housing: 3.18 cm diameter (1.25")
  - Overall Height: 10.7 cm (4.2")
- Weight: 142 g (0.31 lbs.)
- Mounting: Three 6-32 mounting holes are tapped into the base for use with the 2009S Lowering Frame or other mounting devices.
- Cable: Requires 2222UWB Underwater Cable (available in 3, 10, 30, 50, 100 meter lengths)

Specifications subject to change without notice.

LI-1500 Light Sensor Logger

The LI-1500 Light Sensor Logger provides a direct digital readout and data logging from up to three LI-COR sensors at the same time. Log manually or set up one-time, daily, or continual logging routines. Take advantage of the intuitive, menu-driven interface, optional GPS system, high frequency measurements up to 500 Hz, and built-in math functions.

Why choose the LI-1500?

- Large 1-GB memory for storing data and up to 100 sensor-specific multipliers
- Rugged, weather-resistant housing and optional GPS for outdoor use or transect measurements
- Eight math functions, including integration, natural logarithm, and underwater attenuation

LI-1500 Specifications

Current Inputs: 3 BNC connectors for LI-COR sensors

Output Channels:

- Light
- 8 Math Channels: addition, subtraction, multiplication, division, natural logarithm, integration, daily integration, attenuation
- GPS (optional)
- Prompt
- Battery Voltage

Input Channel Specifications:

- Frequency Rejection: >70dB at 50 or 60 Hz (1 input channel @ sampling rates of 1, 2, 5, 10, 20Hz)
- Current Accuracy: ± 0.3% of full scale reading @25 °C
- Signal Ranges:

Range #	Current Range	Resolution (Typical)
1	0 – 0.250 µA	0.0305 nA
2	0 – 2.50 µA	0.1525 nA
3	0 - 25 µA	1.525 nA
4	0 - 250 µA	15.25 nA

- Raw Mode (1 – 500 Hz): Selectable Range
- Standard Modes (Continual, Manual, Daily, One Time):
  - Auto range for total sampling rate ≤ 3 Hz (e.g. 1 Hz sampling on three input channels)
  - Fixed range (selectable) for total sampling rates > 3 Hz (e.g. 2 Hz sampling on two input channels)

Sampling Rates:

- Standard Modes: 0.01 Hz, 0.1 Hz, 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz
- Raw Mode: 1 – 500 Hz (1 Hz through 500 Hz in whole number increments)

Logging Rates:

- Standard Modes Sampling: Every Sample, 100 msec, 200 msec, 500 msec, 1 sec, 5 sec, 10 sec, 15 sec, 30 sec, 60 sec, 100 sec, 5 min, 15 min, 30 min, 1 hr, 2 hr, 3 hr, 6 hr, 12 hr, 24 hr
- Raw Mode Sampling: Every sample (1 – 500 Hz)

Averaging:

- Multiple averaging windows available with standard mode sampling

Display: 128 x 64 graphics display

Real-Time Clock:

- Year, Month, Day, Hour, Minute, Seconds
- Accuracy of ± 3 minutes per month

Data Storage Capacity: 1 GB (FAT16 file system)

Communications: USB (as mass storage device)

Global Positioning System (Option): GPS RADIONOVA® RF Antenna Module

Power Supply Options:

- 4 “AA” size batteries
- USB, AC-DC power adapter
- USB, external battery power pack (customer supplied)

Battery Life:

- 80 hours life (typical usage with 1 Hz sampling and logging rate)
- 40 hours life (typical usage with GPS option on)

Environmental Conditions:

- Operating Temperature Range: -20 to 50°C
- Humidity Range: 0 to 95% RH (non-condensing conditions)
- Storage Temperature Range: -40 to 65°C

Size: 20.9 x 9.8 x 3.5 cm (8.2" x 3.9" x 1.4")

Weight: 0.454 kg (1.0 lb) with batteries

Specifications subject to change without notice.

LI-250A Light Meter

The LI-250A Light Meter provides a direct digital readout for any LI-COR radiation sensor equipped with a BNC connector. It displays instantaneous sensor output or 15-second averages, along with measurement units for any LI-COR sensor (µmol s^{-1} m^{-2}, lux, klux, or W m^{-2}).

Why choose the LI-250A?

- Retains two sensor multipliers in memory to aid in switching between sensors, or for storing in-air and in-water multipliers when used with underwater sensors
- Automatic range selection for the best accuracy and resolution in a wide variety of light environments
- Uses a high-gain amplifier for long-term stability, automatic zeroing, and low input impedance, resulting in excellent linearity

LI-250A Light Meter Specifications

- Accuracy:
  - 25 °C: Typically ± 0.4% of reading ± 3 counts on the least significant digit displayed (all ranges).
  - 0 - 55 °C: Typically ± 0.6% of reading ± 3 counts on the least significant digit displayed (all ranges).
- Range Selection: Autoranging (3 ranges).
- Linearity: ± 0.05%.
- Sensors: Designed for LI-COR sensors with BNC-type connectors.
- Sensor Calibration: Each sensor is supplied with a calibration multiplier. Calibration multipliers for two sensors can be stored in memory. Calibration multipliers are entered from the keypad.
- Signal Averaging: Sensor output can be collected and displayed as a 15-second average (approximately 60 readings). Averages are retained on the display in HOLD mode.
- Display: 4 ½" digit LCD display. Updated every 0.5 seconds in Instantaneous mode.
- Battery Life: 150 hours typical with continuous operation.
- Power Requirement: One 9V Alkaline battery.
- Operating Conditions: 0 to 55 °C, 0 to 95% RH (non-condensing).
- Storage Conditions: -55 to 60 °C, 0 to 95% RH (non-condensing).
- Size: 14 L × 7.7 W × 3.8 cm D (5.5" × 3" x 1.5").
- Weight: 0.26 kg (0.57 lbs).
- LI-250A Range and Resolution.

Sensor	Range	Resolution
Quantum	199 µmol s^{-1} m^{-2} 1999 19999	0.01 µmol s^{-1} m^{-2} 0.1 1
Pyranometer	19 W m^{-2} 199 1999	0.001 W m^{-2} 0.01 0.1
Photometric	199 lux 1999 19999	0.01 lux 0.1 1

Specifications subject to change without notice.

Science

LI-COR terrestrial light sensors are cosine-corrected, following Lambert's cosine law. A cosine-corrected sensor provides the most accurate measurements of radiation on a flat surface from all angles. Cosine correction ensures accurate measurements under various conditions such as low light levels and low solar elevation angles.

The design of the sensor creates the proper cosine response at angles of incidence up to 82°. Radiation is received by an acrylic disc called a diffuser, or “eye”. When radiation strikes with a greater angle of incidence, more is received by the edge of the diffuser. This compensates for increasing reflection from the top surface as the angle of incidence grows larger. Beyond an angle of about 80°, the rim of the sensor begins to block some light in order to maintain the correct response as more radiation is received by the edge of the diffuser. At a 90° angle of incidence, the rim completely blocks the diffuser, in keeping with a proper cosine response.

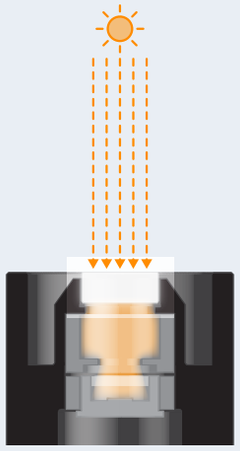
LI-COR light sensors create the proper cosine response at various angles of incidence.

1. 0°: Light is received only by the top surface of the sensor eye.

2. 60°: Light is received by the edge of the eye, compensating for increasing reflection from the top.

3. 80°: The rim of the sensor begins to block some light, preventing too much from striking the edge.

4. 90°: The rim completely blocks the sensor eye, in keeping with a proper cosine response.



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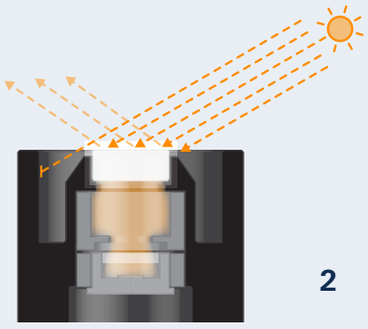

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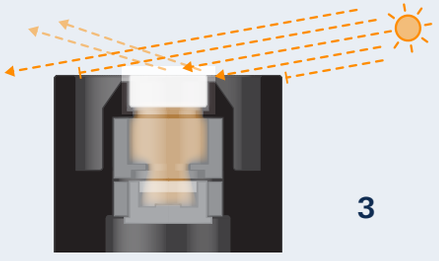

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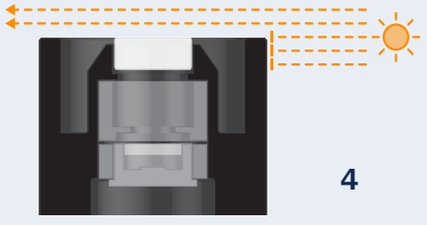

4

LI-COR Calibration Standards

Calibration is an integral step in the manufacture of all LI-COR optical radiation-measuring instruments. Because of slight variation in internal optical components, it is necessary to characterize each individual sensor before it leaves LI-COR. This calibration data is supplied as a "calibration constant," which indicates the amount of sensor output for a given amount of measurable energy input.

Calibration constants are used to convert the raw signal into the appropriate units of solar radiation. A readout device such as the LI-1500 Light Sensor Logger or LI-250A Light Meter can store calibration multipliers to do this conversion automatically. Other loggers and meters must have their data scaled by a factor determined from the calibration constant to derive the appropriate units.

The characteristics of the optical components may be affected by environmental conditions. We recommend recalibration every two years to ensure correct measurements.

Pyranometer Calibration

LI-200R Pyranometers are calibrated against an Eppley® Precision Spectral Pyranometer (PSP) under natural daylight conditions. Calibration uncertainty under these conditions is estimated as ± 3% typical, within ± 60° angle of incidence.*

Quantum Sensor Calibration

Quantum sensors, including the LI-190R, LI-191R, LI-192, and LI-193, are calibrated using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the U.S. National Institute of Standards and Technology (NIST). The absolute calibration specification for quantum sensors is ± 5% (typically ± 3%) traceable to NIST.

Photometric Sensor Calibration

The LI-210R photometric sensors are calibrated using 683 lumens per watt as a value of spectral luminous efficiency at a wavelength of 555 nm. This value conforms to the recommendations of the International Committee for Weights and Measures (CIPM). Calibration is performed using working standard quartz halogen lamps, which have been calibrated against reference standard lamps traceable to the NIST.

*Preliminary specification

Specifications subject to change without notice.

Ordering Information

Sensors

Terrestrial Sensors

Sensor: LI-190R Quantum Sensor, LI-200R Pyranometer, or LI-210R Photometric Sensor

Cable length: 2 m, 5 m, 15 m, or 50 m

Termination type: BNC, bare leads, millivolt adapter, or SMV (Standard Output Millivolt Adapter)

LI-191R Line Quantum Sensor

Each LI-191R includes a bubble level and carrying case.

Cable length: 2 m or 5 m

Termination type: BNC, Millivolt Adapter, or SMV (Standard Output Millivolt Adapter)

Underwater Quantum Sensors

Sensor: LI-192 Underwater Quantum Sensor or LI-193 Spherical Underwater Quantum Sensor

Cable length: 3 m, 10 m, 30 m, 50 m, or 100 m

Termination type: BNC or Millivolt Adapter

Logger and Meter

LI-1500 Light Sensor Logger

The LI-1500 connects up to three light sensors with BNC terminals. Includes four AA batteries, USB cable, AC power supply adapter, carabiner clip, carrying case, Windows® file viewer software. Sensors sold separately.

LI-1500G Light Sensor Logger with GPS

GPS-enabled.

LI-1500G-UW Light Sensor Logger with GPS – Underwater Package

GPS-enabled. Includes underwater lowering frame and carrying case for underwater light sensors, lowering frame, and cables.

LI-1500-UW Light Sensor Logger – Underwater Package

LI-1500 without GPS. Includes underwater lowering frame and carrying case for underwater light sensors, lowering frame, and cables.

LI-250A Light Meter

Connects to any light sensor with a BNC terminal and displays instantaneous or 15-second averaged measurements.

Accessories

1500GPS Upgrade Kit
User-installable upgrade adds GPS functionality to any LI-1500.

1500-01 Underwater Carrying Case
Case holds one LI-1500, underwater lowering frame, two LI-192 Underwater Quantum Sensors, two LI-193 Spherical Underwater Quantum Sensors, one terrestrial sensor (LI-190R, LI-200R, or LI-210R), and 3-meter or 10-meter underwater cable.

LI-250A Carrying Case
Fabric case for the LI-250A and one light sensor.

2001S Sensor Base Cover
Protects the base and cable when the sensor head is removed.

2003S Mounting and Leveling Fixture
For the LI-190R, LI-200R, and LI-210R Sensors. Anodized aluminum with stainless steel leveling screws and a weatherproof spirit level. 7.6 cm diameter (3.0") and 95 g (0.21 lbs.).

2009S Lowering Frame
Mounts one or two LI-192SA or LI-193SA sensors for lowering into water.

2420 Light Sensor Amplifier
Amplifies signal from light sensors. For use with logging devices that require an amplified voltage signal. Provides 15 gain settings to accommodate a wide variety of data loggers.

2420-BNC – For light sensors with BNC connectors.

2420-BL – For light sensors with bare leads.

Millivolt Adapters
Convert BNC connector to bare leads and the output signal to millivolts (mV). For use with logging devices that require a voltage signal. SMV-type adapters feature a standard output (0 to 10 mV) so that multipliers do not need to be changed when changing sensors. SMV-type adapters are factory adjusted to match a particular sensor's output. Provide the sensor's serial number when ordering.

2220 Millivolt Adapter – For the LI-200R Pyranometer.

2290 Millivolt Adapter – For the LI-190R Quantum Sensor, LI-210R Photometric Sensor, and LI-191R Line Quantum Sensor.

2291 Millivolt Adapter – For the LI-192SA and LI-193SA Underwater Sensors.

2320 (SMV) – For the LI-200R Pyranometer.

2319 (SMV) – For the LI-190R Quantum Sensor or LI-191R Line Quantum Sensor.

2321 (SMV) – For the LI-210R Photometric Sensor.

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980-15539 06/15

The LI-COR board of directors would like to take this opportunity to return thanks to God for His merciful providence in allowing LI-COR to develop and commercialize products, through the collective effort of dedicated employees, that enable the examination of the wonders of His works.

"Trust in the LORD with all your heart and do not lean on your own understanding. In all your ways acknowledge Him, and He will make your paths straight."

– Proverbs 3:5,6

ANEXO E:

Hoja de datos del sensor AC CR3111-3000

CR3100 Series

CR3109-1500

CR3110-3000

CR3111-3000

CR3113-2000

The **CR3100** Series Split Core Current Transformer is designed to provide a low cost method to monitoring electrical current. A unique hinge and locking snap allows attachment without interrupting the current-carrying wire. High secondary turn will develop signals up to 10.0 VAC across a burden resistor.

Applications

Portable Instruments
Sub-Metering
Monitor Motor Loads

Features

Small Size
Low Cost
High Secondary Turns
Secure Locking Hinge

Specifications

Maximum Continuous Primary Current	4 X Ir
Insulation Voltage	3500 Vac/1min
Storage Temp.	-45°C thru +85°C
Operating Temp.	-40°C thru +65 °C

Regulatory Agencies

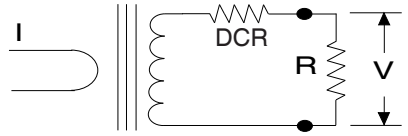
CR3110-3000 ONLY

PART NUMBERS	
CR3109 - 1500	30 AMP
CR3110 - 3000	75 AMP
CR3111 - 3000	100 AMP
CR3113 - 2000	150 AMP

SPLIT CORE CURRENT TRANSFORMERS

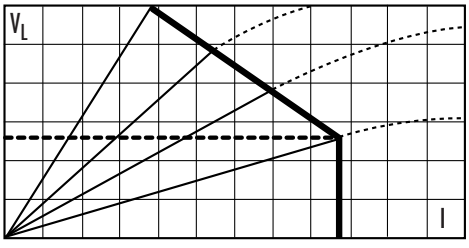
Part Number	Imax	Vmax RMS	Te (typ.)	DCR Ω	Frequency
CR3109-1500	30	5	1510	187	20 - 1 KHz
CR3110-3000	75	15	3100	515	20 - 1 KHz
CR3111-3000	100	19	3150	390	20 - 1 KHz
CR3113-2000	150	16	2125	58	20 - 1 KHz

I_r = Maximum Input Current to be linearly sensed V_{max} = Maximum Voltage (Saturation) CT will develop
T_e = Effective turns ratio including losses (All Specifications tested at 60 Hz)

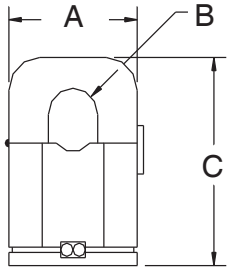


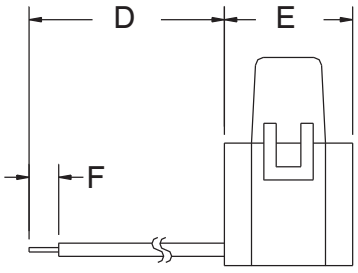
$$V_L = Vmax - \left[\frac{I \times DCR}{T_e} \right] \qquad V = \frac{I \times R}{T_e}$$

For best linearity, choose R such that $V < 0.8\ V_L$



OUTLINE DRAWING





Part Number	A	B	C	D	E	F
CR3109-1500	0.76 (19.2)	0.19 (4.90)	1.24 (31.5)	6.10 (1.55)	0.82 (20.8)	0.20 (5.08)
CR3110-3000	1.00 (25.5)	0.40 (10.2)	1.57 (40.0)	5.91 (150)	1.04 (26.5)	0.24 (6.10)
CR3111-3000	1.24 (31.4)	0.62 (15.7)	1.77 (45.0)	6.10 (155)	1.22 (31.0)	0.20 (5.08)
CR3113-2000	2.68 (68.7)	0.98 (24.9)	2.56 (65.0)	118 (3000)	0.72 (18.4)	0.20 (5.08)

The Professional Energy Monitoring Company
CR MAGNETICS
ISO 9001:2008 Quality Management System

3500 Scarlet Oak Blvd. St. Louis MO USA 63122 V: 636-343-8518 F: 636-343-5119
Web: http://www.crmagnetics.com

E-mail: sales@crmagnetics.com

ANEXO F:

Hoja de datos del sensor DC L01Z100S05

Hall Effect Current Sensors L01Z***S05 Series

Features:

- Open Loop type
- Printed circuit board mounting
- Unipolar power supply
- Aperture for cable or bus bar
- Insulated plastic case according to UL94V0

Advantage:

- Excellent accuracy
- Very good linearity
- Low temperature drift
- Wide frequency bandwidth
- No insertion loss
- High Immunity To External Interference
- Optimised response time
- Current overload capability

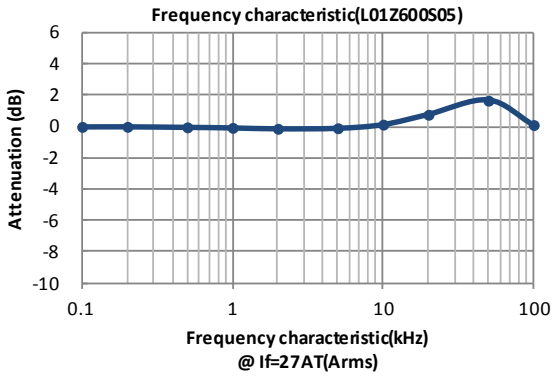
Specifications

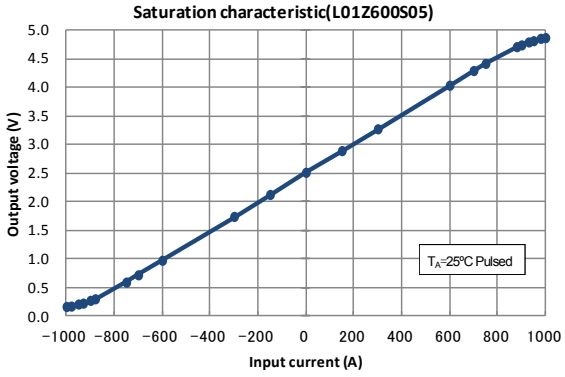
T_A=25ºC, V_{CC}=+5V, R_L=10kΩ

Parameters	Symbol	L01Z050S05	L01Z100S05	L01Z150S05	L01Z200S05	L01Z300S05	L01Z400S05	L01Z500S05	L01Z600S05
Primary nominal current	I_f	50AT	100AT	150AT	200AT	300AT	400AT	500AT	600AT
Saturation current	I_{fmax}	≥ ± I_f × 1.25							
Rated output voltage (at If)	V_o	V_{of}+1.5V ±0.045V	V_{of}+1.5V ± 0.035V						
Offset voltage[1](at If=0A)	V_{of}	V_{REF}[1] ±0.035V	V_{REF}[1] ± 0.030V						
Saturation output voltage	$V_{o\ min/max}$	$V_{o\ min}$ ≤ 0.5V, 4. 5V ≤ $V_{o\ max}$							
Output linearity[2](0A～If)	ε_L	≤ ±1% (at If)							
Power supply voltage	V_{CC}	5V ±2%							
Consumption current	Icc	≤ 15mA							
Response time[3]	t_r	≤ 10μs (at di/dt = 100A / μs)							
Thermal drift of gain[4]	TcVo	≤ ± 2mV/ºC	≤ ± 1.5mV/ºC						
Thermal drift of offset	TcVof	≤ ± 2mV/ºC	≤ ± 1.0mV/ºC						
Hysteresis error (at If=0A→If→0A)	V_{OH}	≤ 8mV			≤ 4mV		≤ 6mV		
Insulation voltage	V_d	AC2500V for 1minute (sensing current 0.5mA), inside of through hole ⇔ terminal							
Insulation resistance	R_{IS}	≥ 500MΩ (at DC500V), inside of through hole ⇔ terminal							
Ambient operation temperature	T_A	-10ºC~+80ºC							
Ambient storage temperature	T_S	-15ºC~+85ºC							

[1] V_{REF} = V_{CC}./ 2 (ratiometric). After removal of core hysteresis— [2] Without offset — [3] Time between 90% input current full scale and 90% of sensor output full scale — [4] Without Thermal drift of offset

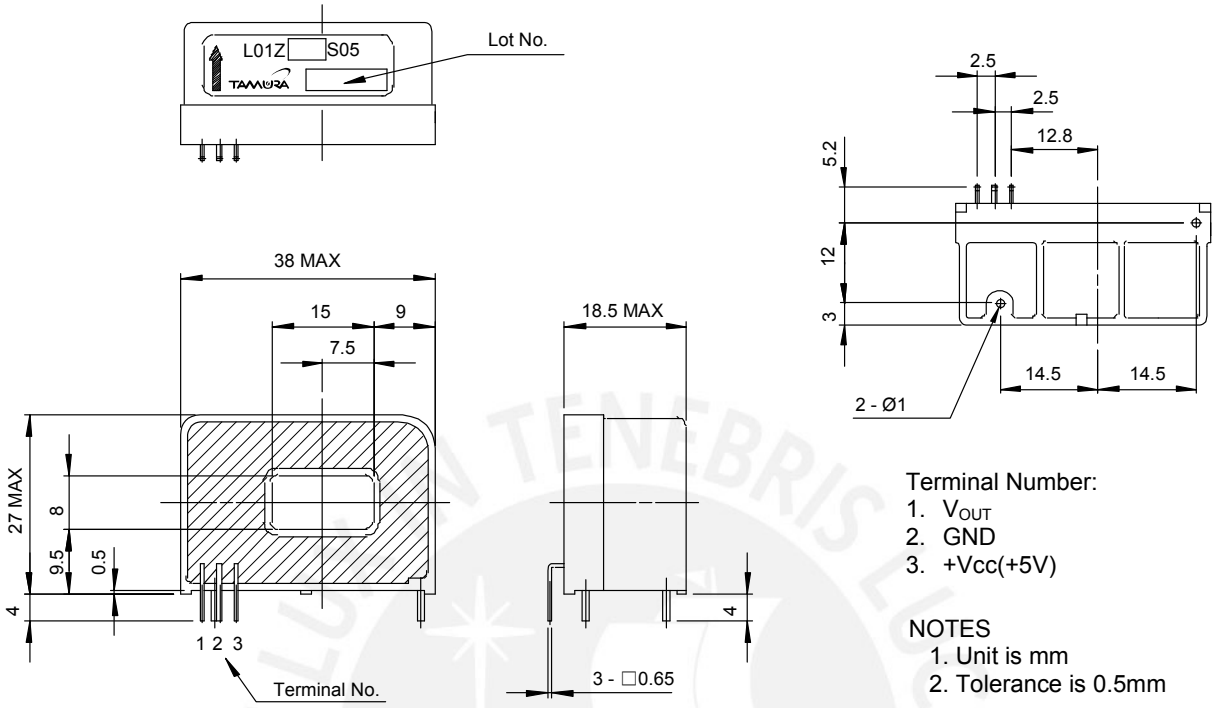
Electrical Performances





Hall Effect Current Sensors L01Z***S05 Series

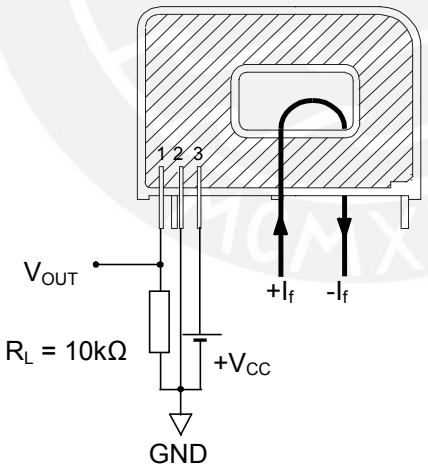
Mechanical dimensions



Terminal Number:
1. V_{OUT}
2. GND
3. +Vcc(+5V)

NOTES
1. Unit is mm
2. Tolerance is 0.5mm

Electrical connection diagram



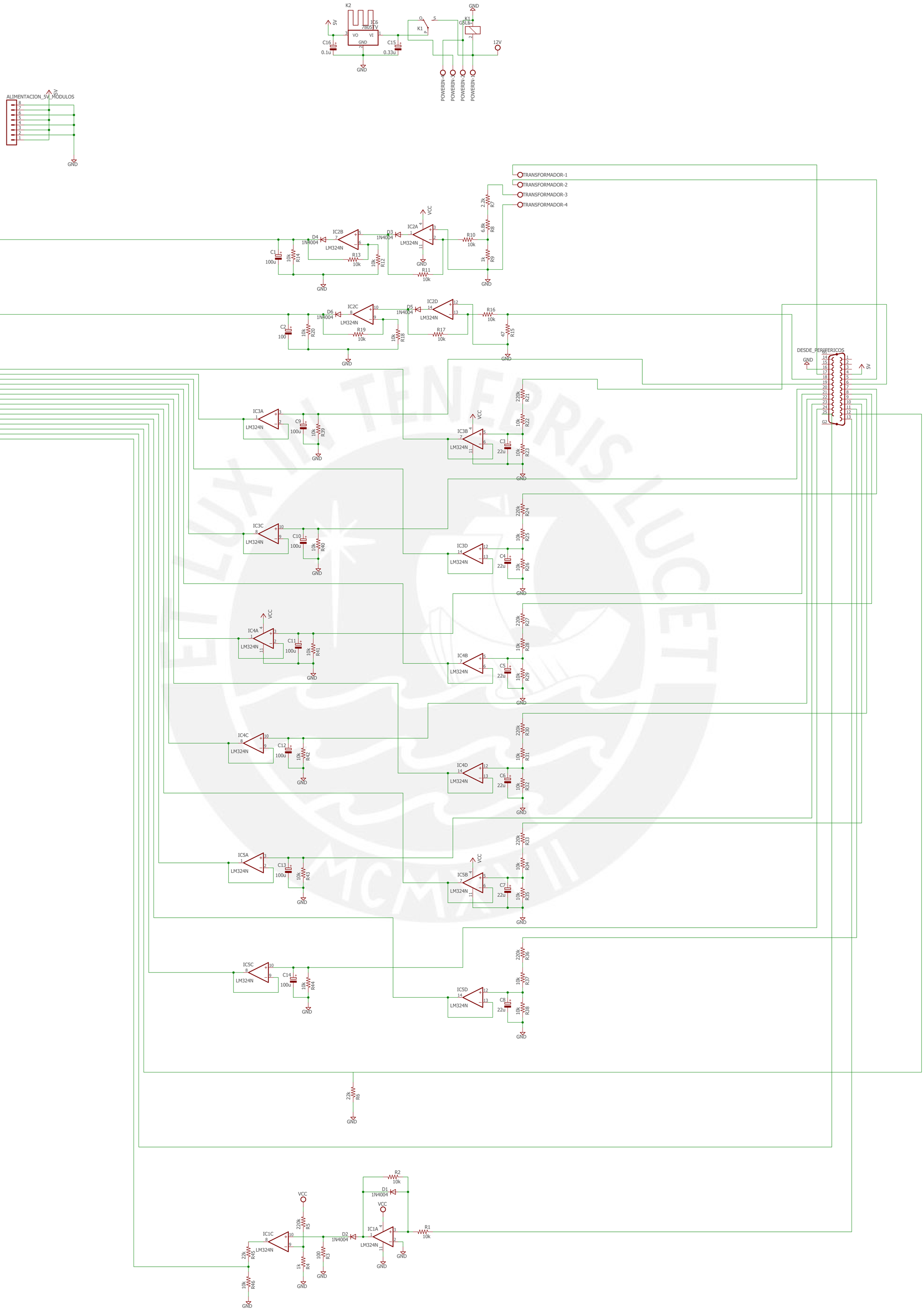
Package & Weight Information

Weight	Pcs/box	Pcs/carton	Pcs/pallet
45g	50	200	4800

ANEXO G:

Diseño y Esquemático de Placa Principal y de Periféricos

Placa Central


ALIMENTACION_5V_MODULOS
5V
GND
K2
5V
IC6
7805TV
VO
VI
GND
C16
0.1u
C15
0.33u
GND
O
S
K1
K1
G5L6-1
GND
12V
POWERIN-4
POWERIN-3
POWERIN-2
POWERIN-1
TRANSFORMADOR-1
TRANSFORMADOR-2
TRANSFORMADOR-3
TRANSFORMADOR-4
HACIA_ARDUINO
GND
DESDE_PERIFERICOS
GND
5V
IC1A
IC1C
IC2A
IC2B
IC2C
IC2D
IC3A
IC3B
IC3C
IC3D
IC4A
IC4B
IC4C
IC4D
IC5A
IC5B
IC5C
IC5D
LM324N
VCC
D1
D2
D3
D4
D5
D6
1N4004
R1
10k
R2
10k
R3
100
R4
1k
R5
220k
R6
22k
R7
2.2k
R8
6.8k
R9
1k
R10
10k
R11
10k
R12
10k
R13
10k
R14
10k
R15
47
R16
10k
R17
10k
R18
10k
R19
10k
R20
10k
R21
220k
R22
10k
R23
10k
R24
220k
R25
10k
R26
10k
R27
220k
R28
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R29
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R39
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R41
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R42
10k
R43
10k
R44
10k
R45
22k
R46
10k
C1
100u
C2
100
C3
22u
C4
22u
C5
22u
C6
22u
C7
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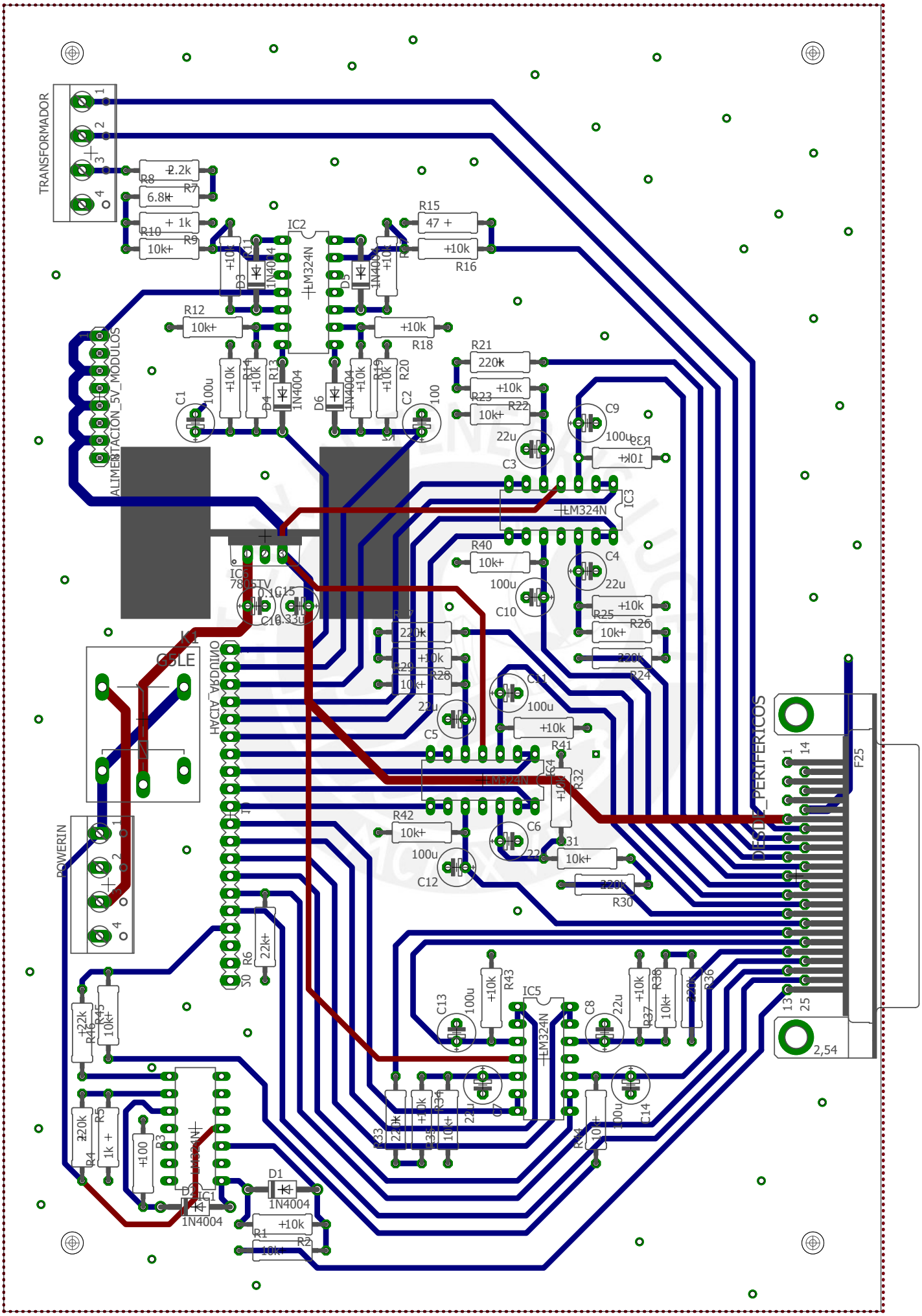
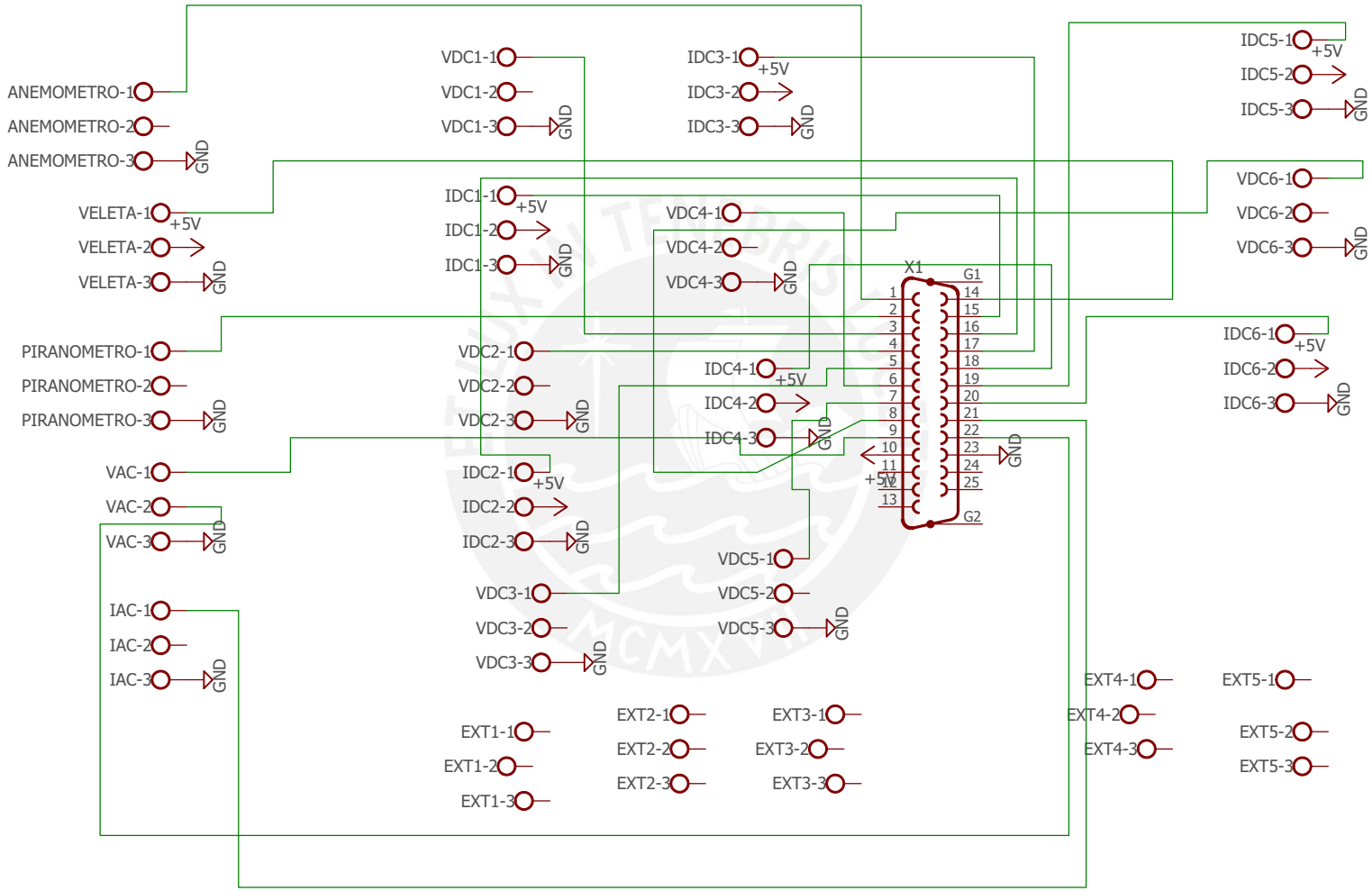
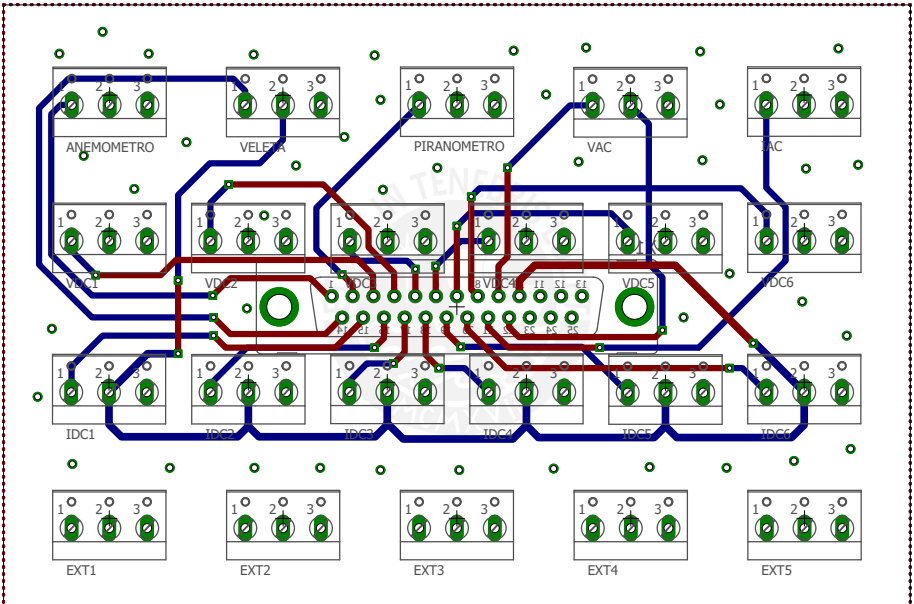
100u
C12
100u
C13
100u
C14
100u


TRANSFORMADOR
ALIMENTACION_5V_MODULOS
SALIDAS_ACTUADORES
DESDE_PERIFERICOS
POWERIN
G5LE
IC1
IC2
IC3
IC5
LM324N
7805TV
1N4004
2,54

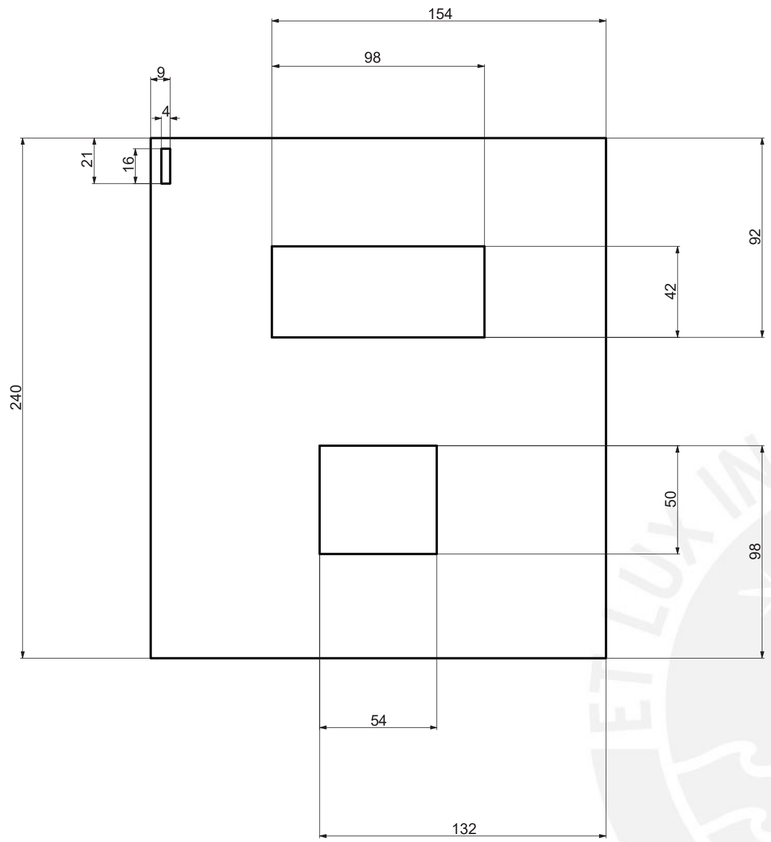
Placa de Conexiones

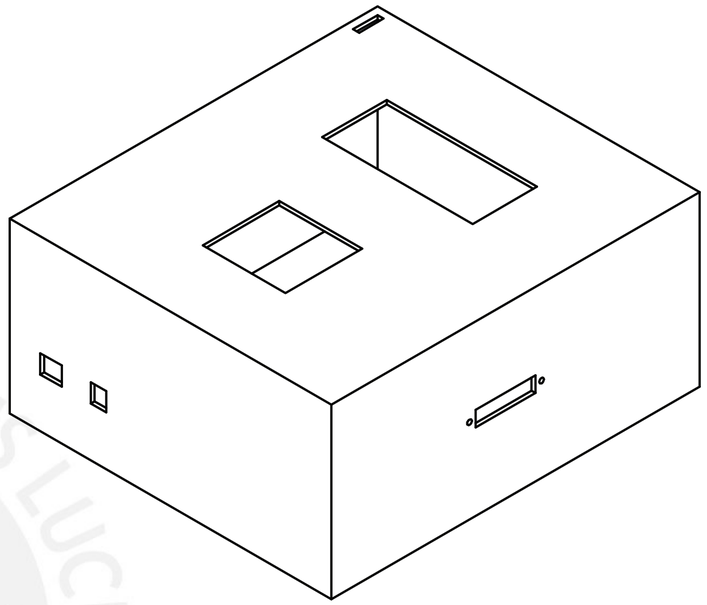

ANEMOMETRO-1
ANEMOMETRO-2
ANEMOMETRO-3
GND
VELETA-1
+5V
VELETA-2
VELETA-3
GND
PIRANOMETRO-1
PIRANOMETRO-2
PIRANOMETRO-3
GND
VAC-1
VAC-2
VAC-3
GND
IAC-1
IAC-2
IAC-3
GND
VDC1-1
VDC1-2
VDC1-3
GND
IDC1-1
+5V
IDC1-2
IDC1-3
GND
VDC2-1
VDC2-2
VDC2-3
GND
IDC2-1
+5V
IDC2-2
IDC2-3
GND
VDC3-1
VDC3-2
VDC3-3
GND
EXT1-1
EXT1-2
EXT1-3
EXT2-1
EXT2-2
EXT2-3
IDC3-1
+5V
IDC3-2
IDC3-3
GND
EXT3-1
EXT3-2
EXT3-3
VDC4-1
VDC4-2
VDC4-3
GND
IDC4-1
+5V
IDC4-2
IDC4-3
GND
VDC5-1
VDC5-2
VDC5-3
GND
X1
G1
G2
+5V
GND
EXT4-1
EXT4-2
EXT4-3
IDC5-1
+5V
IDC5-2
IDC5-3
GND
EXT5-1
EXT5-2
EXT5-3
VDC6-1
VDC6-2
VDC6-3
GND
IDC6-1
+5V
IDC6-2
IDC6-3
GND

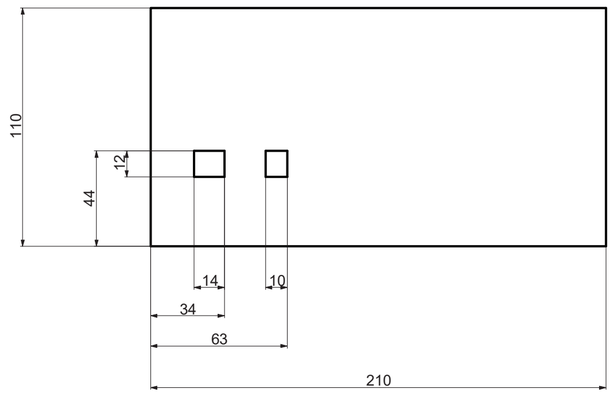

ANEMOMETRO
VELETA
PIRANOMETRO
VAC
VAC
VDC1
VDC2
VDC3
VDC4
VDC5
VDC6
IDC1
IDC2
IDC3
IDC4
IDC5
IDC6
EXT1
EXT2
EXT3
EXT4
EXT5

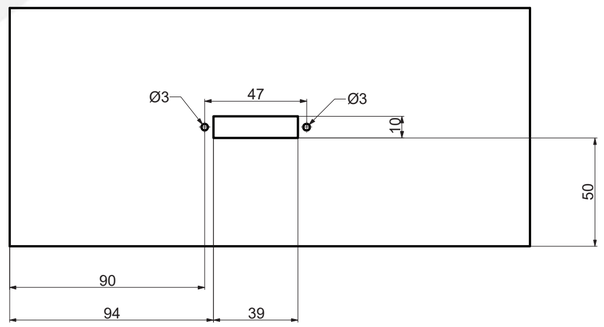
ANEXO H:

Diseño de chasis del dispositivo de monitoreo









UNIDAD: MILIMETROS

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ
FACULTAD DE CIENCIAS E INGENIERÍA - INGENIERÍA ELECTRÓNICA

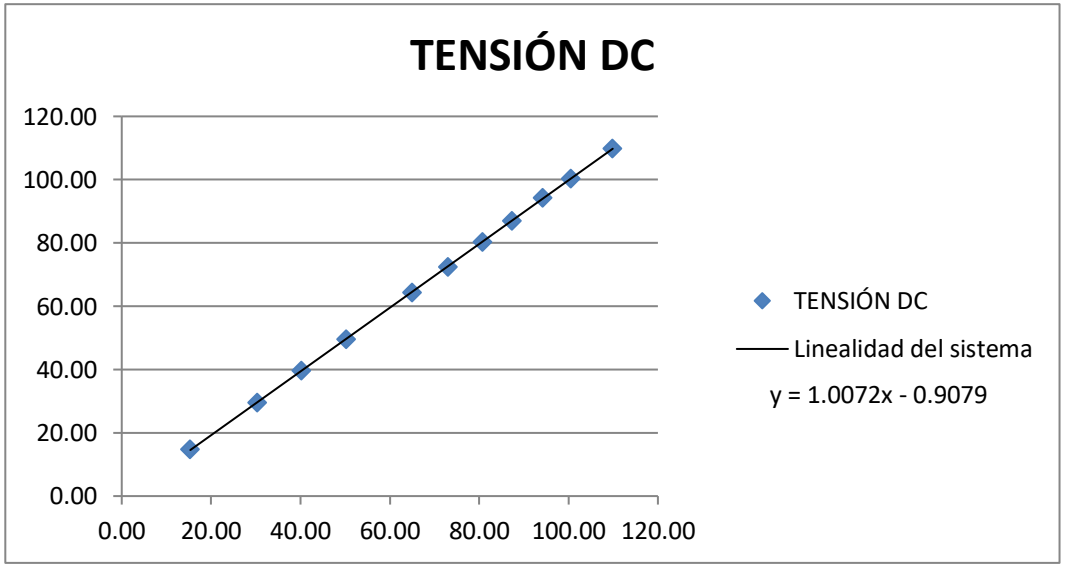
DISPOSITIVO DE MONITOREO PARA UNA MICRO-RED ELÉCTRICA CHASIS	ESCALA 1 : 2
VICENTE MAURICIO, RICHARD BRYAN	FECHA: 14.05.2019

ANEXO I:

Datos y cálculos del sistema de monitoreo

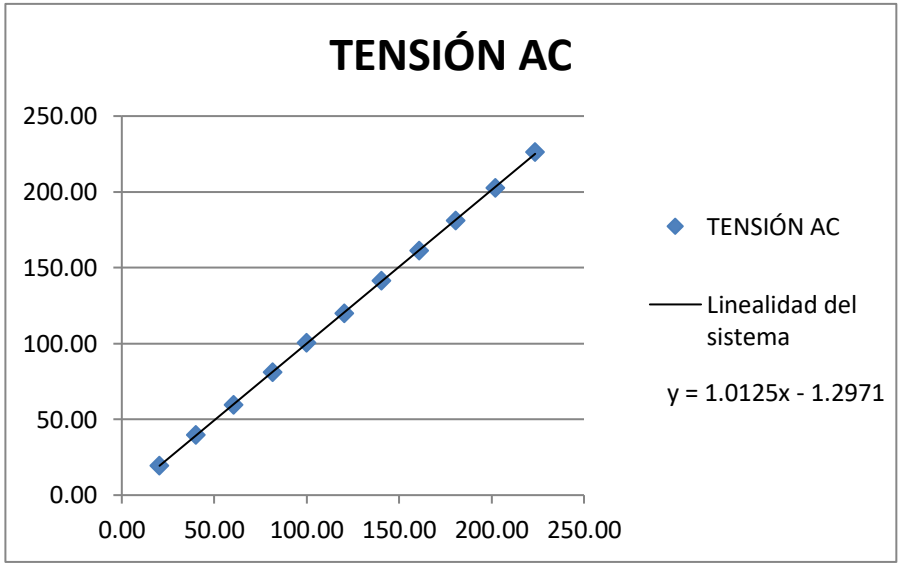
TENSIÓN DC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
15	14.77	14.77	14.77	14.77	15.36	0.00	-3.84
30	29.65	29.65	29.65	29.65	30.33	0.00	-2.24
40	39.61	39.61	39.61	39.61	40.30	0.00	-1.71
50	49.69	49.69	49.69	49.69	50.30	0.00	-1.21
65	64.45	64.45	64.45	64.45	65.00	0.00	-0.85
73	72.42	72.42	72.42	72.42	73.00	0.00	-0.79
80	80.39	80.39	80.39	80.39	80.80	0.00	-0.51
87	87.07	87.07	87.07	87.07	87.40	0.00	-0.38
95	94.22	94.34	94.22	94.26	94.30	0.07	-0.04
100	100.46	100.46	100.46	100.46	100.60	0.00	-0.14
110	109.92	109.80	109.92	109.88	109.90	0.07	-0.02
					PROMEDIO	**0.01**	**-1.07**



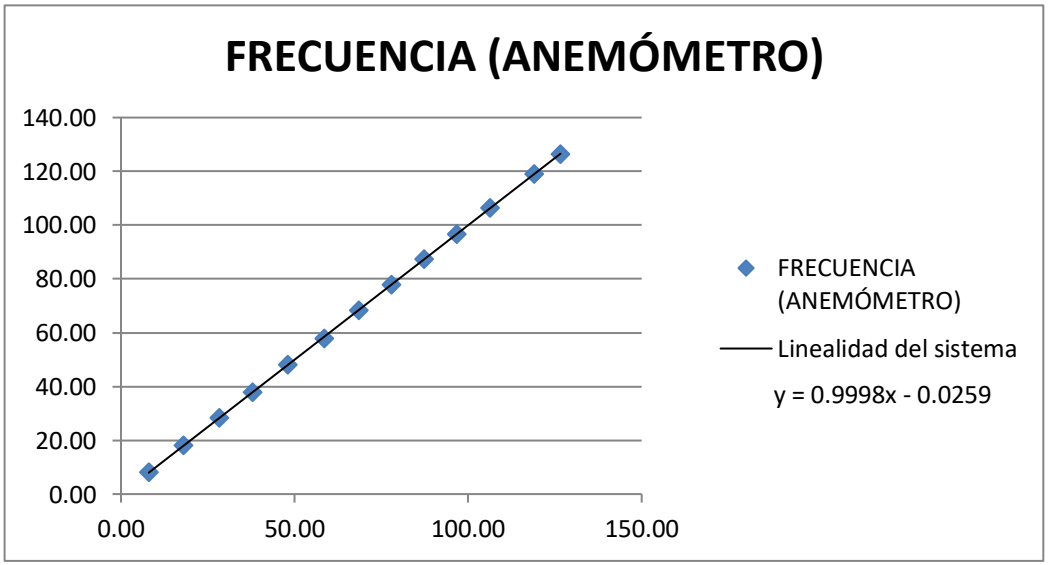
TENSIÓN AC

Valor Referencial	DATOS					CÁLCULOS	
	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio			
20	19.54	19.54	19.54	19.54	20.40	0.00	-4.22
40	39.69	39.69	39.77	39.72	40.15	0.05	-1.08
60	59.53	59.53	59.53	59.53	60.40	0.00	-1.44
80	81.20	80.90	80.90	81.00	81.60	0.17	-0.74
100	100.74	100.74	100.44	100.64	100.00	0.17	0.64
120	119.97	119.97	119.97	119.97	120.40	0.00	-0.36
140	140.43	141.65	141.65	141.24	140.50	0.70	0.53
160	161.80	161.49	161.18	161.49	161.00	0.31	0.30
180	181.64	180.72	181.33	181.23	180.70	0.47	0.29
200	202.40	203.01	202.70	202.70	202.00	0.31	0.35
220	227.43	226.21	224.64	226.09	223.60	1.40	1.12
					PROMEDIO	**0.33**	**-0.42**



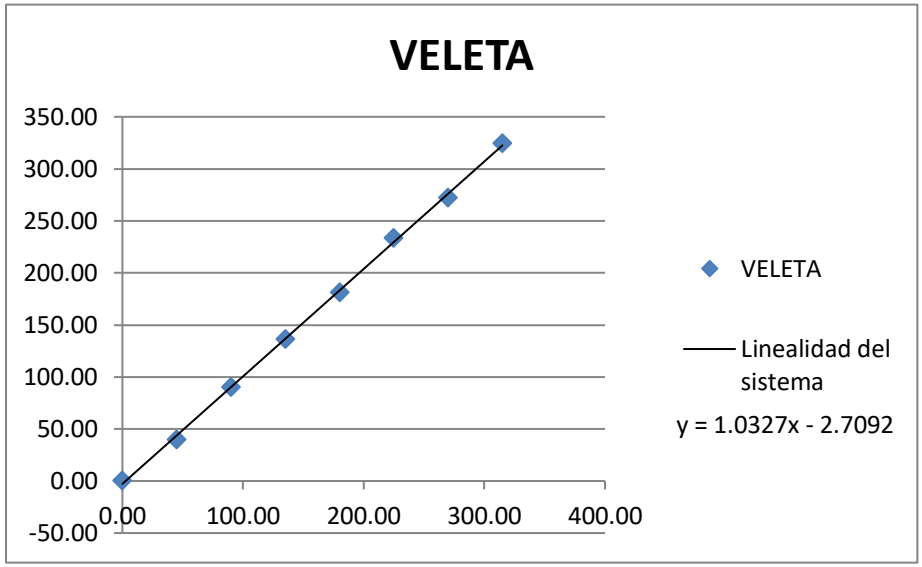
FRECUENCIA (ANEMÓMETRO)

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Osciloscopio Tektronix	Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio			
8.00	8.01	8.01	8.01	8.01	8.00	0.00	0.12
18.00	18.07	18.07	18.07	18.07	18.05	0.00	0.11
28.00	28.32	28.32	28.32	28.32	28.25	0.00	0.25
38.00	37.98	37.98	37.98	37.98	37.88	0.00	0.26
48.00	48.05	48.05	48.05	48.05	48.08	0.00	-0.06
58.00	57.91	57.91	57.91	57.91	58.47	0.00	-0.96
68.00	68.31	68.31	68.31	68.31	68.50	0.00	-0.28
78.00	77.96	77.96	77.96	77.96	77.88	0.00	0.10
88.00	87.44	87.44	87.44	87.44	87.41	0.00	0.03
98.00	96.73	96.73	96.73	96.73	96.71	0.00	0.02
108.00	106.44	106.44	106.44	106.44	106.40	0.00	0.04
118.00	119.14	119.14	119.12	119.13	119.10	0.01	0.03
125.00	126.47	126.49	126.50	126.49	126.60	0.02	-0.09
					PROMEDIO	**0.00**	**-0.03**



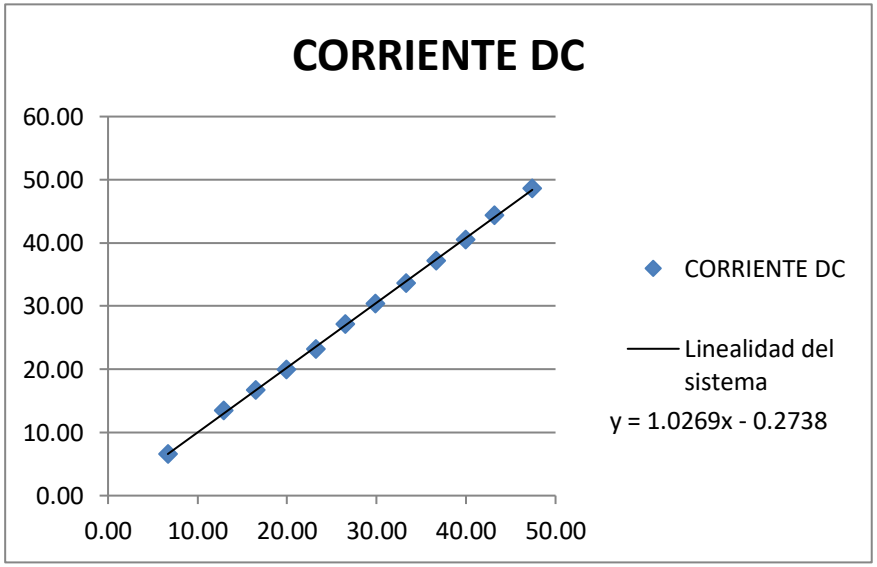
VELETA

Valor Referencial	DATOS				CÁLCULOS	
	Mediciones del Sistema				Precisión	Error de medición (%)
	medida 1	medida 2	medida 8	promedio		
0.00	0.69	0.69	0.69	0.69	0.00	-
45.00	39.91	39.91	39.91	39.91	0.00	-11.31
90.00	90.61	90.61	90.61	90.61	0.00	0.68
135.00	136.38	136.38	136.38	136.38	0.00	1.02
180.00	181.14	181.14	181.14	181.14	0.00	0.63
225.00	233.89	233.89	233.89	233.89	0.00	3.95
270.00	272.41	272.41	272.41	272.41	0.00	0.89
315.00	324.46	324.46	324.46	324.46	0.00	3.00
				PROMEDIO	**0.00**	**-0.16**



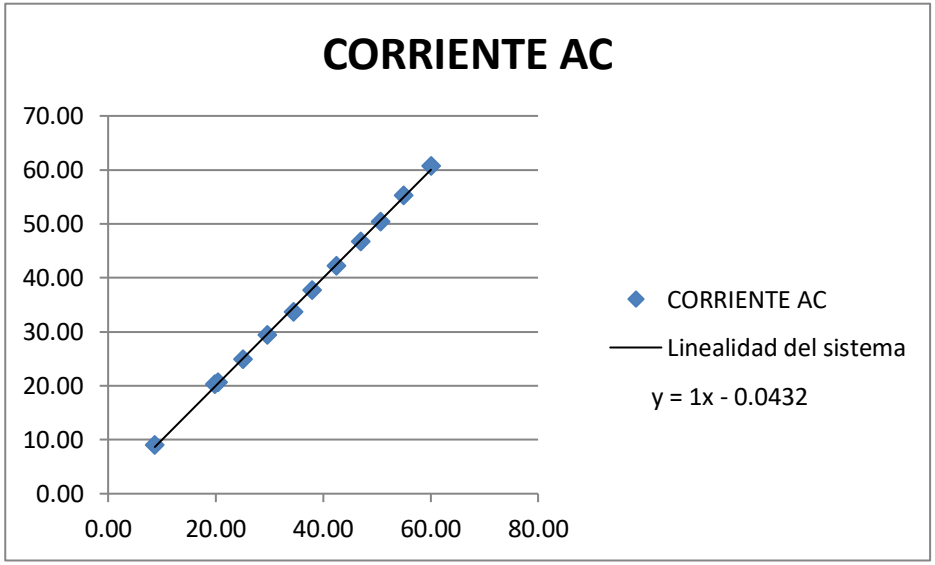
CORRIENTE DC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de Fluke 175	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
6	6.60	6.60	6.60	6.60	6.68	0.00	-1.20
13	13.45	13.45	13.45	13.45	12.96	0.00	3.78
16	16.71	16.71	16.71	16.71	16.47	0.00	1.44
20	19.96	19.96	19.96	19.96	19.95	0.00	0.04
23	23.22	23.22	23.22	23.22	23.22	0.00	0.02
27	27.13	27.13	27.13	27.13	26.48	0.00	2.45
30	30.39	30.39	30.39	30.39	29.90	0.00	1.63
33	33.65	33.65	33.65	33.65	33.28	0.00	1.11
37	37.23	37.23	37.23	37.23	36.64	0.00	1.61
40	40.49	40.49	40.49	40.49	39.96	0.00	1.33
44	44.40	44.40	44.40	44.40	43.18	0.00	2.83
48	48.64	48.64	48.64	48.64	47.41	0.00	2.60
					PROMEDIO	**0.00**	**1.47**



CORRIENTE AC

	DATOS					CÁLCULOS	
Valor Referencial	Mediciones del Sistema				Medición de pinza amperimétrica	Precisión	Error de medición (%)
	medida 1	medida 2	medida 3	promedio			
9	9.01	8.90	9.01	8.97	8.70	0.06	3.14
20	20.30	20.30	20.30	20.30	19.90	0.00	2.01
20.5	20.63	20.63	20.63	20.63	20.50	0.00	0.63
25	24.93	24.93	24.93	24.93	25.10	0.00	-0.68
30	29.43	29.43	29.43	29.43	29.60	0.00	-0.57
33	33.62	33.73	33.62	33.66	34.50	0.06	-2.44
38	37.70	37.70	37.70	37.70	38.00	0.00	-0.79
42	42.31	42.31	42.21	42.28	42.50	0.06	-0.53
47	46.71	46.71	46.71	46.71	47.00	0.00	-0.62
50	50.48	50.38	50.48	50.45	50.70	0.06	-0.50
55	55.09	55.46	55.41	55.32	55.00	0.20	0.58
60	60.75	60.64	60.64	60.68	60.07	0.06	1.01
					PROMEDIO	**0.04**	**0.10**



ANEXO J:

Código fuente para el sistema de monitoreo

```
#include <DS1307RTC.h>
#include <Keypad.h>
#include <Time.h>
#include <TimeLib.h>
#include <Wire.h>
#include <DS1307RTC.h>
#include <SD.h>
#include <SPI.h>
#include <SimpleTimer.h>
#include <FreqMeasure.h>
#include <LiquidCrystal.h>

const byte numRows= 4;
const byte numCols= 4;
char keymap[numRows][numCols]= { {'1', '2', '3', 'A'},
                                 {'4', '5', '6', 'B'},
                                 {'7', '8', '9', 'C'},
                                 {'*', '0', '#', 'D'} };
byte rowPins[numRows] = {30,31,32,33}; //Rows 0 to 3
byte colPins[numCols]= {38,39,40,41}; //Columns 0 to 3
//initializes an instance of the Keypad class
Keypad myKeypad= Keypad(makeKeymap(keymap), rowPins, colPins, numRows, numCols);

const int rs = 12, en = 11, d4 = 25, d5 = 24, d6 = 23, d7 = 22;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

SimpleTimer timer;
double sum=0;
int count=0;
File myFile;
int saveInd=0;
float Sensor0=0;
float Sensor1=0;
float Sensor2=0;
float Sensor3=0;
float Sensor4=0;
float Sensor5=0;
float Sensor6=0;
float Sensor7=0;
float Sensor8=0;
float Sensor9=0;
float Sensor10=0;
float Sensor11=0;
float Sensor12=0;
float Sensor13=0;
float Sensor14=0;
float Sensor15=0;
float Sensor16=0;
```

```
float Sensor[17]={Sensor0, Sensor1, Sensor2, Sensor3, Sensor4, Sensor5, Sensor6, Sensor7,
Sensor8, Sensor9, Sensor10, Sensor11, Sensor12, Sensor13, Sensor14, Sensor15, Sensor16};
String
Unidades[17]={"Vac","Aac","Vdc","Adc","Vdc","Adc","Vdc","Adc","Vdc","Adc","Vdc","Adc","Vd
c","Adc","lum","deg","m/s"};


int Ind=0;
int IndSensor=0;

int Ind0=0;
int Ind1=1;
int Ind2=2;
int Ind3=3;

void setup() {

 //Serial.begin(9600);

 lcd.begin(20, 4);
 lcd.clear();
 lcd.setCursor(6,0);
 lcd.print("Datalogger");
 lcd.setCursor(2,1);
 lcd.print("Trabajo de tesis");
 lcd.setCursor(2,2);
 lcd.print("Vicente Richard");
 lcd.setCursor(7,3);
 lcd.print("20122893");
 delay(3000);

 setSyncProvider(RTC.get);//sincronizar con reloj RTC
 if (timeStatus() != timeSet) {//comprobar que se encuentra conectado al modulo RTC
       lcd.clear();
       lcd.setCursor(1,1);
       lcd.print("No es posible");
       lcd.setCursor(1,2);
       lcd.print("sincronizar reloj");
       delay(3000);}
 else {
       lcd.clear();
       lcd.setCursor(1,1);
       lcd.print("RTC ha sincronizado");
       lcd.setCursor(1,2);
       lcd.print("tiempo del sistema");
       delay(3000);}

 lcd.clear();
```

```
 lcd.setCursor(2,1);
 lcd.print("Iniciando SD ...");
 delay(3000);

 if (!SD.begin(4)) {//comprobar que se encuentra la tarjeta micro sd en canal 4
  lcd.clear();
  lcd.setCursor(0,1);
  lcd.print("No pudo inicializar");
  return;
 }

 lcd.clear();
 lcd.setCursor(3,1);
 lcd.print("Inicializacion");
 lcd.setCursor(6,2);
 lcd.print("exitosa");
 delay(3000);
 SD.begin(4);

 if(!SD.exists("datalog.csv"))//comprobar si no existe el archivo datalog.csv
 {
    myFile = SD.open("datalog.csv", FILE_WRITE);//crear archivo
    if (myFile) {
      lcd.clear();
      lcd.setCursor(3,1);
      lcd.print("Archivo nuevo");
      lcd.setCursor(1,2);
      lcd.print("Escribiendo fila 1");
      delay(3000);
      myFile.println("sep=,");//definir "," como separador
      myFile.println("Fecha(DD/MM/YYY),Hora,Vac1,Iac1,PotAC1,Vdc1,Idc1,PotDC1,Vdc2,Idc2,P
      otDC2,Vdc3,Idc3,PotDC3,Vdc4,Idc4,PotDC4,Vdc5,Idc5,PotDC5,Vdc6,Idc6,PotDC6,IntLum,D
      irViento,VelViento");//Indices de valores
      myFile.close();
    }
 }

 timer.setInterval(1000, mainCode);//ejecutar mainCode cada 1000 milisegundos
 FreqMeasure.begin();       //iniciar medición de frecuencia
 Ind==0;

}
```

```
void loop() {

  timer.run();            //iniciar timer

  if (FreqMeasure.available()) {//calcular promedio de lecturas
  sum = sum + FreqMeasure.read();
  count = count + 1;
   if (count > 30) {
    Sensor16 = ((FreqMeasure.countToFrequency(sum / count))*96)/125;
    sum = 0;
    count = 0;
   }
  }
  char keypressed = myKeypad.getKey();
  if (keypressed != NO_KEY){
      if (Ind==0){
       if (keypressed=='1'){
         Ind=1;
         IndSensor=0;
       }
       else if (keypressed=='2'){
         Ind=2;
       }
       else if (keypressed=='3'){
         Ind=3;
       }
       else if (keypressed=='4'){
         Ind=4;
       }
      }
      else if (Ind==1){
       if (keypressed=='D'){
         Ind=0;
       }
       else if (keypressed=='B'){
         if (IndSensor<16){IndSensor=IndSensor+1;}
         else {IndSensor=0;}
       }
       else if (keypressed=='A'){
         if (IndSensor>0){IndSensor=IndSensor-1;}
         else {IndSensor=16;}
       }
      }
      else if (Ind==2){
       if (keypressed=='D'){
         Ind=0;
       }
      }
```

```
      else if (Ind==3){
        if (keypressed=='D'){
          Ind=0;
        }
      }
      else if (Ind==4){
        if (keypressed=='D'){
          Ind=0;
        }
      }
  }

}

void mainCode(){
  Sensor0 = analogRead(A0)*(5.0/1023.0)*62.459061;          //VAC1
  Sensor[0] = Sensor0;
  Sensor1 = analogRead(A1)*(5.0/1023.0)*21.4289912;          //IAC1
  Sensor[1] = Sensor1;
  Sensor2 = analogRead(A12)*(5.0/1023.0)*24;                 //VDC1
  Sensor[2] = Sensor2;
  if(analogRead(A13)<=3){Sensor3=0;}
  else  {Sensor3 = (((analogRead(A13)*(5.0/1023.0))-2.55)*66.666667);}  //IDC1
  Sensor[3] = Sensor3;
  Sensor4 = analogRead(A10)*(5.0/1023.0)*24;
  Sensor[4] = Sensor4;
  if(analogRead(A11)<=3){Sensor5=0;}
  else  {Sensor5 = (((analogRead(A11)*(5.0/1023.0))-2.55)*66.666667);}
  Sensor[5] = Sensor5;
  Sensor6 = analogRead(A8)*(5.0/1023.0)*24;
  Sensor[6] = Sensor6;
  if(analogRead(A9)<=3){Sensor7=0;}
  else  {Sensor7 = (((analogRead(A9)*(5.0/1023.0))-2.55)*66.666667);}
  Sensor[7] = Sensor7;
  Sensor8 = analogRead(A6)*(5.0/1023.0)*24;
  Sensor[8] = Sensor8;
  if(analogRead(A7)<=3){Sensor9=0;}
  else  {Sensor9 = (((analogRead(A7)*(5.0/1023.0))-2.55)*66.666667);}
  Sensor[9] = Sensor9;
  Sensor10 = analogRead(A4)*(5.0/1023.0)*24;
  Sensor[10] = Sensor10;
  if(analogRead(A5)<=3){Sensor11=0;}
  else  {Sensor11 = (((analogRead(A5)*(5.0/1023.0))-2.55)*66.666667);}
  Sensor[11] = Sensor11;
  Sensor12 = analogRead(A2)*(5.0/1023.0)*24;
  Sensor[12] = Sensor12;
  if(analogRead(A3)<=3){Sensor13=0;}
  else  {Sensor13 = (((analogRead(A3)*(5.0/1023.0))-2.55)*66.666667);}
```

```
  Sensor[13] = Sensor13;
  Sensor14 = analogRead(A14)*(5.0/1023.0)*606.060606;    //sensado de intensidad luminosa
  Sensor[14] = Sensor14;
  Sensor15 = analogRead(A15)*(5.0/1023.0)*71;                //sensado de dirección de viento
  Sensor[15] = Sensor15;
  Sensor[16] = Sensor16;

  if (Ind==0){Home();}
  if (Ind==1){Measurements();}
  if (Ind==2){Status();}
  if (Ind==3){Utilities();}
  if (Ind==4){Settings();}

  if(saveInd<14){      //guardar datos cada 15s
   saveInd=saveInd+1;
  }
  else {
   saveSD();
   saveInd=0;
  }
}

void Home(){
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("1. Medidas");
 lcd.setCursor(0,1);
 lcd.print("2. Status");
 lcd.setCursor(0,2);
 lcd.print("3. Utilidades");
 lcd.setCursor(0,3);
 lcd.print("4. Settings");
}

void Measurements(){

 if(IndSensor==14){
  Ind0=14;
  Ind1=15;
  Ind2=16;
  Ind3=0;
 }
 if(IndSensor==15){
  Ind0=15;
  Ind1=16;
  Ind2=0;
  Ind3=1;
 }
```

```
 if(IndSensor==16){
  Ind0=16;
  Ind1=0;
  Ind2=1;
  Ind3=2;
 }
 if((IndSensor>=0)&&(IndSensor<=13)){
  Ind0=IndSensor;
  Ind1=IndSensor+1;
  Ind2=IndSensor+2;
  Ind3=IndSensor+3;
 }

 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print(Ind0);
 lcd.print(". ");
 lcd.print(Sensor[Ind0]);
 lcd.print(" ");
 lcd.print(Unidades[Ind0]);
 lcd.setCursor(0,1);
 lcd.print(Ind1);
 lcd.print(". ");
 lcd.print(Sensor[Ind1]);
 lcd.print(" ");
 lcd.print(Unidades[Ind1]);
 lcd.setCursor(0,2);
 lcd.print(Ind2);
 lcd.print(". ");
 lcd.print(Sensor[Ind2]);
 lcd.print(" ");
 lcd.print(Unidades[Ind2]);
 lcd.setCursor(0,3);
 lcd.print(Ind3);
 lcd.print(". ");
 lcd.print(Sensor[Ind3]);
 lcd.print(" ");
 lcd.print(Unidades[Ind3]);
}

void Status(){
 lcd.clear();
 lcd.setCursor(0,1);
 lcd.print("2. Status");
}
```

```
void Utilities(){
  lcd.clear();
  lcd.setCursor(0,2);
  lcd.print("3. Utilidades");
}

void Settings(){
  lcd.clear();
  lcd.setCursor(0,3);
  lcd.print("4. Settings");
}

void saveDigits(int digits) {
  myFile.print(":");
  if(digits < 10)
    myFile.print('0');
  myFile.print(digits);
}

void saveSD(void) {

  myFile = SD.open("datalog.csv", FILE_WRITE);  //abrir  el archivo

  if (myFile) {
      //guardar datos en la tarjeta micro sd
      myFile.print(day());
      myFile.print("/");
      myFile.print(month());
      myFile.print("/");
      myFile.print(year());
      myFile.print(",");
      myFile.print(hour());
      saveDigits(minute());
      saveDigits(second());
      myFile.print(",");
      myFile.print(Sensor0);
      myFile.print(",");
      myFile.print(Sensor1);
      myFile.print(",");
      myFile.print(Sensor1*Sensor0);
      myFile.print(",");
      myFile.print(Sensor2);
      myFile.print(",");
      myFile.print(Sensor3);
      myFile.print(",");
      myFile.print(Sensor3*Sensor2);
      myFile.print(",");
      myFile.print(Sensor4);
```

```
      myFile.print(",");
      myFile.print(Sensor5);
      myFile.print(",");
      myFile.print(Sensor5*Sensor4);
      myFile.print(",");
      myFile.print(Sensor6);
      myFile.print(",");
      myFile.print(Sensor7);
      myFile.print(",");
      myFile.print(Sensor7*Sensor6);
      myFile.print(",");
      myFile.print(Sensor8);
      myFile.print(",");
      myFile.print(Sensor9);
      myFile.print(",");
      myFile.print(Sensor9*Sensor8);
      myFile.print(",");
      myFile.print(Sensor10);
      myFile.print(",");
      myFile.print(Sensor11);
      myFile.print(",");
      myFile.print(Sensor11*Sensor10);
      myFile.print(",");
      myFile.print(Sensor12);
      myFile.print(",");
      myFile.print(Sensor13);
      myFile.print(",");
      myFile.print(Sensor13*Sensor12);
      myFile.print(",");
      myFile.print(Sensor14);
      myFile.print(",");
      myFile.print(Sensor15);
      myFile.print(",");
      myFile.println(Sensor16);

      myFile.close();     //cerrar el archivo

  }
  else {
     lcd.clear();
     lcd.setCursor(3,1);
     lcd.print("Error al abrir");
     lcd.setCursor(5,2);
     lcd.print("el archivo");
     delay(3000);
  }
}
```