PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA

DISEÑO DE EFECTOS Y VARIACIÓN DE COLORES MEDIANTE DEGRADÉ EN LEDS DE POTENCIA RGB APLICADOS A PANELES PUBLICITARIOS

Anexos

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Lima, octubre del 2010

DISPLAYTRONIC

A DIVISION OF ZE XIAMEN CO., LTD.

SPECIFICATIONS FOR LIQUID CRYSTAL DISPLAY

PART NUMBER: **ACM 1602N SERIES**

DATE: **August 9, 1999**

1.0 MECHANICAL SPECS

1. Overall Module Size	85.0mm(W) x 29.5mm(H) x max 13.5mm(D) for LED backlight version 85.0mm(W) x 29.5mm(H) x max 9.5mm(D) for reflective version
2. Dot Size	0.56mm(W) x 0.61mm(H)
3. Dot Pitch	0.61mm(W) x 0.66mm(H)
4. Duty	1/16
5. Controller IC	KS0066
6. LC Fluid Options	TN, STN
7. Polarizer Options	Reflective, Transflective, Transmissive
8. Backlight Options	LED
9. Temperature Range Options	Standard(0ºC ~ 50ºC), Wide(-20ºC ~ 70ºC)

2.0 ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Min	Typ	Max	Unit
Operating temperature (Standard)	Top	0	-	50	ºC
Storage temperature (Standard)	Tst	-10	-	60	ºC
Operating temperature (Wide temperature)	Top	-20	-	70	ºC
Storage temperature (Wide temperature)	Tst	-30	-	80	ºC
Input voltage	Vin	Vss		Vdd	V
Supply voltage for logic	Vdd- Vss	2.7	-	5.5	V
Supply voltage for LCD drive	Vdd- Vo	3.0	4.6	6.5	V

3.0 ELECTRICAL CHARACTERISTICS

Item	Symbol	Condition	Min	Typ	Max	Unit
Input voltage (high)	Vih	H level	2.2	-	Vdd	V
Input voltage (low)	Vil	L level	0	-	0.6	V
Recommended LC Driving Voltage (Standard Temp)	Vdd - Vo	0°C	-	4.8	5.4	V
		25°C	4.2	4.6	-	
		50°C	3.9	4.3	-	
Recommended LC Driving Voltage (Wide Temp)	Vdd -Vo	-20°C	-	6.4	7.2	V
		0°C	-	4.8	-	
		50°C	-	4.2	-	
		70°C	3.5	4.0	-	
Power Supply Current	Idd	Vdd=5.0V, fosc=270kHz	-	0.8	1.8	mA
LED Power Supply Voltage	Vfled	R=6.8Ω	-	4.6	5.0	V
LED Power Supply Current	Ifled	R=6.8Ω	-	120	300	mA

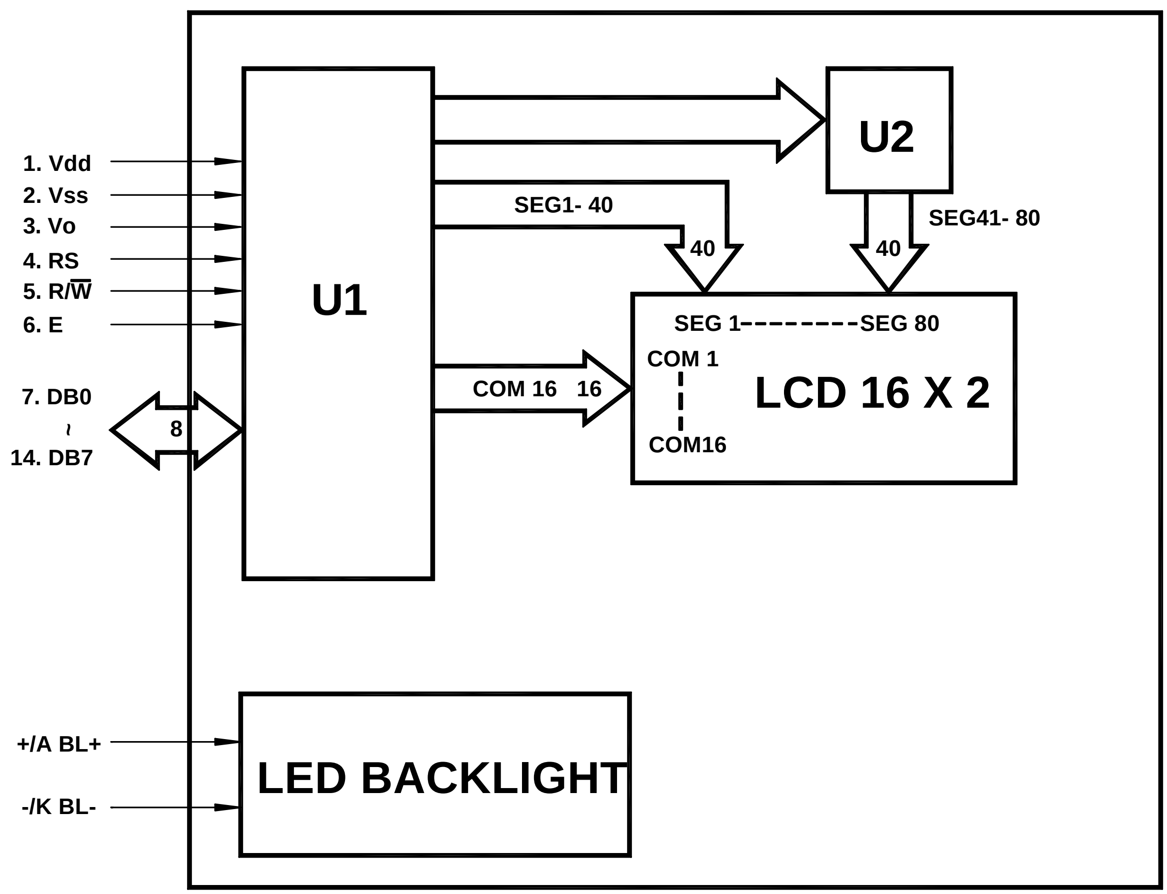
4.0 OPTICAL CHARACTERISTICS (Ta=25°C, Vdd= 5.0V±0.25V, TN LC fluid)

Item	Symbol	Condition	Min	Typ	Max	Unit
Viewing angle (horizontal)	θ	Cr ≥ 4.0	-25	-	-	deg
Viewing angle (vertical)	ϕ	Cr ≥ 4.0	-30	-	30	deg
Contrast Ratio	Cr	ϕ=0°, θ=0°	-	2	-	
Response time (rise)	Tr	ϕ=0°, θ=0°	-	120	150	ms
Response time (fall)	Tf	ϕ=0°, θ=0°	-	120	150	ms

4.1 OPTICAL CHARACTERISTICS (Ta=25°C, Vdd= 5.0V±0.25V, STN LC fluid)

Item	Symbol	Condition	Min	Typ	Max	Unit
Viewing angle (horizontal)	θ	Cr ≥ 2.0	-60	-	35	deg
Viewing angle (vertical)	ϕ	Cr ≥ 2.0	-40	-	40	deg
Contrast Ratio	Cr	ϕ=0°, θ=0°	-	6	-	
Response time (rise)	Tr	ϕ=0°, θ=0°	-	150	250	ms
Response time (fall)	Tf	ϕ=0°, θ=0°	-	150	250	ms

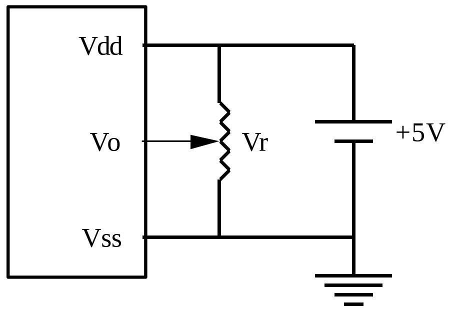
5.0 BLOCK DIAGRAM



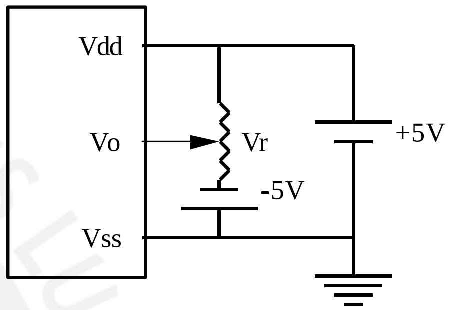
6.0 PIN ASSIGNMENT

Pin No.	Symbol	Function
1	Vdd	+5V
2	Vss	Ground
3	Vo	LCD contrast adjust
4	RS	Register select
5	R/W	Read / write
6	E	Enable
7	DB0	Data bit 0
8	DB1	Data bit 1
9	DB2	Data bit 2
10	DB3	Data bit 3
11	DB4	Data bit 4
12	DB5	Data bit 5
13	DB6	Data bit 6
14	DB7	Data bit 7
+/A	BL+	Power Supply for BL+
-/K	BL-	Power Supply for BL-

7.0 POWER SUPPLY



STANDARD TEMP RANGE



WIDE TEMP RANGE

Vr = 10KΩ ~ 20KΩ

8.0 TIMING CHARACTERISTICS

Item	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Enable cycle time	t_C	Fig. a, Fig. b	500	-	-	ns
Enable pulse width	t_W	Fig. a, Fig. b	220	-	-	ns
Enable rise/fall time	t_R , t_F	Fig. a, Fig. b	-	-	25	ns
RS, R/W set up time	t_{SU}	Fig. a, Fig. b	40	-	-	ns
RS, R/W hold time	t_H	Fig. a, Fig. b	10	-	-	ns
Data delay time	t_D	Fig. b	-	-	120	ns
Data set up time	t_{DSU}	Fig. a	60	-	-	ns
Data hold time	t_{DH}	Fig. a, Fig. b	20	-	-	ns

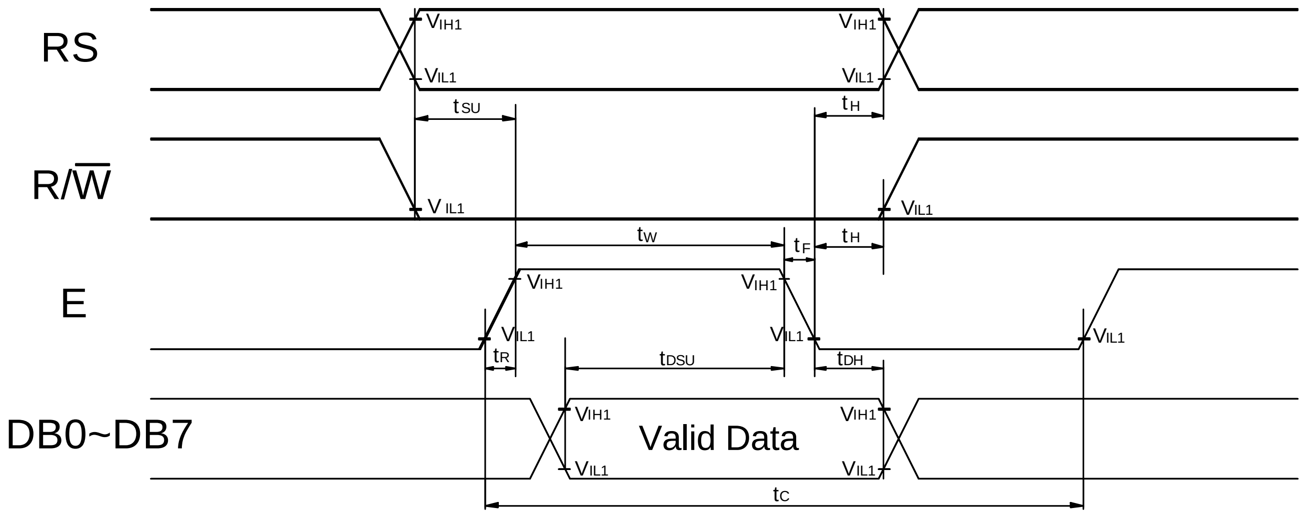


Fig. a Interface timing (data write)

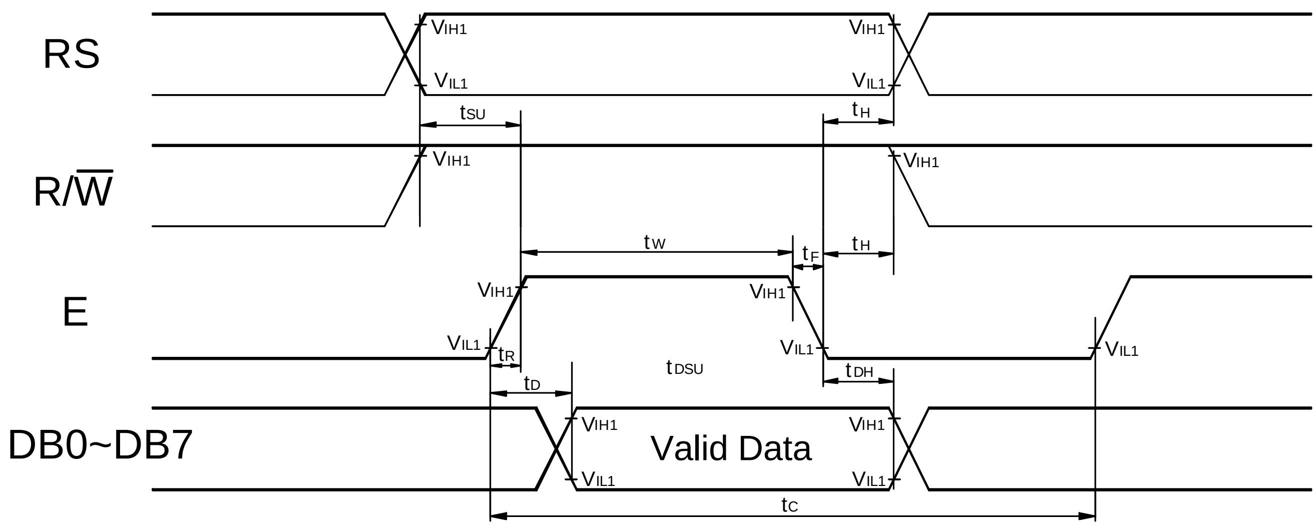
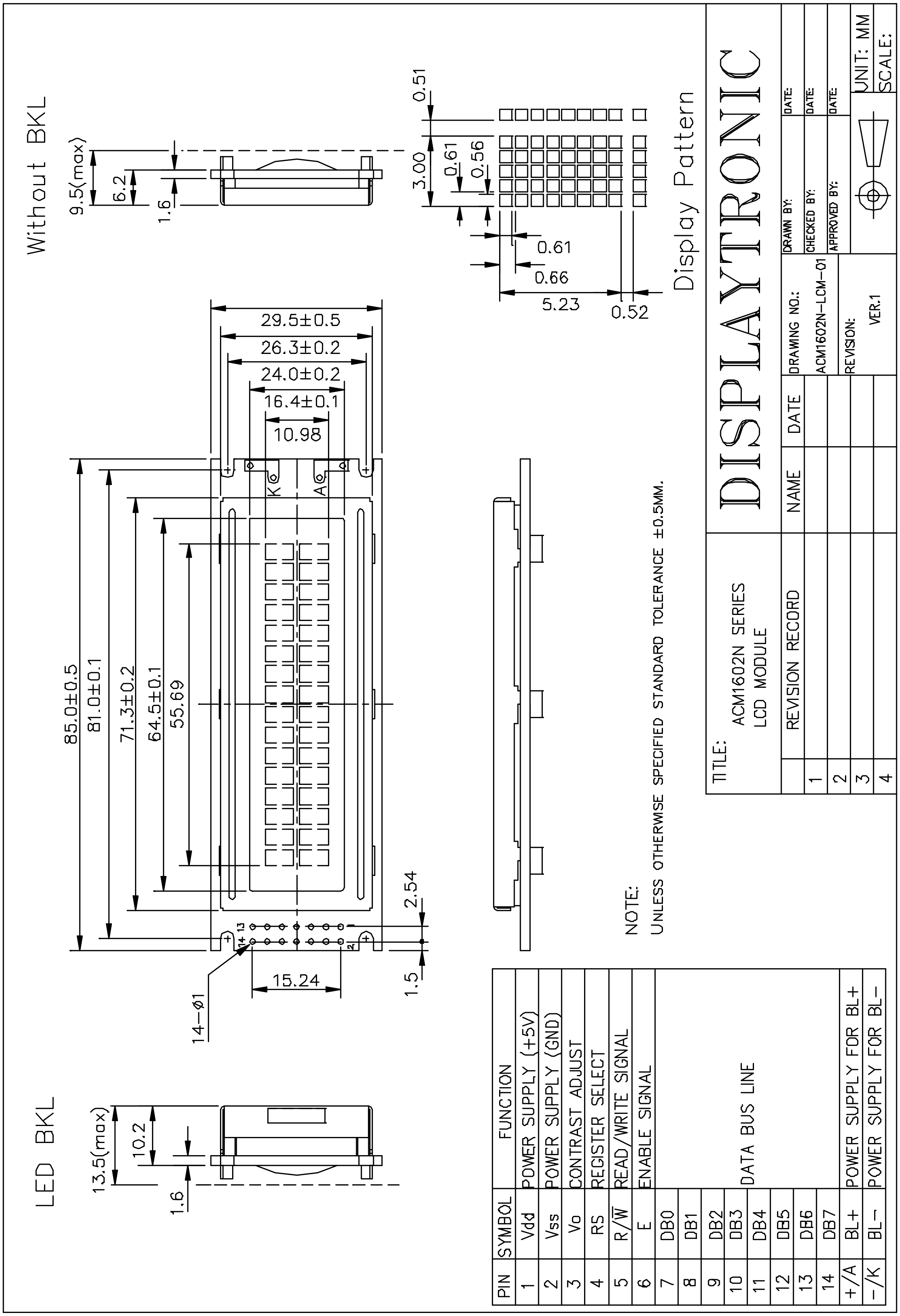


Fig. b Interface timing (data read)

9.0 MECHANICAL DIAGRAM



10.0 RELIABILITY TEST

Storage Condition	Content	Evaluations and Assessment*			
		Current Consumption	Oozing	Contrast	Other Appearances
Operation at high temperature and humidity	40º C,90% RH,240hrs	Twice initial value or less	none	More than 80% of initial value	No abnormality
High temperature storage	60º C, 240hrs	Twice initial value or less	none	More than 80% of initial value	No abnormality
Low temperature storage	-20º C, 240hrs	Twice initial value or less		More than 80% of initial value	No abnormality

*Evaluations and assessment to be made two hours after returning to room temperature (25º C±5º C).
*The LCDs subjected to the test must not have dew condensation.

11.0 DISPLAY INSTRUCTION TABLE

COMMAND	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	DESCRIPTION	Executing time fosc=250khz
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears Display & Returns to Address 0.	1.64ms
Cursor at Home	0	0	0	0	0	0	0	0	1	x	Returns Cursor to Address 0. Also returns the display being shifted to the original position. DDRAM contents remain unchanged.	1.64ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	I/D: Set Cursor Moving Direction I/D=1: Increment I/D=0: Decrement S: Specify Shift of Display S=1: The display is shifted S=0: The display is not shifted	40µs
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Display D=1: Display on D=0: Display off Cursor C=1: Cursor on C=0: Cursor off Brink B=1: Brink on B=0: Brink off	40µs
Cursor / Display Shift	0	0	0	0	0	1	S/C	R/L	x	x	Moves cursor or shifts the display w/o changing DD RAM contents S/C=0: Cursor Shift (RAM unchanged) S/C=1: Display Shift (RAM unchanged) R/L=1: Shift to the Right R/L=0: Shift to the Left	40µs
Function Set	0	0	0	0	1	DL	N	F	x	x	Sets data bus length (DL), # of display lines (N), and character fonts (F). DL=1: 8 bits F=0: 5x7 dots DL=0: 4 bits F=1: 5x10 dots N=0: 1 line display N=1: 2 lines display	40µs
Set CG RAM Address	0	0	0	1	Character Generator (CG) RAM Address						Sets CG RAM address. CG RAM data is sent and received after this instruction.	40µs
Set DD RAM Address	0	0	1	Display Data (DD) RAM Address / Cursor Address							Sets DD RAM address. DD Ram data is sent and received after this instruction.	40µs
Busy Flag / Address Read	0	1	BF	Address counter used for both DD & CG RAM address							Reads Busy Flag (BF) and address counter contents.	40µs
Write Data	1	0	Write Data								Writes data into DDRAM or CGRAM.	46µs
Read Data	1	1	Read Data								Reads data from DDRAM or CGRAM.	46µs

x: Don't Care.

12.0 STANDARD CHARACTER PATTERNS

Lower 4 Bits \ Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
xxxx0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
xxxx0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
xxxx0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
xxxx0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
xxxx0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
xxxx0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
xxxx1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
xxxx1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	⁻¹	y
xxxx1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
xxxx1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	×	万
xxxx1100	(5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
xxxx1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
xxxx1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
xxxx1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Note: The character generator RAM is the RAM with which the user can rewrite character patterns by program.

FAIRCHILD SEMICONDUCTOR®

January 2009

4N25M, 4N26M, 4N27M, 4N28M, 4N35M, 4N36M, 4N37M, H11A1M, H11A2M, H11A3M, H11A4M, H11A5M General Purpose 6-Pin Phototransistor Optocouplers

Features

- UL recognized (File # E90700, Volume 2)
- VDE recognized (File # 102497)
  – Add option V (e.g., 4N25VM)

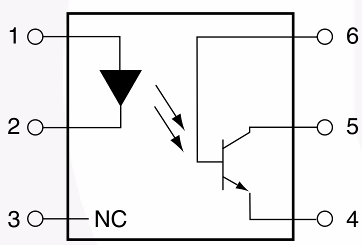
Applications

- Power supply regulators
- Digital logic inputs
- Microprocessor inputs

Description

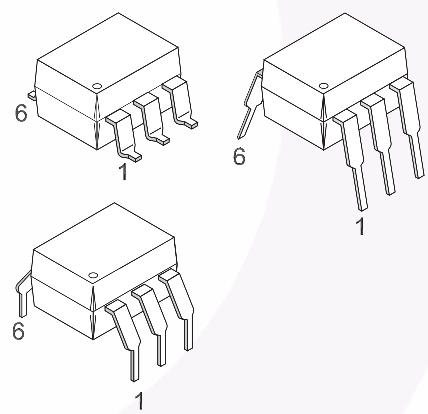
The general purpose optocouplers consist of a gallium arsenide infrared emitting diode driving a silicon phototransistor in a 6-pin dual in-line package.

Schematic



PIN 1. ANODE
2. CATHODE
3. NO CONNECTION
4. EMITTER
5. COLLECTOR
6. BASE

Package Outlines



Absolute Maximum Ratings (T_A = 25°C unless otherwise specified)

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Value	Units
TOTAL DEVICE			
T_{STG}	Storage Temperature	-40 to +150	°C
T_{OPR}	Operating Temperature	-40 to +100	°C
T_{SOL}	Wave solder temperature (see page 8 for reflow solder profile)	260 for 10 sec	°C
P_D	Total Device Power Dissipation @ T_A = 25°C	250	mW
	Derate above 25°C	2.94	
EMITTER			
I_F	DC/Average Forward Input Current	60	mA
V_R	Reverse Input Voltage	6	V
I_F(pk)	Forward Current – Peak (300µs, 2% Duty Cycle)	3	A
P_D	LED Power Dissipation @ T_A = 25°C	120	mW
	Derate above 25°C	1.41	mW/°C
DETECTOR			
V_{CEO}	Collector-Emitter Voltage	30	V
V_{CBO}	Collector-Base Voltage	70	V
V_{ECO}	Emitter-Collector Voltage	7	V
P_D	Detector Power Dissipation @ T_A = 25°C	150	mW
	Derate above 25°C	1.76	mW/°C

Electrical Characteristics (T_A = 25°C unless otherwise specified)

Individual Component Characteristics

Symbol	Parameter	Test Conditions	Min.	Typ.*	Max.	Unit
EMITTER						
V_F	Input Forward Voltage	I_F = 10mA		1.18	1.50	V
I_R	Reverse Leakage Current	V_R = 6.0V		0.001	10	µA
DETECTOR						
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 1.0mA, I_F = 0	30	100		V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100µA, I_F = 0	70	120		V
BV_{ECO}	Emitter-Collector Breakdown Voltage	I_E = 100µA, I_F = 0	7	10		V
I_{CEO}	Collector-Emitter Dark Current	V_{CE} = 10V, I_F = 0		1	50	nA
I_{CBO}	Collector-Base Dark Current	V_{CB} = 10V			20	nA
C_{CE}	Capacitance	V_{CE} = 0V, f = 1 MHz		8		pF

Isolation Characteristics

Symbol	Characteristic	Test Conditions	Min.	Typ.*	Max.	Units
V_{ISO}	Input-Output Isolation Voltage	f = 60Hz, t = 1 sec	7500			Vac(pk)
R_{ISO}	Isolation Resistance	V_{I-O} = 500 VDC	10^{11}			Ω
C_{ISO}	Isolation Capacitance	V_{I-O} = &, f = 1MHz		0.2	2	pF

*Typical values at T_A = 25°C

Electrical Characteristics (Continued) (T_A = 25°C unless otherwise specified)

Transfer Characteristics

Symbol	Parameter	Test Conditions	Device	Min.	Typ.*	Max.	Unit
DC CHARACTERISTICS							
CTR	Current Transfer Ratio, Collector to Emitter	I_F = 10mA, V_{CE} = 10V	4N35M, 4N36M, 4N37M	100			%
			H11A1M	50			
			H11A5M	30			
			4N25M, 4N26M H11A2M, H11A3M	20			
			4N27M, 4N28M H11A4M	10			
		I_F = 10mA, V_{CE} = 10V, T_A = -55°C	4N35M, 4N36M, 4N37M	40			
		I_F = 10mA, V_{CE} = 10V, T_A = +100°C	4N35M, 4N36M, 4N37M	40			
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 2mA, I_F = 50mA	4N25M, 4N26M, 4N27M, 4N28M,			0.5	V
		I_C = 0.5mA, I_F = 10mA	4N35M, 4N36M, 4N37M			0.3	
			H11A1M, H11A2M, H11A3M, H11A4M, H11A5M			0.4	
AC CHARACTERISTICS							
T_{ON}	Non-Saturated Turn-on Time	I_F = 10mA, V_{CC} = 10V, R_L = 100Ω (Fig. 11)	4N25M, 4N26M, 4N27M, 4N28M, H11A1M, H11A2M, H11A3M, H11A4, H11A5M		2		µs
		I_C = 2mA, V_{CC} = 10V, R_L = 100Ω (Fig. 11)	4N35M, 4N36M, 4N37M		2	10	µs
T_{OFF}	Turn-off Time	I_F = 10mA, V_{CC} = 10V, R_L = 100Ω (Fig. 11)	4N25M, 4N26M, 4N27M, 4N28M, H11A1M, H11A2M, H11A3M, H11A4M, H11A5M		2		µs
		I_C = 2mA, V_{CC} = 10V, R_L = 100Ω (Fig. 11)	4N35M, 4N36M, 4N37M		2	10	

* Typical values at T_A = 25°C

Typical Performance Curves

Fig. 1 LED Forward Voltage vs. Forward Current

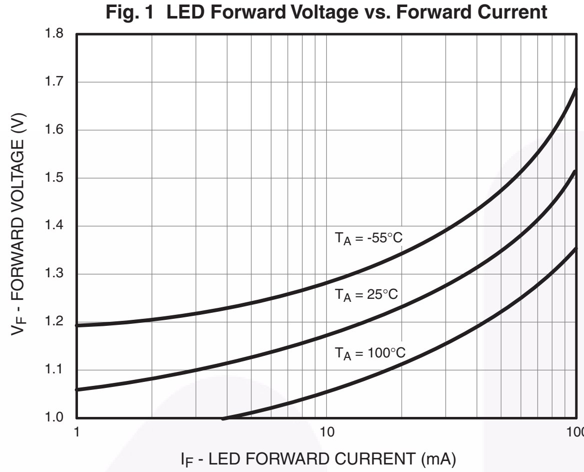


Fig. 2 Normalized CTR vs. Forward Current

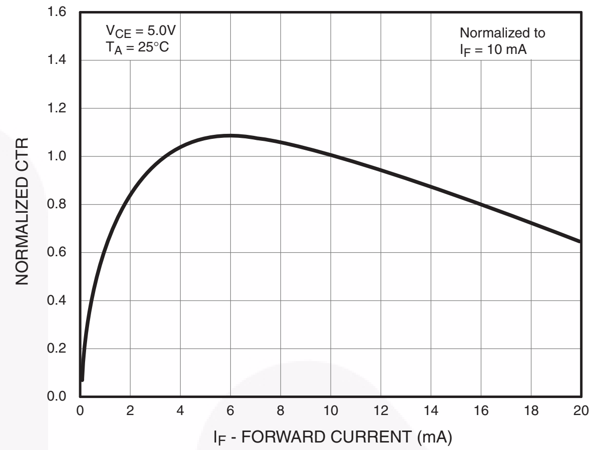


Fig. 3 Normalized CTR vs. Ambient Temperature

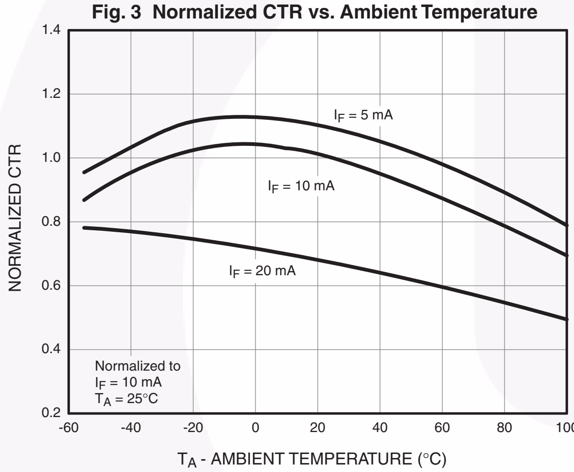


Fig. 4 CTR vs. RBE (Unsaturated)

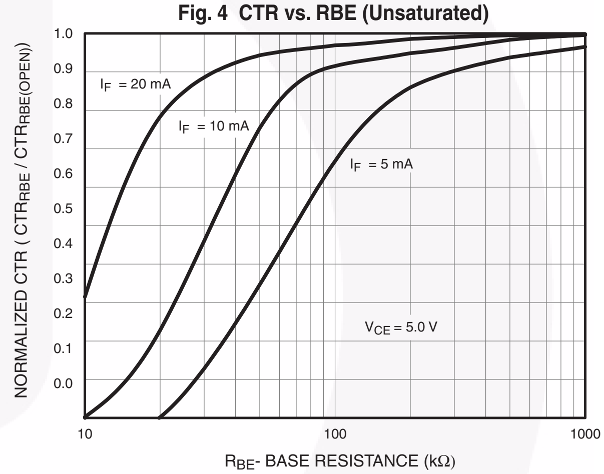


Fig. 5 CTR vs. RBE (Saturated)

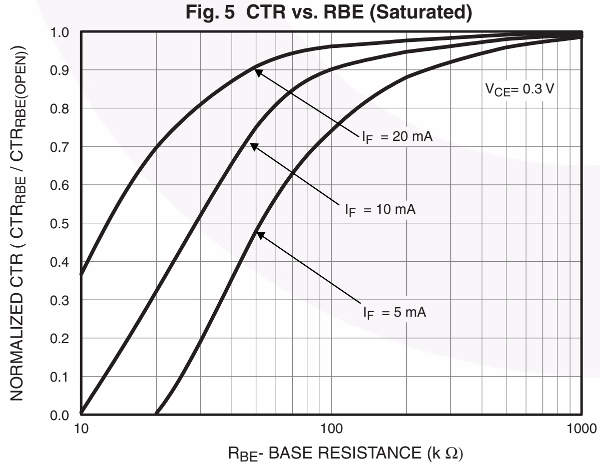
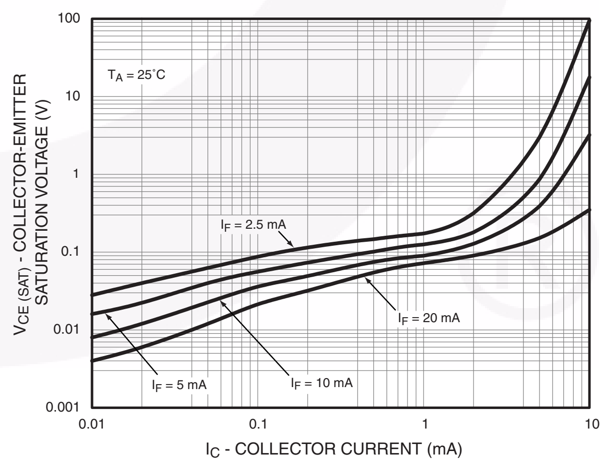


Fig. 6 Collector-Emitter Saturation Voltage vs. Collector Current



Typical Performance Curves (Continued)

Fig. 7 Switching Speed vs. Load Resistor

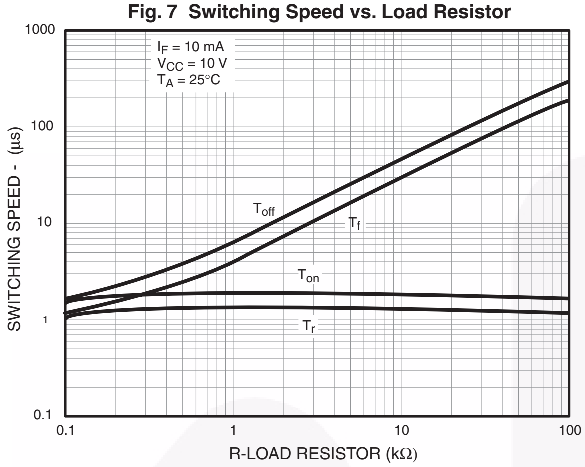


Fig. 8 Normalized t_{on} vs. R_{BE}

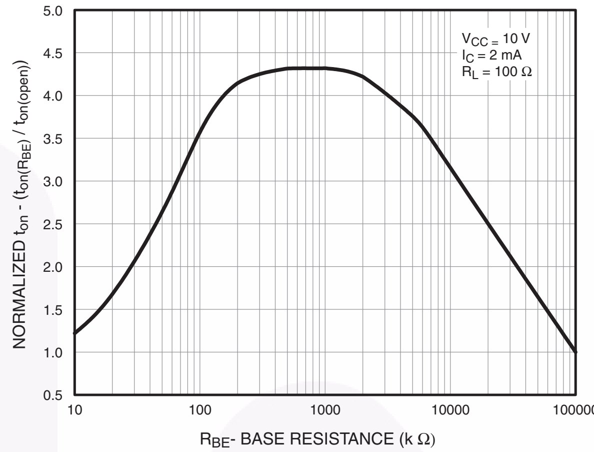


Fig. 9 Normalized t_{off} vs. R_{BE}

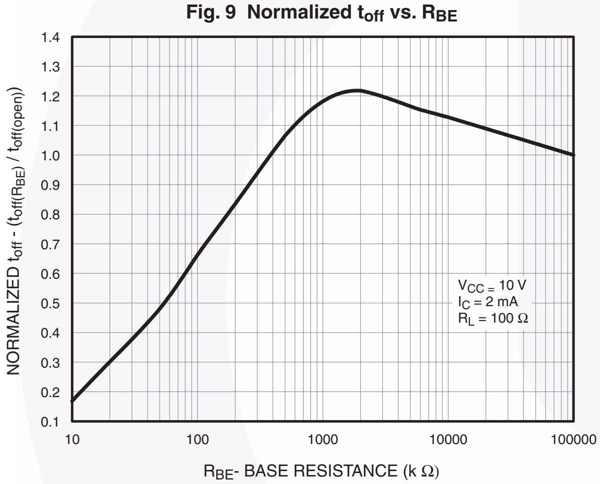
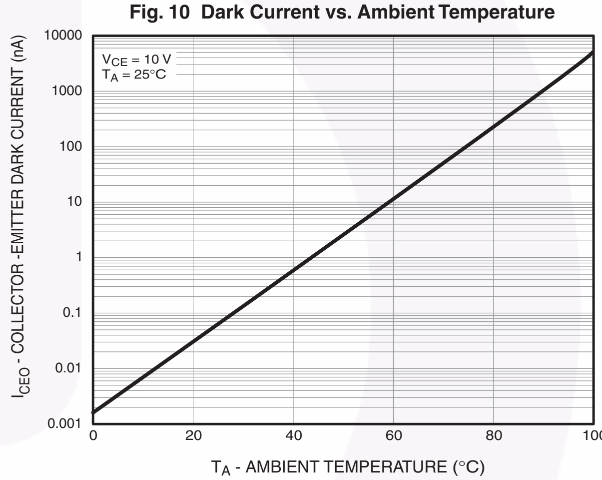


Fig. 10 Dark Current vs. Ambient Temperature



TEST CIRCUIT

WAVE FORMS

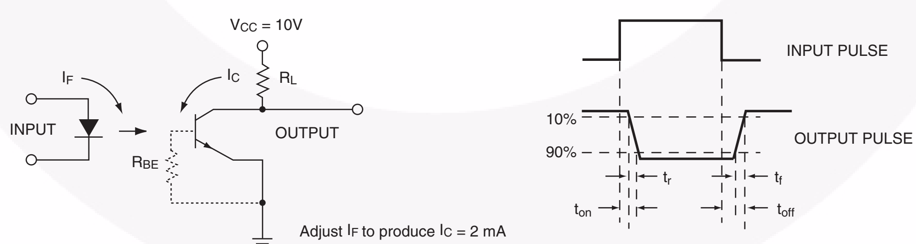
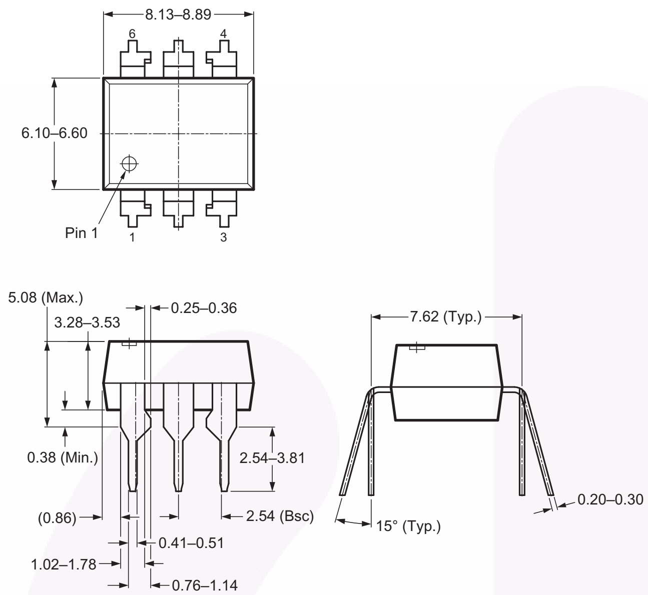


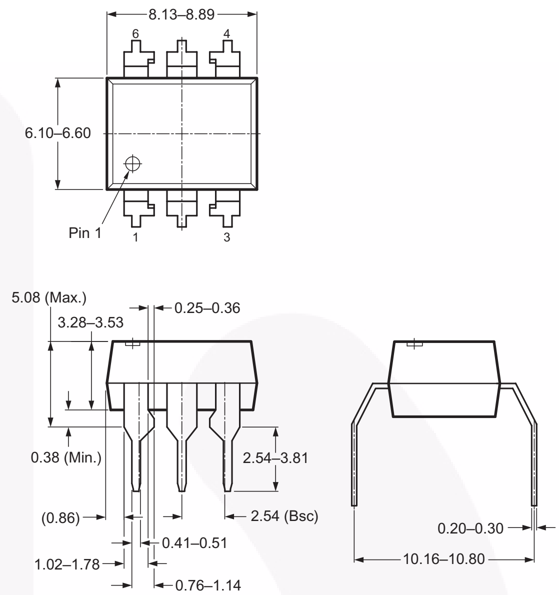
Figure 11. Switching Time Test Circuit and Waveforms

Package Dimensions

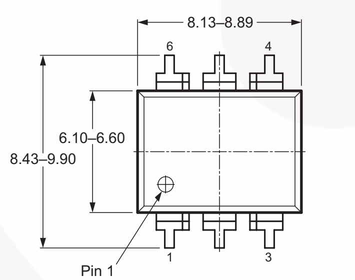
Through Hole

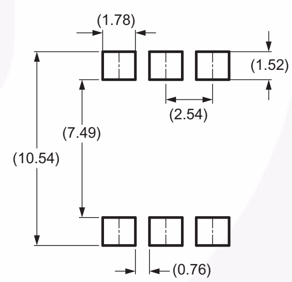


0.4" Lead Spacing

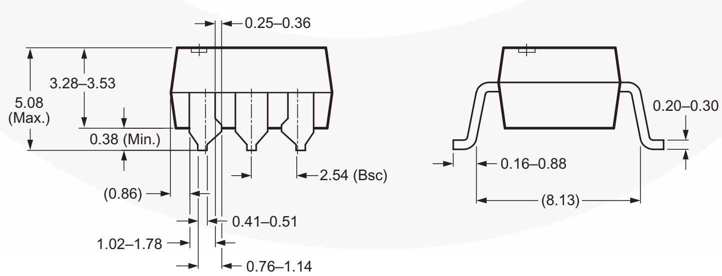


Surface Mount





Rcommended Pad Layout

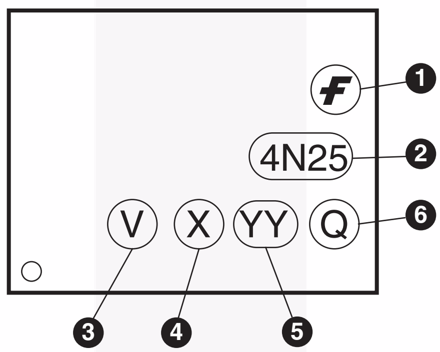


Note:
All dimensions in mm.

Ordering Information

Option	Order Entry Identifier (Example)	Description
No option	4N25M	Standard Through Hole Device
S	4N25SM	Surface Mount Lead Bend
SR2	4N25SR2M	Surface Mount; Tape and Reel
T	4N25TM	0.4" Lead Spacing
V	4N25VM	VDE 0884
TV	4N25TVM	VDE 0884, 0.4" Lead Spacing
SV	4N25SVM	VDE 0884, Surface Mount
SR2V	4N25SR2VM	VDE 0884, Surface Mount, Tape and Reel

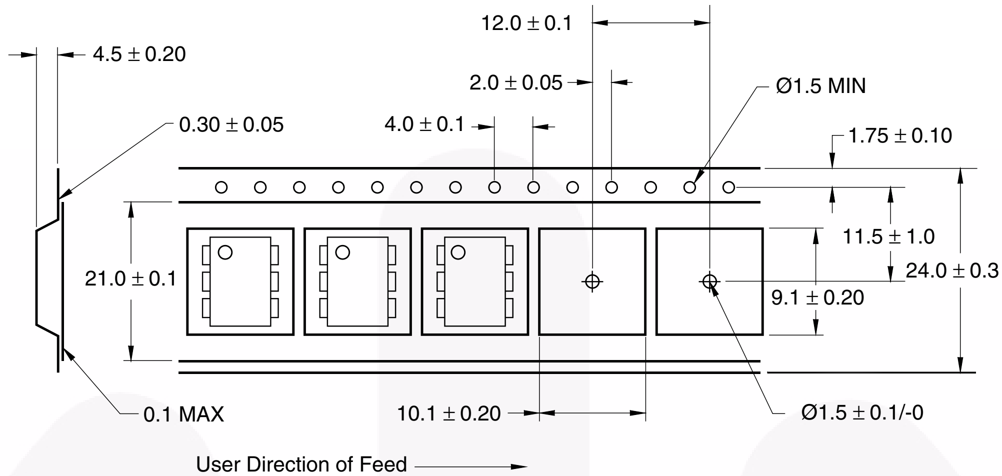
Marking Information



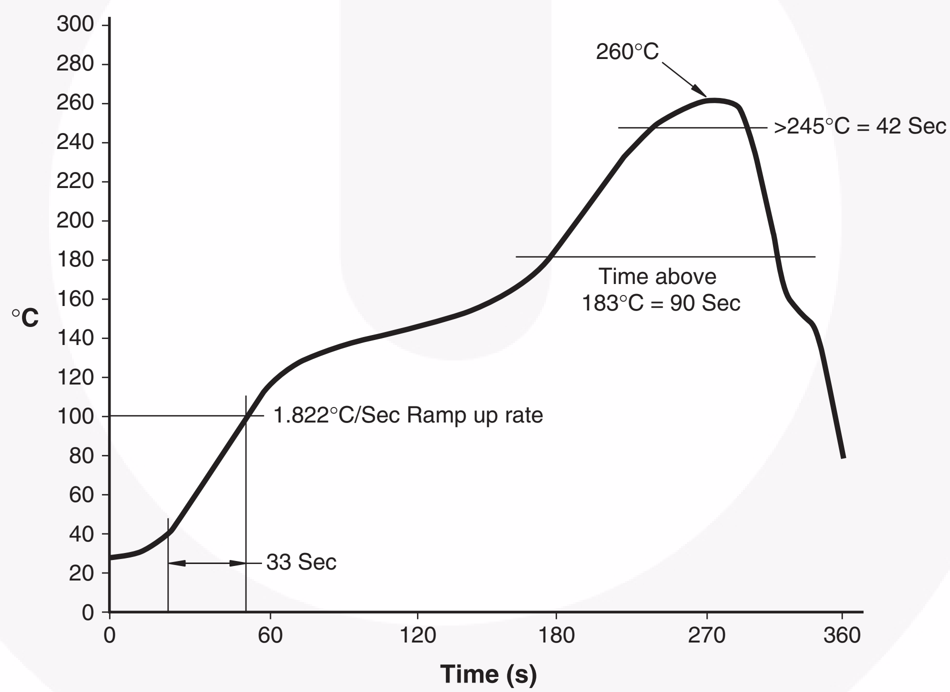
Definitions	
1	Fairchild logo
2	Device number
3	VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table)
4	One digit year code, e.g., ‘7’
5	Two digit work week ranging from ‘01’ to ‘53’
6	Assembly package code

*Note – Parts that do not have the ‘V’ option (see definition 3 above) that are marked with date code ‘325’ or earlier are marked in portrait format.

Carrier Tape Specification



Reflow Profile



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PRODUCT STATUS DEFINITIONS

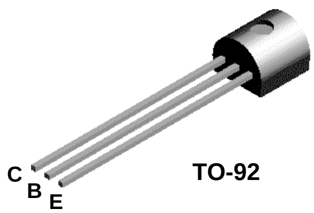
Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

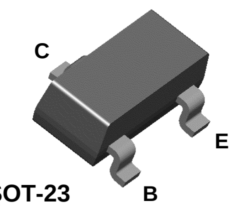
Rev. I38

FAIRCHILD SEMICONDUCTOR™

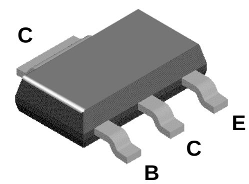
2N3904 MMBT3904 PZT3904



TO-92



SOT-23
Mark: 1A



SOT-223

NPN General Purpose Amplifier

This device is designed as a general purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CEO}	Collector-Emitter Voltage	40	V
V_{CBO}	Collector-Base Voltage	60	V
V_{EBO}	Emitter-Base Voltage	6.0	V
I_C	Collector Current - Continuous	200	mA
T_J, T_{stg}	Operating and Storage Junction Temperature Range	-55 to +150	°C

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics

T_A = 25°C unless otherwise noted

Symbol	Characteristic	Max			Units
		2N3904	*MMBT3904	**PZT3904	
P_D	Total Device Dissipation Derate above 25°C	625 5.0	350 2.8	1,000 8.0	mW mW/°C
$R_{\theta JC}$	Thermal Resistance, Junction to Case	83.3			°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	357	125	°C/W

*Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

**Device mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm^2.

NPN General Purpose Amplifier

(continued)

Electrical Characteristics

$T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1.0$ mA, $I_B = 0$	40		V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10$ μA, $I_E = 0$	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ μA, $I_C = 0$	6.0		V
I_{BL}	Base Cutoff Current	$V_{CE} = 30$ V, $V_{EB} = 3$V		50	nA
I_{CEX}	Collector Cutoff Current	$V_{CE} = 30$ V, $V_{EB} = 3$V		50	nA
ON CHARACTERISTICS*					
h_{FE}	DC Current Gain	$I_C = 0.1$ mA, $V_{CE} = 1.0$ V $I_C = 1.0$ mA, $V_{CE} = 1.0$ V $I_C = 10$ mA, $V_{CE} = 1.0$ V $I_C = 50$ mA, $V_{CE} = 1.0$ V $I_C = 100$ mA, $V_{CE} = 1.0$ V	40 70 100 60 30	 300 	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 10$ mA, $I_B = 1.0$ mA $I_C = 50$ mA, $I_B = 5.0$ mA		0.2 0.3	V V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 10$ mA, $I_B = 1.0$ mA $I_C = 50$ mA, $I_B = 5.0$ mA	0.65	0.85 0.95	V V
SMALL SIGNAL CHARACTERISTICS					
f_T	Current Gain - Bandwidth Product	$I_C = 10$ mA, $V_{CE} = 20$ V, f = 100 MHz	300		MHz
C_{obo}	Output Capacitance	$V_{CB} = 5.0$ V, $I_E = 0$, f = 1.0 MHz		4.0	pF
C_{ibo}	Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 1.0 MHz		8.0	pF
NF	Noise Figure	$I_C = 100$ μA, $V_{CE} = 5.0$ V, R_S =1.0kΩ,f=10 Hz to 15.7kHz		5.0	dB
SWITCHING CHARACTERISTICS					
t_d	Delay Time	$V_{CC} = 3.0$ V, $V_{BE} = 0.5$ V,		35	ns
t_r	Rise Time	$I_C = 10$ mA, $I_{B1} = 1.0$ mA		35	ns
t_s	Storage Time	$V_{CC} = 3.0$ V, $I_C = 10$mA		200	ns
t_f	Fall Time	$I_{B1} = I_{B2} = 1.0$ mA		50	ns

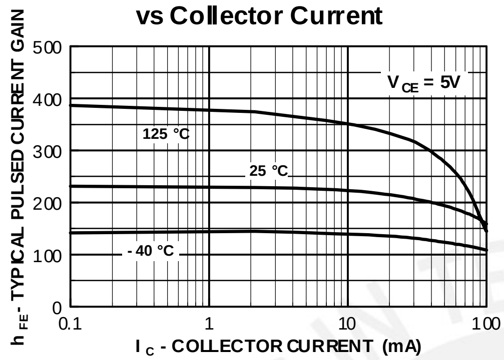
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

Spice Model

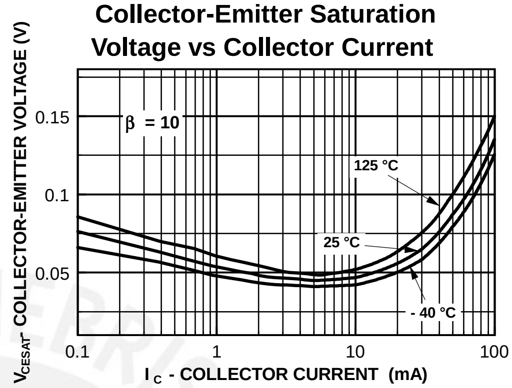
NPN (Is=6.734f Xti=3 Eg=1.11 Vaf=74.03 Bf=416.4 Ne=1.259 Ise=6.734 Ikf=66.78m Xtb=1.5 Br=.7371 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=3.638p Mjc=.3085 Vjc=.75 Fc=.5 Cje=4.493p Mje=.2593 Vje=.75 Tr=239.5n Tf=301.2p Itf=.4 Vtf=4 Xtf=2 Rb=10)

Typical Characteristics

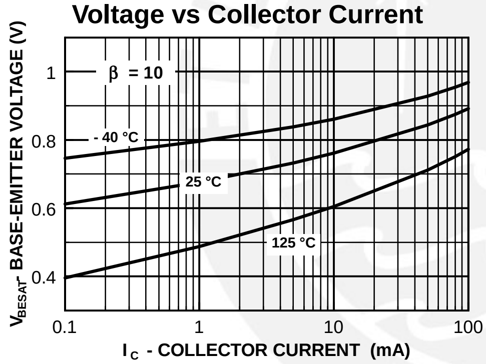
Typical Pulsed Current Gain vs Collector Current



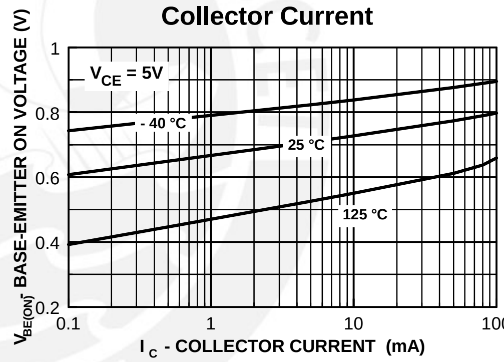
Collector-Emitter Saturation Voltage vs Collector Current



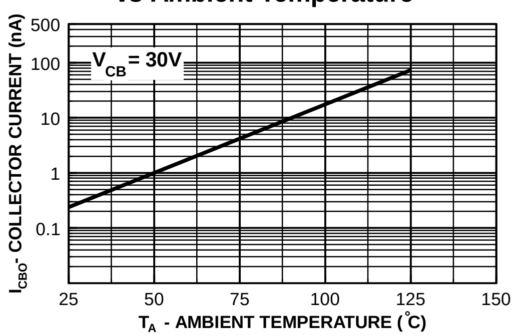
Base-Emitter Saturation Voltage vs Collector Current



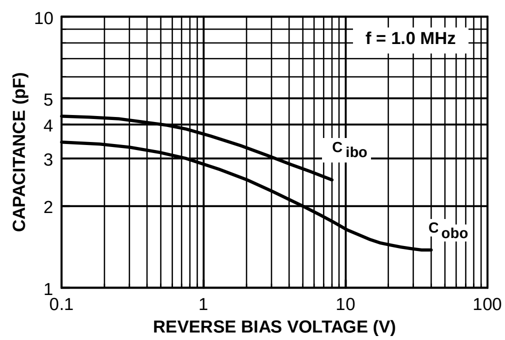
Base-Emitter ON Voltage vs Collector Current



Collector-Cutoff Current vs Ambient Temperature



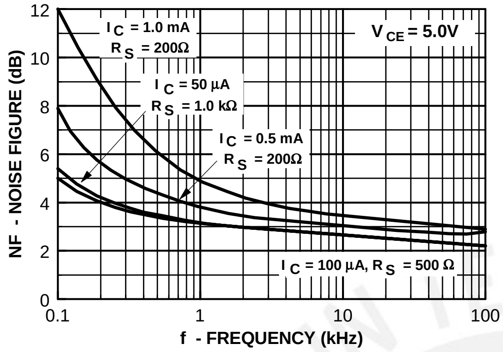
Capacitance vs Reverse Bias Voltage



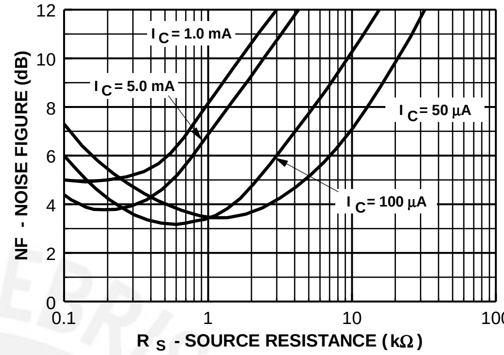
NPN General Purpose Amplifier
(continued)

Typical Characteristics (continued)

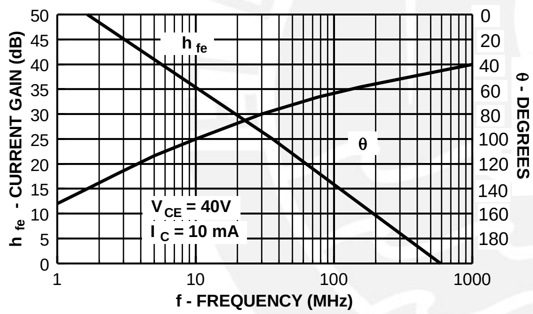
Noise Figure vs Frequency



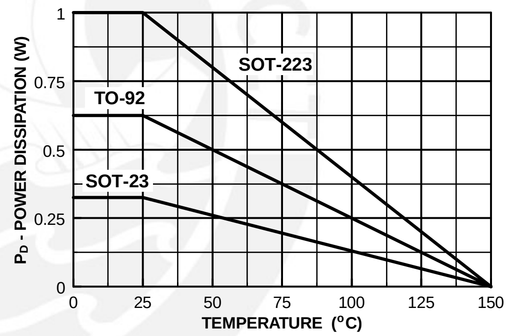
Noise Figure vs Source Resistance



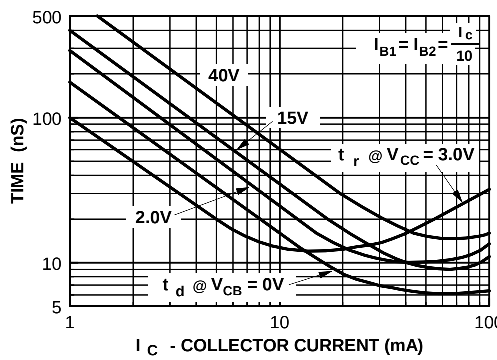
Current Gain and Phase Angle vs Frequency



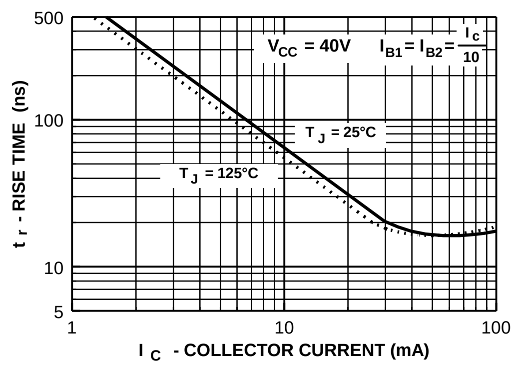
Power Dissipation vs Ambient Temperature



Turn-On Time vs Collector Current



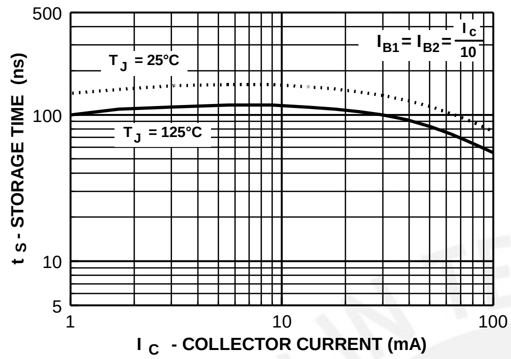
Rise Time vs Collector Current



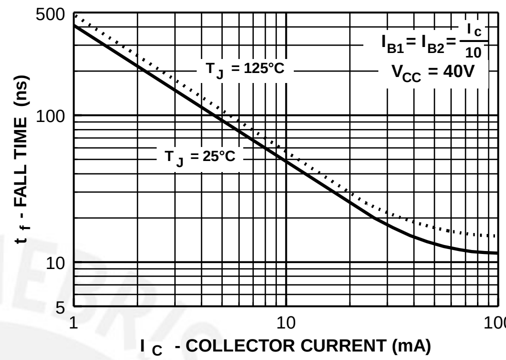
NPN General Purpose Amplifier
(continued)

Typical Characteristics (continued)

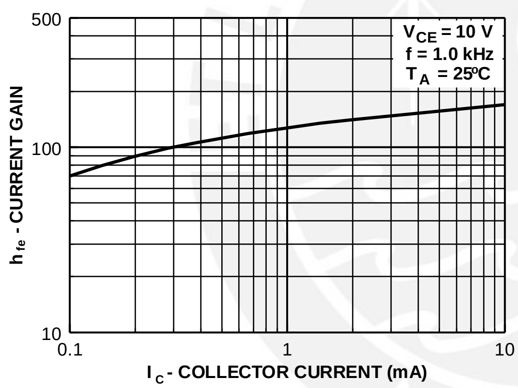
Storage Time vs Collector Current



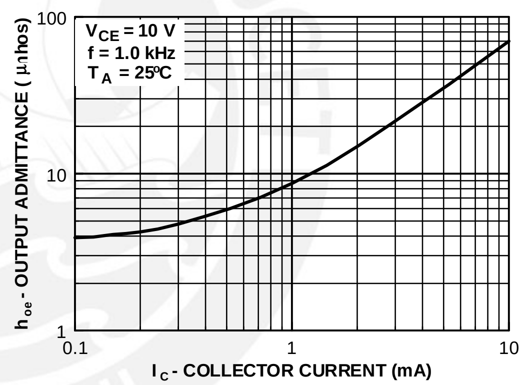
Fall Time vs Collector Current



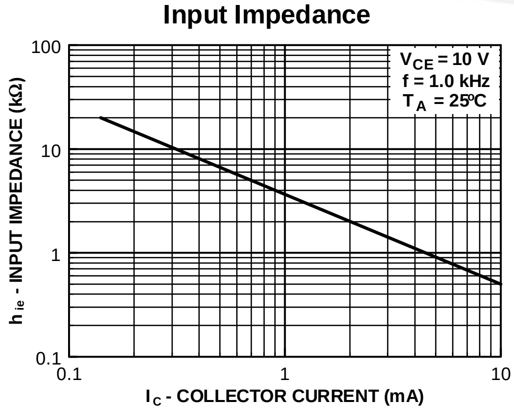
Current Gain



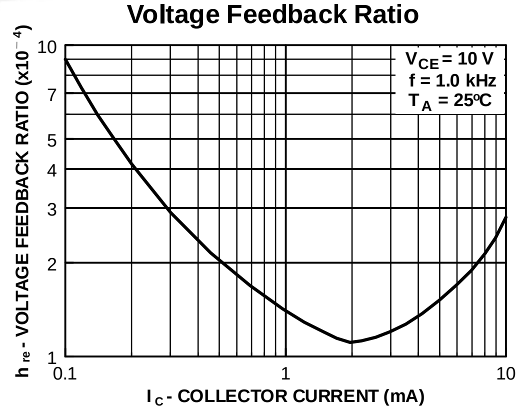
Output Admittance



Input Impedance



Voltage Feedback Ratio



Test Circuits

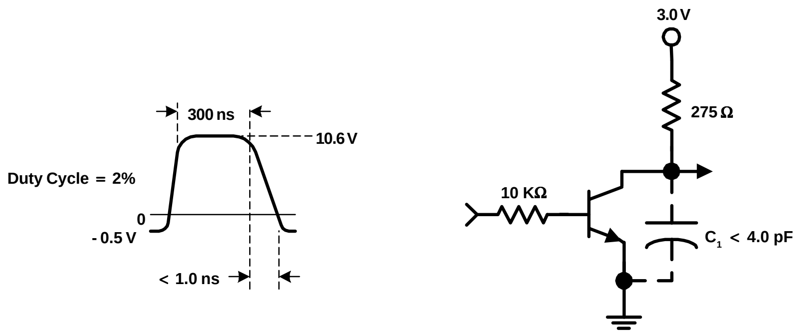


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

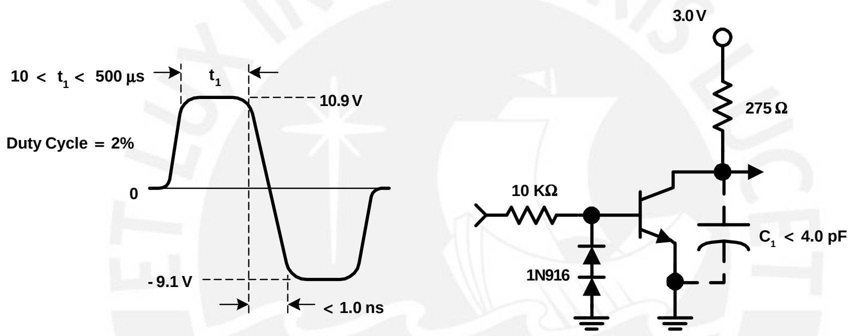


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

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DOME™	ISOPLANAR™	Quiet Series™	
E^2CMOS™	MICROWIRE™	SILENT SWITCHER®	
EnSigna™	OPTOLOGIC™	SMART START™	
FACT™	OPTOPLANAR™	SuperSOT™-3	
FACT Quiet Series™	PACMAN™	SuperSOT™-6	
FAST®	POP™	SuperSOT™-8	

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Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

Rev. G

Advanced Power MOSFET

IRF540A

FEATURES

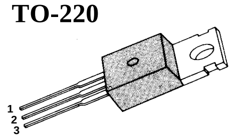
- Avalanche Rugged Technology
- Rugged Gate Oxide Technology
- Lower Input Capacitance
- Improved Gate Charge
- Extended Safe Operating Area
- 175℃ Operating Temperature
- Lower Leakage Current : 10 μA (Max.) @ V_{DS} = 100V
- Lower $R_{DS(ON)}$: 0.041 Ω(Typ.)

BV_{DSS} = 100 V

$R_{DS(on)}$ = 0.052Ω

I_D = 28 A

TO-220



1.Gate 2. Drain 3. Source

Absolute Maximum Ratings

Symbol	Characteristic	Value	Units
V_{DSS}	Drain-to-Source Voltage	100	V
I_D	Continuous Drain Current (T_C=25℃)	28	A
	Continuous Drain Current (T_C=100℃)	19.8	
I_{DM}	Drain Current-Pulsed ①	110	A
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulsed Avalanche Energy ②	523	mJ
I_{AR}	Avalanche Current ①	28	A
E_{AR}	Repetitive Avalanche Energy ①	10.7	mJ
dv/dt	Peak Diode Recovery dv/dt ③	6.5	V/ns
P_D	Total Power Dissipation (T_C=25℃)	107	W
	Linear Derating Factor	0.71	W/℃
T_J , T_{STG}	Operating Junction and Storage Temperature Range	- 55 to +175	℃
T_L	Maximum Lead Temp. for Soldering Purposes, 1/8" from case for 5-seconds	300	

Thermal Resistance

Symbol	Characteristic	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	--	1.4	℃/W
$R_{\theta CS}$	Case-to-Sink	0.5	--	
$R_{\theta JA}$	Junction-to-Ambient	--	62.5	

Rev. B

FAIRCHILD SEMICONDUCTOR™

IRF540A

N-CHANNEL
POWER MOSFET

Electrical Characteristics (T_C=25℃ unless otherwise specified)

Symbol	Characteristic	Min.	Typ.	Max.	Units	Test Condition
BV_{DSS}	Drain-Source Breakdown Voltage	100	--	--	V	V_{GS}=0V,I_D=250μA
$\Delta BV/\Delta T_J$	Breakdown Voltage Temp. Coeff.	--	0.11	--	V/℃	I_D=250 μA ***See Fig 7***
$V_{GS(th)}$	Gate Threshold Voltage	2.0	--	4.0	V	V_{DS}=5V,I_D=250μA
I_{GSS}	Gate-Source Leakage , Forward	--	--	100	nA	V_{GS}=20V
	Gate-Source Leakage , Reverse	--	--	-100		V_{GS}=-20V
I_{DSS}	Drain-to-Source Leakage Current	--	--	10	μA	V_{DS}=100V
		--	--	100		V_{DS}=80V,T_C=150℃
$R_{DS(on)}$	Static Drain-Source On-State Resistance	--	--	0.052	Ω	V_{GS}=10V,I_D=14A ④
g_{fs}	Forward Transconductance	--	22.56	--	Ω	V_{DS}=40V,I_D=14A ④
C_{iss}	Input Capacitance	--	1320	1710	pF	V_{GS}=0V,V_{DS}=25V,f =1MHz ***See Fig 5***
C_{oss}	Output Capacitance	--	325	380		
C_{rss}	Reverse Transfer Capacitance	--	148	170		
$t_{d(on)}$	Turn-On Delay Time	--	18	50	ns	V_{DD}=50V,I_D=28A, R_G=9.1Ω ***See Fig 13*** ④⑤
t_r	Rise Time	--	18	50		
$t_{d(off)}$	Turn-Off Delay Time	--	90	180		
t_f	Fall Time	--	56	120		
Q_g	Total Gate Charge	--	60	78	nC	V_{DS}=80V,V_{GS}=10V, I_D=28A ***See Fig 6 & Fig 12*** ④⑤
Q_{gs}	Gate-Source Charge	--	10.8	--		
Q_{gd}	Gate-Drain(“Miller”) Charge	--	27.9	--		

Source-Drain Diode Ratings and Characteristics

Symbol	Characteristic	Min.	Typ.	Max.	Units	Test Condition
I_S	Continuous Source Current	--	--	28	A	Integral reverse pn-diode in the MOSFET
I_{SM}	Pulsed-Source Current ①	--	--	110		
V_{SD}	Diode Forward Voltage ④	--	--	1.5	V	T_J=25℃,I_S=28A,V_{GS}=0V
t_{rr}	Reverse Recovery Time	--	132	--	ns	T_J=25℃,I_F=28A
Q_{rr}	Reverse Recovery Charge	--	0.63	--	μC	di_F/dt=100A/μs ④

Notes ;

① Repetitive Rating : Pulse Width Limited by Maximum Junction Temperature
② L=1mH, I_{AS}=28A, V_{DD}=25V, R_G=27Ω, Starting T_J=25°C
③ $I_{SD} \leq$ 28A, di/dt $\leq$ 400A/μs, $V_{DD} \leq BV_{DSS}$, Starting T_J=25°C
④ Pulse Test : Pulse Width = 250 μs, Duty Cycle ≤2%
⑤ Essentially Independent of Operating Temperature

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Fig 1. Output Characteristics

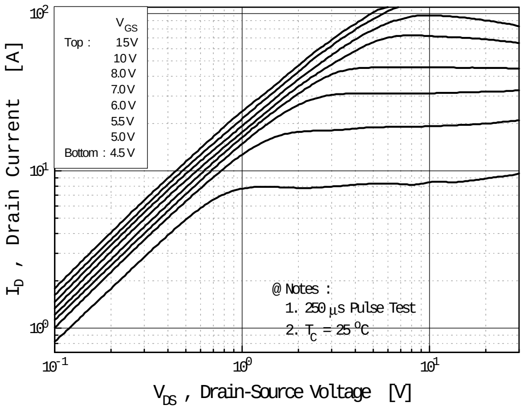

Fig 2. Transfer Characteristics

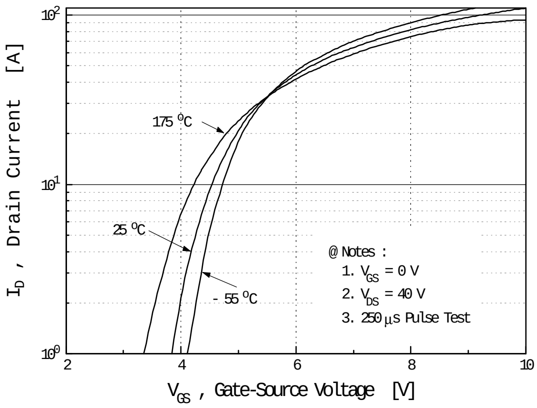

Fig 3. On-Resistance vs. Drain Current

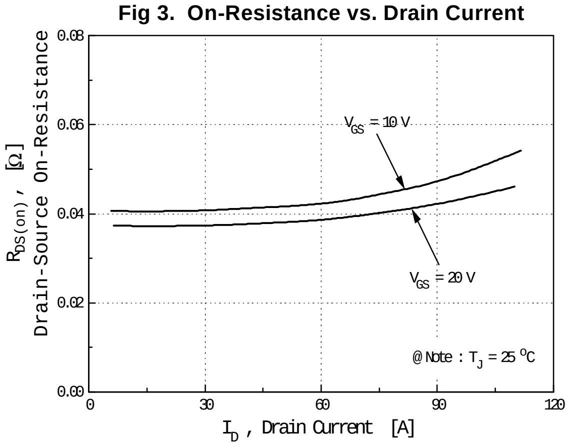

Fig 4. Source-Drain Diode Forward Voltage

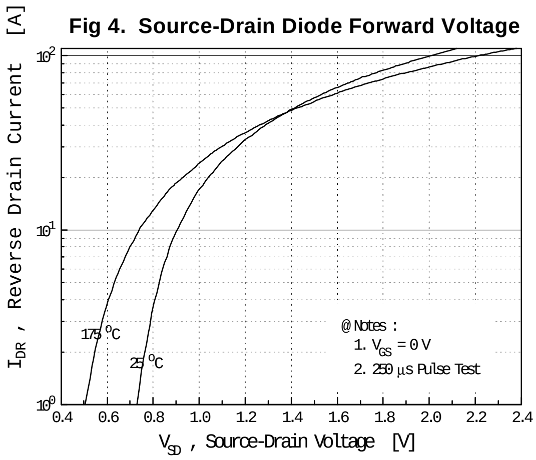

Fig 5. Capacitance vs. Drain-Source Voltage

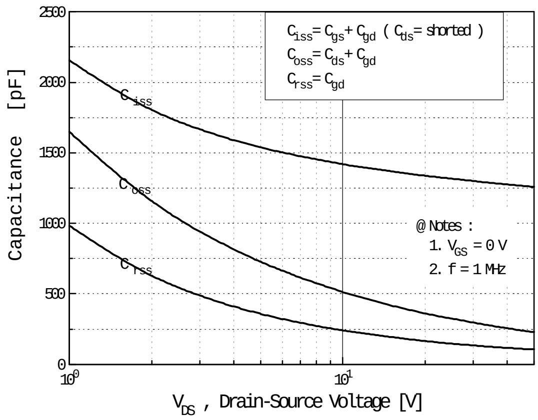

Fig 6. Gate Charge vs. Gate-Source Voltage

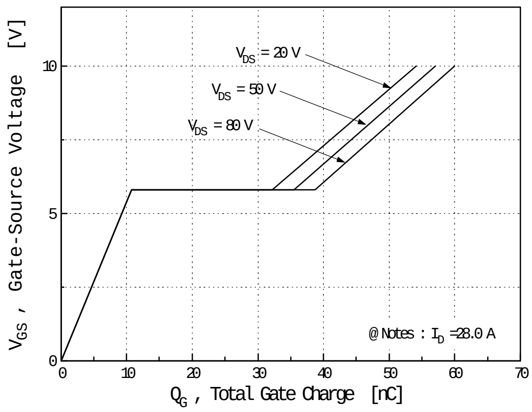

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Fig 7. Breakdown Voltage vs. Temperature

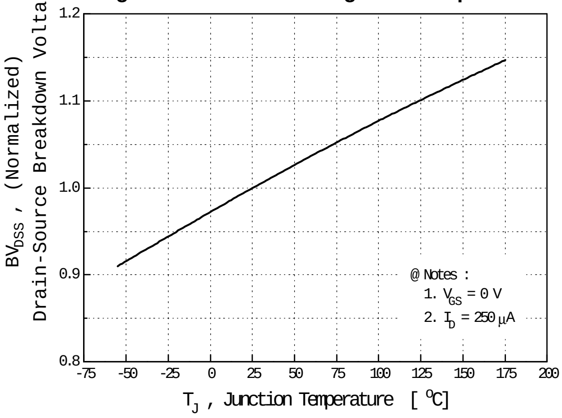


Fig 8. On-Resistance vs. Temperature

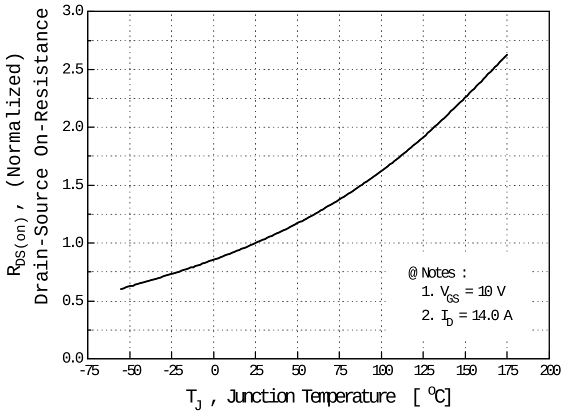


Fig 9. Max. Safe Operating Area

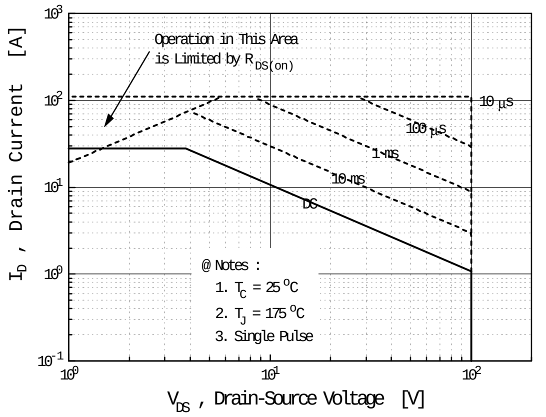


Fig 10. Max. Drain Current vs. Case Temperature

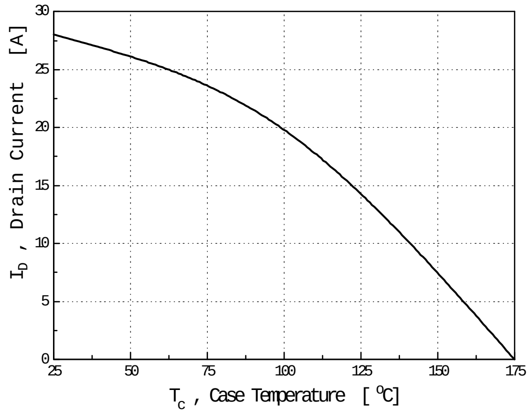


Fig 11. Thermal Response

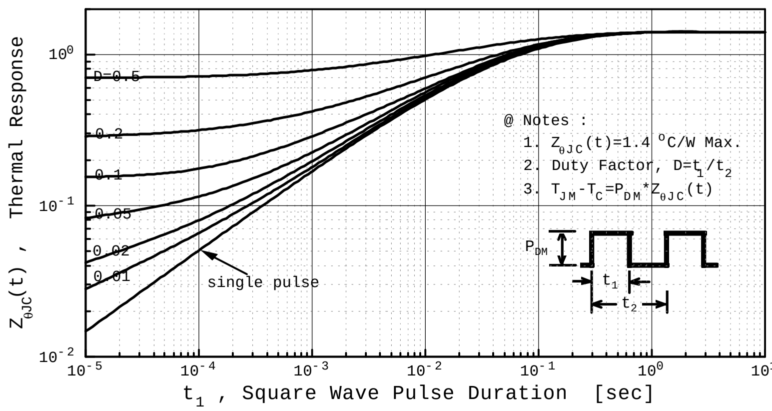


Fig 12. Gate Charge Test Circuit & Waveform

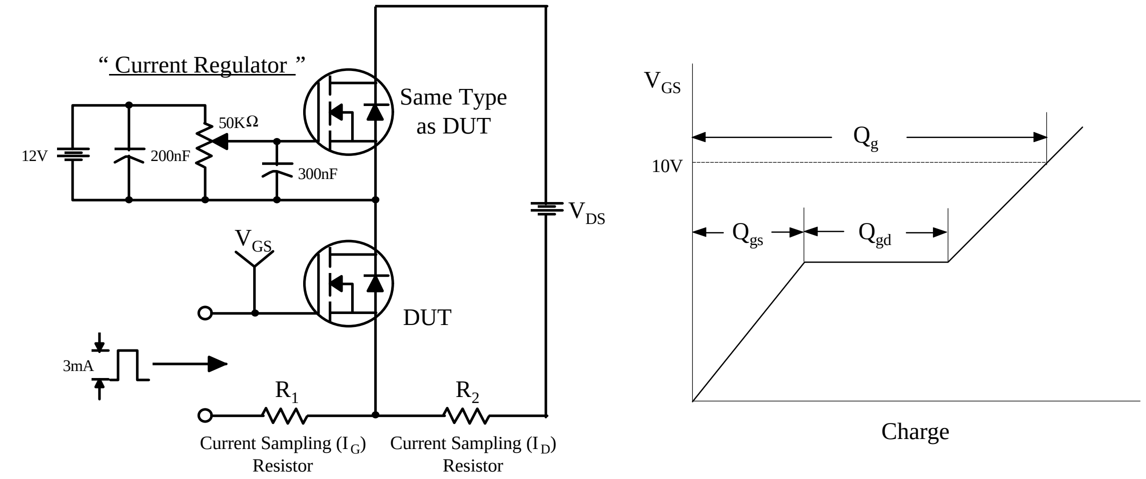


Fig 13. Resistive Switching Test Circuit & Waveforms

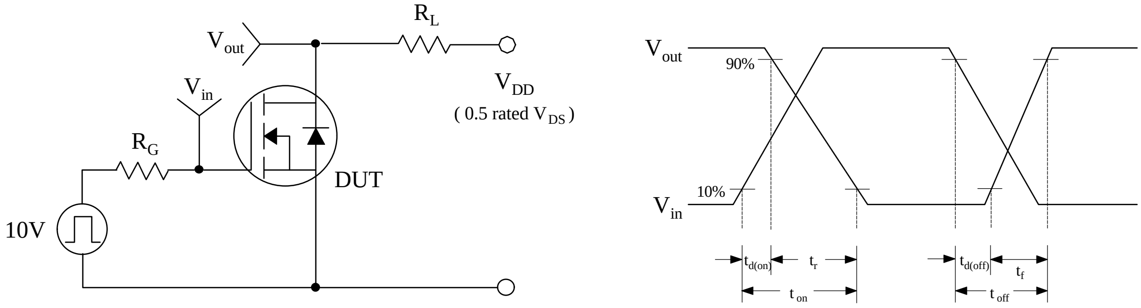


Fig 14. Unclamped Inductive Switching Test Circuit & Waveforms

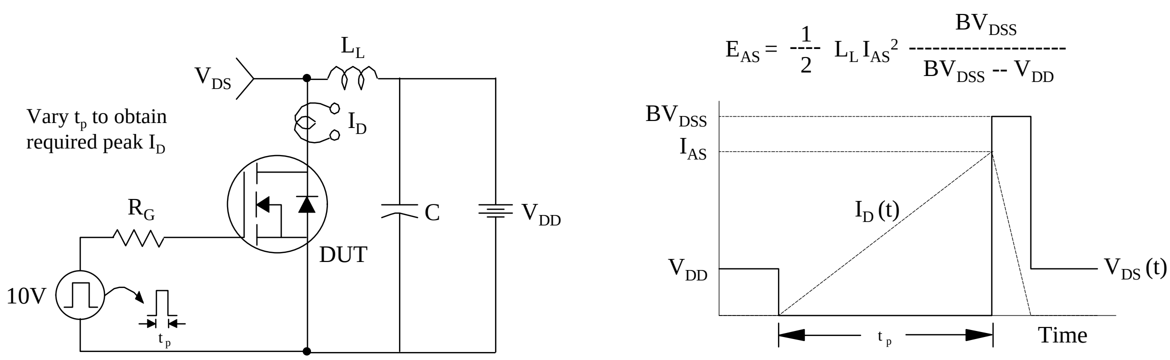
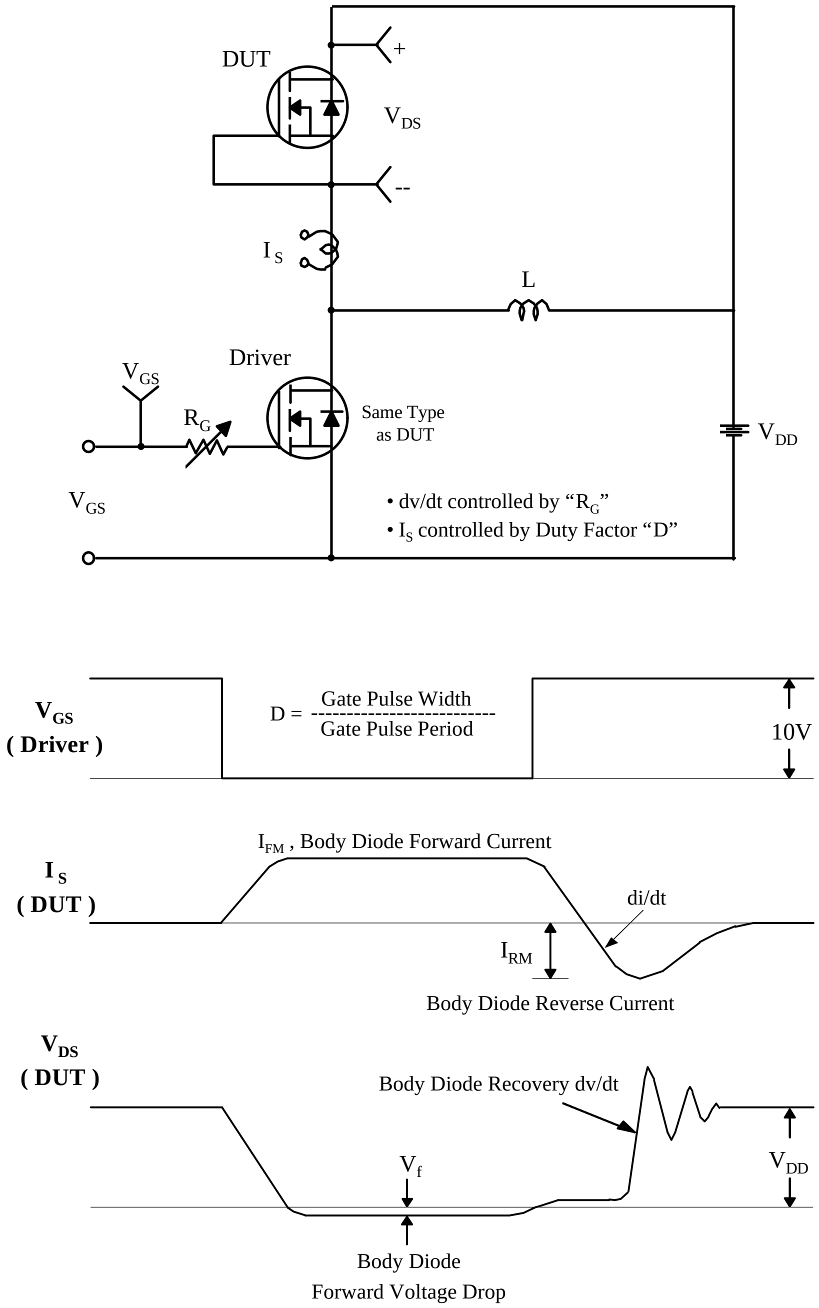


Fig 15. Peak Diode Recovery dv/dt Test Circuit & Waveforms



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

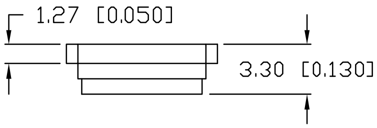
PRODUCT STATUS DEFINITIONS

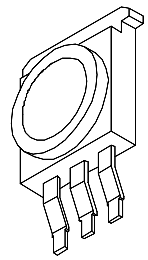
Definition of Terms

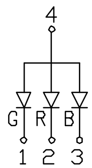
Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

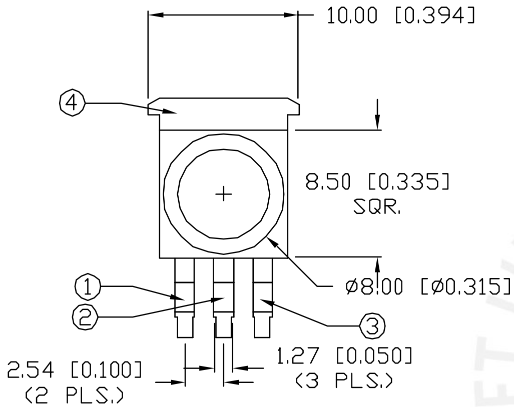
UNCONTROLLED DOCUMENT

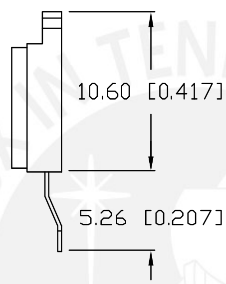
PART NUMBER	REV.
SML-LX1610RGBW/A	











ELECTRO-OPTICAL CHARACTERISTICS T_A=25°C

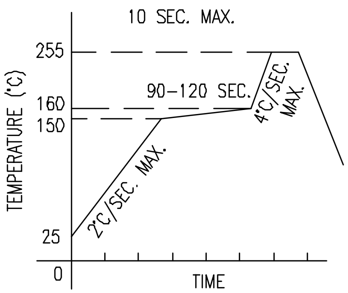
PARAMETER		MIN	TYP	MAX	UNITS	TEST COND
PEAK WAVELENGTH			626 (RED)		nm	
			525 (GREEN)		nm	
			470 (BLUE)		nm	
FORWARD VOLTAGE	(R)		2.1	2.79	V_f	I_f=300mA
	(G)		3.5	3.99	V_f	I_f=350mA
	(B)		3.5	3.99	V_f	I_f=350mA
REVERSE VOLTAGE		5.0			V_r	I_r=100μA
TOTAL FLUX	(R/G/B)		25/25/8		lm	
VIEWING ANGLE			110		2x theta	
EMITTED COLOR:	RED/GREEN/BLUE					
EPOXY LENS FINISH:	WHITE DIFFUSED					

LIMITS OF SAFE OPERATION AT 25°C

PARAMETER	COLORS	MAX	UNITS
PEAK FORWARD CURRENT*	(R/G/B)	350/500/500	mA
STEADY CURRENT	(R/G/B)	300/350/350	mA
POWER DISSIPATION		3.5	W
OPERATING TEMP.		− 30 TO + 85	°C
STORAGE TEMP.		− 30 TO + 85	°C
SOLDERING TEMP.		+ 260	°C
2.0mm FROM BODY			3 SEC. MAX

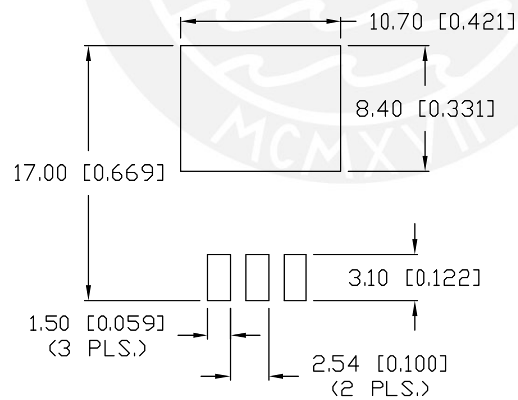
*T<10μS

LEAD FREE REFLOW PROFILE



TOTAL TIME ABOVE 220°C IS 60 SECONDS MAX.

SOLDER PAD LAYOUT



CAUTION: STATIC SENSITIVE DEVICE
FOLLOW PROPER E.S.D. HANDLING PROCEDURES WHEN WORKING WITH THIS PART.

NOTES:

1. 50 PCS. IN EACH TUBE.

Pb

UNCONTROLLED DOCUMENT

*UNLESS OTHERWISE SPECIFIED TOLERANCES PER DECIMAL PRECISION ARE: X=±1 (±0.039), X.X=±0.5 (±0.020), X.XX=±0.25 (±0.010), X.XXX=±0.127 (±0.005). LEAD SIZE=±0.05 (±0.002), LEAD LENGTH=±0.75 (±0.030). MIN= +DECIMAL PRECISION −0.00 MAX.= +0.00 −DECIMAL PRECISION

REV.	PART NUMBER
	SML-LX1610RGBW/A

10.60 x 10mm HIGH POWER LED, RGB LEDs.

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RELIABILITY NOTE

OUR MANY YEARS OF EXPERIENCE DATA ACCUMULATION INDICATE THAT SOLDER HEAT IS A MAJOR CAUSE OF EARLY AND FUTURE FAILURE. PLEASE PAY ATTENTION TO YOUR SOLDERING PROCESS.

LUMEX INC. We Tame Photons To Work For You

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JN			PAGE: 1 OF 1
			SCALE: N/A

FAIRCHILD SEMICONDUCTOR®

March 2008

LM78XX/LM78XXA
3-Terminal 1A Positive Voltage Regulator

Features

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

General Description

The LM78XX series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM7805CT	±4%	TO-220	-40°C to +125°C
LM7806CT			
LM7808CT			
LM7809CT			
LM7810CT			
LM7812CT			
LM7815CT			
LM7818CT			
LM7824CT			
LM7805ACT	±2%		0°C to +125°C
LM7806ACT			
LM7808ACT			
LM7809ACT			
LM7810ACT			
LM7812ACT			
LM7815ACT			
LM7818ACT			
LM7824ACT			

Block Diagram

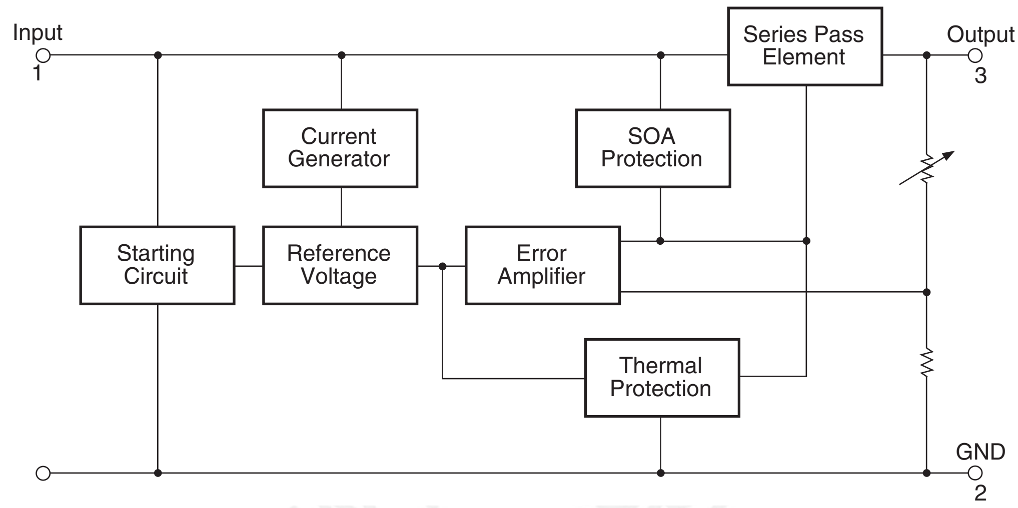


Figure 1.

Pin Assignment

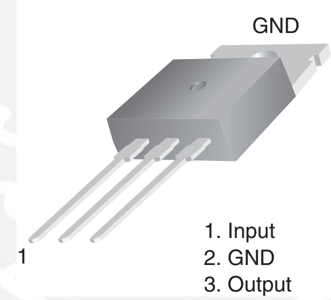


Figure 2.

Absolute Maximum Ratings

Absolute maximum ratings are those values beyond which damage to the device may occur. The datasheet specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. Fairchild does not recommend operation outside datasheet specifications.

Symbol	Parameter		Value	Unit
V_I	Input Voltage	V_O = 5V to 18V	35	V
		V_O = 24V	40	V
$R_{\theta JC}$	Thermal Resistance Junction-Cases (TO-220)		5	°C/W
$R_{\theta JA}$	Thermal Resistance Junction-Air (TO-220)		65	°C/W
T_{OPR}	Operating Temperature Range	LM78xx	-40 to +125	°C
		LM78xxA	0 to +125	
T_{STG}	Storage Temperature Range		-65 to +150	°C

Electrical Characteristics (LM7805)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		4.8	5.0	5.2	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 7V to 20V		4.75	5.0	5.25	
Regline	Line Regulation(1)	T_J = +25°C	V_O = 7V to 25V	–	4.0	100	mV
			V_I = 8V to 12V	–	1.6	50.0	
Regload	Load Regulation(1)	T_J = +25°C	I_O = 5mA to 1.5A	–	9.0	100	mV
			I_O = 250mA to 750mA	–	4.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.03	0.5	mA
		V_I = 7V to 25V		–	0.3	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift(2)	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	42.0	–	$\mu V/V_O$
RR	Ripple Rejection(2)	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(2)	f = 1kHz		–	15.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current(2)	T_J = +25°C		–	2.2	–	A

Notes:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
2. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7806) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 11V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		5.75	6.0	6.25	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 8.0V to 21V		5.7	6.0	6.3	
Regline	Line Regulation(3)	T_J = +25°C	V_I = 8V to 25V	–	5.0	120	mV
			V_I = 9V to 13V	–	1.5	60.0	
Regload	Load Regulation(3)	T_J = +25°C	I_O = 5mA to 1.5A	–	9.0	120	mV
			I_O = 250mA to 750mA	–	3.0	60.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V		–	–	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift(4)	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	45.0	–	µV/V_O
RR	Ripple Rejection(4)	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(4)	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(4)	T_J = +25°C		–	2.2	–	A

Notes:

3. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
4. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7808) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 14V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		7.7	8.0	8.3	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 10.5V to 23V		7.6	8.0	8.4	
Regline	Line Regulation(5)	T_J = +25°C	V_I = 10.5V to 25V	–	5.0	160	mV
			V_I = 11.5V to 17V	–	2.0	80.0	
Regload	Load Regulation(5)	T_J = +25°C	I_O = 5mA to 1.5A	–	10.0	160	mV
			I_O = 250mA to 750mA	–	5.0	80.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.05	0.5	mA
		V_I = 10.5V to 25V		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(6)	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	52.0	–	µV/V_O
RR	Ripple Rejection(6)	f = 120Hz, V_O = 11.5V to 21.5V		56.0	73.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(6)	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current(6)	T_J = +25°C		–	2.2	–	A

Notes:

5. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
6. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7809) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 15V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		8.65	9.0	9.35	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 11.5V to 24V		8.6	9.0	9.4	
Regline	Line Regulation(7)	T_J = +25°C	V_I = 11.5V to 25V	–	6.0	180	mV
			V_I = 12V to 17V	–	2.0	90.0	
Regload	Load Regulation(7)	T_J = +25°C	I_O = 5mA to 1.5A	–	12.0	180	mV
			I_O = 250mA to 750mA	–	4.0	90.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 11.5V to 26V		–	–	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift(8)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	58.0	–	µV/V_O
RR	Ripple Rejection(8)	f = 120Hz, V_O = 13V to 23V		56.0	71.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(8)	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(8)	T_J = +25°C		–	2.2	–	A

Notes:

7. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
8. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7810) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 16V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		9.6	10.0	10.4	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 12.5V to 25V		9.5	10.0	10.5	
Regline	Line Regulation[9]	T_J = +25°C	V_I = 12.5V to 25V	–	10.0	200	mV
			V_I = 13V to 25V	–	3.0	100	
Regload	Load Regulation[9]	T_J = +25°C	I_O = 5mA to 1.5A	–	12.0	200	mV
			I_O = 250mA to 750mA	–	4.0	400	
I_Q	Quiescent Current	T_J = +25°C		–	5.1	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12.5V to 29V		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[10]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	58.0	–	µV/V_O
RR	Ripple Rejection[10]	f = 120Hz, V_O = 13V to 23V		56.0	71.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[10]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[10]	T_J = +25°C		–	2.2	–	A

Notes:

9. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
10. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7812) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 19V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		11.5	12.0	12.5	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 14.5V to 27V		11.4	12.0	12.6	
Regline	Line Regulation(11)	T_J = +25°C	V_I = 14.5V to 30V	–	10.0	240	mV
			V_I = 16V to 22V	–	3.0	120	
Regload	Load Regulation(11)	T_J = +25°C	I_O = 5mA to 1.5A	–	11.0	240	mV
			I_O = 250mA to 750mA	–	5.0	120	
I_Q	Quiescent Current	T_J = +25°C		–	5.1	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.1	0.5	mA
		V_I = 14.5V to 30V		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(12)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	76.0	–	µV/V_O
RR	Ripple Rejection(12)	f = 120Hz, V_I = 15V to 25V		55.0	71.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(12)	f = 1kHz		–	18.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current(12)	T_J = +25°C		–	2.2	–	A

Notes:

11. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
12. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7815) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 23V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		14.4	15.0	15.6	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 17.5V to 30V		14.25	15.0	15.75	
Regline	Line Regulation[13]	T_J = +25°C	V_I = 17.5V to 30V	–	11.0	300	mV
			V_I = 20V to 26V	–	3.0	150	
Regload	Load Regulation[13]	T_J = +25°C	I_O = 5mA to 1.5A	–	12.0	300	mV
			I_O = 250mA to 750mA	–	4.0	150	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 17.5V to 30V		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[14]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	90.0	–	µV/V_O
RR	Ripple Rejection[14]	f = 120Hz, V_I = 18.5V to 28.5V		54.0	70.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[14]	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[14]	T_J = +25°C		–	2.2	–	A

Notes:

13. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
14. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7818) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 27V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		17.3	18.0	18.7	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 21V to 33V		17.1	18.0	18.9	
Regline	Line Regulation(15)	T_J = +25°C	V_I = 21V to 33V	–	15.0	360	mV
			V_I = 24V to 30V	–	5.0	180	
Regload	Load Regulation(15)	T_J = +25°C	I_O = 5mA to 1.5A	–	15.0	360	mV
			I_O = 250mA to 750mA	–	5.0	180	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 21V to 33V		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(16)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	110	–	µV/V_O
RR	Ripple Rejection(16)	f = 120Hz, V_I = 22V to 32V		53.0	69.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(16)	f = 1kHz		–	22.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(16)	T_J = +25°C		–	2.2	–	A

Notes:

15. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
16. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7824) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 33V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		23.0	24.0	25.0	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 27V to 38V		22.8	24.0	25.25	
Regline	Line Regulation(17)	T_J = +25°C	V_I = 27V to 38V	–	17.0	480	mV
			V_I = 30V to 36V	–	6.0	240	
Regload	Load Regulation(17)	T_J = +25°C	I_O = 5mA to 1.5A	–	15.0	480	mV
			I_O = 250mA to 750mA	–	5.0	240	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.1	0.5	mA
		V_I = 27V to 38V		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(18)	I_O = 5mA		–	-1.5	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	60.0	–	µV/V_O
RR	Ripple Rejection(18)	f = 120Hz, V_I = 28V to 38V		50.0	67.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
rO	Output Resistance(18)	f = 1kHz		–	28.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current(18)	T_J = +25°C		–	2.2	–	A

Notes:

17. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
18. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7805A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 10V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		4.9	5.0	5.1	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 7.5V to 20V		4.8	5.0	5.2	
Regline	Line Regulation[19]	V_I = 7.5V to 25V, I_O = 500mA		–	5.0	50.0	mV
		V_I = 8V to 12V		–	3.0	50.0	
		T_J = +25°C	V_I = 7.3V to 20V	–	5.0	50.0	
			V_I = 8V to 12V	–	1.5	25.0	
Regload	Load Regulation[19]	T_J = +25°C, I_O = 5mA to 1.5A		–	9.0	100	mV
		I_O = 5mA to 1A		–	9.0	100	
		I_O = 250mA to 750mA		–	4.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 7.5V to 20V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[20]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[20]	f = 120Hz, I_O = 500mA, V_I = 8V to 18V		–	68.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[20]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[20]	T_J = +25°C		–	2.2	–	A

Notes:

19. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
20. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7806A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 11V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		5.58	6.0	6.12	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 8.6V to 21V		5.76	6.0	6.24	
Regline	Line Regulation[21]	V_I = 8.6V to 25V, I_O = 500mA		–	5.0	60.0	mV
		V_I = 9V to 13V		–	3.0	60.0	
		T_J = +25°C	V_I = 8.3V to 21V	–	5.0	60.0	
			V_I = 9V to 13V	–	1.5	30.0	
Regload	Load Regulation[21]	T_J = +25°C, I_O = 5mA to 1.5A		–	9.0	100	mV
		I_O = 5mA to 1A		–	9.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	4.3	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 19V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 8.5V to 21V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[22]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[22]	f = 120Hz, I_O = 500mA, V_I = 9V to 19V		–	65.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[22]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[22]	T_J = +25°C		–	2.2	–	A

Notes:

21. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
22. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7808A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 14V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		7.84	8.0	8.16	V
		I_O = 5mA to 1A, $P_O \leq$ 15W, V_I = 10.6V to 23V		7.7	8.0	8.3	
Regline	Line Regulation(23)	V_I = 10.6V to 25V, I_O = 500mA		–	6.0	80.0	mV
		V_I = 11V to 17V		–	3.0	80.0	
		T_J = +25°C	V_I = 10.4V to 23V	–	6.0	80.0	
			V_I = 11V to 17V	–	2.0	40.0	
Regload	Load Regulation(23)	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 11V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 10.6V to 23V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift(24)	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	$\mu V/V_O$
RR	Ripple Rejection(24)	f = 120Hz, I_O = 500mA, V_I = 11.5V to 21.5V		–	62.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(24)	f = 1kHz		–	18.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(24)	T_J = +25°C		–	2.2	–	A

Notes:

23. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
24. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7809A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 15V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		8.82	9.0	9.16	V
		I_O = 5mA to 1A, $P_O \leq$ 15W, V_I = 11.2V to 24V		8.65	9.0	9.35	
Regline	Line Regulation(25)	V_I = 11.7V to 25V, I_O = 500mA		–	6.0	90.0	mV
		V_I = 12.5V to 19V		–	4.0	45.0	
		T_J = +25°C	V_I = 11.5V to 24V	–	6.0	90.0	
			V_I = 12.5V to 19V	–	2.0	45.0	
Regload	Load Regulation(25)	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 11.7V to 25V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift(26)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection(26)	f = 120Hz, I_O = 500mA, V_I = 12V to 22V		–	62.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(26)	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(26)	T_J = +25°C		–	2.2	–	A

Notes:

25. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
26. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7810A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 16V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		9.8	10.0	10.2	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 12.8V to 25V		9.6	10.0	10.4	
Regline	Line Regulation(27)	V_I = 12.8V to 26V, I_O = 500mA		–	8.0	100	mV
		V_I = 13V to 20V		–	4.0	50.0	
		T_J = +25°C	V_I = 12.5V to 25V	–	8.0	100	
			V_I = 13V to 20V	–	3.0	50.0	
Regload	Load Regulation(27)	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12.8V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 13V to 26V, T_J = +25°C		–	–	0.5	
$\Delta V_O/\Delta T$	Output Voltage Drift(28)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection(28)	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		–	62.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(28)	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(28)	T_J = +25°C		–	2.2	–	A

Notes:

27. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
28. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7812A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 19V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		11.75	12.0	12.25	V
		I_O = 5mA to 1A, $P_O \le$ 15W, V_I = 14.8V to 27V		11.5	12.0	12.5	
Regline	Line Regulation(29)	V_I = 14.8V to 30V, I_O = 500mA		–	10.0	120	mV
		V_I = 16V to 22V		–	4.0	120	
		T_J = +25°C	V_I = 14.5V to 27V	–	10.0	120	
			V_I = 16V to 22V	–	3.0	60.0	
Regload	Load Regulation(29)	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.1	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 14V to 27V, I_O = 500mA		–	–	0.8	
		V_I = 15V to 30V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift(30)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection(30)	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		–	60.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(30)	f = 1kHz		–	18.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(30)	T_J = +25°C		–	2.2	–	A

Note:

29. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
30. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7815A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 23V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		14.75	15.0	15.3	V
		I_O = 5mA to 1A, $P_O \leq$ 15W, V_I = 17.7V to 30V		14.4	15.0	15.6	
Regline	Line Regulation[31]	V_I = 17.4V to 30V, I_O = 500mA		–	10.0	150	mV
		V_I = 20V to 26V		–	5.0	150	
		T_J = +25°C	V_I = 17.5V to 30V	–	11.0	150	
			V_I = 20V to 26V	–	3.0	75.0	
Regload	Load Regulation[31]	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 17.5V to 30V, I_O = 500mA		–	–	0.8	
		V_I = 17.5V to 30V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[32]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[32]	f = 120Hz, I_O = 500mA, V_I = 18.5V to 28.5V		–	58.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[32]	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[32]	T_J = +25°C		–	2.2	–	A

Notes:

31. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
32. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7818A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 27V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		17.64	18.0	18.36	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 21V to 33V		17.3	18.0	18.7	
Regline	Line Regulation(33)	V_I = 21V to 33V, I_O = 500mA		–	15.0	180	mV
		V_I = 21V to 33V		–	5.0	180	
		T_J = +25°C	V_I = 20.6V to 33V	–	15.0	180	
			V_I = 24V to 30V	–	5.0	90.0	
Regload	Load Regulation(33)	T_J = +25°C, I_O = 5mA to 1.5A		–	15.0	100	mV
		I_O = 5mA to 1A		–	15.0	100	
		I_O = 250mA to 750mA		–	7.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12V to 33V, I_O = 500mA		–	–	0.8	
		V_I = 12V to 33V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift(34)	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection(34)	f = 120Hz, I_O = 500mA, V_I = 22V to 32V		–	57.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance(34)	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current(34)	T_J = +25°C		–	2.2	–	A

Notes:

33. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

34. These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7824A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 33V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		23.5	24.0	24.5	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 27.3V to 38V		23.0	24.0	25.0	
Regline	Line Regulation[35]	V_I = 27V to 38V, I_O = 500mA		–	18.0	240	mV
		V_I = 21V to 33V		–	6.0	240	
		T_J = +25°C	V_I = 26.7V to 38V	–	18.0	240	
			V_I = 30V to 36V	–	6.0	120	
Regload	Load Regulation[35]	T_J = +25°C, I_O = 5mA to 1.5A		–	15.0	100	mV
		I_O = 5mA to 1A		–	15.0	100	
		I_O = 250mA to 750mA		–	7.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 27.3V to 38V, I_O = 500mA		–	–	0.8	
		V_I = 27.3V to 38V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[36]	I_O = 5mA		–	-1.5	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[36]	f = 120Hz, I_O = 500mA, V_I = 28V to 38V		–	54.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[36]	f = 1kHz		–	20.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[36]	T_J = +25°C		–	2.2	–	A

Notes:

35. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
36. These parameters, although guaranteed, are not 100% tested in production.

Typical Performance Characteristics

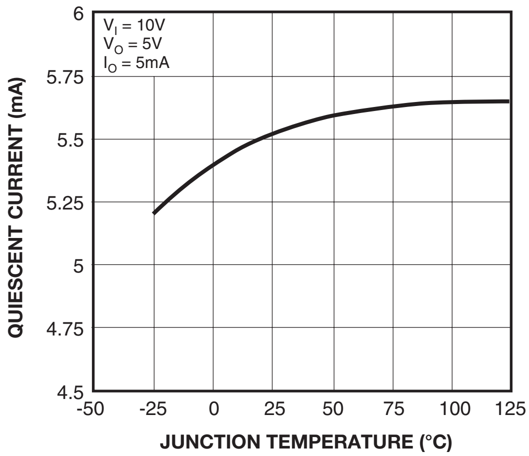


Figure 3. Quiescent Current

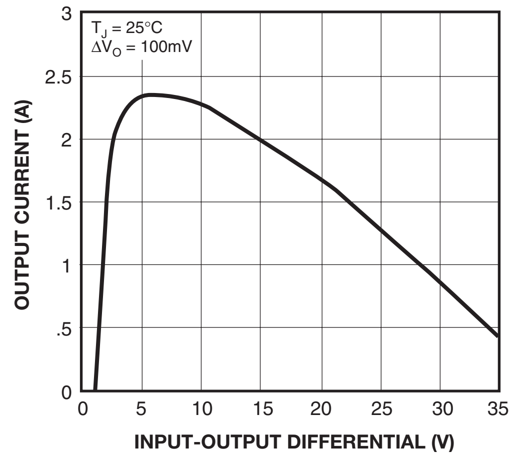


Figure 4. Peak Output Current

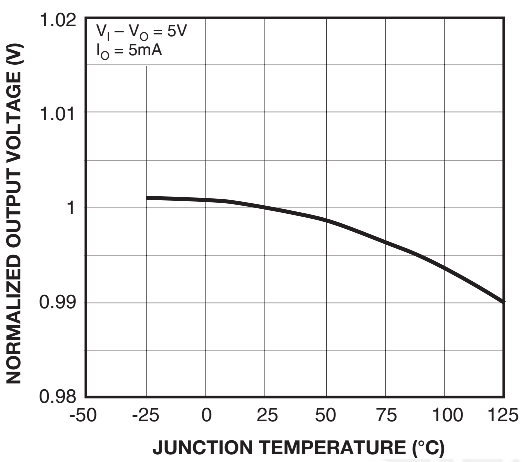


Figure 5. Output Voltage

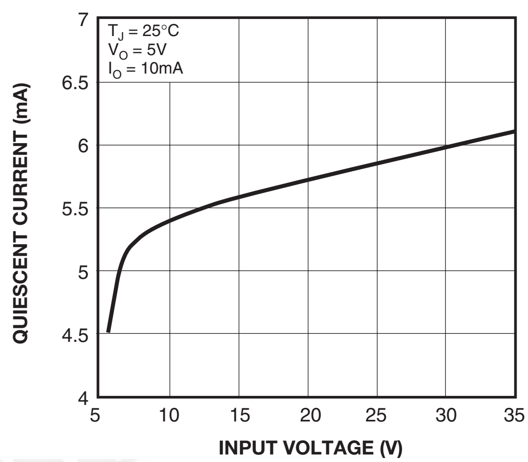


Figure 6. Quiescent Current

Typical Applications

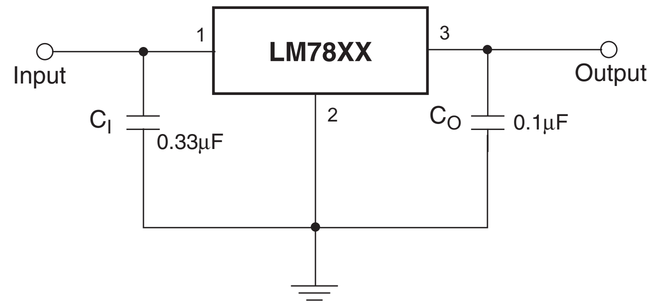


Figure 7. DC Parameters

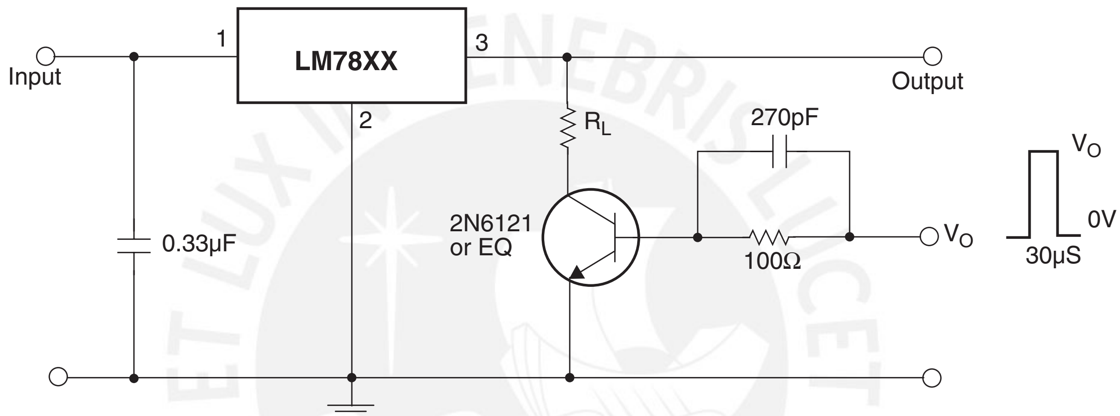


Figure 8. Load Regulation

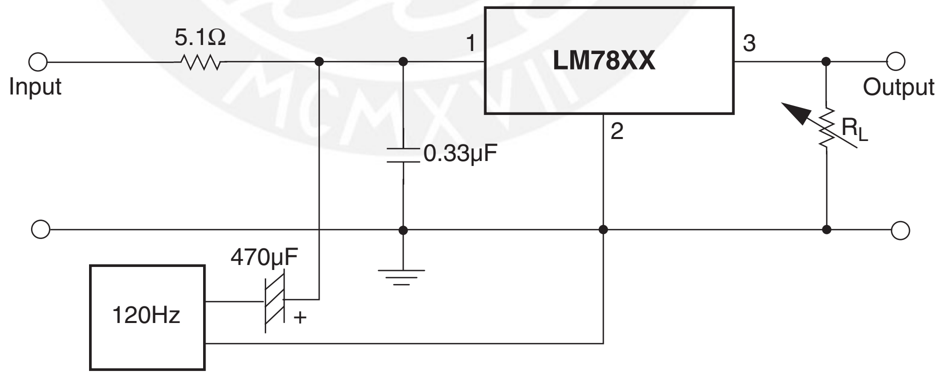


Figure 9. Ripple Rejection

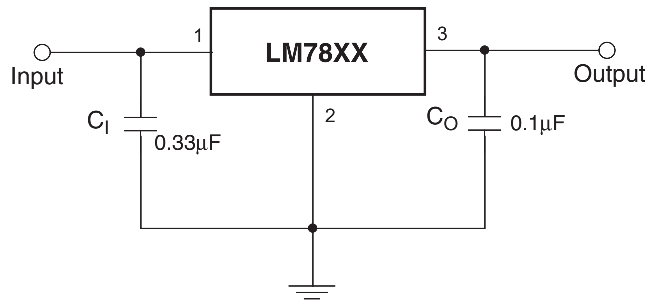
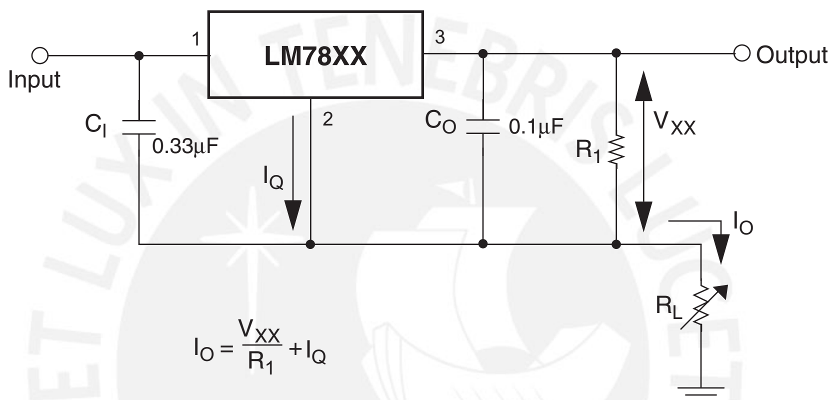


Figure 10. Fixed Output Regulator



Notes:
1. To specify an output voltage, substitute voltage value for "XX." A common ground is required between the input and the output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.
2. C_I is required if regulator is located an appreciable distance from power supply filter.
3. C_O improves stability and transient response.

Figure 11.

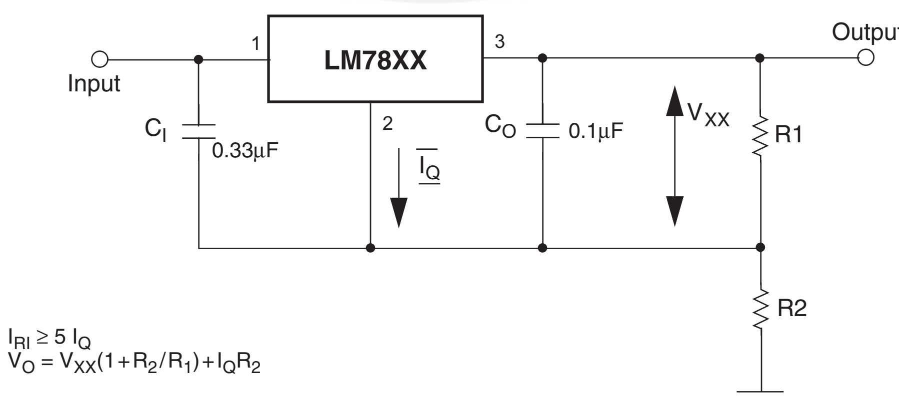


Figure 12. Circuit for Increasing Output Voltage

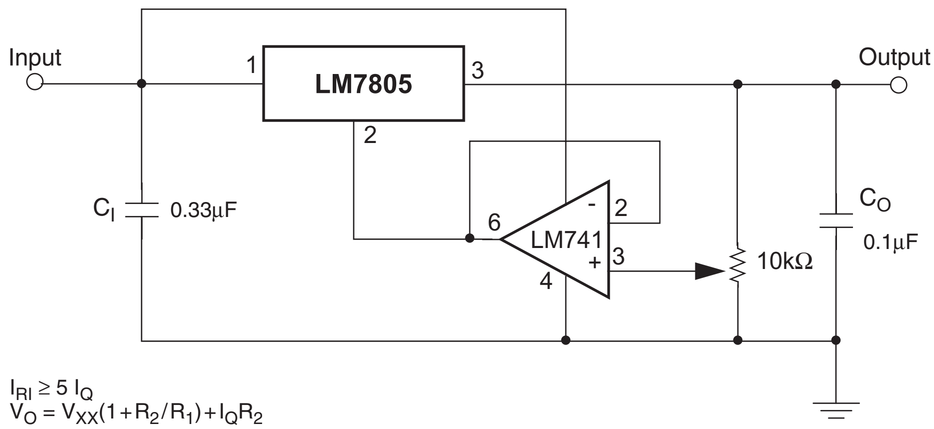


Figure 13. Adjustable Output Regulator (7V to 30V)

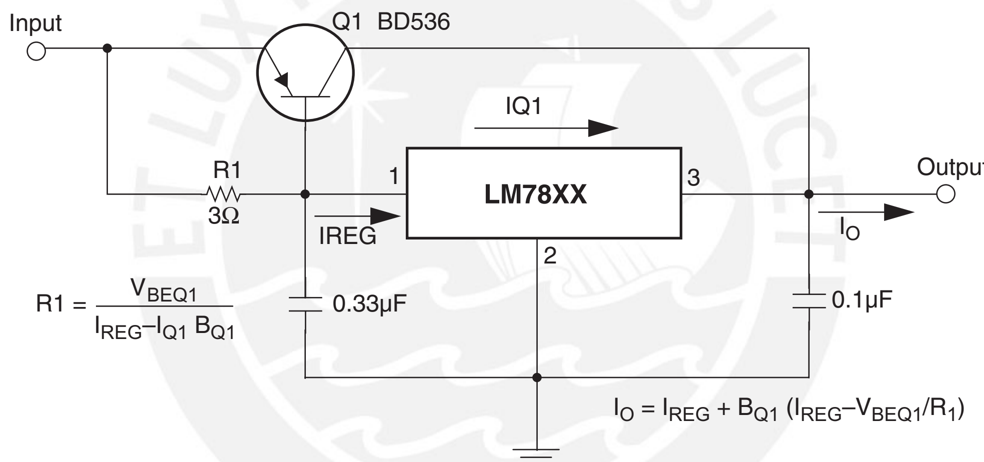


Figure 14. High Current Voltage Regulator

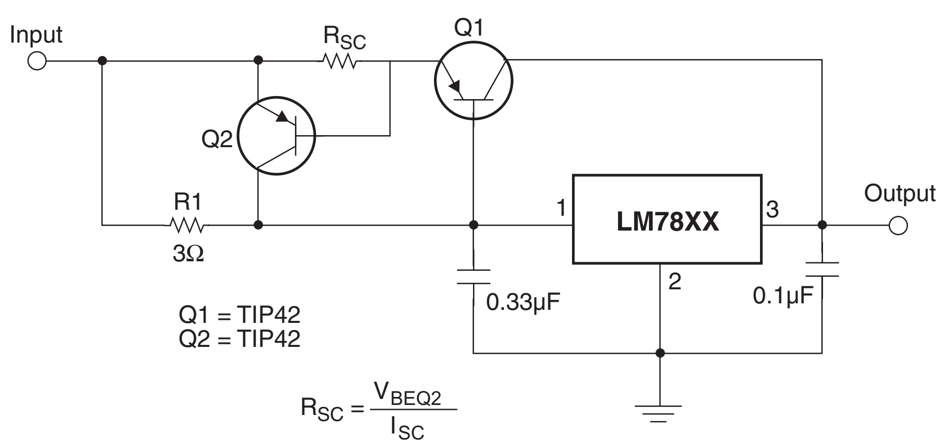


Figure 15. High Output Current with Short Circuit Protection

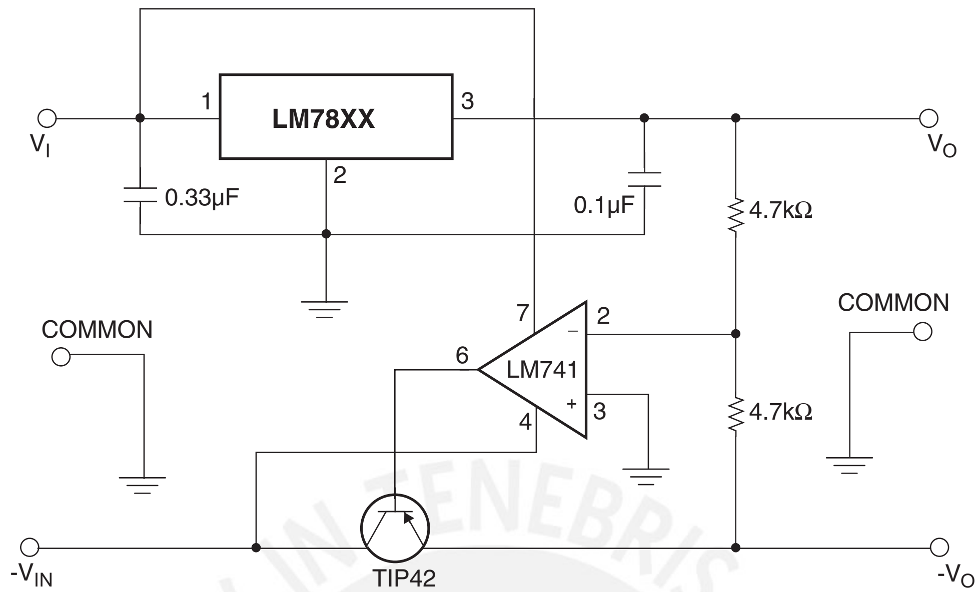


Figure 16. Tracking Voltage Regulator

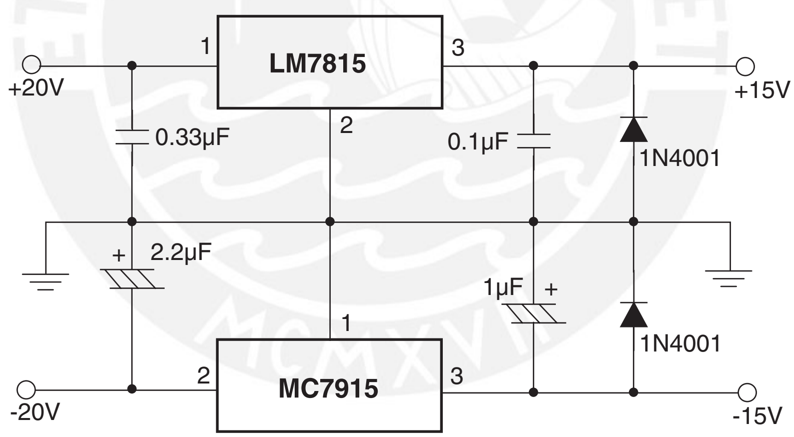


Figure 17. Split Power Supply (±15V – 1A)

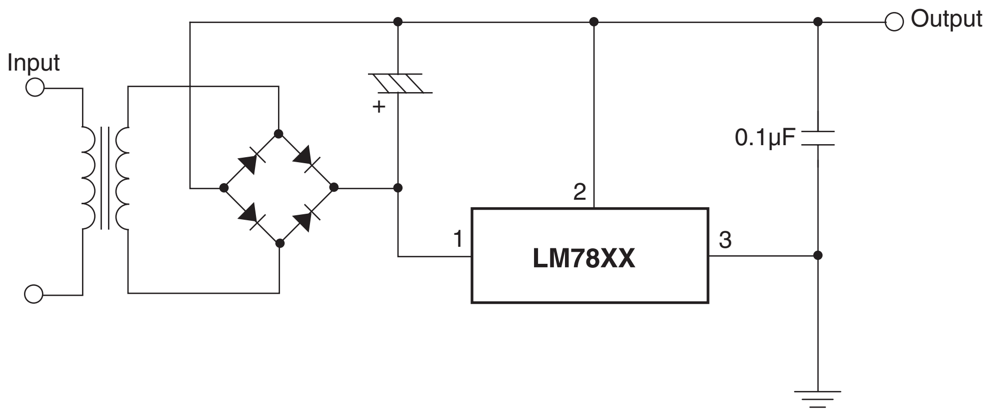


Figure 18. Negative Output Voltage Circuit

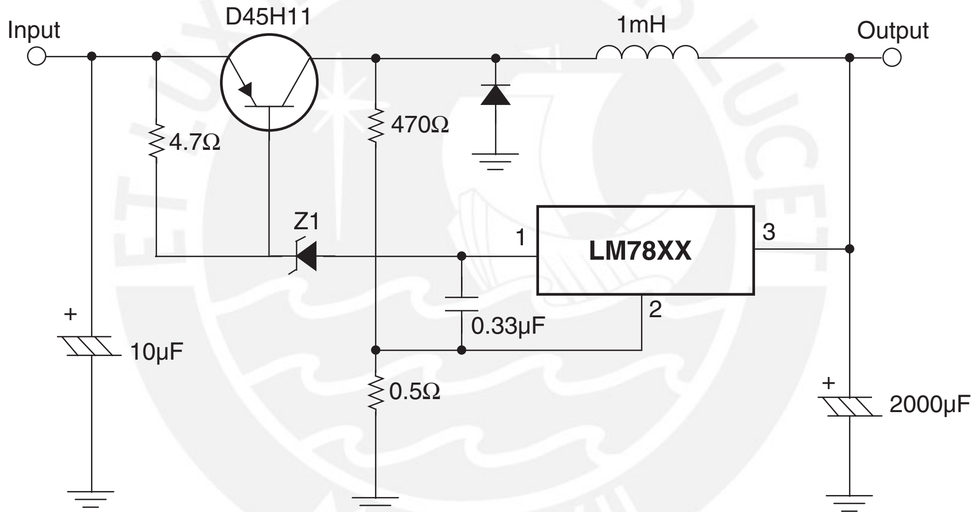
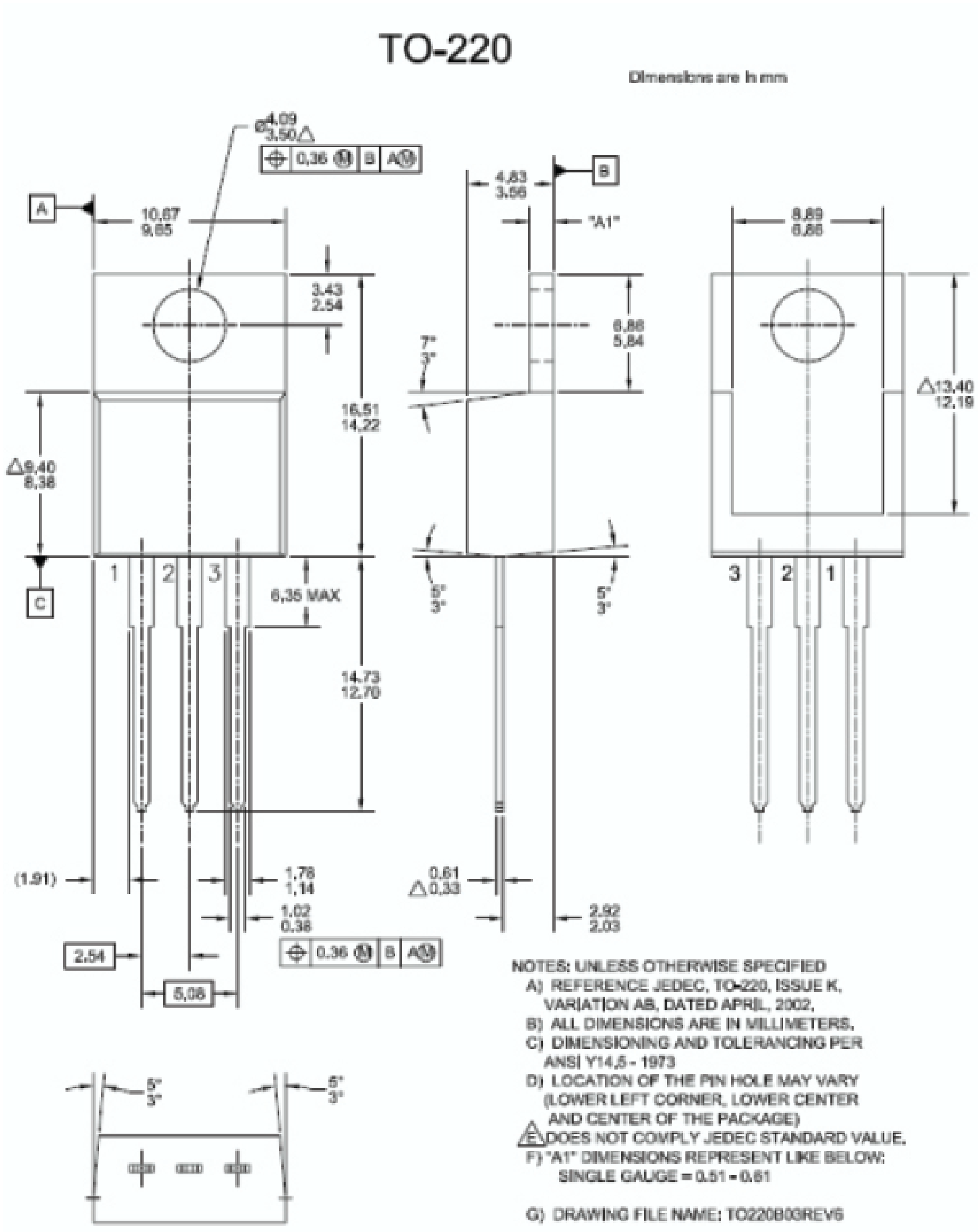


Figure 19. Switching Regulator

Mechanical Dimensions

Dimensions in millimeters



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PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
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Rev. I19

ANEXO B

- **Partes del ojo humano**

  - **Cristalino:** es una lente flexible biconvexa, es decir convergente, que puede modificar su forma para enfocar las imágenes en la retina. Esta modificación la realizan los músculos filiares.

  - **Iris:** es un diafragma que regula la entrada de luz mediante la variación del diámetro de la pupila.

  - **Retina:** es la capa fotosensible. Contiene una delicada película de fibras nerviosas que divergen del nervio óptico y terminan en unas neuronas con forma de conos y bastones que mediante un proceso fotoquímico transforman los estímulos luminosos en impulsos sensoriales.

  - **Conos y bastones:** los primeros están dedicados a la distinción de los colores, mientras que los bastones sólo perciben la luz sin distinguir los colores; sin embargo su sensibilidad se incrementa notablemente bajo niveles de iluminación débiles, mientras que los conos no funcionan en esas circunstancias.

    Los conos son sensibles a los colores, permitiendo la discriminación de los detalles finos, se encuentran concentrados en la fóvea, que es un área de 0.3 mm. de diámetro y aquí el ojo centra la imagen del objeto que debe ser examinado minuciosamente.

    Los bastones son los responsables de la visión a bajos niveles de iluminación; están distribuidos por toda la retina, y aumentan a medida que nos alejamos de ella.

  - **Nervio óptico:** está formado por las fibras nerviosas, que conducen las señales recibidas por los conoces y bastones al cerebro.

  - **Humor acuoso y humor vítreo:** son los líquidos transparentes que llenan las cámaras anterior y posterior al cristalino respectivamente.

- **Párpados y pestañas:** sirven como sistema de protección.

-

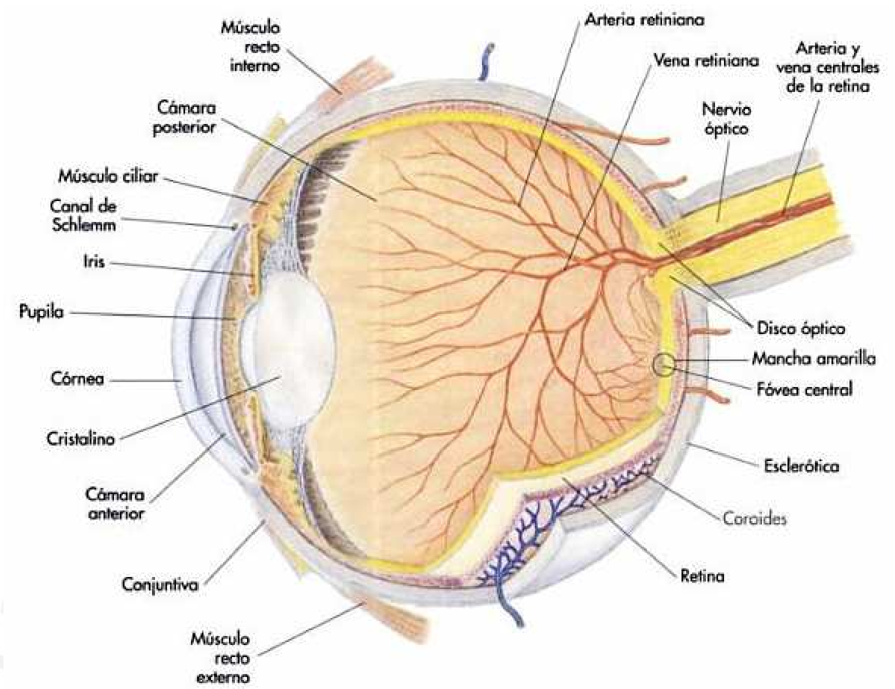

Figura B.1.1 Partes del ojo humano [11]

- **Visión humana** [12]

El funcionamiento del ojo humano produce lo que conocemos como visión humana, mediante las siguientes etapas:

La luz entra en el ojo a través de la pupila y es refractada para enfocarla en la retina. La refracción ocurre cuando la luz pasa a través de la córnea, el humor acuoso, el cristalino y el humor vítreo en su camino hasta la retina.

La capa más interna de la retina contiene los bastones y los conos, que son las células fotorreceptoras del ojo, quienes responden al estímulo luminoso mediante la producción de un impulso nervioso.
Los bastones y conos sinaptan con las neuronas de las capas bipolar y ganglionar de la retina. Las señales nerviosas abandonan la retina y salen del ojo por el nervio óptico, en la superficie posterior del globo ocular.

Después de salir del ojo, el nervio óptico entra en el encéfalo y llega hasta la corteza visual del lóbulo occipital. En esa zona, la interpretación visual de los impulsos generados por los estímulos luminosos en los bastones y los conos de la retina produce la visión.

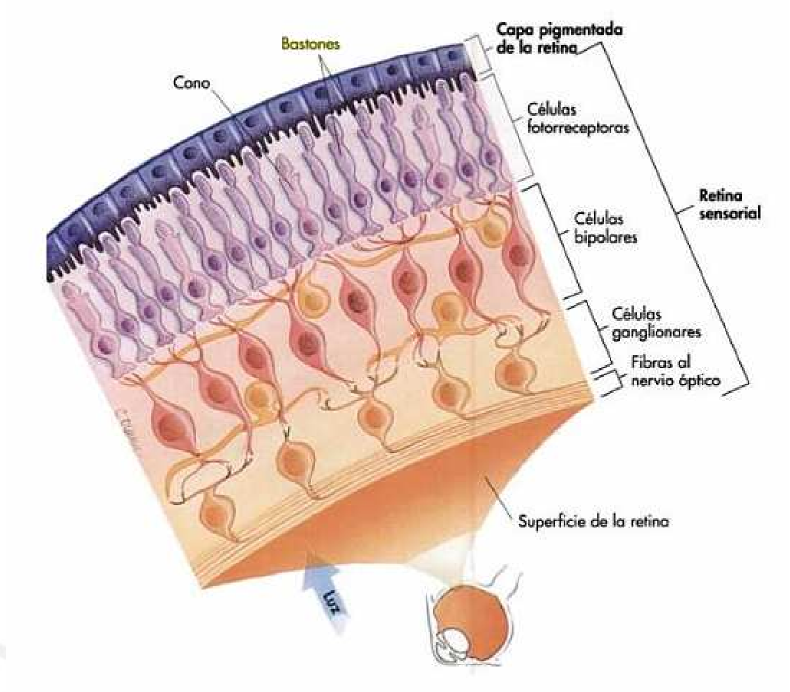

Figura B.1.2 Partes de la retina [12]

- **Campo visual** [11]

El campo visual puede dividirse en zonas con distinta calidad de visión, en función del ángulo de apertura con relación a la línea de visión:

- **Zona de visibilidad precisa:** corresponde a un ángulo de apertura de 1°.

- **Zona de visibilidad media:** formada por un ángulo de 40°, se ven los movimientos de los objetos, los contrastes fuertes y puede desplazarse la mirada entre objetos de modo fácil.

- **Zona periférica:** comprendida entre los 40° y 70°, solo se percibe l os objetos en movimiento y las luminancias muy contrastadas.

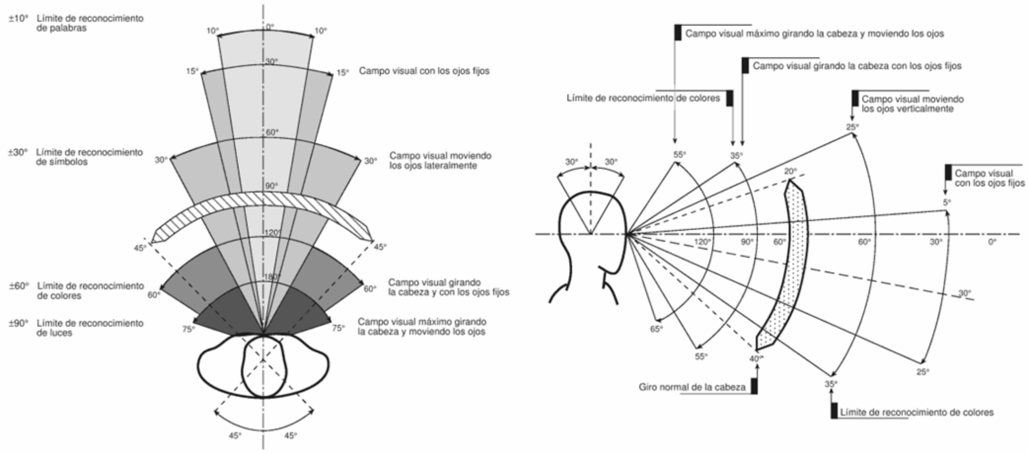

Figura B.1.3 Campo visual [12]

- **<u>Características del campo visual</u>**

- **<u>Acomodación</u>**

Es la capacidad del ojo para enfocar los objetos situados a distancias variables. Para que un objeto se distinga con precisión es necesario que su imagen se produzca sobre la retina; para conseguirlo los músculos filiares modifican la convexidad del cristalino. Los objetos lejanos requieren una disminución en la curvatura del cristalino que lo convierta en menos convergente para los objetos próximos la curvatura es opuesta.

La velocidad y precisión en la acomodación aumentan con el nivel de iluminación y con el contraste entre el objeto observado y el fondo.

- **<u>Agudeza visual</u>**

Es el poder de resolución del ojo, es decir la aptitud para percibir los detalles más pequeños de los objetos, la posibilidad de ver los puntos muy próximos y de apreciar los contornos y formas. Aumenta con el nivel de iluminación y el contraste.

- **<u>Velocidad de percepción</u>**

Es el tiempo transcurrido desde que un objeto esta dentro del campo visual hasta que es percibido por el cerebro. Aumenta con el nivel de iluminación y con el contraste.

- **Sensibilidad a los contrastes**

Es la aptitud visual de apreciar las distancias entre puntos situados en planos diferentes, logrados mediante:

- La comparación de las dimensiones de los objetos.
- El paralelaje de movimientos. Moviendo los ojos, los objetos más cercanos se mueven más rápidamente que los alejados.
- La visión binocular, obtenida gracias a la interpretación por parte del cerebro de las imágenes en ambos ojos.

ANEXO C

Se muestran las subrutinas utilizadas en el programa principal:

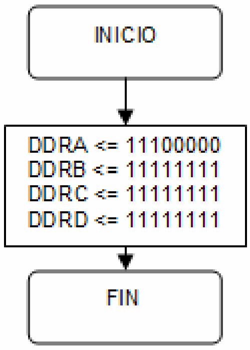

Figura C.1.1 Diagrama de flujo de subrutina configurar_puertos

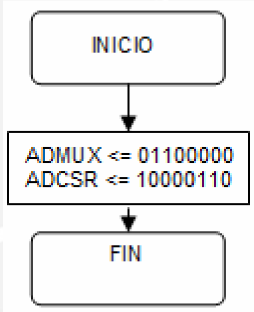

Figura C.1.2 Diagrama de flujo de subrutina configurar_ADC

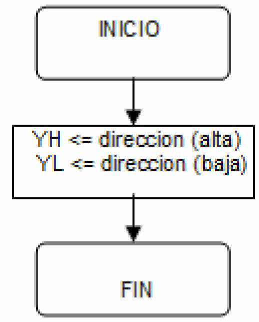

Figura C.1.3 Diagrama de flujo de subrutina direccionar_EEPROM

Figura C.1.4 Diagrama de flujo de subrutina configurar_LCD

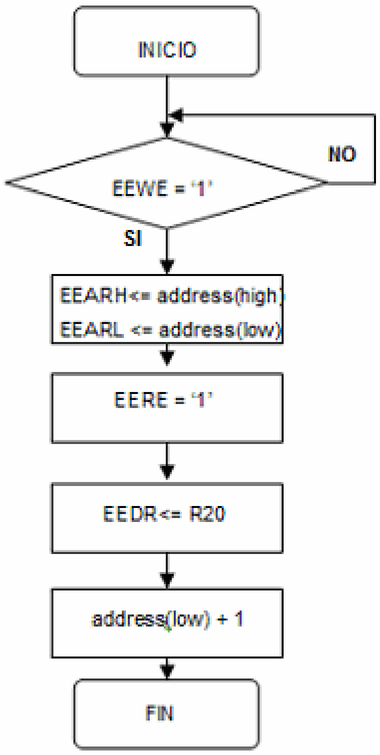

Figura C.1.5 Diagrama de flujo de subrutina lee_EEPROM

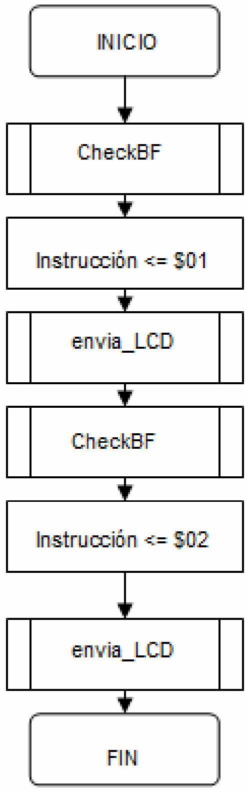

Figura C.1.6 Diagrama de flujo de subrutina limpia_pantalla

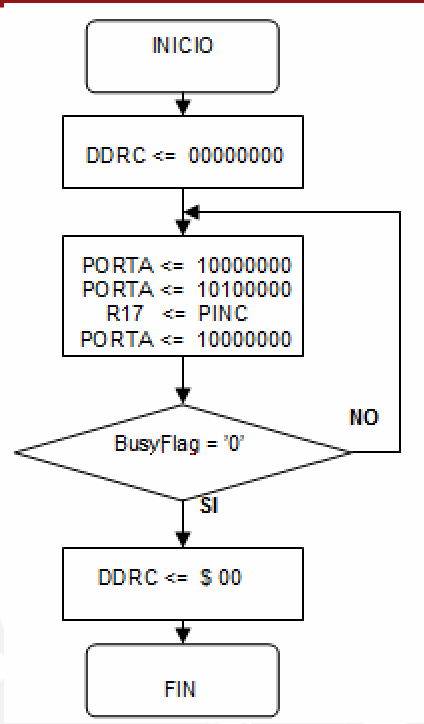

Figura C.1.7 Diagrama de flujo de subrutina CheckBF

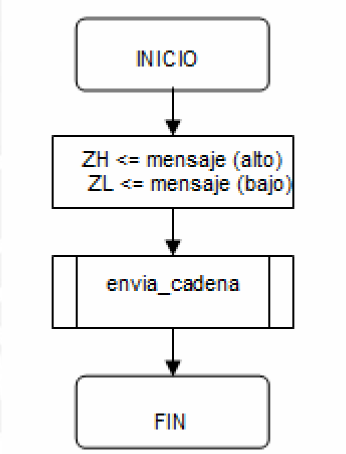

Figura C.1.8 Diagrama de flujo de subrutina imprime_mensaje

ANEXO D

- **Instrucción de selección de origen de reproducción**

El programa solicita al usuario seleccionar la ubicación del efecto a reproducir, ya sea reproducir algún efecto pregrabado (el cuál no es posible modificarlo) o grabado (por el mismo usuario).

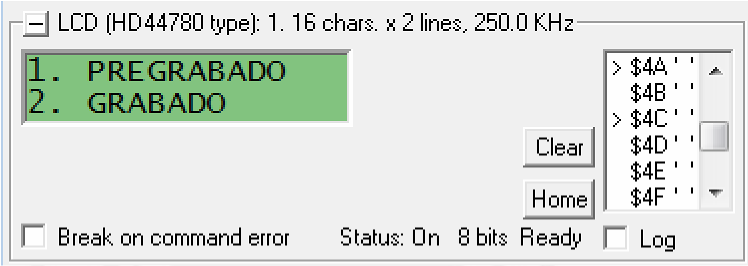

Figura D.1.1 Instrucción de selección de origen de reproducción en el display LCD del simulador

- **Instrucción de selección de ubicación para reproducción**

El programa solicita al usuario seleccionar la ubicación del efecto a reproducir, luego de haber seleccionado su origen (pregrabado o grabado), si el origen es pregrabado existen 3 posibles selecciones, en caso contrario un máximo de 4 selecciones posibles.

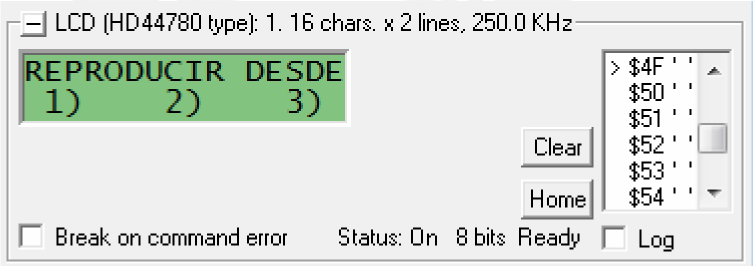

Figura D.1.2 Instrucción de selección de ubicación para reproducción en el display LCD del simulador

- **<u>Pantalla de confirmación de selección</u>**

Luego de haber seleccionado el efecto por el usuario, el display LCD muestra una pantalla, indicando cuál es la opción que ha elegido, para luego reproducirla.

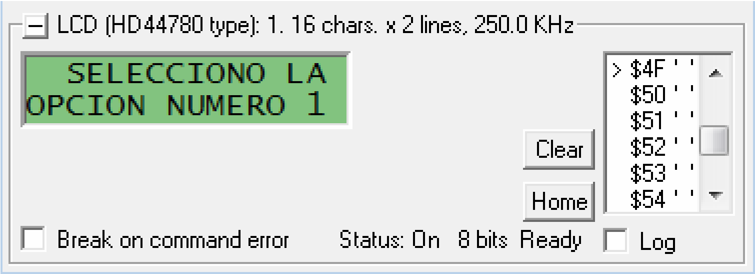

Figura D.1.3 Indicación de opción seleccionada en el display LCD del simulador

- **<u>Pantalla de reproducción de efecto</u>**

Esta pantalla es mostrada en el display LCD cuando se está reproduciendo algun efecto, ya se sea variación, como se muestra en la figura D.1.4, o en el caso de degradé.

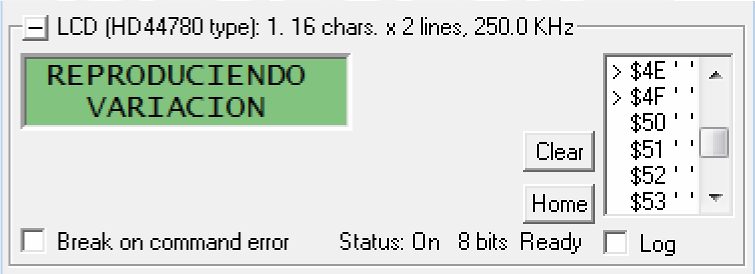

Figura D.1.4 Indicación de reproducción de efecto “variación” en el display LCD del simulador

- **<u>Instrucción de selección de ubicación para grabación</u>**

El programa solicita al usuario seleccionar la ubicación del efecto hacia donde se desea guardar, donde se cuenta con 4 ubicaciones posibles.

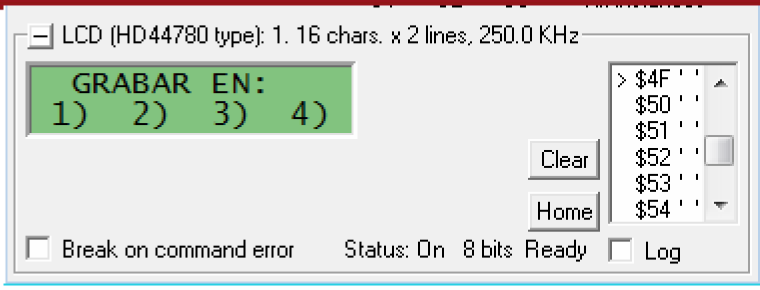

Figura D.1.5 Instrucción de selección de ubicación para grabación en el display LCD del simulador

- **<u>Instrucción de selección de intensidad de color</u>**

El programa solicita al usuario seleccionar la intensidad de cada componente para cada led (rojo, verde y azul de cada led de potencia RGB), tanto las intensidades del color inicial, como del color final.

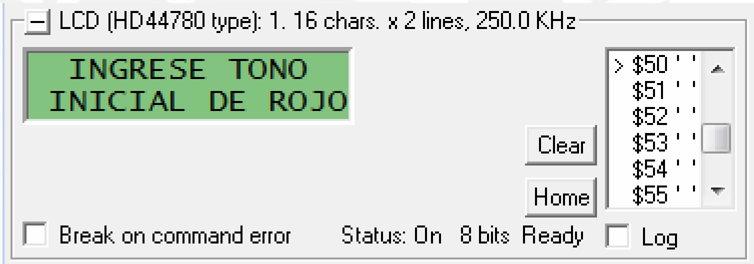

Figura D.1.6 Instrucción de selección de intensidad de color en el display LCD del simulador

- **<u>Pantalla de indicador de intensidad</u>**

En esta pantalla se observa el grado de intensidad que el usuario le está asignando a cada componente de cada led, la cual va cambiando según se varie la interfaz asignada a esta función.

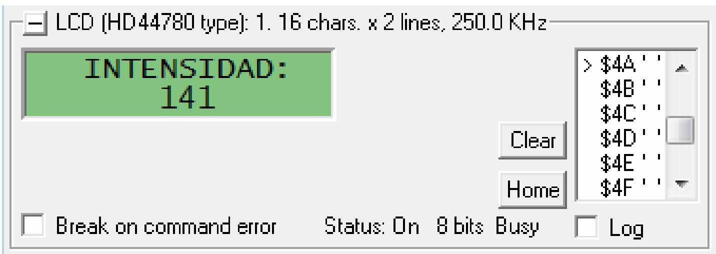

Figura D.1.7 Indicación del nivel de intensidad asignado enel display LCD del simulador

ANEXO E

- **Circuito de los subsistemas de control e interfaz**

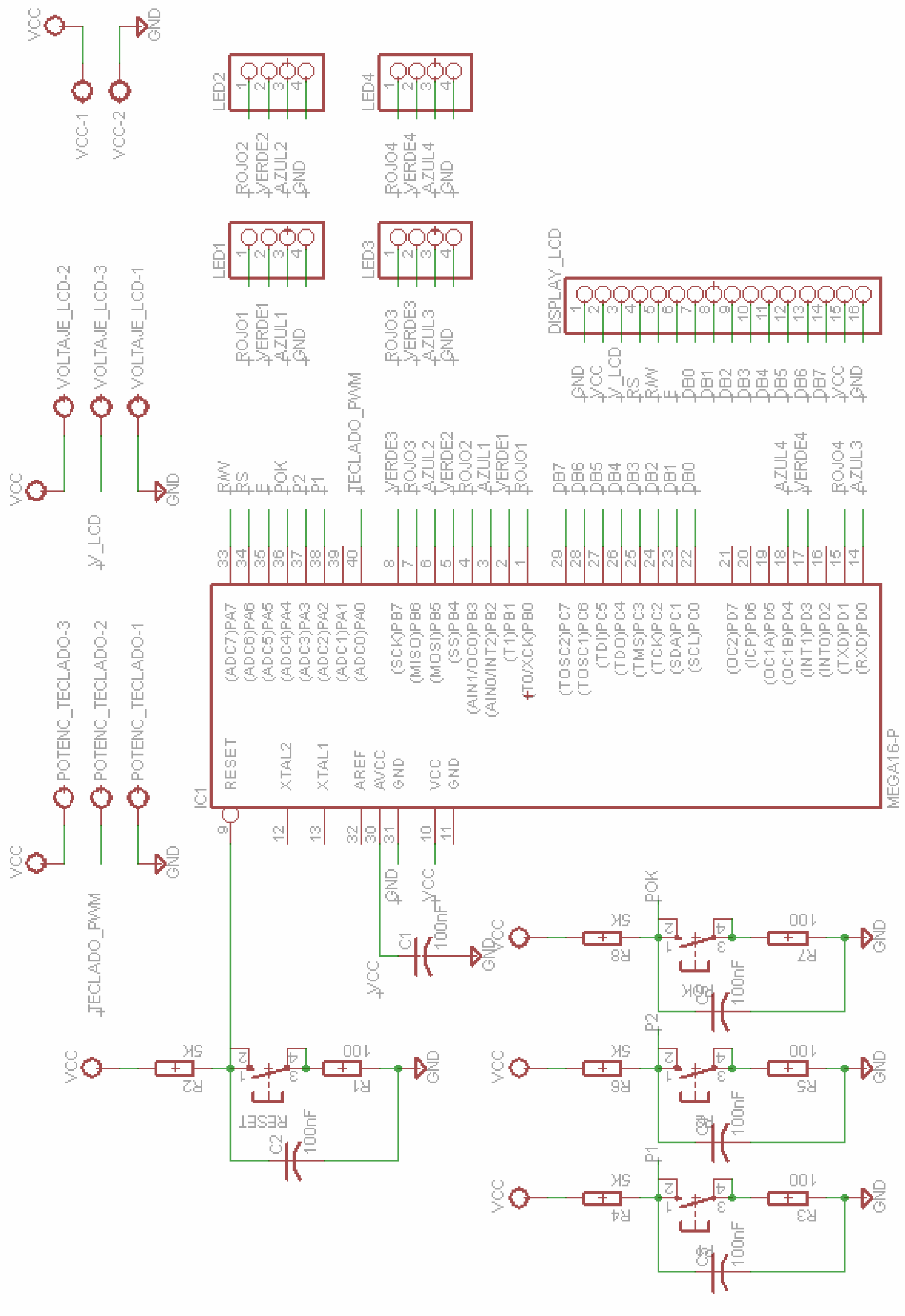

Figura E.1.1 Diagrama esquemático de los subsistemas de control e interfaz

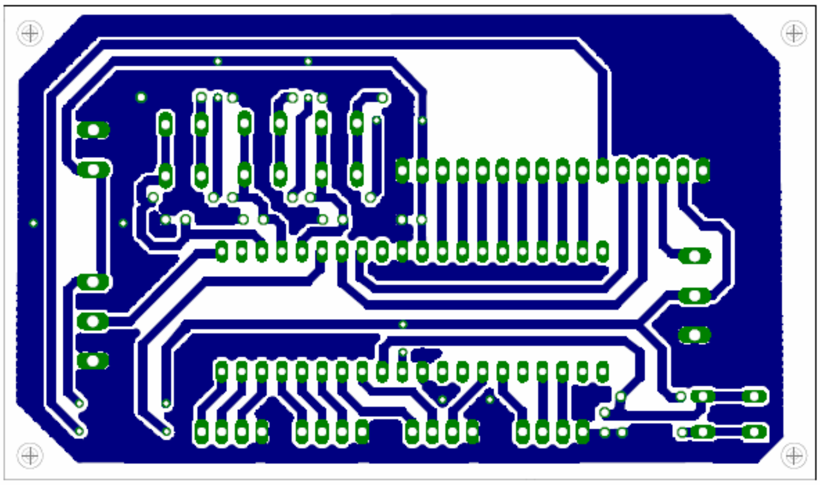

Figura E.1.2 Diagrama de pistas de los subsistemas de control e interfaz

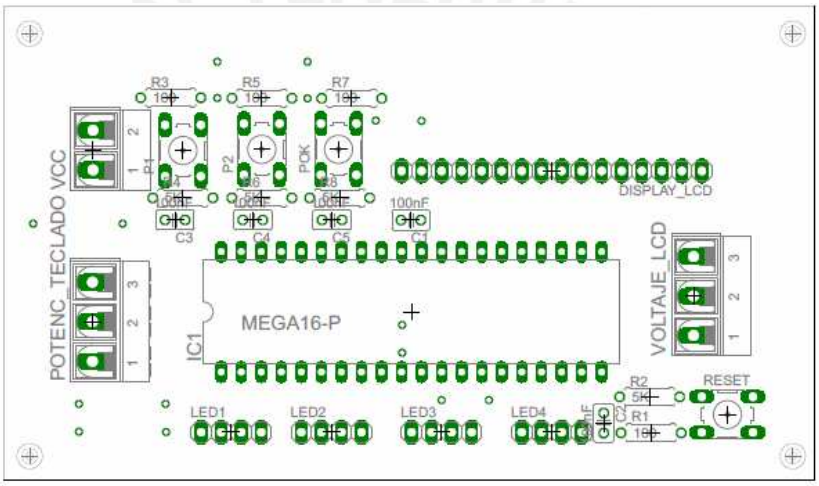

Figura E.1.3 Diagrama de componentes de los subsistemas de control e interfaz

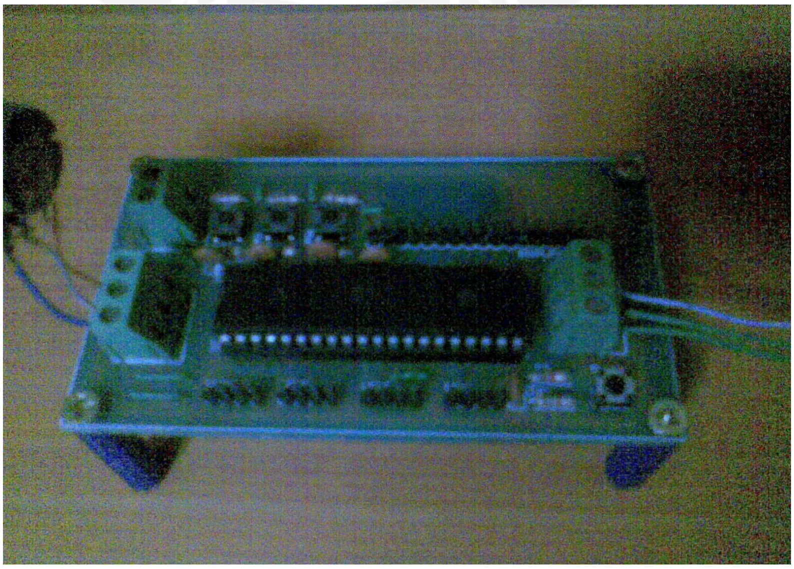

Figura E.1.4 Implementación de los subsistemas de control e interfaz

- **Circuito del subsistema de actuación**

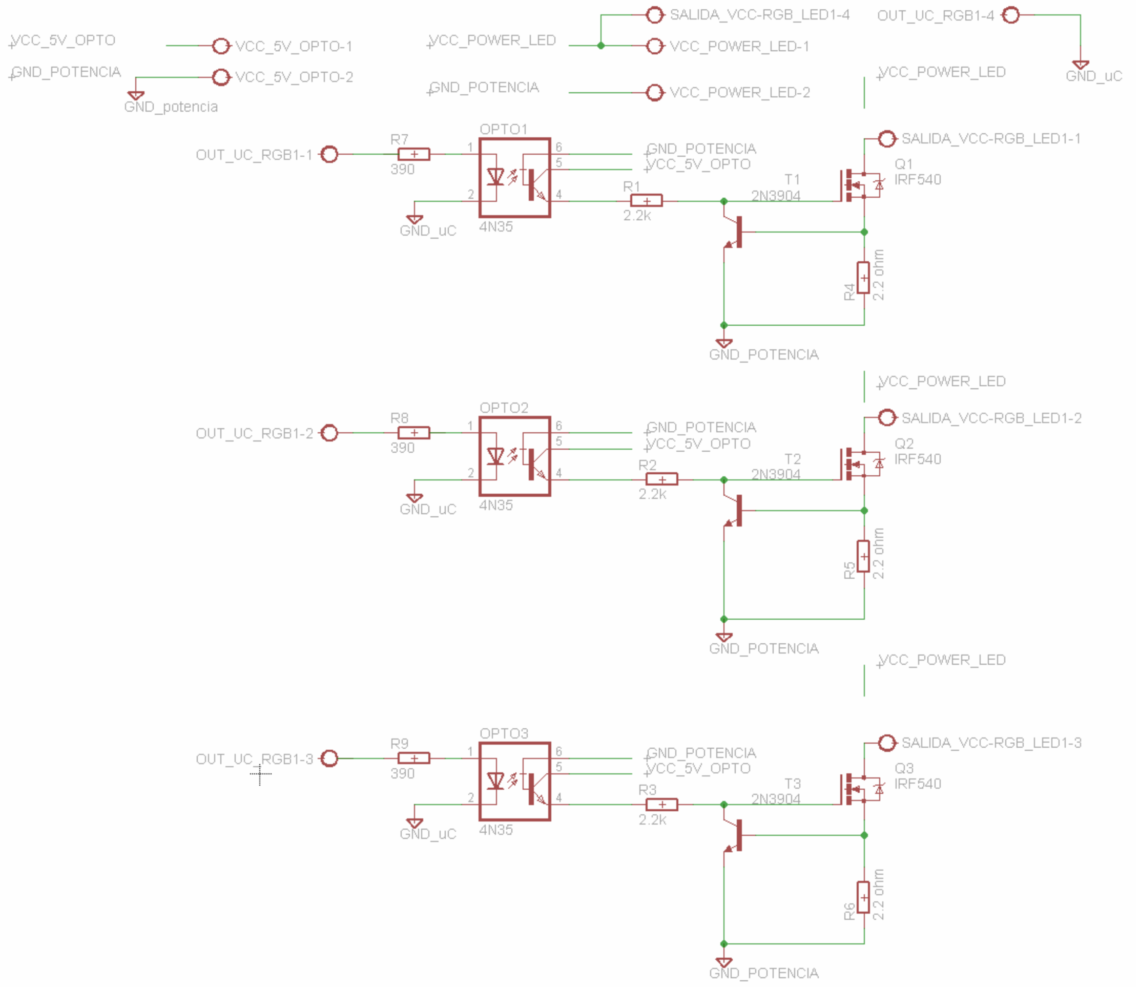

Figura E.1.5 Diagrama esquemático del subsistema de actuación

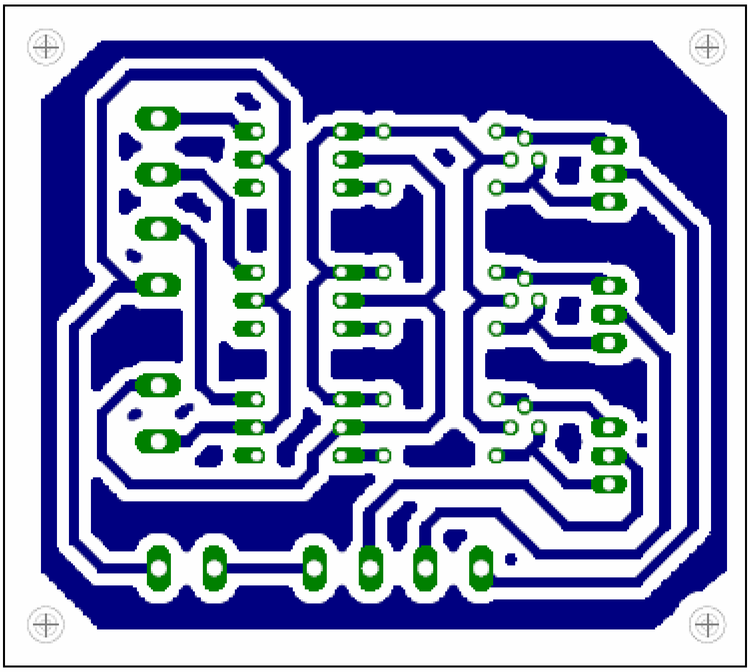

Figura E.1.6 Diagrama de pistas del subsistema de actuación

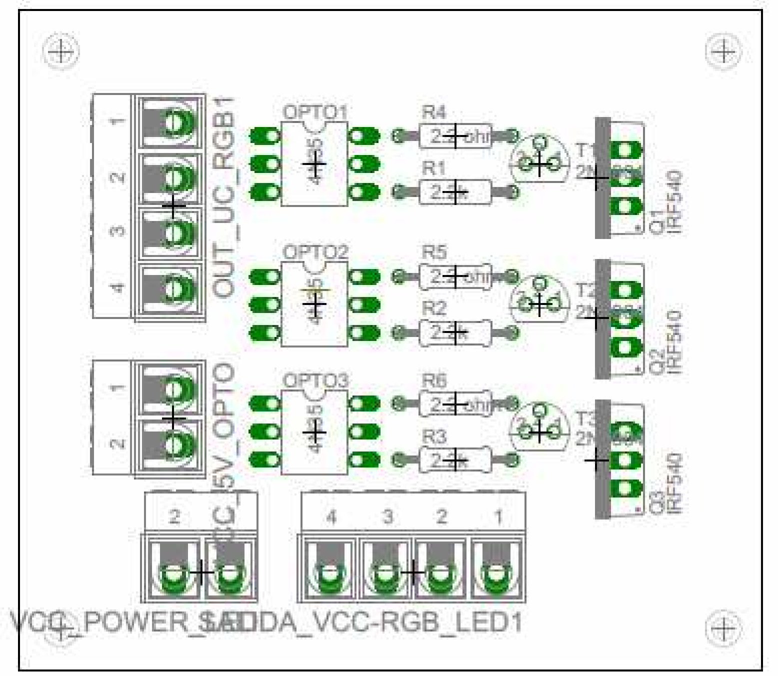

Figura E.1.7 Diagrama de componentes del subsistema de actuación

Figura E.1.8 Implementación del subsistema de actuación

- **Circuito de leds de potencia RGB del prototipo**

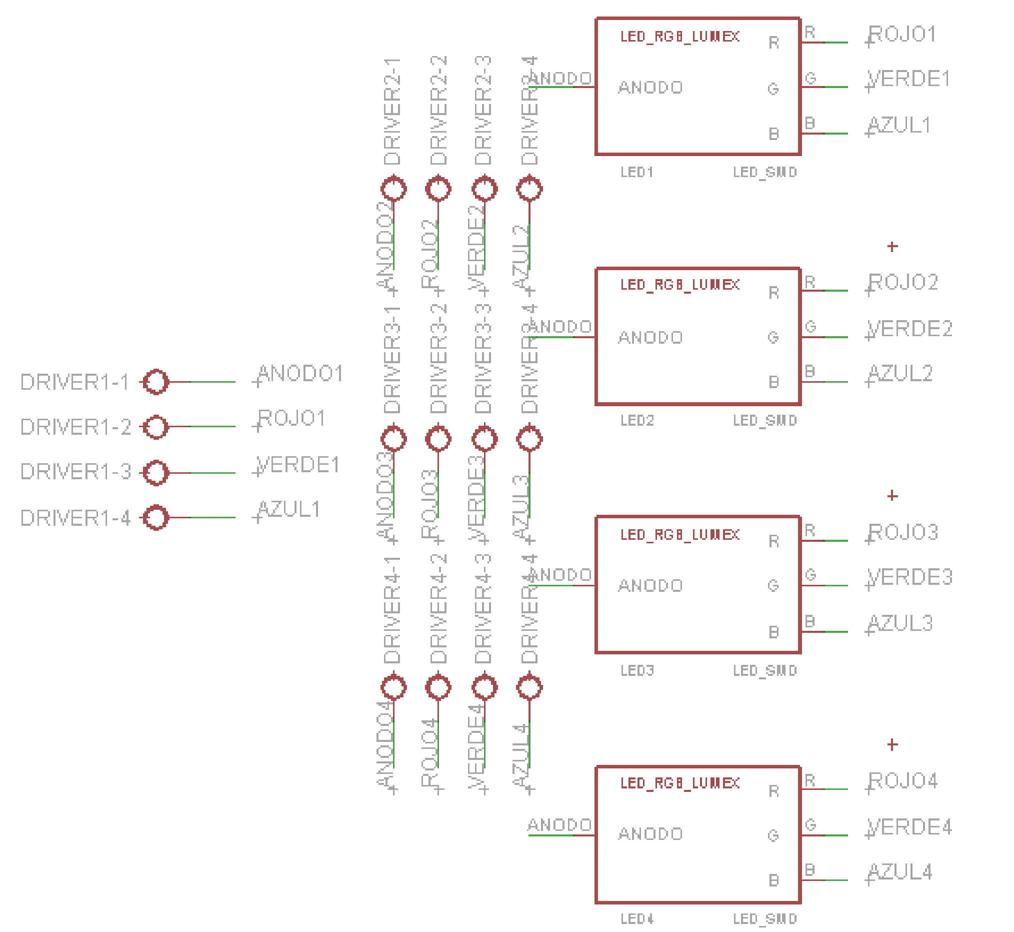

Figura E.1.9 Diagrama esquemático del leds de potencia RGB del prototipo

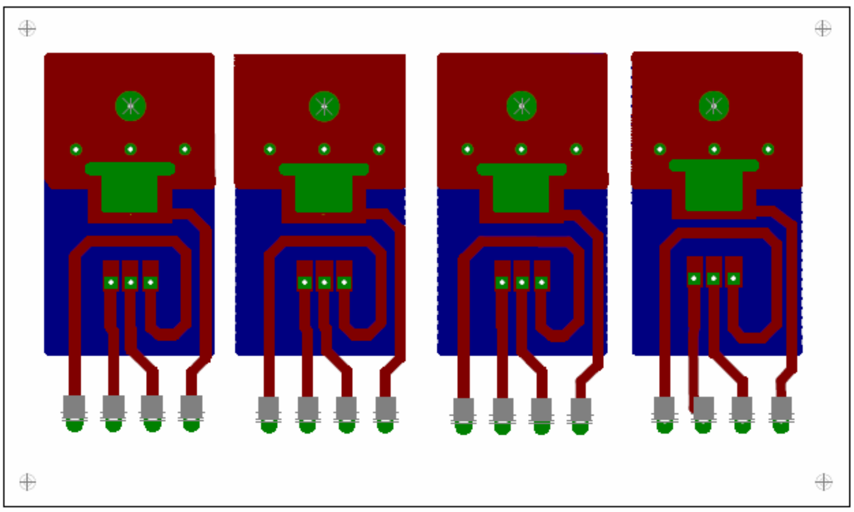

Figura E.1.10 Diagrama de pistas del leds de potencia RGB del prototipo

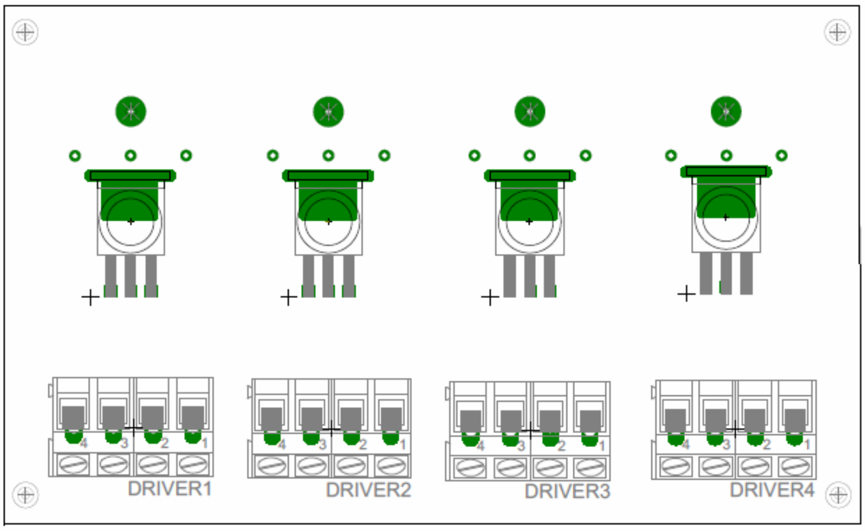

Figura E.1.11 Diagrama de componentes del leds de potencia RGB del prototipo

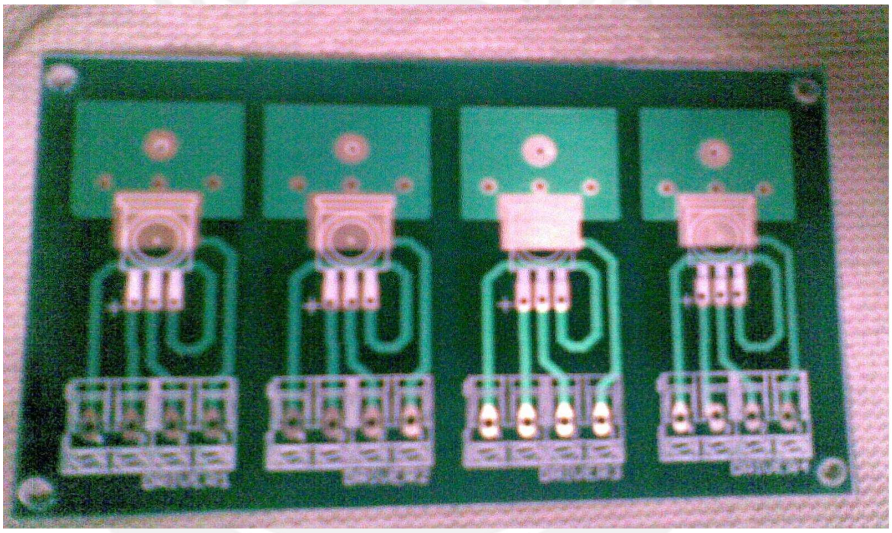

Figura E.1.12 Implementación de tarjeta de leds de potencia RGB del prototipo

ANEXO F

- **Resultados**

Se muestran 2 ejemplos implementados adicionales para cada efecto de degradé.

- **Variación**

En las figuras F.1.1, F.1.2 y F.1.3 se muestran los colores del efecto N°2 implementado en el prototipo, donde el color inicial es amarillo y el final es rojo.

Figura F.1.1 Color inicial en el efecto N°2 de variación

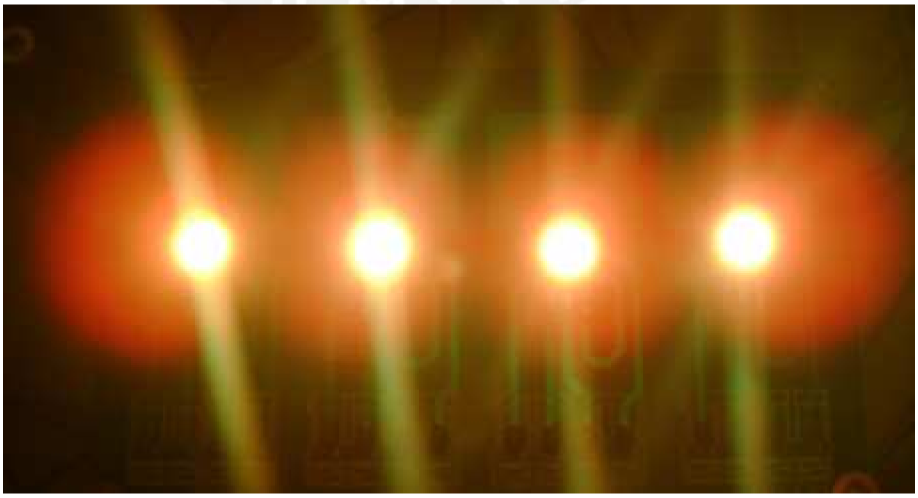

Figura F.1.2 Color intermedio en el efecto N°2 de variación

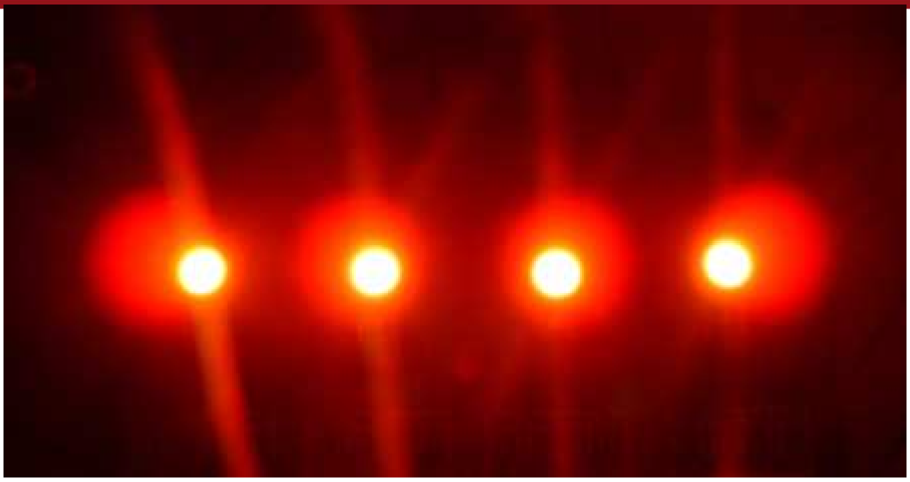

Figura F.1.3 Color final en el efecto N°2 de variación

En las figuras F.1.4, F.1.5 y F.1.6 se muestran los colores del efecto N°3 implementado en el prototipo, donde el color in icial es azul y el final es verde.

Figura F.1.4 Color inicial en el efecto N°3 de variación

Figura F.1.5 Color intermedio en el efecto N°3 de variación

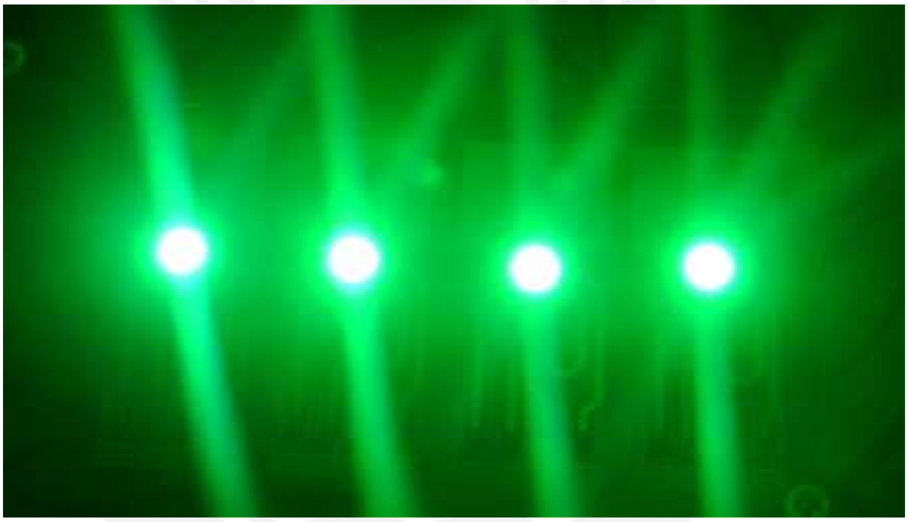

Figura F.1.6 Color final en el efecto N°3 de variación

- **Degradé**

En las figuras F.1.7 y F.1.8 se muestran 2 ejemplos implementados en el prototipo.

En la primera de ambas figuras, se ve el degradé entre los colores rojo y amarillo, teniendo al medio los colores rojo-anaranjado y naranja.

Figura F.1.7 Efecto N°2 de degradé desde rojo a amarillo

En la figura F.1.8 observamos el degradé entre el blanco y rojo, teniendo como colores intermedios rosado y fucsia.

Figura F.1.8 Efecto N°3 de degradé desde blanco a rojo

ANEXO G

- **Diseño de fuente switching para alimentación de diseño**

Según los requerimientos calculados en el capítulo 3, se necesita diseñar una fuente switching con salida múltiple (20.9V @ 6A y 5V @ 1A) con una potencia mínima total de 126.4W.

Debido a que las fuentes switching poseen distintas topologías, es necesaria elegir una para realizar el diseño, para lo cuál se muestra un gráfico comparativo con relación a voltajes de entrada y potencia necesaria donde se muestra la topología recomendada para obtener una mejor eficiencia:

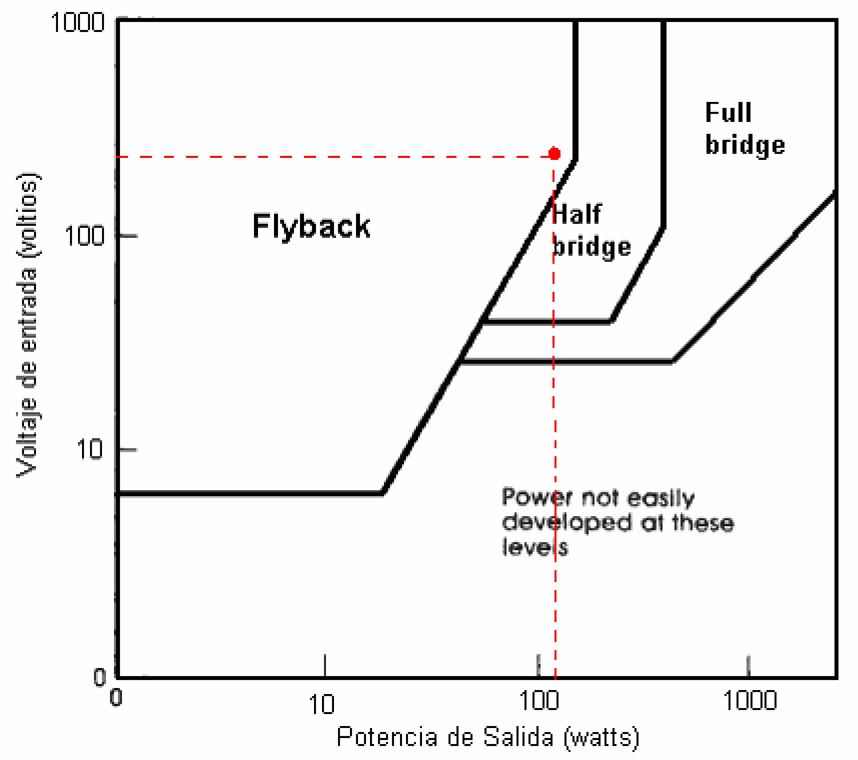

Figura G.1.1 Gráfica para selección de topología según potencia y $V_{entrada}$ [40]

Del gráfico previo, ya que nuestro $V_{entrada}$ es 220V y la potencia es 126.4W, podemos deducir que la mejor topología es Flyback.

Esta topología se tiene como bloques de operación las mostradas en la figura G.1.2:

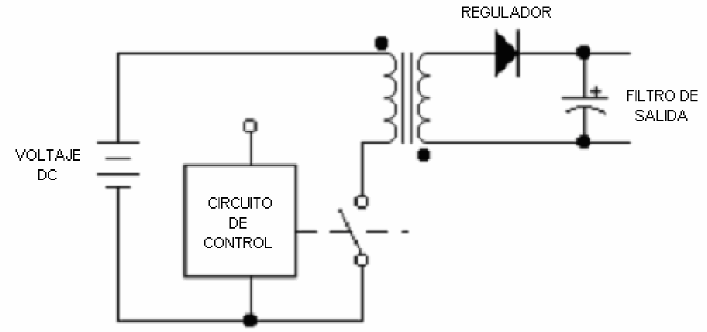

Figura G.1.2 Esquema básico del flyback [41]

Donde se observa una alimentación inicial DC, que se obtiene luego de variar la señal AC por un puente de diodos y condensadores. Vemos también el transformador, el cuál entregará la potencia desde un lado al otro mediante el almacenamiento de energía magnética.

El circuito de control se encargará de decidir la operación del transformador mediante un interruptor, de manera que al estar cerrado, se acumule la energía en el lado primario, y al abrirse, toda esta energía se transfiera hacia el lado secundario. Finalmente, se utiliza un regulador y un condensador a la salida para estabilizar la señal.

El presente diseño estará basado en el diseño realizado en el circuito de la figura G.1.3, adaptando los componentes a los requerimientos para poder entregar la potencia adecuada.

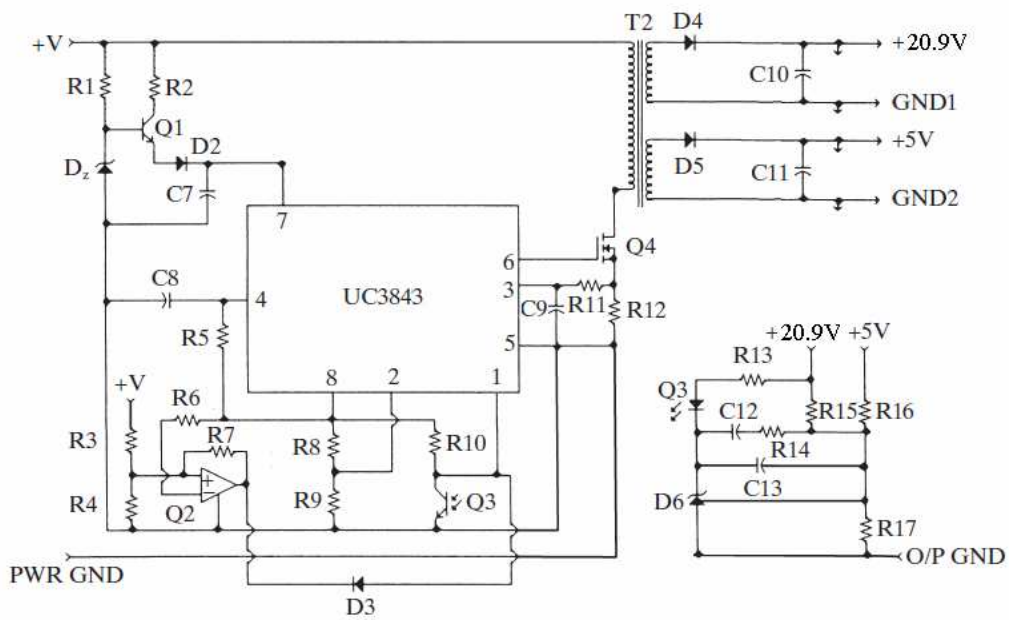

Figura G.1.3 Circuito de fuente flyback a diseñar [42]

A continuación, se diseñará paso a paso la fuente:

1. **Especificaciones de diseño**

- Rango de voltaje de entrada: 180VAC – 260VAC @ 60Hz
- Voltajes de salida: +20.9VDC @ 6A
  + 5VDC @ 1A
- Voltaje de salida de rizado (deseado): $100mV_{pp}$

2. **Consideraciones de prediseño**

- Potencia de salida total:

$$P_{SALIDA} = (20.9V)(6A) + (5V)(1A)$$
$$P_{SALIDA} = (20.9V)(6A) + (5V)(0.1735A)$$
$$P_{SALIDA} = 126.27\,watts$$

- Potencia de entrada (estimada):

$$P_{ENTRADA} = P_{SALIDA} / eficiencia$$
$$P_{ENTRADA} = 126.27 / 0.8(asumido)$$
$$P_{ENTRADA} = 157.84\,watts$$

- Voltajes DC de entrada:

$$V_{ENTRADA(MENOR)} = (180VAC)(1.4142)$$
$$V_{ENTRADA(MENOR)} = 254.558VDC$$
$$V_{ENTRADA(MAYOR)} = (260VAC)(1.4142)$$
$$V_{ENTRADA(MAYOR)} = 367.695VDC$$

- Corrientes de entrada promedio:

1. Corriente promedio mayor: $I_{ENTRADA(MAX)} = P_{ENTRADA} / V_{ENTRADA(MIN)}$

$$I_{ENTRADA(MAX)} = 157.84W / 254.558VDC$$
$$I_{ENTRADA(MAX)} = 0.62\,A$$

2. Corriente promedio menor: $I_{ENTRADA(MIN)} = P_{ENTRADA} / V_{ENTRADA(MAX)}$

$$I_{ENTRADA(MAX)} = 157.84W / 367.695VDC$$
$$I_{ENTRADA(MAX)} = 0.429\,A$$

Como ya tenemos las corrientes, podemos seleccionar el calibre del cable adecuado, que según tabla AWG, es el #23.

- Corriente pico estimada (lado primario)

$$I_{PICO} = 5.5 P_{SALIDA} / V_{ENTRADA(MIN)}$$

$$I_{PICO} = 5.5(126.27W)/(254.558VDC)$$

$$I_{PICO} = 5.5(126.27W)/(254.558VDC)$$

$$I_{PICO} = 2.73A$$

- Tendrá salidas múltiples (20.9 VDC y 5 VDC).
- La etapa de control de la fuente será realizada por el integrado UC3843P [43] a una frecuencia de 50Khz. (determinada de diseño), ya que este integrado es encontrado fácilmente en el mercado local.
- El $T_{APAGADO}$ se considerará el 30% de la inversa de la f_{op} (criterio de diseño) [42], es decir 6us.
- El valor de $\delta_{(MAX)}$ (ciclo máximo de trabajo) se considerará 0.5 como criterio de diseño, ya que con este valor se reduce al mínimo las pérdidas en el MOSFET de la etapa de control [42].

3. **<u>Diseño del transformador</u>**

Para el diseño de transformador de la fuente conmutada, el núcleo más común es en forma de E-E. Para este nivel de potencia, el tamaño apropiado por lado es de 30 mm. por lado [42], este núcleo puede ser encontrado en Magnetics Inc. el número de parte F-43515-EC [44].

En su hoja técnica, nos brinda información importante para continuar el diseño, como el A_C (área del núcleo) siendo 0.87 cm^2, las pérdidas del núcleo de 232 mW/cm^3, entre otros datos.

- La inductancia primaria mínima requerida es:

$$L_{PRIMARIA} = \frac{V_{ENTRADA(MENOR)}\delta_{(MAX)}}{I_{PICO} \cdot f} = \frac{(254.558V)(0.5)}{(2.73A)(50000)}$$

$$L_{PRIMARIA} = 932.44\mu H$$

- El flujo de densidad máximo (B_{MAX}) del núcleo se determinará mediante el gráfico de [42], ya que tenemos de dato la $f_{operación}$ y las pérdidas de núcleo. Entonces, mediante la figura G.1.4:

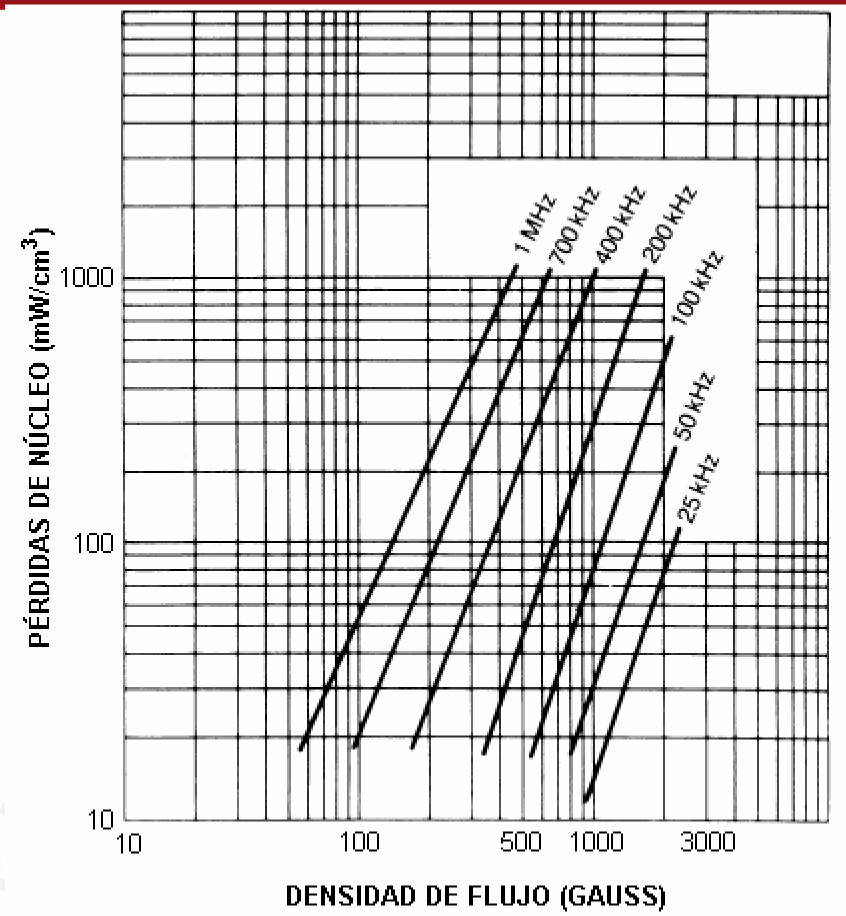

Figura G.1.4 Gráfica para determinación de densidad de flujo [42]

- De la figura previa, se puede observar que para unas pérdidas de núcleo de 232 mW/cm^3 y una frecuencia de 50 Khz. se deduce que la B_{MAX} es aproximadamente 2000 Gauss.
- El entrehierro requerido para evitar la saturación del núcleo es:

$$l_{ENTREHIERRO} = \frac{(0.4\pi.L_{PRIMARIA} I_{PICO})10^8}{A_C B_{MAX}^2} = \frac{(0.4\pi)(0.00093244)(2.73)10^8}{(0.87cm^2)(2000G)^2}$$

$$l_{ENTREHIERRO} = 0.091cm$$

Comercialmente, el valor más cercano de longitud para este entrehierro es de 0.1734 cm. con una inductancia (A_L) de 100mH/1000vueltas [44]. El núcleo con este entrehierro es F-43515-EC-02 en la empresa Magnetics Inc.

- El número máximo de vueltas necesarias para el bobinado primario es:

$$N_{PRIMARIO} = 1000\sqrt{\frac{L_{PRIMARIO}}{A_L}} = 1000\sqrt{\frac{0.93244mH}{100mH}} = 96.56\,vueltas$$

El cuál para fines de diseño se redondea a 97 vueltas.

- El número de vueltas requeridas para la salida de 20.9V es:

$$N_{SECUNDARIO} = \frac{N_{PRIMARIO}(V_{SALIDA} + V_{DIODO})(1-\partial_{MAX})}{V_{ENTRADA(MINIMO)}.\partial_{MAX}}$$

$$N_{SECUNDARIO} = \frac{(97vueltas)(20.9V + 0.7V)(1-0.5)}{(254.558V)(0.5)}$$

$$N_{SECUNDARIO} = 8.23\ vueltas$$

Se redondea para fines prácticos a 8 vueltas.

- Bajo el mismo análisis, el número de vueltas requeridas para la salida de 5V es:

$$N_{SECUNDARIO} = \frac{(97vueltas)(5V + 0.7V)(1-0.5)}{(254.558V)(0.5)}$$

$$N_{SECUNDARIO} = 2.17\ vueltas$$

Se redondea para fines prácticos a 2 vueltas.

- Los cables a usar en cada bobinado serán (de tabla vf1):

Primario: I_{MAX} = 2.73A, #17 AWG, 1 hilo

+20.9V: I_{MAX} = 6A, #19 AWG, 4 hilos

+5V: I_{MAX} = 1A, #21 AWG, 1 hilo

4. <u>Diseño del filtro de salida</u>

Hallamos la tensión inversa de los diodos D4 y D5 (V_R)

- Para la salida de +20.9V:

$$V_R > V_{SALIDA} + \frac{N_{SECUNDARIO}}{N_{PRIMARIO}} V_{ENTRADA(MAXIMO)}$$

$$V_R > 20.9 + \frac{8vueltas}{97vueltas}(367.965)$$

$$V_R > 51.25\ V$$

- Para la salida de +5V:

$$V_R > V_{SALIDA} + \frac{N_{SECUNDARIO}}{N_{PRIMARIO}} V_{ENTRADA(MAXIMO)}$$

$$V_R > 5 + \frac{2vueltas}{97vueltas}(367.965)$$

$$V_R > 12.59\ V$$

- Siguiendo el criterio de diseño:

$$I_{DIRECTA} > I_{PROMEDIO}$$

Para el caso de 20.9V debemos elegir un diodo rectificador que pueda soportar al menos 6A y trabaje a un voltaje mayor al calculado. Se elige el modelo MBR760 [45] pues cumple con dichos requerimientos. ($I_{DIRECTA}$ = 7.5A y V_R=60V). Entonces D4=MBR760.

Análogamente, en el caso de 5V debemos elegir un diodo rectificador que pueda soportar al menos 1A y trabaje a un voltaje mayor a 12.6V. Se elige el modelo MBR320 [46] pues cumple con dichos requerimientos. ($I_{DIRECTA}$ = 3A y V_R=20V). Por lo que D5=MBR320.

- Para determinar el valor mínimo de los condensadores filtros en la salidas, (C10 y C11) tenemos:

Para la salida de +20.9V:

$$C_{SALIDA(MINIMO)} = \frac{I_{SALIDA} T_{APAGADO}}{V_{RIZADO(deseado)}}$$

$$C_{SALIDA(MINIMO)} = \frac{(6A)(6\mu s)}{100mV}$$

$$C_{SALIDA(MINIMO)} = 360\mu F = C10$$

Debido a que comercialmente ese valor no existe, mediante el arreglo en paralelo se pueden colocar 2 condensadores de 180uF @ 35V.

Para la salida de +5V:

$$C_{SALIDA(MINIMO)} = \frac{I_{SALIDA} T_{APAGADO}}{V_{RIZADO(deseado)}}$$

$$C_{SALIDA(MINIMO)} = \frac{(1A)(6\mu s)}{100mV}$$

$$C_{SALIDA(MINIMO)} = 60\mu F = C11$$

Debido a que comercialmente ese valor no existe, mediante el arreglo en paralelo se pueden colocar 2 condensadores de 33uF @10V.

5. Diseño de la etapa de control

- La alimentación para el controlador deberá ser mediante un circuito de ‘arranque y puesta en marcha’, pues no se puede alimentar directamente desde el $V_{ENTRADA}$, ya que es mucho mayor a los máximos permitidos, la función de este circuito es brindar una tensión estable para el controlador. Existen diversas configuraciones propuestas en [42], dentro de las cuales se seleccionará el siguiente circuito visto en la figura G.1.5:

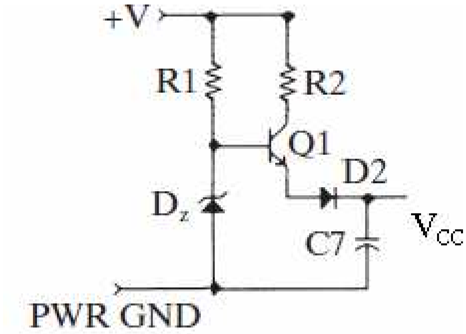

Figura G.1.5 Circuito para alimentación del controlador [42]

Se empieza seleccionando el diodo zener, bajo el criterio de $V_{ZENER} > V_{CC(MIN)}$, el modelo 1N5241A [47] cumple el requerimiento (V_{ZENER}=12V y $V_{CC(MIN)}$ que según su H. T. es 11.5V).

$$R1 = \frac{V_{ENTRADA(MIN)} - V_{ZENER}}{I_{ZENER(MIN)}} = \frac{254.558 - 12}{20mA} = 12.8K$$

$$R2 = \frac{V_{ENTRADA(MIN)} - V_{ZENER}}{30mA} = \frac{254.558 - 12}{30mA} = 8.08K$$

Para la selección del transistor, se sigue el criterio: $V_{CEO} > V_{ENTRADA(MAX)}$, I_c = 30 mA, El transistor Q1 será MPSA44, ya que cumple dichas necesidades mencionadas previamente[52], el diodo D2 será el 1N4148 y el condensador de desacoplo C7 de 10uF.

- Según la hoja técnica del controlador [43], se debe colocar un R_T y un C_T para determinar la frecuencia de oscilación (en nuestro caso, predeterminado a 50KHz.)

$$f = \frac{1.72}{R_T C_T}$$

Asumiendo un R_T de 39K (R5), entonces para f=50KHz determinamos C_T:

$$C_T = \frac{1.72}{(39K)(50KHz)}$$

$$C_T = 822\,pF = C8$$

- Ya que se utilizará un MOSFET como conmutador, se necesita seleccionarlo bajo el siguiente criterio:

$$V_{DSS} > V_{ENTRADA(MAX)} + \frac{N_{PRIMARIO}}{N_{SECUNDARIO}}(V_{SALIDA} + V_{DIODO})$$

De la hoja técnica del MBR760 [45], se observa que el voltaje es de 0.75V, entonces hallando V_{DSS}:

$$V_{DSS} > 367.695V + \frac{97}{8}(20.9 + 0.75)$$

$$V_{DSS} > 630.2V$$

Y en cuanto a la corriente a soportar:

$$I_D > I_{PICO}$$

$$I_D > 2.73A$$

Por lo que el MOSFET IRFB9N65A cumple los requisitos (V_{DSS}=650V y I_D=8.5A) tal como indica su hoja técnica [49].

- Como ya se indicó en la etapa de prediseño, se seleccionó el controlador UC3843P, pues es de fácil adquisición y es muy comúnmente utilizado para el control en fuentes switching.
- El voltaje de lazo de realimentación debe estar aislado del voltaje de la línea de entrada, por lo que se requiere utilizar un opto-aislador. El modelo MOC8102 (Q3) será utilizado en esta etapa por ser de fácil adquisición y bajo consumo, según su hoja técnica. [50]

Para mejorar los efectos de la regulación, debemos sensar la corriente en respuesta a los cambios de carga, para esto, nos ayudamos de un diodo de referencia (D6), en este caso de una referencia de precisión como el TL431CP.

En la etapa de retroalimentación, la corriente es de 1mA para la salida del D3, por lo que el TL431CP debe permitir obtener dicha corriente a través del pin del controlador, entonces debemos de agregar un control de corriente para este propósito. De hoja técnica del opto-aislador [50], tenemos:

$$R_{10} = \frac{1.0V}{1.0mA} = 1K\Omega$$

El led para limitar la corriente del opto-aislador será:

$$R_{13} = \frac{V_{SALIDA} - (V_{OPTO} + V_{TL431})}{I_{OPTO}}$$

$$R_{13} = \frac{20.9 - (1.4 + 2.5)}{6mA} = 2.83K$$

Cambiamos R_{13} hacia su valor más cercano comercial, que es 2.7K.

Ya que la corriente de sensado es de 1mA determinamos R_{17}:

$$R_{17} = \frac{V_{TL431}}{I_{SENSADO}} = \frac{2.5V}{1mA} = 2.5K$$

Igualmente cambiamos el valor de R_{17} a un valor comercial, en este caso 2.7K.

Recalculando la $I_{SENSADO}$ con los valores actuales:

$$I_{SENSADO} = \frac{V_{TL431}}{R_{17}}$$

$$I_{SENSADO} = \frac{2.5V}{2.7K}$$

$$I_{SENSADO} = 0.926mA$$

Ahora se debe asignar el grado de sensibilidad para cada salida, según la aplicación para la cuál es diseñada. Debido a que la salida de +20.9V alimentará unos leds de potencia RGB se requiere que la alimentación se de con una salida constante, por lo que se asignará una sensibilidad de 100%, y para el caso de la alimentación de la etapa de control (+5V), todos los componentes que lo conforman pueden soportar variaciones de ±1V, lo cual representa 20% en voltaje.

$$R_{SENSIBILIDAD} = \frac{V_{SALIDA} - V_{TL431}}{(\%_{SENSIBILIDAD})(I_{SENSADO})} = R15\; y\; R16$$

Entonces para la salida de +20.9V:

$$R_{15} = \frac{20.9V - 2.5V}{1(0.926mA)} = 19.87K$$, 2 resistencias de 10K

Salida de +5V:

$$R_{16} = \frac{5V - 2.5V}{(1-0.2)(0.926mA)} = 2.69K$$, 1 resistencia de 2.7K

En la figura G.1.6 se observa el circuito de retroalimentación del circuito [42]:

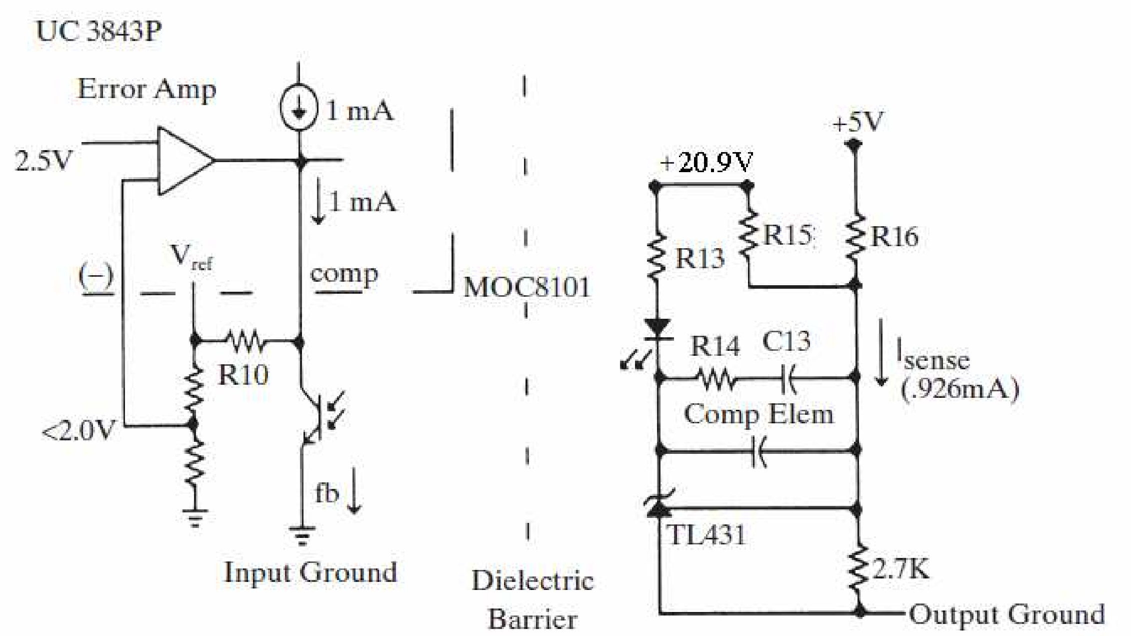

Figura G.1.6 Circuito de realimentación [42]

- En el caso que el voltaje de entrada caiga por debajo del mínimo diseñado, puede hacer variar la etapa de control y así saltar a un ciclo de trabajo distinto al deseado, y de esta manera no controlar la salida, lo que ocasionaría una mala entrega de potencia a la carga, y consecuentemente malograr la fuente, así como la propia carga.

Es por esto, que para evitar dicho posible inconveniente, se agrega un comparador de voltaje simple, para muestrear que la entrada este en el rango diseñado. El circuito de comparación se muestra en la figura G.1.7:

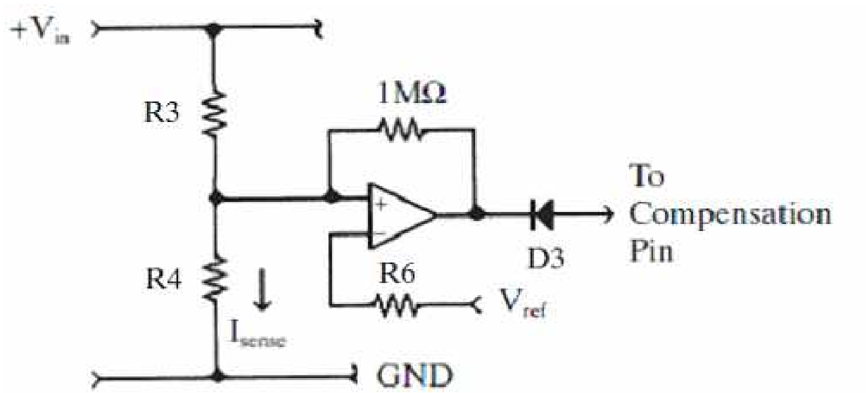

Figura G.1.7 Circuito de comparación de entrada [42]

Para el cuál, necesitamos utilizar un OPAMP (Q2), por lo que se escogerá el modelo LM111, ya que es de propósito general, además se observa que el valor de R_7 es 1M, seguidamente se calcularán los valores de las resistencias de dicha configuración mediante:

$$R_3 = \frac{V_{ENTRADA(MIN)} - V_{REFERENCIA}}{I_{SENSADO}}$$

De la hoja técnica del controlador [43], obtenemos el $V_{REFERENCIA}$=5V, reemplazando:

$$R_3 = \frac{254.558 - 5}{0.926mA} = 270K$$

Determinando R_2:

$$R_4 = \frac{V_{REFERENCIA}}{I_{SENSADO}}$$

$$R_4 = \frac{5\ V}{0.926mA} = 5.4K$$

Determinando R_3:

$$R_6 = R_3 // R_4$$

$$R_6 = 270K // 5.4K$$

$$R_6 = 5.29K$$

El diodo de la salida del OPAMP (D3) hacia el pin de compensación será el modelo 1N4148 pues es para protección.

- La resistencia de sensado de corriente en el MOSFET es según hoja técnica del UC3843P [43]:

$$R_{SENSADO} = \frac{1.0\ V}{I_{PICO}} = \frac{1V}{2.73A} = 0.366\Omega = R_{12}$$

Adicionalmente, se recomienda adicionar un filtro pasa-bajo (FPB), con resistencia R_{11} de 1K y condensador C_9 de 470uF.

- En los pines 2 del controlador, según H.T. debe estar el voltaje de retroalimentación (V_{FB}), que es igual al V_{CE} en saturación del emisor del MOC8102, el cual es 0.4V [50], este será obtenido mediante el pin 8 V_{REF} mediante un divisor de voltaje, tal como se sugiere en la figura G.1.8:

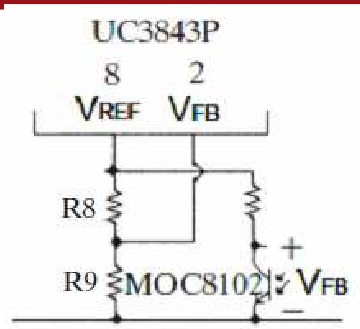

Figura G.1.8 Divisor de voltaje para obtener V_{FB} [42]

Calculando los valores, con V_{REF}=5V (dado por el pin 8) y V_{FB}=0.4V, entonces:

$$\frac{R_9}{R_8+R_9}=\frac{0.4V}{5V}$$

$$11.5R_9=R_8$$

Entonces se asigna a R_9=1K y R_8=11.5K

- Para compensar el diseño del lazo de retroalimentación, es necesario hacer su análisis en frecuencia, para ambas salidas.

$$f=\frac{1}{2\pi(V_{SALIDA}/I_{SALIDA})(C_{SALIDA})}$$

En la salida de +20.9V, se tiene la siguiente frecuencia:

$$f_{+20.9V}=\frac{1}{2\pi(20.9V/6A)(360\mu F)}$$

$$f_{+20.9V}=126.92\,Hz$$

Para +5V, se tiene la siguiente frecuencia:

$$f_{+5V}=\frac{1}{2\pi(5V/1A)(66\mu F)}$$

$$f_{+5V}=482.29\,Hz$$

La ganancia del sistema se da mediante:

$$A_{DC}=\frac{(V_{ENTRADA(MAXiMA)}-V_{SALIDA})^2(\#vueltas_{secundario})}{(V_{ENTRADA(MAXiMA)})(V_e)(\#vueltas_{primario})}$$

Por lo tanto la ganancia máxima es da con la menor salida: +5V.

$$A_{DC}=\frac{(367.695V-5V)^2(2vueltas)}{(367.695V)(1V)(97vueltas)}$$

$$A_{DC}=7.376$$

La ganancia expresada en dB:

$$G_{DC(MAX)} = 20\log(A_{DC})$$

$$G_{DC(MAX)} = 17.356dB$$

El ancho de banda BW debería ser igual a 10Khz, por lo que la ganancia que se necesita agregar para lograr dicho ancho de banda es de:

$$G = 20\log(\frac{10KHz}{f_{MENOR\,SALIDA}}) - G_{DC(MAX)}$$

$$G = 20\log(\frac{10KHz}{126.92Hz}) - 17.356dB$$

$$G = 20.573dB = 10.682 = A_{BW}$$

Con este valor de ganancia faltante, calculamos los componentes para compensar y alcanzar dicho ancho de banda.

$$C_{13} = \frac{1}{2\pi(R_4)(A_{BW})(20KHz)} = \frac{1}{2\pi(20K)(10.682)(20KHz)} = 37\,pF$$

$R_{14} = R_{15}(A_{BW}) = (20K)(10.682) = 213.84K$, se hace 220K

$$C_{12} = \frac{1}{2\pi(f_{MENOR})(R_{14})} = \frac{1}{2\pi(126.92)(213.84K)} = 5.89\,pF$$

6. Diseño del filtro de entrada EMI

- El propósito principal del filtro EMI es filtrar el ruido y los armónicos que genera la fuente conmutada.

Un buen punto para iniciar el diseño es asumir 24dB de atenuación a 50Khz. Por lo que la frecuencia de esquina del filtro es:

$$f_C = f_{TRABAJO}10^{\left(\frac{ATENUACIÓN}{40}\right)}$$

$$f_C = (50KHz)10^{\left(\frac{-24}{40}\right)} = 12.5KHz$$

Debemos utilizar el criterio de atenuación de -3dB o 0.707 (ξ) y de esta manera no producir ruido (armónicos). Además, se asume que la impedancia de la línea de entrada es 50Ω.

Calculando el valor de inductancia del filtro:

$$L = \frac{R_L.\zeta}{\pi.\mathrm{f_c}} = \frac{(50)(0.707)}{\pi(12.5KHz)} = 900\mu H$$

$$C = \frac{1}{(2\pi \mathrm{f_C})^2 L} = \frac{1}{[2\pi(12.5KHz)]^2(900\mu H)} = 0.18\mu F$$

El valor comercial más cercano de ese condensador es 0.05µF, por lo que, para mantener la misma frecuencia, se debe recalcular el valor de la inductancia.

$$L = \frac{1}{(2\pi \mathrm{f_C})^2 C} = \frac{1}{[2\pi(12.5KHz)]^2(0.05\mu F)} = 3.24mH$$

Ya que se diseño el filtro EMI, se continuará en esta sección diseñando la etapa de entrada en AC, cuya configuración típica es como se ve en la figura G.1.9:

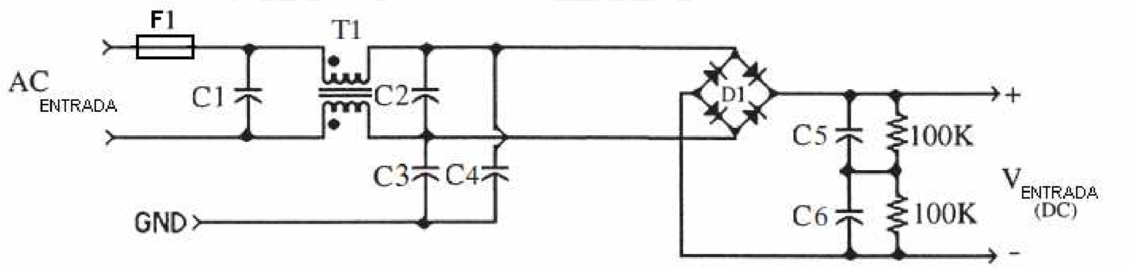

Figura G.1.9 Circuito filtro de entrada [42]

Los diodos del puente (D1), serán del modelo 1N4004 pues la corriente que pasará por ahí es menor a 1A, calculando C_3:

$$C_5 = \frac{0.3P_{ENTRADA}}{f_{AC}(V_{ENTRADA(MIN)})(V_{RIZADO(DESEADO)})^2}$$

$$C_5 = \frac{0.3(157.84W)}{60Hz(254.558V)(100mV)^2} = 300\mu F = C_6$$

El fusible de protección F_1 será de 2A pues la corriente máxima que pasará en la entrada será menor a 1A.

Finalmente, con todos los componentes calculados, la fuente switching queda como la figura G.1.10:

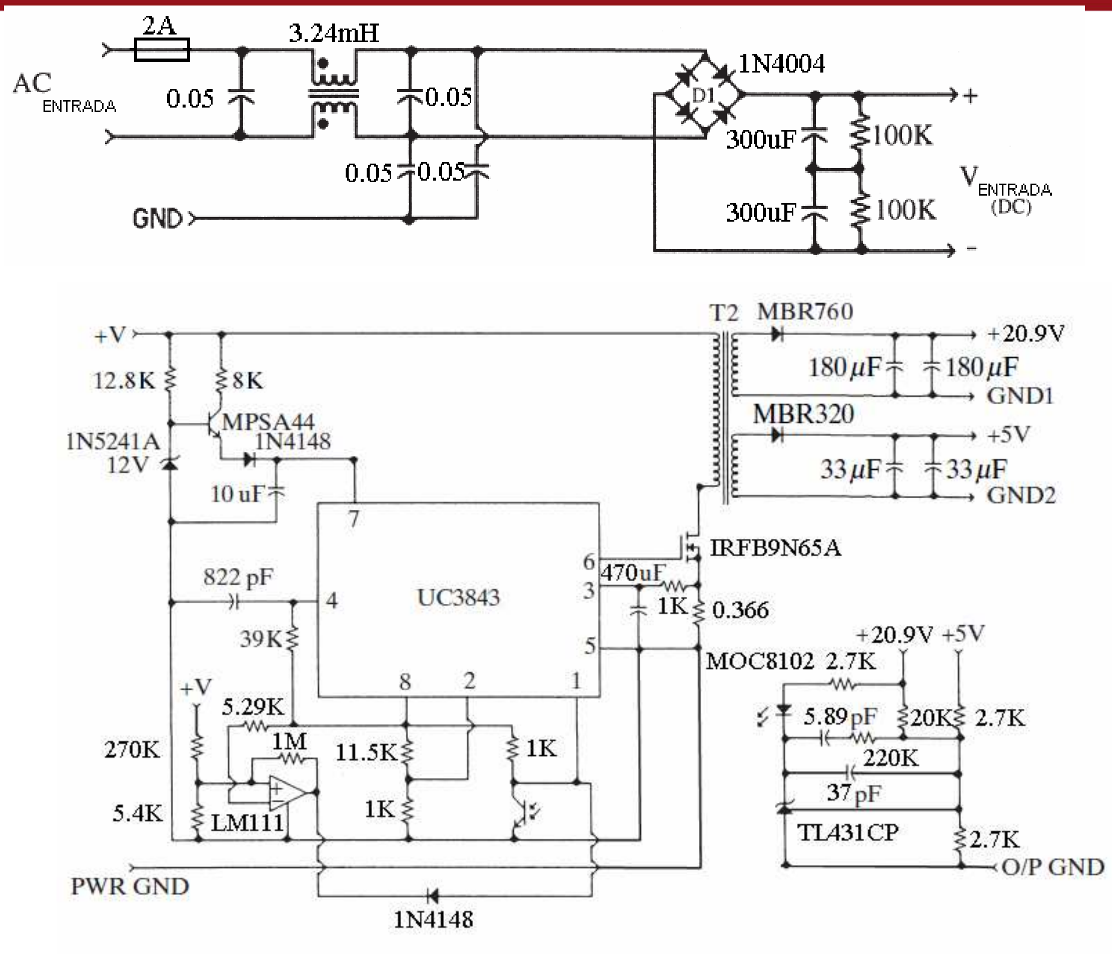

Figura G.1.10 Diseño final de la fuente flyback de 126W