<u>รายการอ้างอิง</u>

1. วิรุฬห์ มังคละวิรัช และ สุวิทย์ ปุณณชัยยะ. กล้องจุลทรรศน์รังสีเอกซ์แบบฉายภาพ. <u>วารสารศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี</u> ปีที่ 2 ฉบับที่ 2 (2535):107-137.
2. วิรุฬห์ มังคละวิรัช และ สุวิทย์ ปุณณชัยยะ. กล้องจุลทรรศน์อิเล็กตรอน. <u>วารสาร ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี</u> ปีที่ 1 ฉบับที่ 2(2534):129-165.
3. สุวิทย์ ปุณณชัยยะ และ เดโช ทองอร่าม. แคโทดสำหรับกล้องจุลทรรศน์อิเล็กตรอน. <u>วารสารศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี</u> ปีที่ 4 ฉบับที่ 2 (2537):139-169.
4. A.G. Michette and C.J. Buckley. <u>X-ray Science and Technology.</u> UK.:Bookcraft Bathgar,1993.
5. Albert.D. Helfrick and William .D.Cooper. <u>Modern Electronic Instrumentation and Measurement Techniques.</u> United States of America. Prentice-Hall,Inc.,1990.
6. Balzers. <u>Vacuum Components Edition 86/88</u>. Switzerland, 1986
7. Cecil E. Hall. <u>Introduction to Electron Microscopy</u>. New York: Mcgraw-Hill Book Company, Inc., 1966.
8. Dale E. Newbury, David C. Joy, Patrick Echlin, Charles E. Fiori and Joseph I. Goldstein. <u>Advanced Scanning Electron Microscopy and X-ray Microanalysis.</u> New York: Plenum Press, 1986.
9. Emmett F. Kaelble. <u>Hand Book of X-rays.</u> New York: Mcgraw-Hill Book Company, Inc., 1967.
10. Yada, Keiji, Takahashi, Shoichi. Target Material for Projection X-Ray Microscope Obervation of Biological Samples . <u>J.Electron Microscope</u>. 38 (1989).

ภาคผนวก

ภาคผนวก ก.

การออกแบบและคำนวณหม้อแปลงไฟฟ้าศักดาสูง

งานวิจัยนี้เลือกใช้หม้อแปลงชนิดแกนเฟอร์ไรต์แบบ EI 50 ซึ่งรายละเอียดของแกนชนิดนี้จากทางผู้ผลิตระบุว่า $A_e = 2.30\ cm^2$, $B_s = 3300$ Gauss ดังนั้นขั้นตอนการออกแบบสามารถดำเนินการได้ดังนี้

กำหนดให้

$f = 10$ kilohertz

$B_{max} = 3000$ Gauss

$V_p = 28$ Volts

$V_s = 5.5$ kilovolts

$I_D = 800$ Circular mils/ Ampere

$I_p = 1.5$ Ampere

$I_s = 500$ microampere

หาจำนวนรอบทางด้านปฐมภูมิ

$$N_p = V_p \times 10^8 / 4.44 f B_{max} A_e$$
$$= 28 \times 10^8 / 4.44 \times 10 \times 10^3 \times 3000 \times 2.30$$
$$= 9.13957 \text{ รอบ}$$

หาขนาดลวดทองแดงด้านปฐมภูมิ

$$\text{ขนาดลวดทองแดง} = I_p \times I_D$$
$$= 1.5 \times 800$$
$$= 1200 \text{ Circular mils}$$

จากตารางขนาดลวดทองแดงได้ขนาดลวดทองแดงเบอร์ 19 AWG

ดังนั้นทางด้านปฐมภูมิใช้ลวดทองแดง เบอร์ 19 AWG พัน 10 รอบ

ตรวจสอบค่า B_{max} ขณะ $V_{in\ max}$

$$B_{max} = V_p \times 10^8 / 4.44 f N_p A_e$$
$$= 28 \times 10^8 / 4.44 \times 10 \times 10^3 \times 10 \times 2.30$$
$$= 2741.872 \text{ Gauss}$$

$$N_s = N_p \times (V_s/V_p)$$
$$= 10 \times (5.5 \times 10^3/28)$$
$$= 1964.2857 \text{ รอบ}$$

หาขนาดลวดทองแดงด้านทุติยภูมิ

$$\text{ขนาดลวดทองแดง} = I_s \times I_D$$
$$= 500 \times 10^{-6} \times 800$$
$$= 0.4 \text{ Circular mils}$$

จากตารางขนาดลวดทองแดงได้ขนาดลวดทองแดงเบอร์ 45 AWG ดังนั้นทางด้านทุติยภูมิใช้ลวดทองแดง เบอร์ 45 AWG พัน 2000 รอบ

ภาคผนวก ข.

การคำนวณไลน์เรกูเลชันและโหลดเรกูเลชัน

$$\text{เปอร์เซนต์ไลน์เรกูเลชัน} = \frac{[(V_{oh}-V_{ol})/V_o]}{[(V_{ih}-V_{il})/V_i]} \times 100$$

โดยที่ V_o = แรงดันเอาท์พุทปกติ

V_{oh} = แรงดันเอาท์พุทที่เปลี่ยนแปลงสูงสุด

V_{ol} = แรงดันเอาท์พุทที่เปลี่ยนแปลงต่ำสุด

V_i = แรงดันอินพุทปกติ

V_{ih} = แรงดันอินพุทที่เปลี่ยนแปลงสูงสุด

V_{il} = แรงดันอินพุทที่เปลี่ยนแปลงต่ำสุด

ซึ่งได้ผลทดสอบดังนี้

แรงดันเอาท์พุทปกติ = 27.51

แรงดันเอาท์พุทที่เปลี่ยนแปลงสูงสุด = 27.51

แรงดันเอาท์พุทที่เปลี่ยนแปลงต่ำสุด = 27.508

แรงดันอินพุทปกติ = 220

แรงดันอินพุทที่เปลี่ยนแปลงสูงสุด = 242.08

แรงดันอินพุทที่เปลี่ยนแปลงต่ำสุด = 198.03

ดังนั้นจะได้ค่าไลน์เรกูเลชั่น $= \frac{[(27.51-27.508)/27.51]}{[(242.08-198.03)/220]} \times 100$

= 0.036309 เปอร์เซนต์

$$\text{เปอร์เซนต์โหลดเรกูเลชัน} = [(V_O-V_l)/V_O] \times 100$$

โดยที่ V_O = แรงดันเอาท์พุทขณะไม่มีโหลด

V_l = แรงดันเอาท์พุทเมื่อจ่ายกระแสโหลดเต็มที่

ซึ่งได้ผลทดสอบดังนี้

แรงดันเอาท์พุทขณะไม่มีโหลด = 27.541 โวลท์

แรงดันเอาท์พุทเมื่อจ่ายกระแสโหลดเต็มที่ = 27.510 โวลท์

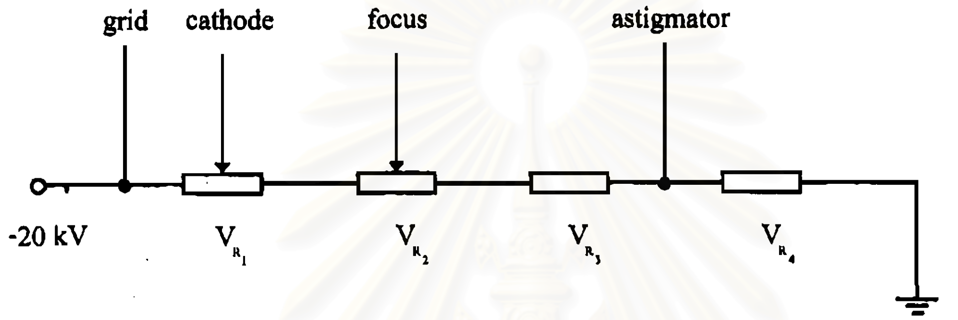
ดังนั้นจะได้ค่าโหลดเรกูเลชัน = [(27.541-27.510)/27.541] x 100

= 0.112559 เปอร์เซนต์

ภาคผนวก ค.

การออกแบบวงจรควบคุมลำอิเล็กตรอน

จากความต้องการศักดาไฟฟ้าที่ขั้วไฟฟ้าต่างๆของหลอดรังสีแคโทด



ออกแบบวงจรแบ่งแรงดันไฟฟ้าที่ breeding current = 63.17 μA.

กำหนดให้ V_{R_1} = 208.5 V.

V_{R_2} = 208.5 V.

V_{R_3} = 631.5 V.

V_{R_4} = 18951.5 V.

ดังนั้นจะได้

$R_1 = 208.5/63.17 \times 10^{-6} = 3300617.382\ \Omega = 3.3\ M\Omega$

$R_2 = 208.5/63.17 \times 10^{-6} = 3300617.382\ \Omega = 3.3\ M\Omega$

$R_3 = 631.5/63.17 \times 10^{-6} = 9711888.555\ \Omega = 9.7\ M\Omega$

$R_4 = 18951.5/63.17 \times 10^{-6} = 300007915.1\ \Omega = 300\ M\Omega$

ภาคผนวก ง.

คู่มือไอซี

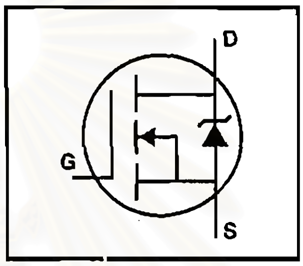
PD-9.308K

International
IOR Rectifier

IRF730

HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements



$V_{DSS} = 400V$

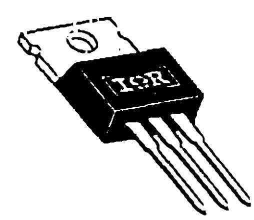
$R_{DS(on)} = 1.0\Omega$

$I_D = 5.5A$

Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.



TO-220AB

Absolute Maximum Ratings

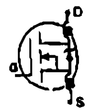
	Parameter	Max.	Units
I_D @ $T_C = 25°C$	Continuous Drain Current, V_{GS} @ 10 V	5.5	A
I_D @ $T_C = 100°C$	Continuous Drain Current, V_{GS} @ 10 V	3.5	
I_{DM}	Pulsed Drain Current ①	22	
P_D @ $T_C = 25°C$	Power Dissipation	74	W
	Linear Derating Factor	0.59	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	290	mJ
I_{AR}	Avalanche Current ①	5.5	A
E_{AR}	Repetitive Avalanche Energy ①	7.4	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1 N•m)	

Thermal Resistance

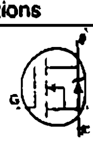
	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	—	1.7	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	—	62	

IRF730

Electrical Characteristics @ $T_J = 25°C$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	400	—	—	V	V_{GS}=0V, I_D= 250µA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.54	—	V/°C	Reference to 25°C, I_D= 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	1.0	Ω	V_{GS}=10V, I_D=3.3A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D= 250µA
g_{fs}	Forward Transconductance	2.9	—	—	S	V_{DS}=50V, I_D=3.3A ④
I_{DSS}	Drain-to-Source Leakage Current	—	—	25	µA	V_{DS}=400V, V_{GS}=0V
		—	—	250		V_{DS}=320V, V_{GS}=0V, T_J=125°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS}=20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS}=-20V
Q_g	Total Gate Charge	—	—	38	nC	I_D=3.5A
Q_{gs}	Gate-to-Source Charge	—	—	5.7		V_{DS}=320V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	22		V_{GS}=10V See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	10	—	ns	V_{DD}=200V
t_r	Rise Time	—	15	—		I_D=3.5A
$t_{d(off)}$	Turn-Off Delay Time	—	38	—		R_G=12Ω
t_f	Fall Time	—	14	—		R_D=57Ω See Figure 10 ④
L_D	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6 mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	7.5	—		
C_{iss}	Input Capacitance	—	700	—	pF	V_{GS}=0V
C_{oss}	Output Capacitance	—	170	—		V_{DS}=25V
C_{rss}	Reverse Transfer Capacitance	—	64	—		f=1.0MHz See Figure 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	5.5	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	22		
V_{SD}	Diode Forward Voltage	—	—	1.6	V	T_J=25°C, I_S=5.5A, V_{GS}=0V ④
t_{rr}	Reverse Recovery Time	—	270	530	ns	T_J=25°C, I_F=3.7A
Q_{rr}	Reverse Recovery Charge	—	1.8	2.2	µC	di/dt=100A/µs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is neglegible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature (See Figure 11)

② V_{DD}=50V, starting T_J=25°C, L=16mH R_G=25Ω, I_{AS}=5.5A (See Figure 12)

③ I_{SD}≤5.5A, di/dt≤90A/µs, V_{DD}≤$V_{(BR)DSS}$, T_J≤150°C

④ Pulse width ≤ 300 µs; duty cycle ≤2%.

National Semiconductor

LM117A/LM117/LM317A/LM317 3-Terminal Adjustable Regulator

General Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

The LM117 series devices with a "K" suffix are packaged in standard TO-3 transistor packages, while those with an "H" suffix are in a solid Kovar-base TO-39 transistor package. The LM117A and LM117 are rated for operation from −55°C to +150°C, the LM317A from −40°C to +125°C, and the LM317 from 0°C to +125°C. The LM317AT and the LM317T are available in a TO-220 plastic package and the LM317MP in a TO-202 plastic package.

For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet.

LM117 Series Packages and Power Capability

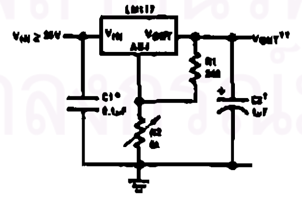
Part Number Suffix	Package	Rated Power Dissipation	Design Load Current
K	TO-3	20W	1.5A
H	TO-39	2W	0.5A
T	TO-220	20W	1.5A
MP	TO-202	2W	0.5A

Features

- Guaranteed 1% output voltage tolerance (LM117A, LM317A)
- Guaranteed max. 0.01%/V line regulation (LM117A, LM317A)
- Guaranteed max. 0.3% load regulation (LM117A, LM117)
- Guaranteed 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- 100% electrical burn-in
- 80 dB ripple rejection
- Output is short-circuit protected

Typical Applications

1.2V–25V Adjustable Regulator



TL/H/9063-1

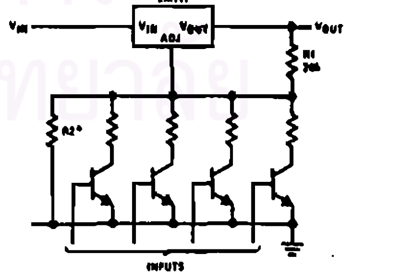
Full output current not available at high input-output voltages

*Needed if device is more than 6 inches from filter capacitors.

†Optional—improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

††$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}(R_2)$

Digitally Selected Outputs



TL/H/9063-2

*Sets maximum V_{OUT}

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.
(Note 2)

Power Dissipation	Internally Limited
Input-Output Voltage Differential	+40V, −0.3V
Storage Temperature	−65°C to +150°C
Lead Temperature	
Metal Package (Soldering, 10 seconds)	300°C
Plastic Package (Soldering, 4 seconds)	260°C
ESD Tolerance (Note 5)	3 kV

Operating Temperature Range

LM117A/LM117	$-55°C \le T_J \le +150°C$
LM317A	$-40°C \le T_J \le +125°C$
LM317	$0°C \le T_J \le +125°C$

Preconditioning

Thermal Limit Burn-In	All Devices 100%

Electrical Characteristics

Specifications with standard type face are for $T_J = 25°C$, and those with **boldface type** apply over full Operating Temperature Range. Unless otherwise specified, $V_{IN} - V_{OUT} = 5V$, and $I_{OUT} = 10$ mA. (Note 3)

Parameter	Conditions	LM117A			LM117			Units
		Min	Typ	Max	Min	Typ	Max	
Reference Voltage		1.238	1.250	1.262				V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\ mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	**1.225**	**1.250**	**1.270**	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.005	0.01		0.01	0.02	%/V
			0.01	**0.02**		**0.02**	**0.05**	%/V
Load Regulation	$10\ mA \le I_{OUT} \le I_{MAX}$ (Note 4)		0.1	0.3		0.1	0.3	%
			0.3	**1**		**0.3**	**1**	%
Thermal Regulation	20 ms Pulse		0.03	0.07		0.03	0.07	%/W
Adjustment Pin Current			**50**	**100**		**50**	**100**	μA
Adjustment Pin Current Change	$10\ mA \le I_{OUT} \le I_{MAX}$ $3V \le (V_{IN} - V_{OUT}) \le 40V$		**0.2**	**5**		**0.2**	**5**	μA
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$		**1**			**1**		%
Minimum Load Current	$(V_{IN} - V_{OUT}) = 40V$		**3.5**	**5**		**3.5**	**5**	mA
Current Limit	$(V_{IN} - V_{OUT}) \le 15V$ K Package H Package	 **1.5** **0.5**	 **2.2** **0.8**	 **3.4** **1.8**	 **1.5** **0.5**	 **2.2** **0.8**	 **3.4** **1.8**	 A A
	$(V_{IN} - V_{OUT}) = 40V$ K Package H Package	 0.3 0.15	 0.4 0.2		 0.3 0.15	 0.4 0.2		 A A
RMS Output Noise, % of V_{OUT}	$10\ Hz \le f \le 10\ kHz$		0.003			0.003		%
Ripple Rejection Ratio	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 0\ \mu F$		**65**			**65**		dB
	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 10\ \mu F$	**66**	**80**		**66**	**80**		dB
Long-Term Stability	$T_J = 125°C$, 1000 hrs		0.3	1		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package H Package		2.3 12	3 15		2.3 12	3 15	°C/W °C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package H Package		35 140			35 140		°C/W °C/W

Electrical Characteristics (Continued)

Specifications with standard type face are for $T_J = 25°C$, and those with boldface type apply over full Operating Temperature Range. Unless otherwise specified, $V_{IN} - V_{OUT} = 5V$, and $I_{OUT} = 10$ mA. (Note 3)

Parameter	Conditions	LM317A			LM317			Units
		Min	Typ	Max	Min	Typ	Max	
Reference Voltage		1.238	1.250	1.262				V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\ mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	**1.225**	**1.250**	**1.270**	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.005	0.01		0.01	0.04	%/V
			0.01	**0.02**		**0.02**	**0.07**	%/V
Load Regulation	$10\ mA \le I_{OUT} \le I_{MAX}$ (Note 4)		0.1	0.5		0.1	0.5	%
			0.3	**1**		**0.3**	**1.5**	%
Thermal Regulation	20 ms Pulse		0.04	0.07		0.04	0.07	%/W
Adjustment Pin Current			**50**	**100**		**50**	**100**	μA
Adjustment Pin Current Change	$10\ mA \le I_{OUT} \le I_{MAX}$, $3V \le (V_{IN} - V_{OUT}) \le 40V$		**0.2**	**5**		**0.2**	**5**	μA
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$		**1**			**1**		%
Minimum Load Current	$(V_{IN} - V_{OUT}) = 40V$		**3.5**	**10**		**3.5**	**10**	mA
Current Limit	$(V_{IN} - V_{OUT}) \le 15V$							
	K and T Package	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	A
	H Package	**0.5**	**0.8**	**1.8**	**0.5**	**0.8**	**1.8**	A
	P Package				**0.5**	**0.8**	**1.8**	A
	$(V_{IN} - V_{OUT}) = 40V$							
	K and T Package	0.15	0.4		0.15	0.4		A
	H Package	0.075	0.2		0.075	0.2		A
	P Package				0.075	0.2		A
RMS Output Noise, % of V_{OUT}	$10\ Hz \le f \le 10\ kHz$		0.003			0.003		%
Ripple Rejection Ratio	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 0\ \mu F$		**65**			**65**		dB
	$V_{OUT} = 10V$, $f = 120$ Hz, $C_{ADJ} = 10\ \mu F$	**66**	**80**		**66**	**80**		dB
Long-Term Stability	$T_J = 125°C$, 1000 hrs		0.3	1		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package		2.3	3		2.3	3	°C/W
	H Package		12	15		12	15	°C/W
	T Package		4	5		4		°C/W
	P Package					7		°C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package		35			35		°C/W
	H Package		140			140		°C/W
	T Package		50			50		°C/W
	P Package					80		°C/W

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

Note 2: Refer to RETS117AH drawing for the LM117AH, the RETS117H drawing for the LM117H, the RETS117AK drawing for the LM117AK, or the RETS117K for the LM117K military specifications.

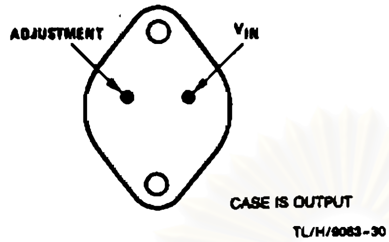
Note 3: Although power dissipation is internally limited, these specifications are applicable for maximum power dissipations of 2W for the TO-39 and TO-202, and 20W for the TO-3 and TO-220. I_{MAX} is 1.5A for the TO-3 and TO-220 packages and 0.5A for the TO-39 and TO-202 packages. All limits (i.e., the numbers in the Min. and Max. columns) are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 4: Regulation is measured at a constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specifications for thermal regulation.

Note 5: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Connection Diagrams (See Physical Dimension section for further information)

(TO-3)
Metal Can Package

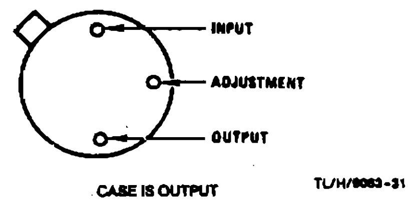


Bottom View

Steel Packages
Order Number LM117AK STEEL, LM117K STEEL, LM317AK STEEL or LM317K STEEL
See NS Package Number K02A

Aluminum Packages
Order Number LM317AKC or LM317KC
See NS Package Number KC02A

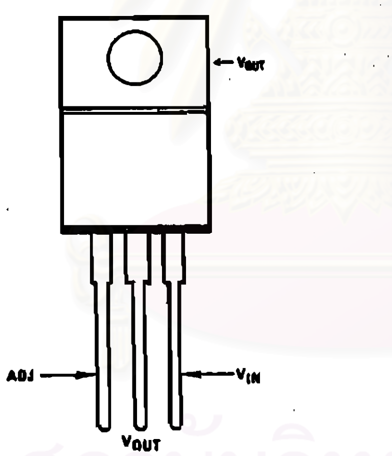
(TO-39)
Metal Can Package



Bottom View

Order Number LM117AH, LM117H, LM317AH or LM317H
See NS Package Number H03A

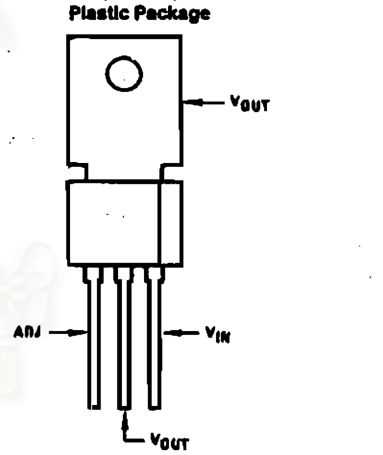
(TO-220)
Plastic Package



Front View

Order Number LM317AT or LM317T
See NS Package Number T03B

(TO-202)
Plastic Package



Front View

Order Number LM317MP
See NS Package Number P03A

LM111, LM211, LM311, LM311Y
DIFFERENTIAL COMPARATORS WITH STROBES

D1312, SEPTEMBER 1973–REVISED FEBRUARY 1992

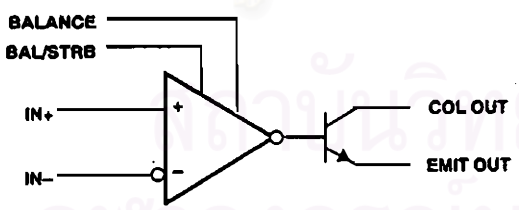
- **Fast Response Times**
- **Strobe Capability**
- **Maximum Input Bias Current . . . 300 nA**
- **Maximum Input Offset Current . . . 70 nA**
- **Can Operate From Single 5-V Supply**
- **Designed to Be Interchangeable With National Semiconductor LM111, LM211, and LM311**

description

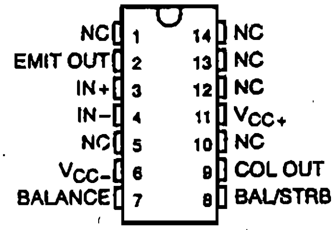
The LM111, LM211, and LM311 are single high-speed voltage comparators. These devices are designed to operate from a wide range of power supply voltages, including ±15-V supplies for operational amplifiers and 5-V supplies for logic systems. The output levels are compatible with most TTL and MOS circuits. These comparators are capable of driving lamps or relays and switching voltages up to 50 V at 50 mA. All inputs and outputs can be isolated from system ground. The outputs can drive loads referenced to ground, V_{CC+} or V_{CC-}. Offset balancing and strobe capabilities are available, and the outputs can be wire-OR connected. If the strobe is low, the output will be in the off state regardless of the differential input.

The LM111 is characterized for operation over the full military range of −55°C to 125°C. The LM211 is characterized for operation from −40°C to 85°C, and the LM311 is characterized for operation from 0°C to 70°C.

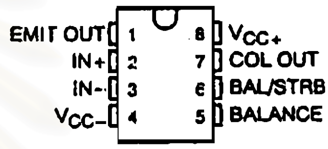
functional block diagram



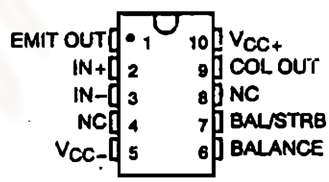
LM111 . . . J PACKAGE
(TOP VIEW)



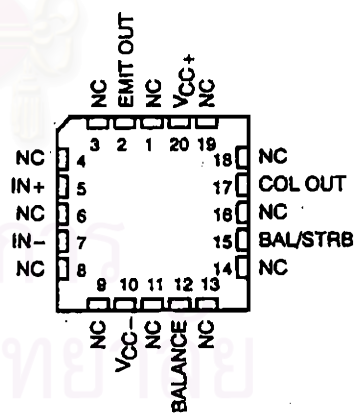
LM111 . . . JG PACKAGE
LM211, LM311 . . . D, DB, P, OR PW PACKAGE
(TOP VIEW)



LM111 . . . U PACKAGE
(TOP VIEW)



LM111 . . . FK PACKAGE
(TOP VIEW)



NC–No internal connection

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC+} (see Note 1)		18 V
Supply voltage, V_{CC-} (see Note 1)		−18 V
Supply voltage, $V_{CC+} - V_{CC-}$		36 V
Differential input voltage (see Note 2)		±30 V
Input voltage (either input, see Notes 1 and 3)		±15 V
Voltage from emitter output to V_{CC-}		30 V
Voltage from collector output to V_{CC-}:	LM111	50 V
	LM211	50 V
	LM311	40 V
Duration of output short circuit (see Note 4)		10 s
Continuous total dissipation		See Dissipation Rating Table
Operating free-air temperature range:	LM111	−55°C to 125°C
	LM211	−40°C to 85°C
	LM311	0°C to 70°C
Storage temperature range		−65°C to 150°C
Case temperature for 60 seconds: FK package		260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J, JG, or U package		300°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D, DB, P, or PW package		260°C

NOTES: 1. All voltage values, unless otherwise noted, are with respect to the midpoint between V_{CC+} and V_{CC-}
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or ± 15 V, whichever is less.
4. The output may be shorted to ground or either power supply.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	500 mW	5.8 mW/°C	64°C	464 mW	377 mW	–
DB or PW	500 mW	4.2 mW/°C	31°C	336 mW	–	–
FK	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
J	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
JG	500 mW	8.4 mW/°C	90°C	500 mW	500 mW	210 mW
P	500 mW	8.0 mW/°C	88°C	500 mW	500 mW	–
U	500 mW	5.4 mW/°C	57°C	432 mW	351 mW	135 mW

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, $V_{CC+} - V_{CC-}$		3.5	30	V
Input voltage ($\|V_{CC\pm}\| \le 15$ V)		$V_{CC-} + 0.5$	$V_{CC+} - 1.5$	V
Operating free-air temperature range, T_A	LM111	−55	125	°C
	LM211	−40	85	
	LM311	0	70	

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A†	LM111, LM211 MIN	LM111, LM211 TYP‡	LM111, LM211 MAX	LM311 MIN	LM311 TYP‡	LM311 MAX	UNIT
V_{IO}	Input offset voltage	See Note 5		25°C		0.7	3		2	7.5	mV
				Full range			4			10	
I_{IO}	Input offset current	See Note 5		25°C		4	10		6	50	nA
				Full range			20			70	
I_{IB}	Input bias current	V_O = 1 V to 14 V		25°C		75	100		100	250	nA
				Full range			150			300	
$I_{IL(S)}$	Low-level strobe current (see Note 6)	$V_{(strobe)}$ = 0.3 V,	$V_{ID} \le -10$ mV	25°C		−3			−3		mA
V_{ICR}	Common-mode input voltage range			Full range	13 to −14.5	13.8 to −14.7		13 to −14.5	13.8 to −14.7		V
A_{VD}	Large-signal differential voltage amplification	V_O = 5 V to 35 V,	R_L = 1 kΩ	25°C	40	200		40	200		V/mV
I_{OH}	High-level (collector) output current	I_{strobe} = −3 mA, V_{ID} = 5 mV,	V_{OH} = 35 V	25°C		0.2	10				nA
				Full range			0.5				µA
		V_{ID} = 5 mV,	V_{OH} = 35 V	25°C					0.2	50	nA
V_{OL}	Low-level (collector-to-emitter) output voltage	I_{OL} = 50 mA	V_{ID} = −5 mV	25°C		0.75	1.5				V
			V_{ID} = −10 mV	25°C					0.75	1.5	
		V_{CC+} = 4.5 V, V_{CC-} = 0, I_{OL} = 8 mA	V_{ID} = −6 mV	Full range		0.23	0.4				
			V_{ID} = −10 mV	Full range					0.23	0.4	
I_{CC+}	Supply current from V_{CC+}, output low	V_{ID} = −10 mV,	No load	25°C		5.1	6		5.1	7.5	mA
I_{CC-}	Supply current from V_{CC-}, output high	V_{ID} = 10 mV,	No load	25°C		−4.1	−5		−4.1	−5	mA

† Unless otherwise noted, all characteristics are measured with BALANCE and BAL/STRB open and the emitter output grounded. Full range for LM111 is −55°C to 125°C, for LM211 is −40°C to 85°C, and for LM311 is 0°C to 70°C.

‡ All typical values are at T_A = 25°C.

NOTES: 5. The offset voltages and offset currents given are the maximum values required to drive the collector output up to 14 V or down to 1 V with a pullup resistor of 7.5 kΩ to V_{CC+}. These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.

6. The strobe should not be shorted to ground; it should be current driven at −3 mA to −5 mA, see Figures 13 and 27.

switching characteristics, $V_{CC\pm} = \pm 15$ V, $T_A = 25$°C

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Response time, low-to-high-level output	R_C = 500 Ω to 5 V, C_L = 5 pF, See Note 7		115		ns
Response time, high-to-low-level output			165		ns

NOTE 7: The response time specified is for a 100-mV input step with 5-mV overdrive and is the interval between the input step function and the instant when the output crosses 1.4 V.

electrical characteristics at $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	See Note 5				2	7.5	mV
I_{IO}	Input offset current	See Note 5				6	50	nA
I_{IB}	Input bias current	V_O = 1 V to 14 V				100	250	nA
$I_{IL(S)}$	Low-level strobe current (see Note 6)	V_{strobe} = 0.3 V,	$V_{ID} \le -10$ mV			−3		mA
V_{ICR}	Common-mode input voltage range				13 to −14.5	13.8 to −14.7		V
A_{VD}	Large-signal differential voltage amplification	V_O = 5 V to 35 V,	R_L = 1 kΩ		40	200		V/mV
I_{OH}	High-level (collector) output current	I_{strobe} = −3 mA,	V_{ID} = 5 mV,	V_{OH} = 35 V		0.2	50	nA
V_{OL}	Low-level (collector-to-emitter) output voltage	I_{OL} = 50 mA,	V_{ID} = −10 mV			0.75	1.5	V
I_{CC+}	Supply current from V_{CC+}, output low	V_{ID} = −10 mV,	No load			5.1	7.5	mA
I_{CC-}	Supply current from V_{CC-}, output low	V_{ID} = 10 mV,	No load			−4.1	−5	mA

† Unless otherwise noted, all characteristics are measured with BALANCE and BAL/STRB open and the emitter output grounded.

NOTES: 5. The offset voltages and offset currents given are the maximum values required to drive the collector output up to 14 V or down to 1 V with a pullup resistor of 7.5 kΩ to V_{CC+}. These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.

6. The strobe should not be shorted to ground; it should be current driven at −3 mA to −5 mA, see Figures 13 and 27.

switching characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Response time, low-to-high-level output	R_C = 500 Ω to 5 V, C_L = 5 pF, See Note 7		115		ns
Response time, high-to-low-level output			165		ns

NOTE 7: The response time specified is for a 100-mV input step with 5-mV overdrive and is the interval between the input step function and the instant when the output crosses 1.4 V.

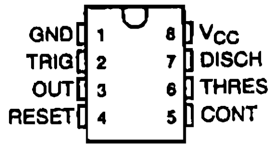
NE555, NE555Y, SA555, SE555, SE555C PRECISION TIMERS

D1669, SEPTEMBER 1973—REVISED FEBRUARY 1992

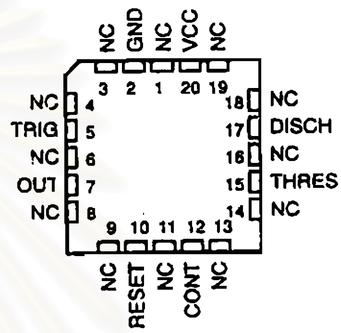
- **Timing From Microseconds to Hours**
- **Astable or Monostable Operation**
- **Adjustable Duty Cycle**
- **TTL-Compatible Output Can Sink or Source up to 200 mA**
- **Functionally Interchangeable With the Signetics NE555, SA555, SE555, SE555C; Have Same Pinout**

SE555C FROM TI IS NOT RECOMMENDED FOR NEW DESIGNS

D, JG, OR P PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



NC–No internal connection

description

These devices are precision monolithic timing circuits capable of producing accurate time delays or oscillation. In the time-delay or monostable mode of operation, the timed interval is controlled by a single external resistor and capacitor network. In the astable mode of operation, the frequency and duty cycle may be independently controlled with two external resistors and a single external capacitor.

The threshold and trigger levels are normally two-thirds and one-third, respectively, of V_{CC}. These levels can be altered by use of the control voltage terminal. When the trigger input falls below the trigger level, the flip-flop is set and the output goes high. If the trigger input is above the trigger level and the threshold input is above the threshold level, the flip-flop is reset and the output is low. RESET can override all other inputs and can be used to initiate a new timing cycle. When RESET goes low, the flip-flop is reset and the output goes low. Whenever the output is low, a low-impedance path is provided between DISCH and ground.

The output circuit is capable of sinking or sourcing current up to 200 mA. Operation is specified for supplies of 5 V to 15 V. With a 5-V supply, output levels are compatible with TTL inputs.

The NE555 is characterized for operation from 0°C to 70°C. The SA555 is characterized for operation from −40°C to 85°C. The SE555 and SE555C are characterized for operation over the full military range of −55°C to 125°C.

AVAILABLE OPTIONS

T_A	PACKAGE					CHIP FORM (Y)
	V_{THRES} max V_{CC} = 15 V	SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (P)	
0°C to 70°C	11.2 V	NE555D			NE555P	NE555Y
−40°C to 85°C	11.2 V	SA555D			SA555P	
−55°C to 125°C	10.6 V 11.2 V	SE555D SE555CD	SE555FK SE555CFK	SE555JG SE555CJG	SE555P SE555CP	

The D package is available taped and reeled. Add the suffix R to the device type (e.g., NE555DR).

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (See Note 1)		18 V
Input voltage (CONT, RESET, THRES, and TRIG)		V_{CC}
Output current		±225 mA
Continuous total dissipation		See Dissipation Rating Table
Operating free-air temperature range:	NE555	0°C to 70°C
	SA555	−40°C to 85°C
	SE555, SE555C	−55°C to 125°C
Storage temperature range		−65°C to 150°C
Case temperature for 60 seconds: FK package		260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package		260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package		300°C

NOTE 1: All voltage values are with respect to network ground terminal.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	N/A
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG (SE555, SE555C)	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
JG (SA555, NE555C)	825 mW	6.6 mW/°C	528 mW	429 mW	N/A
P	1000 mW	8.0 mW/°C	640 mW	520 mW	N/A

recommended operating conditions

	NE555		SA555		SE555		SE555C		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	4.5	16	4.5	16	4.5	18	4.5	16	V
Input voltage (CONT, RESET, THRES, and TRIG)		V_{CC}		V_{CC}		V_{CC}		V_{CC}	V
Output current		±200		±200		±200		±200	mA
Operating free-air temperature, T_A	0	70	−40	85	−55	125	−55	125	°C

electrical characteristics, V_{CC} = 5 V to 15 V, T_A = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		SE555 MIN	SE555 TYP	SE555 MAX	NE555, SA555, SE555C MIN	NE555, SA555, SE555C TYP	NE555, SA555, SE555C MAX	UNIT
THRES voltage level	V_{CC} = 15 V		9.4	10	10.6	8.8	10	11.2	V
	V_{CC} = 5 V		2.7	3.3	4	2.4	3.3	4.2	
THRES current (see Note 2)				30	250		30	250	nA
TRIG voltage level	V_{CC} = 15 V		4.8	5	5.2	4.5	5	5.6	V
	V_{CC} = 5 V		1.45	1.67	1.9	1.1	1.67	2.2	
TRIG current	TRIG at 0 V			0.5	0.9		0.5	2	μA
RESET voltage level			0.3	0.7	1	0.3	0.7	1	V
RESET current	RESET at V_{CC}			0.1	0.4		0.1	0.4	mA
	RESET at 0 V			−0.4	−1		−0.4	−1.5	
DISCH switch off-state current				20	100		20	100	nA
CONT voltage (open circuit)	V_{CC} = 15 V		9.6	10	10.4	9	10	11	V
	V_{CC} = 5 V		2.9	3.3	3.8	2.6	3.3	4	
Low-level output voltage	V_{CC} = 15 V	I_{OL} = 10 mA		0.1	0.15		0.1	0.25	V
		I_{OL} = 50 mA		0.4	0.5		0.4	0.75	
		I_{OL} = 100 mA		2	2.2		2	2.5	
		I_{OL} = 200 mA		2.5			2.5		
	V_{CC} = 5 V	I_{OL} = 5 mA		0.1	0.2		0.1	0.35	
		I_{OL} = 8 mA		0.15	0.25		0.15	0.4	
High-level output voltage	V_{CC} = 15 V	I_{OH} = −100 mA	13	13.3		12.75	13.3		V
		I_{OH} = −200 mA		12.5			12.5		
	V_{CC} = 5 V	I_{OH} = −100 mA	3	3.3		2.75	3.3		
Supply current	Output low, No load	V_{CC} = 15 V		10	12		10	15	mA
		V_{CC} = 5 V		3	5		3	6	
	Output high, No load	V_{CC} = 15 V		9	10		9	13	
		V_{CC} = 5 V		2	4		2	5	

NOTE 2: This parameter influences the maximum value of the timing resistors R_A and R_B in the circuit of Figure 12. For example, when V_{CC} = 5 V, the maximum value is $R = R_A + R_B \approx 3.4$ MΩ, and for V_{CC} = 15 V, the maximum value is 10 MΩ.

operating characteristics, V_{CC} = 5 V and 15 V

PARAMETER		TEST CONDITIONS†	SE555 MIN	SE555 TYP	SE555 MAX	NE555, SA555, SE555C MIN	NE555, SA555, SE555C TYP	NE555, SA555, SE555C MAX	UNIT
Initial error of timing interval‡	Each timer, monostable§	T_A = 25°C		0.5%	1.5%		1%	3%	
	Each timer, astable¶			1.5%			2.25%		
Temperature coefficient of timing interval	Each timer, monostable§	T_A = MIN to MAX		30	100		50		ppm/°C
	Each timer, astable¶			90			150		
Supply voltage sensitivity of timing interval	Each timer, monostable§	T_A = 25°C		0.05	0.2		0.1	0.5	%/V
	Each timer, astable¶			0.15			0.3		
Output pulse rise time		C_L = 15 pF,		100	200		100	300	ns
Output pulse fall time		T_A = 25°C		100	200		100	300	

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ Timing interval error is defined as the difference between the measured value and the average value of a random sample from each process run.
§ Values specified are for a device in a monostable circuit similar to Figure 9, with component values as follow: R_A = 2 kΩ to 100 kΩ, C = 0.1 μF.
¶ Values specified are for a device in an astable circuit similar to Figure 12, with component values as follow: R_A = 1 kΩ to 100 kΩ, C = 0.1 μF.

electrical characteristics, V_{CC} = 5 V to 15 V, T_A = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
THRES voltage level	V_{CC} = 15 V		8.8	10	11.2	V
	V_{CC} = 5 V		2.4	3.3	4.2	
THRES current (see Note 2)				30	250	nA
TRIG voltage level	V_{CC} = 15 V		4.5	5	5.6	V
	V_{CC} = 5 V		1.1	1.67	2.2	
TRIG current	TRIG at 0 V			0.5	2	μA
RESET voltage level			0.3	0.7	1	V
RESET current	RESET at V_{CC}			0.1	0.4	mA
	RESET at 0 V			−0.4	−1.5	
DISCH switch off-state current				20	100	nA
CONT voltage (open circuit)	V_{CC} = 15 V		9	10	11	V
	V_{CC} = 5 V		2.6	3.3	4	
Low-level output voltage	V_{CC} = 15 V	I_{OL} = 10 mA		0.1	0.25	V
		I_{OL} = 50 mA		0.4	0.75	
		I_{OL} = 100 mA		2	2.5	
		I_{OL} = 200 mA		2.5		
	V_{CC} = 5 V	I_{OL} = 5 mA		0.1	0.35	
		I_{OL} = 8 mA		0.15	0.4	
High-level output voltage	V_{CC} = 15 V	I_{OH} = −100 mA	12.75	13.3		V
		I_{OH} = −200 mA		12.5		
	V_{CC} = 5 V	I_{OH} = −100 mA	2.75	3.3		
Supply current	Output low, No load	V_{CC} = 15 V		10	15	mA
		V_{CC} = 5 V		3	6	
	Output high, No load	V_{CC} = 15 V		9	13	
		V_{CC} = 5 V		2	5	

NOTE 2: This parameter influences the maximum value of the timing resistors R_A and R_B in the circuit of Figure 12. For example, when V_{CC} = 5 V, the maximum value is $R = R_A + R_B$ ≈ 3.4 MΩ, and for V_{CC} = 15 V, the maximum value is 10 MΩ.

operating characteristics, V_{CC} = 5 V and 15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Initial error of timing interval†	Each timer, monostable‡			1%	3%	
	Each timer, astable§			2.25%		
Supply voltage sensitivity of timing interval	Each timer, monostable‡			0.1	0.5	%/V
	Each timer, astable§			0.3		
Output pulse rise time		C_L = 15 pF		100	300	ns
Output pulse fall time				100	300	

† Timing interval error is defined as the difference between the measured value and the average value of a random sample from each process run.
‡ Values specified are for a device in a monostable circuit similar to Figure 9, with component values as follow: R_A = 2 kΩ to 100 kΩ, C = 0.1 μF.
§ Values specified are for a device in an astable circuit similar to Figure 12, with component values as follow: R_A = 1 kΩ to 100 kΩ, C = 0.1 μF.

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

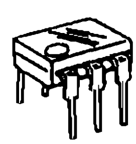
4N25
4N25A
4N26
4N27
4N28

6-Pin DIP Optoisolators
Transistor Output

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Convenient Plastic Dual-In-Line Package
- Most Economical Optoisolator
- High Input-Output Isolation Guaranteed — 7500 Volts Peak
- Meets or Exceeds All JEDEC Registered Specifications
- UL Recognized. File Number E54915
- VDE approved per standard 0883/6.80 (Certificate number 41853), with additional approval to DIN IEC380/VDE0806, IEC435/VDE0805, IEC65/VDE0860, VDE110b, covering all other standards with equal or less stringent requirements, including IEC204/ VDE0113, VDE0160, VDE0832, VDE0833, etc.
- Special lead form available (add suffix "T" to part number) which satisfies VDE0883/ 6.80 requirement for 8 mm minimum creepage distance between input and output solder pads.
- Various lead form options available. Consult "Optoisolator Lead Form Options" data sheet for details.

6-PIN DIP
OPTOISOLATORS
TRANSISTOR OUTPUT



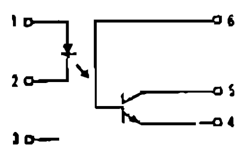
CASE 730A-02
PLASTIC

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	120	mW
Derate above 25°C		1.41	mW/°C
OUTPUT TRANSISTOR			
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	7	Volts
Collector-Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage (1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		2.94	mW/°C
Ambient Operating Temperature Range	T_A	−55 to +100	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16" from case)	T_{sol}	260	°C

(1) Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

SCHEMATIC



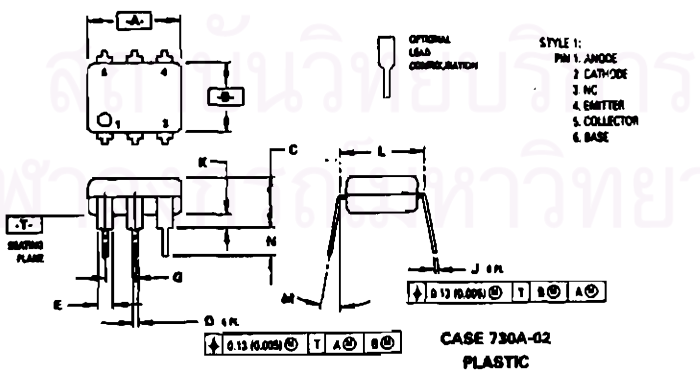
1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

4N25, 4N25A, 4N26, 4N27, 4N28

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = −55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	100	μA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector-Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	4N25,25A,26,27 4N28	I_{CEO}	— —	1 1	50 100	nA
(V_{CE} = 10 V, T_A = 100°C)	All Devices	I_{CEO}	—	1	—	μA
Collector-Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.2	—	nA
Collector-Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector-Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)		h_{FE}	—	500	—	—
Collector-Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
Collector-Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	19	—	pF
Emitter-Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	4N25,25A,26 4N27,28	I_C	2 1	7 5	— —	mA
Collector-Emitter Saturation Voltage (I_C = 2 mA, I_F = 50 mA)		$V_{CE(sat)}$	—	0.15	0.5	Volts
Turn-On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_{on}	—	2.8	—	μs
Turn-Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_{off}	—	4.5	—	μs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_r	—	1.2	—	μs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_f	—	1.3	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)		C_{ISO}	—	0.2	—	pF

OUTLINE DIMENSIONS



CASE 730A-02
PLASTIC

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.13	8.89	0.320	0.350
B	6.10	6.60	0.240	0.260
C	2.93	5.08	0.115	0.200
D	0.41	0.50	0.016	0.020
E	1.02	1.77	0.040	0.070
G	2.54 BSC		0.100 BSC	
J	0.21	0.30	0.008	0.012
K	0.38	2.54	0.015	0.100
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	2.54	3.81	0.100	0.150

ประวัติผู้เขียน

นายวิมล ทรัพย์ส่งสุข เกิดวันที่ 2 กรกฎาคม พ.ศ. 2510 ปีมะแม ที่อำเภอไทรน้อย จังหวัดนนทบุรี สำเร็จการศึกษาปริญญาตรีอุตสาหกรรมศาสตรบัณฑิต สาขาวิศวกรรมไฟฟ้า คณะวิศวกรรมศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ ประสานมิตร ในปีการศึกษา 2537 และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต สาขานิวเคลียร์เทคโนโลยี เมื่อ พ.ศ.2538