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DATASHEET

ÍNDEX

RELÉ

A

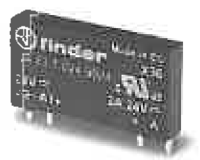
Features

Ultra-slim - Solid State Relays

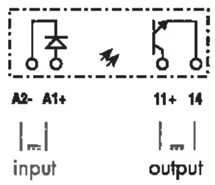
Printed circuit mount
- direct or via PCB socket
35 mm rail mount
- via screw, screwless or push-in terminal sockets

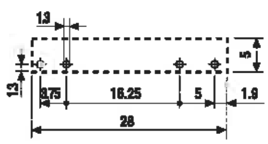
- Single circuit output switching options
  - 2 A 24 V DC
  - 0.1 A 48 V DC
  - 2 A 240 V AC
- Silent, high speed switching with long electrical life
- Ultra slim, 5 mm, package
- Sensitive DC Input circuits (Dual AC/DC input drive possible using 93 series sockets)
- UL Listing (certain relay/socket combinations)
- Wash tight: RT III
- 2,500 V insulation, input-output

34.81-9024



- 2 A, 24 V DC output switching
- PCB or 93 series sockets

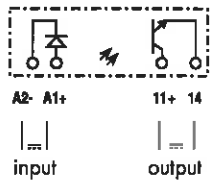


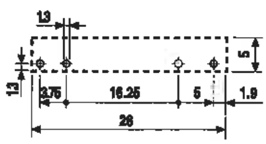


Copper side view

34.81-7048

- 0.1 A, 48 V DC output switching
- PCB or 93 series sockets

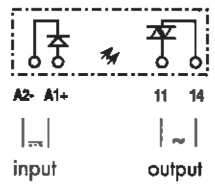


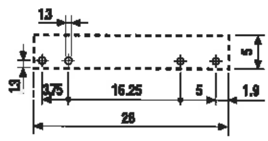


Copper side view

34.81-8240

- 2 A, 240 V AC output switching
- Zero crossing switching
- PCB or 93 series sockets





Copper side view

For outline drawing see page 5

		34.81-9024				34.81-7048		34.81-8240			
Output circuit											
Contact configuration		1 NO (SPST-NO)				1 NO (SPST-NO)		1 NO (SPST-NO)			
Rated current/Maximum peak current (10 ms)	A	2/20				0.1/0.5		2/40			
Rated voltage/Maximum blocking voltage	V	(24/33)DC				(48/60)DC		(240/—)AC			
Switching voltage range	V	(1.5...24)DC				(1.5...48)DC		(12...275)AC			
Repetitive peak off-state voltage	V_{pk}	—				—		600			
Minimum switching current	mA	1				0.05		22			
Max. "OFF-state" leakage current	mA	0.001				0.001		1.5			
Max. "ON-state" voltage drop	V	0.12				1		1.6			
Input circuit											
Nominal voltage	V DC	5	12	24	60	24	60	5	12	24	60
Rated power AC/DC	W	0.035	0.087	0.17	0.18	0.17	0.18	0.060	0.087	0.17	0.18
Operating range	V DC	3.5...12	8...17	16...30	35...72	16...30	35...72	3.5...10	8...17	16...30	35...72
Control current	mA	7	7.2	7	3	7	3	12	7.2	7	3
Release voltage	V DC	1	4	10	20	10	20	1	4	10	20
Impedance	Ω	715	1,940	3,200	21,300	3,200	21,300	416	1,940	3,200	21,300
Technical data											
Operate/release time	ms	0.1/0.6*				0.04/0.6*		12/12*			
Dielectric strength between input/output	V	2,500				2,500		2,500			
Ambient temperature range	°C	–20...+60				–20...+60		–20...+60			
Environmental protection		RT III				RT III		RT III			
Approvals (according to type)											

* Note: all technical data relates to using the relay directly on PCB or PCB socket type 93.11.
If the relay is used with 35 mm rail socket type 93.51, refer to the technical data of 38 Series; if used with types 93.60, 93.61, 93.62, 93.63, 93.64, 93.65, 93.66, 93.67,93.68 and 93.69, refer to the technical data of the *Master**INTERFACE*** 39 Series.

Features

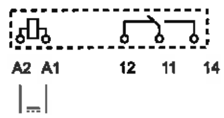
Ultra-slim 1 Pole - 6 A relay

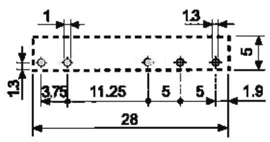
Printed circuit mount
- direct or via PCB socket
35 mm rail mount
- via screw, screwless or push-in terminal sockets

- 1 Pole changeover contacts or 1 Pole normally open contact
- Ultra slim, 5 mm, package
- Sensitive DC coil - 170 mW (Dual AC/DC coil drive possible using 93 series sockets)
- UL Listing (certain relay/socket combinations)
- Cadmium Free contact materials
- 8/8 mm clearance/creepage distance
- 6 kV (1.2/50 μs) insulation, coil-contacts

34.51

- 5 mm wide
- Low coil power
- PCB or 93 series sockets





For UL ratings see:
"General technical information" page V

For outline drawing see page 5

Copper side view

		34.51
Contact specification		
Contact configuration		1 CO (SPDT)
Rated current/Maximum peak current	A	6/10
Rated voltage/Maximum switching voltage	V AC	250/400
Rated load AC1	VA	1,500
Rated load AC15 (230 V AC)	VA	300
Single phase motor rating (230 V AC)	kW	0.185
Breaking capacity DC1: 30/110/220 V	A	6/0.2/0.12
Minimum switching load	mW (V/mA)	500 (12/10)
Standard contact material		AgNi
Coil specification		
Nominal voltage (U_N)	V AC (50/60 Hz)	—
	V DC	5 - 12 - 24 - 48 - 60
Rated power AC/DC	VA (50 Hz)/W	—/0.17
Operating range	AC	—
	DC	(0.7...1.5)U_N
Holding voltage	AC/DC	—/0.4 U_N
Must drop-out voltage	AC/DC	—/0.05 U_N
Technical data		
Mechanical life AC/DC	cycles	—/10 · 10^6
Electrical life at rated load AC1	cycles	60 · 10^3
Operate/release time	ms	5/3
Insulation between coil and contacts (1.2/50 μs)	kV	6 (8 mm)
Dielectric strength between open contacts	V AC	1,000
Ambient temperature range	°C	–40...+85
Environmental protection		RT II
Approvals (according to type)		

Ordering information

Electromechanical relay (EMR)

Example: 34 series slim electromechanical relay, 1 CO (SPDT) 6 A contacts, 24 V sensitive DC coil.

3 4 . 5 1 . 7 . 0 2 4 . 0 0 1 0 (A B C D)

Series

Type
5 = Electromechanical type

No. of poles
1 = 1 pole, 6 A

Coil version
7 = Sensitive DC

Coil voltage
See coil specifications

A: Contact material
0 = Standard AgNi
4 = $AgSnO_2$
5 = AgNi + Au

B: Contact circuit
0 = CO (SPDT)
3 = NO (SPST)

C: Options
1 = None

D: Special versions
0 = Flux proof (RT II)
9 = Flat version

Selecting features and options: only combinations in the same row are possible.
Preferred selections for best availability are shown in **bold**.

Type	Coil version	A	B	C	D
34.51	sens. DC	**0** - 4 - 5	**0** - 3	**1**	**0**
34.51	sens. DC	0 - 4 - 5	0	1	9

Solid state relay (SSR)

Example: 34 series SSR relay, 2 A output, 24 V DC supply.

3 4 . 8 1 . 7 . 0 2 4 . 9 0 2 4

Series

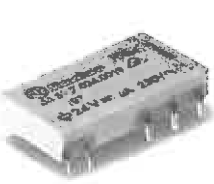
Type
8 = SSR type

Output
1 = 1 NO (SPST-NO)

Input circuit
See input specifications

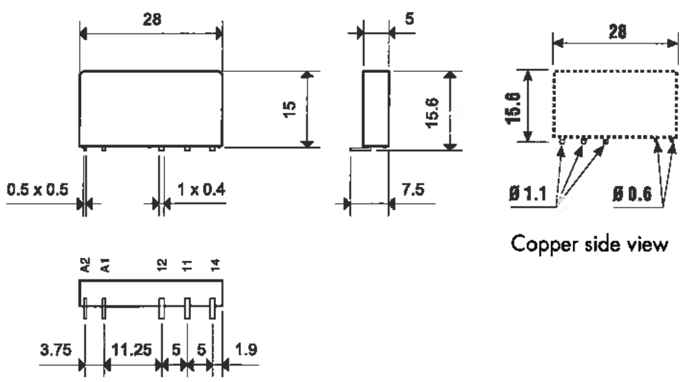
Output circuit
9024 = 2 A - 24 V DC
7048 = 0.1 A - 48 V DC
8240 = 2 A - 240 V AC

Flat pack version



Option = 34.51.7xxx.x019

Environmental protection RT I



Copper side view

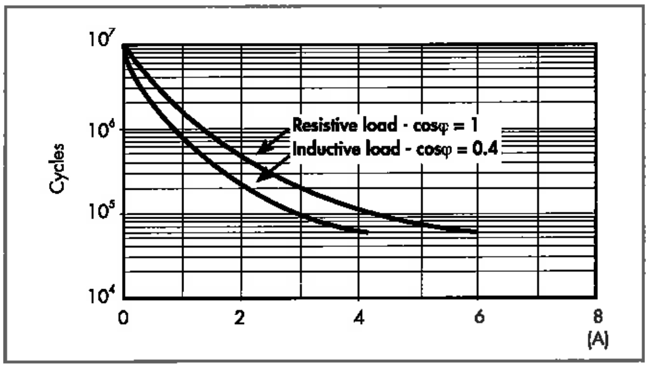
Electromechanical relay

Technical data

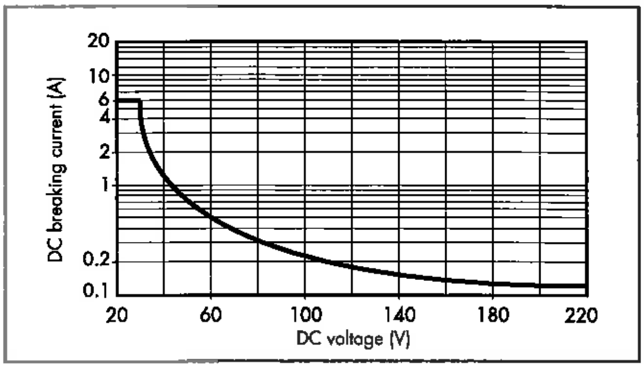
Insulation according to EN 61810-1			
Nominal voltage of supply system	V AC	230/400	
Rated insulation voltage	V AC	250	400
Pollution degree		3	2
Insulation between coil and contact set			
Type of insulation		Reinforced	
Overvoltage category		III	
Rated impulse voltage	kV (1.2/50 μs)	6	
Dielectric strength	V AC	4,000	
Insulation between open contacts			
Type of disconnection		Micro-disconnection	
Dielectric strength	V AC/kV (1.2/50 μs)	1,000/1.5	
Conducted disturbance immunity			
Burst (5...50)ns, 5 kHz, on A1 - A2		EN 61000-4-4	level 4 (4 kV)
Surge (1.2/50 μs) on A1 - A2 (differential mode)		EN 61000-4-5	level 3 (2 kV)
Other data			
Bounce time: NO/NC	ms	1/6	
Vibration resistance (5...55)Hz: NO/NC	g	10/5	
Shock resistance	g	20/14	
Power lost to the environment — without contact current	W	0.2	
Power lost to the environment — with rated current	W	0.5	
Recommended distance between relays mounted on PCB	mm	≥ 5	

Contact specification

F 34 - Electrical life (AC) v contact current



H 34 - Maximum DC1 breaking capacity



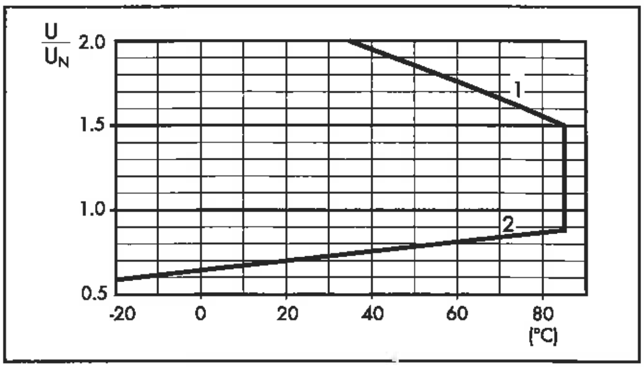
- When switching a resistive load (DC1) having voltage and current values under the curve, an electrical life of ≥ $60 \cdot 10^3$ can be expected.
- In the case of DC13 loads, the connection of a diode in parallel with the load will permit a similar electrical life as for a DC1 load.
  Note: the release time for the load will be increased.

Coil specifications

DC coil data

Nominal voltage U_N V	Coil code	Operating range U_{min} V	Operating range U_{max} V	Resistance R Ω	Rated coil consumption I at U_N mA
5	**7.005**	3.5	7.5	130	38.4
12	**7.012**	8.4	18	840	14.2
24	**7.024**	16.8	36	3,350	7.1
48	**7.048**	33.6	72	12,300	3.9
60	**7.060**	42	90	19,700	3

R 34 - DC coil operating range v ambient temperature



1 - Max. permitted coil voltage.
2 - Min. pick-up voltage with coil at ambient temperature.

X2014, www.findernet.com

Solid state relay

Technical data

EMC specifications		Reference standard	
Electrostatic discharge	contact discharge	EN 61000-4-2	4 kV
	air discharge	EN 61000-4-2	8 kV
Fast transients on supply terminals (burst 5/50 ns, 5 kHz)		EN 61000-4-4	2 kV
Voltage pulses on supply terminals (surge 1.2/50 µs)	common mode	EN 61000-4-5	0.5 kV
	differential mode	EN 61000-4-5	0.5 kV
Other data			
Power lost to the environment	without output current	W	0.17
	with rated current	W	0.4

Input specification

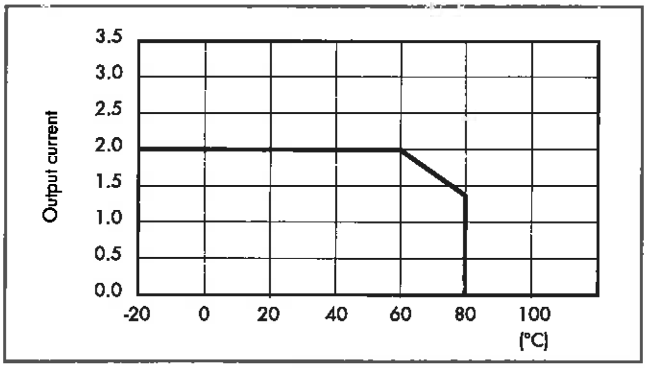
Input data - DC types

Nominal voltage U_N	Input code	Operating range		Release voltage	Impedance	Control current I at U_N
		U_{min}	U_{max}			
V		V	V	V	Ω	mA
5	7.005	3.5	12 (10*)	1	715 (416*)	7 (12*)
12	7.012	8	17	4	1,940	7.2
24	7.024	16	30	10	3,200	7
60	7.060	35	72	20	21,300	3

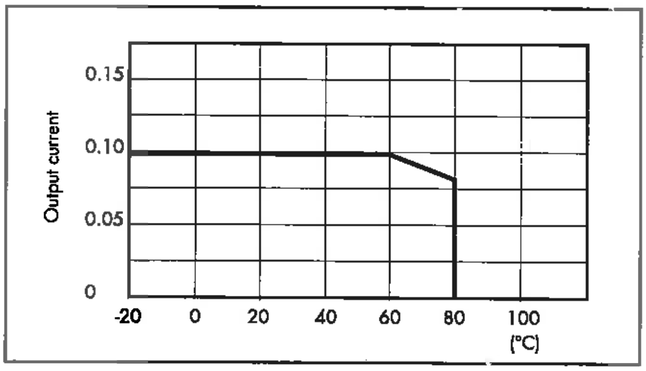
* AC Output version.

Output specification

L 34 - Output current v ambient temperature
SSR - 2 A DC & AC output types

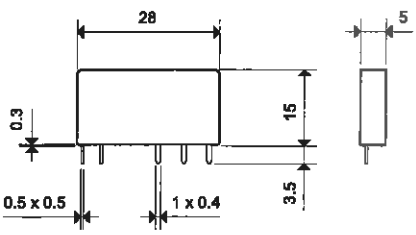


L 34 - Output current v ambient temperature
SSR - 0.1 A DC output types

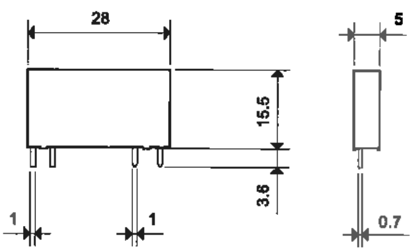


Outline drawings

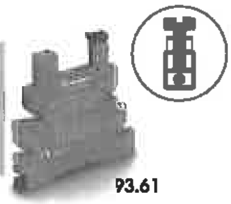
Type 34.51

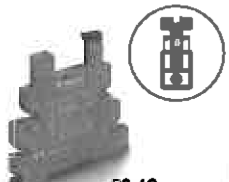


Type 34.81



A


93.61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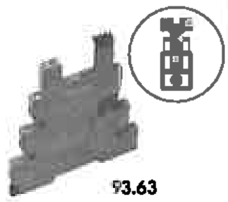
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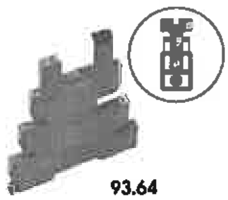
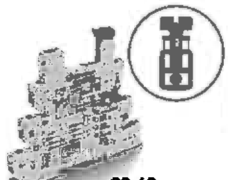

93.64


93.68

Approvals
(according to type):

Screw terminal socket 35mm rail mounting (EN 60715) NEW

Common features
- Space saving 6.2 mm wide
- Connections for 16-way jumper link
- Integral coil indication and protection circuit
- Secure retention and easy ejection by plastic clip
- Dual screw head (blade+cross) terminals

For technical data and supply versions, refer to the *Master***INTERFACE 39 Series** – "Relay interface module"

Electromechanical Relay - EMR

Supply voltage	Relay type	**Socket type** (reference with the 39 Series)				
		*Master***BASIC** (39.11.....)	*Master***PLUS** (39.31.....)	*Master***INPUT** (39.41.....)	*Master***OUTPUT** (39.21.....)	*Master***TIMER** (39.81.....)
6 V AC/DC	34.51.7.005.xx10	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	–
12 V AC/DC	34.51.7.012.xx10	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	93.68.0.024
24 V AC/DC	34.51.7.024.xx10	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	93.68.0.024
60 V AC/DC	34.51.7.060.xx10	–	93.63.7.060	–	–	–
(110...125)V AC/DC*	34.51.7.060.xx10	–	93.63.3.125	–	–	–
(220...240)V AC*	34.51.7.060.xx10	–	93.63.3.230	–	–	–
(110...125)V AC/DC	34.51.7.060.xx10	93.61.0.125	93.63.0.125	93.64.0.125	93.62.0.125	–
(220...240)V AC	34.51.7.060.xx10	93.61.8.230	93.63.8.230	93.64.8.230	93.62.8.230	–
(110...125) V DC	34.51.7.060.xx10	–	93.63.7.125	–	–	–
220 V DC	34.51.7.060.xx10	–	93.63.7.220	–	–	–

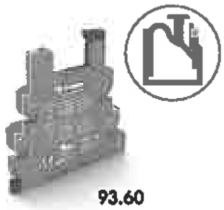
* Leakage current suppression

Solid State Relay - SSR

Supply voltage	Relay type	**Socket type** (reference with the 39 Series)				
		*Master***BASIC** (39.10.....)	*Master***PLUS** (39.30.....)	*Master***INPUT** (39.40.....)	*Master***OUTPUT** (39.20.....)	*Master***TIMER** (39.80.....)
12 V AC/DC	34.81.7.012.xxxx	–	–	–	–	93.68.0.024
24 V AC/DC	34.81.7.024.xxxx	–	93.63.0.024	93.64.0.024	–	93.68.0.024
(110...125)V AC/DC*	34.81.7.060.xxxx	–	93.63.3.125	–	–	–
(220...240)V AC*	34.81.7.060.xxxx	–	93.63.3.230	–	–	–
(110...125)V AC/DC	34.81.7.060.xxxx	93.61.0.125	93.63.0.125	93.64.0.125	93.62.0.125	–
(220...240)V AC	34.81.7.060.xxxx	93.61.8.230	93.63.8.230	93.64.8.230	93.62.8.230	–
6 V DC	34.81.7.005.xxxx	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	–
12 V DC	34.81.7.012.xxxx	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	–
24 V DC	34.81.7.024.xxxx	93.61.7.024	93.63.7.024	93.64.7.024	93.62.7.024	–
60 V DC	34.81.7.060.xxxx	–	93.63.7.060	–	–	–
(110...125) V DC	34.81.7.060.xxxx	–	93.63.7.125	–	–	–
220 V DC	34.81.7.060.xxxx	–	93.63.7.220	–	–	–

* Leakage current suppression

Accessories		
16-way jumper link		093.16 (blue), 093.16.0 (black), 093.16.1 (red)
Dual-purpose plastic separator		093.60
Sheet of marker tags		060.72
Technical data		
Rated values		6 A – 250 V
Dielectric strength		6 kV (1.2/50 μs) between coil and contacts
Protection category		IP20
Ambient temperature	°C	–40...+70
Screw torque	Nm	0.5
Wire strip length	mm	10
Max wire size		Solid wire and stranded wire
	mm^2	1 x (0.2...2.5) / 2 x 1.5
	AWG	1 x (24...14) / 2 x 16



93.60

Push-In terminal socket 35mm rail mounting (EN 60715) NEW

Common features

- Space saving 6.2 mm wide
- Connections for 16-way jumper link
- Integral coil indication and protection circuit
- Secure retention and easy ejection by plastic clip

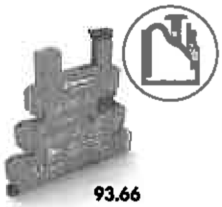
For technical data and supply versions, refer to the *Master***INTERFACE 39 Series** – "Relay interface module"

93.65

Electromechanical Relay - EMR

Supply voltage	Relay type	**Socket type** (reference with the 39 Series)				
		*Master***BASIC** (39.01.....)	*Master***PLUS** (39.61.....)	*Master***INPUT** (39.71.....)	*Master***OUTPUT** (39.51.....)	*Master***TIMER** (39.91.....)
6 V AC/DC	34.51.7.005.xx10	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	–
12 V AC/DC	34.51.7.012.xx10	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	93.69.0.024
24 V AC/DC	34.51.7.024.xx10	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	93.69.0.024
60 V AC/DC	34.51.7.060.xx10	–	93.66.7.060	–	–	–
(110...125)V AC/DC*	34.51.7.060.xx10	–	93.66.3.125	–	–	–
(220...240)V AC*	34.51.7.060.xx10	–	93.66.3.230	–	–	–
(110...125)V AC/DC	34.51.7.060.xx10	93.60.0.125	93.66.0.125	93.67.0.125	93.65.0.125	–
(220...240)V AC	34.51.7.060.xx10	93.60.8.230	93.66.8.230	93.67.8.230	93.65.8.230	–
(110...125) V DC	34.51.7.060.xx10	–	93.66.7.125	–	–	–
220 V DC	34.51.7.060.xx10	–	93.66.7.220	–	–	–

* Leakage current suppression



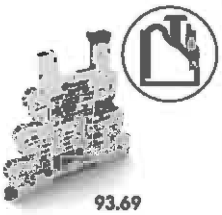
93.66

93.67

Solid State Relay - SSR

Supply voltage	Relay type	**Socket type** (reference with the 39 Series)				
		*Master***BASIC** (39.00.....)	*Master***PLUS** (39.60.....)	*Master***INPUT** (39.70.....)	*Master***OUTPUT** (39.50.....)	*Master***TIMER** (39.90.....)
12 V AC/DC	34.81.7.012.xxxx	–	–	–	–	93.69.0.024
24 V AC/DC	34.81.7.024.xxxx	–	93.66.0.024	93.67.0.024	–	93.69.0.024
(110...125)V AC/DC*	34.81.7.060.xxxx	–	93.66.3.125	–	–	–
(220...240)V AC*	34.81.7.060.xxxx	–	93.66.3.230	–	–	–
(110...125)V AC/DC	34.81.7.060.xxxx	93.60.0.125	93.66.0.125	93.67.0.125	93.65.0.125	–
(220...240)V AC	34.81.7.060.xxxx	93.60.8.230	93.66.8.230	93.67.8.230	93.65.8.230	–
6 V DC	34.81.7.005.xxxx	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	–
12 V DC	34.81.7.012.xxxx	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	–
24 V DC	34.81.7.024.xxxx	93.60.7.024	93.66.7.024	93.67.7.024	93.65.7.024	–
60 V DC	34.81.7.060.xxxx	–	93.66.7.060	–	–	–
(110...125) V DC	34.81.7.060.xxxx	–	93.66.7.125	–	–	–
220 V DC	34.81.7.060.xxxx	–	93.66.7.220	–	–	–

* Leakage current suppression

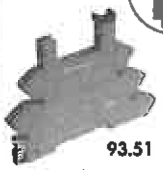


93.69

Approvals
(according to type):

Accessories		
16-way jumper link		093.16 (blue), 093.16.0 (black), 093.16.1 (red)
Dual-purpose plastic separator		093.60
Sheet of marker tags		060.72
Technical data		
Rated values		6 A – 250 V
Dielectric strength		6 kV (1.2/50 μs) between coil and contacts
Protection category		IP20
Ambient temperature	°C	–40...+70
Wire strip length	mm	8
Max wire size		Solid wire and stranded wire
	mm²	1 x (0.2...2.5)
	AWG	1 x (24...14)

A



93.51

Approvals
(according to type):

RINA

Certain relay/socket combinations

Screw less terminal socket 35mm rail mounting (EN 60715)

Common features

- Space saving 6.2 mm wide
- Connections for 20-way jumper link
- Integral coil indication and protection circuit
- Secure retention and easy ejection by plastic clip

For technical data and supply versions, refer to the **38 Series** – "Relay interface module"

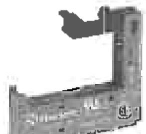
Electromechanical Relay - EMR and Solid State Relay - SSR

Supply voltage	**Relay type** (reference with the 38 Series)		Socket type
	Electromechnanical relay - EMR (38.61.....)	**Solid State Relay - SSR** (38.81.....)	
12 V AC/DC	34.51.7.012.xx10	—	93.51.0.024
24 V AC/DC	34.51.7.024.xx10	—	93.51.0.024
(110...125)V AC/DC	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.0.125
(220...240)V AC/DC	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.0.240
(110...125)V AC/DC *	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.3.125
(220...240)V AC *	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.3.240
(220...240)V AC	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.8.240
12 V DC	34.51.7.012.xx10	34.81.7.012.xxxx	93.51.7.024
24 V DC	34.51.7.024.xx10	34.81.7.024.xxxx	93.51.7.024
60 V DC	34.51.7.060.xx10	34.81.7.060.xxxx	93.51.7.060

* Leakage current suppression

Accessories		
20-way jumper link		093.20
Plastic separator		093.01
Sheet of marker tags		093.64
Technical data		
Rated values		6 A – 250 V
Dielectric strength		6 kV (1.2/50 μs) between coil and contacts
Protection category		IP20
Ambient temperature ($U_N \leq$ 60 V/> 60 V)	°C	–40...+70/–40...+55
Wire strip length	mm	10
Max wire size		Solid wire and stranded wire
	mm²	1 x 2.5 / 2 x 1.5
	AWG	1 x 14 / 2 x 16

X-2014, www.findernet.com

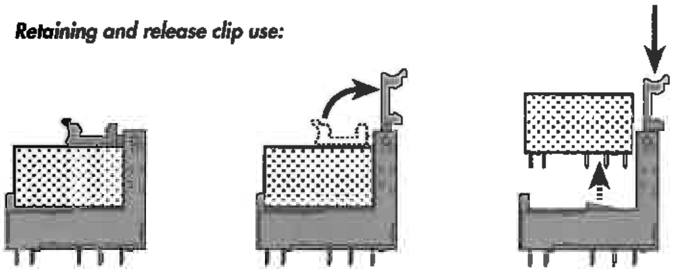


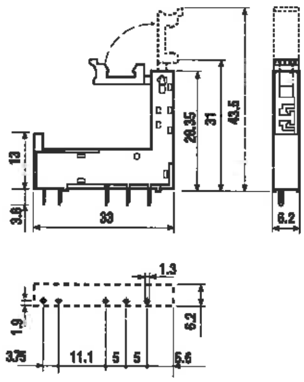
93.11

Approvals
(according to type):

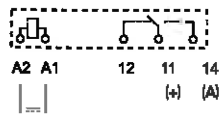
PCB socket with retaining and release clip	**93.11 (blue)**
For relay type	34.51, 34.81
Technical data	
Rated values	6 A - 250 V
Dielectric strength	≥ 6 kV (1.2/50 µs) between coil and contacts
Protection category	IP 20
Ambient temperature °C	–40...+70

Retaining and release clip use:





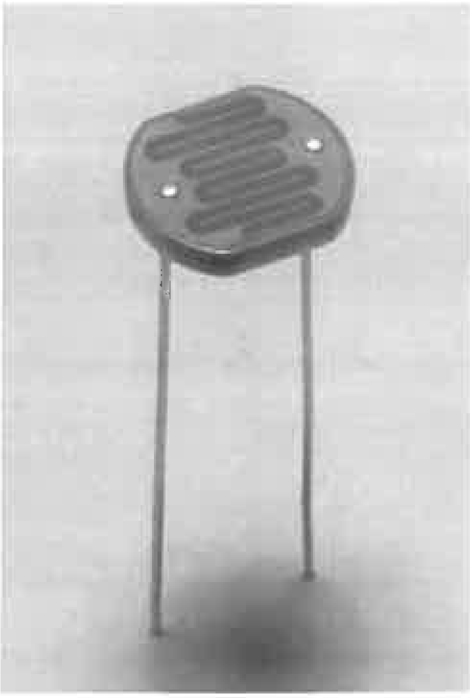
Copper side view



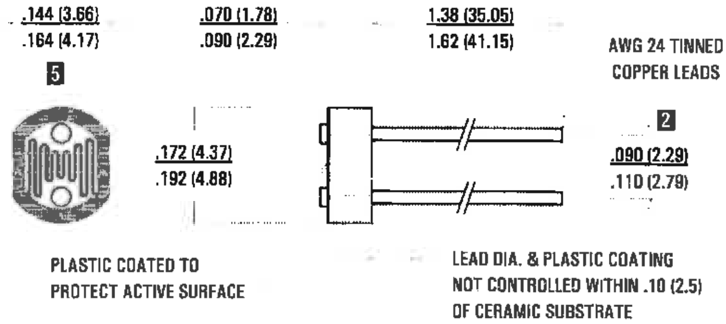
LDR VT900

Photoconductive Cell

VT900 Series



PACKAGE DIMENSIONS inch (mm)



ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Units
Continuous Power Dissipation Derate Above 25°C	P_D $\Delta P_D / \Delta T$	80 1.6	mW mW/°C
Temperature Range Operating and Storage	T_A	–40 to +75	°C

ELECTRO-OPTICAL CHARACTERICTICS @ 25°C (16 hrs. light adapt, min.) [4]

Part Number	Resistance (Ohms) [3] [6] 10 lux 2850 K Min.	10 lux 2850 K Typ.	10 lux 2850 K Max.	2 fc 2850 K Typ.	Dark Min.	Dark sec.	Material Type	Sensitivity (γ, typ.) LOG (R10/R100) / LOG (100/10)	Maximum Voltage (V, pk)	Response Time @ 1 fc (ms, typ.) Rise (1-1/e)	Fall (1/e)
VT9ØN1	6 k	12 k	18 k	6 k	200 k	5	Ø	0.80	100	78	8
VT9ØN2	12 k	24 k	36 k	12 k	500 k	5	Ø	0.80	100	78	8
VT9ØN3	25 k	50 k	75 k	25 k	1 M	5	Ø	0.85	100	78	8
VT9ØN4	50 k	100 k	150 k	50 k	2 M	5	Ø	0.90	100	78	8
VT93N1	12 k	24 k	36 k	12 k	300 k	5	3	0.90	100	35	5
VT93N2	24 k	48 k	72 k	24 k	500 k	5	3	0.90	100	35	5
VT93N3	50 k	100 k	150 k	50 k	500 k	5	3	0.90	100	35	5
VT93N4	100 k	200 k	300 k	100 k	500 k	5	3	0.90	100	35	5
VT935G											
[1] Group A	10 k	18.5 k	27 k	9.3 k	1 M	5	3	0.90	100	35	5
[1] Group B	20 k	29 k	38 k	15 k	1 M	5	3	0.90	100	35	5
[1] Group C	31 k	40.5 k	50 k	20 k	1 M	5	3	0.90	100	35	5

See page 13 for notes.

SENSOR TEMPERATURA

±2.5°C Low-Power, Analog Out TEMPERATURE SENSOR

Check for Samples: TMP20

FEATURES

- ±2.5°C ACCURACY FROM –55°C to +130°C
- SUPPLY VOLTAGE RANGE: 1.8V to 5.5V
- LOW POWER: 4μA (max)
- *Micro*SIZE PACKAGES: SOT563, SC70-5
- SC70 PIN-COMPATIBLE WITH LM20

APPLICATIONS

- CELL PHONES
- DESKTOP AND NOTEBOOK COMPUTERS
- PORTABLE DEVICES
- CONSUMER ELECTRONICS
- BATTERY MANAGEMENT
- POWER SUPPLIES
- HVAC
- THERMAL MONITORING
- DISK DRIVES
- APPLIANCES/WHITE GOODS
- AUTOMOTIVE

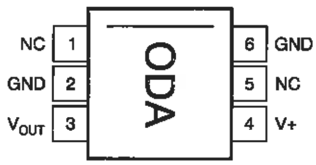
DESCRIPTION

The TMP20 is a CMOS, precision analog output temperature sensor available in the tiny SOT563 package. The TMP20 operates from –55°C to +130°C on a supply voltage of 2.7V to 5.5V with a supply current of 4μA. Operation as low as 1.8V is possible for temperatures between +15°C and +130°C. The linear transfer function has a slope of –11.77mV/°C (typ) and has an output voltage of 1.8639V (typ) at 0°C. The TMP20 has a ±2.5°C accuracy across the entire specified temperature range of –55°C to +130°C.

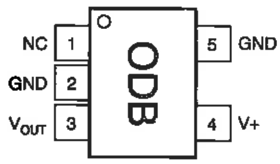
The TMP20 4μA (max) supply current limits self-heating of the device to less than 0.01°C. When V+ is less than 0.5V, the device is in shutdown mode and consumes less than 20nA (typ).

The TMP20 is available in either a 5-lead SC70 or 6-lead SOT563 package, reducing the overall board space required.

DRL PACKAGE
SOT563-6
(TOP VIEW)



DCK PACKAGE
SC70-5
(TOP VIEW)



Note: NC or no-connect pin must be grounded or left floating. Pin 2 on the DRL package has no internal connection; pin 2 on the DCK package is connected to the die substrate. See Layout Information for more information about optimizing the connection of pin 2 on the DCK package for thermal and electrical performance.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
TMP20	SC70-5	DCK	ODB
TMP20	SOT563-6	DRL	ODA

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)

Over operating free-air temperature range, unless otherwise noted.

		TMP20	UNIT
Supply Voltage, V+		+7.0	V
Operating Temperature Range		–55 to +150	°C
Storage Temperature Range		–65 to +150	°C
Junction Temperature (T_J max)		+150	°C
ESD Rating	Human Body Model (HBM)	4000	V
	Charged Device Model (CDM)	1000	V
	Machine Model (MM)	200	V

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

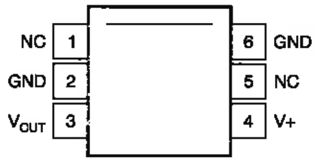
ELECTRICAL CHARACTERISTICS

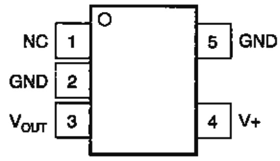
At T_A = +25°C and V+ = 2.7V to 5.5V, unless otherwise noted.

PARAMETER		CONDITIONS	TMP20 MIN	TMP20 TYP	TMP20 MAX	UNIT
TEMPERATURE MEASUREMENT[1]						
Accuracy[2]		T_A = –55°C to +130°C	–2.5		+2.5	°C
vs Supply		V+ = 1.8V to +5.5V, at T_A = +15°C to +130°C	–0.05		+0.05	°C/V
		V+ = 2.7V to +5.5V, at T_A = –50°C to +130°C	–0.05		+0.05	°C/V
Temperature Sensitivity[3]		T_A = –30°C to +100°C	–11.4	–11.77	–12.2	mV/°C
Output Voltage[4]						
		T_A = 0°C		1863.9		mV
		T_A = +25°C		1574		mV
Nonlinearity[5]		–20°C ≤ T_A ≤ +80°C		±0.4		%
ANALOG OUTPUT						
Output Resistance		–600μA ≤ I_{LOAD} ≤ 600μA		10		Ω
Load Regulation		–600μA ≤ I_{LOAD} ≤ 600μA		6		mV
Maximum Capacitive Load			1			nF
POWER SUPPLY						
Specified Voltage Range	V_S	T_A = –55°C to +130°C	2.7		5.5	V
		T_A = +15°C to +130°C[6]	1.8		5.5	V
Quiescent Current	I_Q	V+ = 5.5V, T_A = +25°C		2.6	4	μA
over Temperature		V+ = 5.5V, T = –55°C to +130°C			6	μA
Shutdown Current	I_{SD}	V+ < 0.5V		20		nA
TEMPERATURE RANGE						
Specified Operating Range		V+ = 2.7V to 5.5V	–55		+130	°C
		V+ = 1.8V to 5.5V[6]	+15		+130	°C
Operating Range		V+ = 2.7V to 5.5V	–55		+150	°C
Thermal Resistance	θ_{JA}					
SC70				185		°C/W
SOT563				238		°C/W
Self-Heating						
SC70					0.01	°C
SOT563					0.01	°C

(1) 100% production tested at T_A = +25°C. Specifications over temperature range are assured by design.
(2) Power-supply rejection is encompassed in the accuracy specification.
(3) Temperature sensitivity is the average slope to the equation $V_O = (-11.77 \times T) + 1.860V$.
(4) V_{OUT} is calculated from temperature with the following equation:
$V_O = (-3.88 \times 10^{-6} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639V$,
where T is in °C.
(5) Nonlinearity is the deviation of the calculated output voltage from the best fit straight line.
(6) The TMP20 transfer function requires the output voltage to rise above the 1.8V supply as the temperature decreases below +15°C. When operating at a 1.8V supply, it is normal for the TMP20 output to approach 1.8V and remain at that voltage as the temperature continues to decrease below +15°C. This condition does not damage the device. Once the temperature rises above +15°C, the output voltage resumes changing as the temperature changes, according to the transfer function specified in this document. For more information about the transfer function, see the *Transfer Function* section.

PIN CONFIGURATIONS





Note: NC or no-connect pin must be grounded or left floating.

TMP20 PIN ASSIGNMENTS

TMP20			
PIN NAME	DRL PACKAGE	DCK PACKAGE	DESCRIPTION
NC	1	1	This pin must be grounded or left floating. See Layout Information for more information.
NC or GND	2, 5	2	This pin must be grounded or left floating. For best thermal response, connect to GND plane. See Layout Information for more information.
V_{OUT}	3	3	Analog output.
V+	4	4	Positive supply voltage.
GND	6	5	Ground pin.

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE vs TEMPERATURE

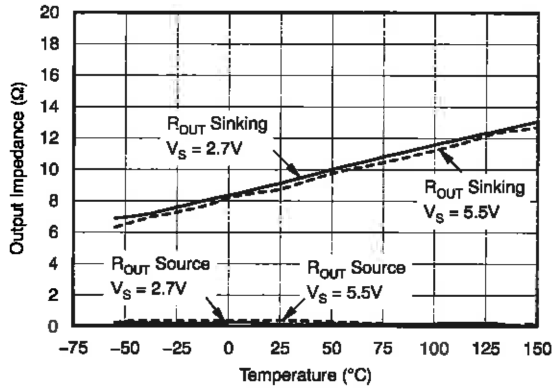


Figure 1.

QUIESCENT CURRENT vs TEMPERATURE

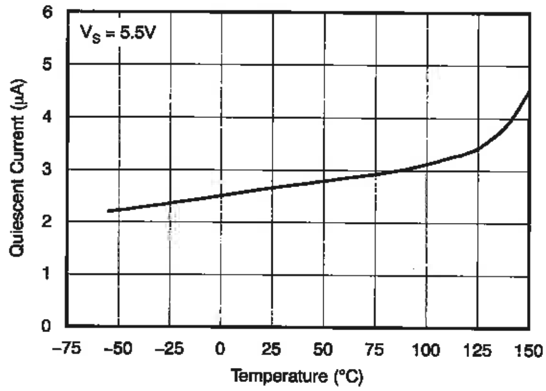


Figure 2.

OUTPUT VOLTAGE vs TEMPERATURE

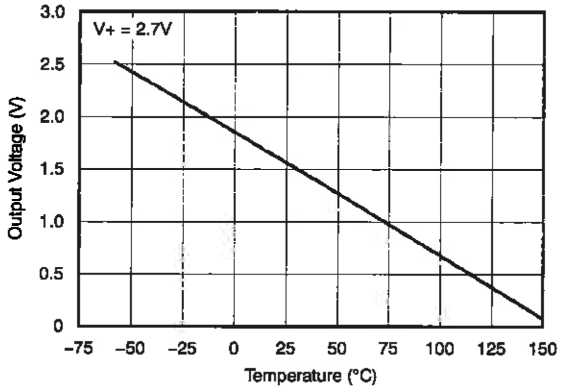


Figure 3.

QUIESCENT CURRENT vs SUPPLY VOLTAGE

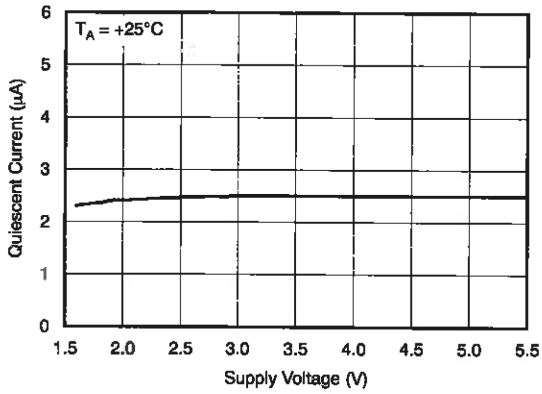


Figure 4.

POWER-SUPPLY REJECTION vs TEMPERATURE

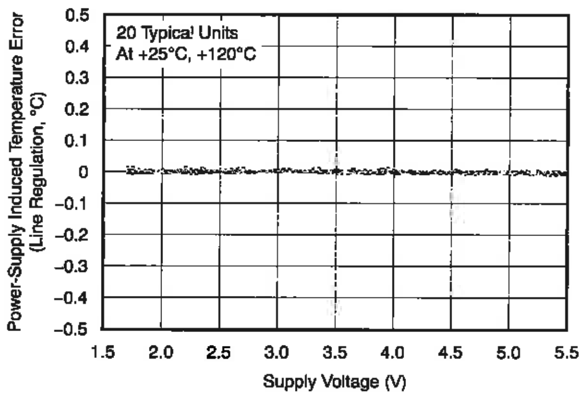


Figure 5.

POWER-SUPPLY REJECTION vs TEMPERATURE

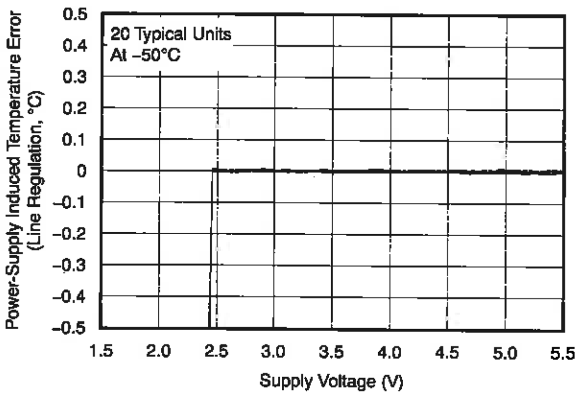


Figure 6.

TYPICAL CHARACTERISTICS (continued)

TEMPERATURE ERROR vs TEMPERATURE

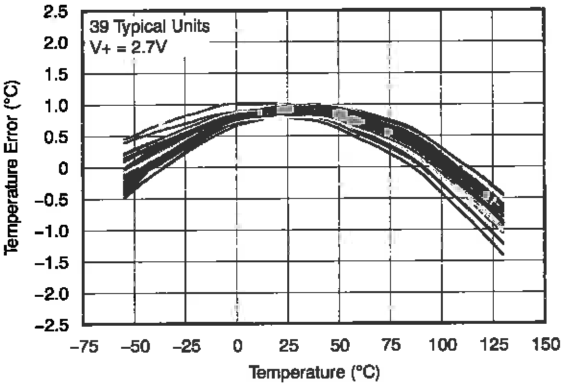


Figure 7.

MINIMUM SUPPLY VOLTAGE vs TEMPERATURE

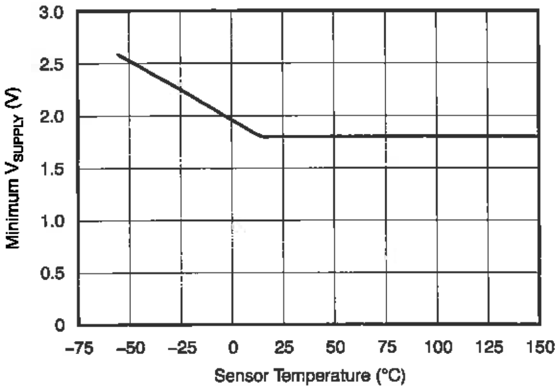


Figure 8.

WIDEBAND OUTPUT NOISE VOLTAGE

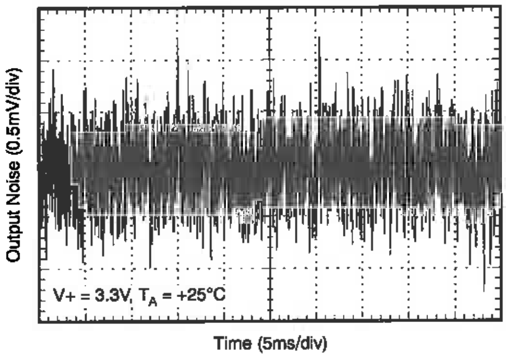


Figure 9.

THERMAL SETTLING (FLUID-FILLED TEMPERATURE BATH)

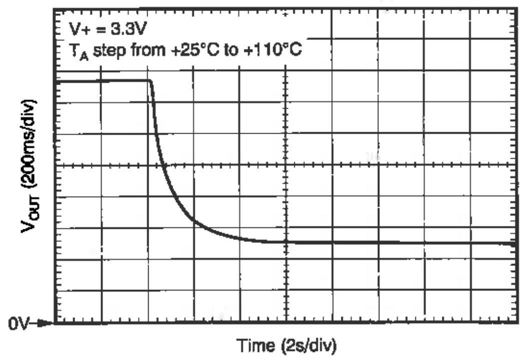


Figure 10.

REGULADOR DE TENSIÓ

LM117/LM317A/LM317-N Three-Terminal Adjustable Regulator

Check for Samples: LM117, LM317A, LM317-N

FEATURES

- **Specified 1% Output Voltage Tolerance (LM317A)**
- **Specified max. 0.01%/V Line Regulation (LM317A)**
- **Specified max. 0.3% Load Regulation (LM117)**
- **Specified 1.5A Output Current**
- **Adjustable Output Down to 1.2V**
- **Current Limit Constant with Temperature**
- **P+ Product Enhancement tested**
- **80 dB Ripple Rejection**
- **Output is Short-Circuit Protected**

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.

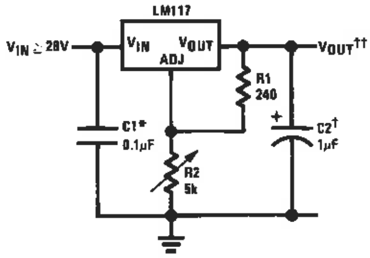
Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection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

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.

Typical Applications



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.

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

Figure 1. 1.2V–25V Adjustable Regulator

LM117/LM317A/LM317-N Package Options

Part Number	Package Drawing	Package Type	Output Current
LM117K STEEL	NDS	TO-3	1.5A
LM317K			
LM317AT	NDE	TO-220	
LM317T			
LM317T/LF01	NDG		
LM317S	KTT	TO-263	
LM317AEMP	DCY	SOT-223	1.0A
LM317EMP			
LM117H	NDT	TO	0.5A
LM317AH			
LM317H			
LM317AMDT	NDP	TO-252	
LM317MDT			

NOTE

For part numbers that can be ordered, please see the Package Option Addendum at the end of the datasheet.

SOT-223 vs. TO-252 Packages

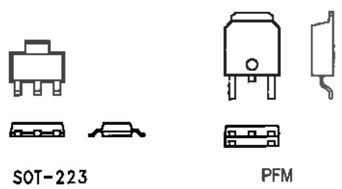
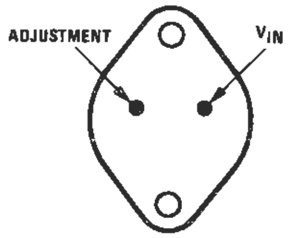


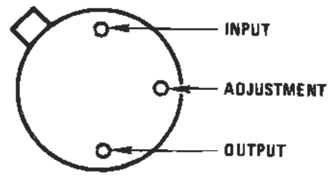
Figure 2. Scale 1:1

Connection Diagrams



CASE IS OUTPUT

Figure 3. TO-3 (NDS) Metal Can Package Bottom View Package Drawing NDS



CASE IS OUTPUT

Figure 4. TO (NDT) Metal Can Package Bottom View Package Drawing NDT

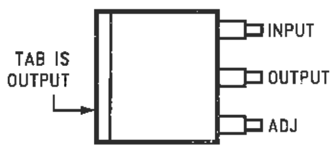


Figure 5. TO-263 (KTT) Surface-Mount Package Top View Package Drawing KTT

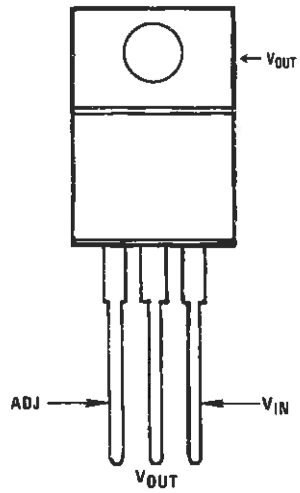


Figure 6. TO-220 (NDE) Plastic Package Front View Package Drawing NDE

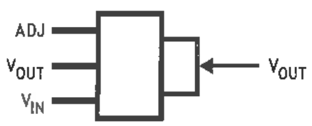


Figure 7. 4-Lead SOT-223 (DCY) Top View Surface-Mount Package Package Number DCY

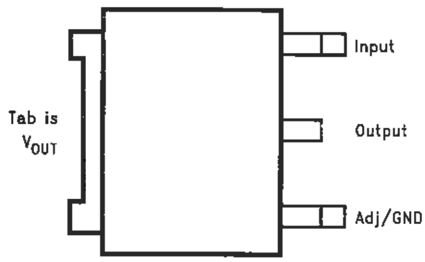


Figure 8. TO-252 (NDP) Front View Surface Mount Package Package Drawing NDP

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS [1][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 [3]		3 kV

(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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) Human body model, 100 pF discharged through a 1.5 kΩ resistor.

OPERATING TEMPERATURE RANGE

LM117	$-55°C \leq T_J \leq +150°C$
LM317A	$-40°C \leq T_J \leq +125°C$
LM317-N	$0°C \leq T_J \leq +125°C$
Preconditioning	
Thermal Limit Burn-In	All Devices 100%

LM317A and LM317-N ELECTRICAL CHARACTERISTICS[1]

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.

Parameter	Conditions		LM317A Min	LM317A Typ	LM317A Max	LM317-N Min	LM317-N Typ	LM317-N Max	Units
Reference Voltage			1.238	1.250	1.262	-	1.25	-	V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\ mA \le I_{OUT} \le I_{MAX}$ [1]		**1.225**	**1.250**	**1.270**	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ [2]			0.005 **0.01**	0.01 **0.02**		0.01 **0.02**	0.04 **0.07**	%/V
Load Regulation	$10\ mA \le I_{OUT} \le I_{MAX}$ [1] [2]			0.1 **0.3**	0.5 **1**		0.1 **0.3**	0.5 **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	$10\ mA \le I_{OUT} \le I_{MAX}$ [1] $3V \le (V_{IN} - V_{OUT}) \le 40V$			**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	$(V_{IN} - V_{OUT}) \le 15V$	NDS, KTT Packages	-	-	-	**1.5**	**2.2**	**3.4**	A
		DCY, NDE Packages	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	
		NDT Package	**0.5**	**0.8**	**1.8**	**0.5**	**0.8**	**1.8**	
	$(V_{IN} - V_{OUT}) = 40V$	NDS, KTT Packages	-	-		0.15	0.40		A
		DCY, NDE Packages	0.15	0.40		0.15	0.40		
		NDT Package	0.075	0.20		0.075	0.20		
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, $C_{ADJ} = 0$ μF			**65**			**65**		dB
	$V_{OUT} = 10V$, f = 120 Hz, $C_{ADJ} = 10$ μF		**66**	**80**		**66**	**80**		dB
Long-Term Stability	$T_J = 125°C$, 1000 hrs			0.3	1		0.3	1	%
Thermal Resistance, θ_{JC} Junction-to-Case	NDS (TO-3) Package			-			2		°C/W
	NDE (TO-220) Package			4			4		
	KTT (TO-263) Package			-			4		
	DCY (SOT-223) Package			23.5			23.5		
	NDT (TO) Package			21			21		
	NDP (TO-252) Package			12			12		
Thermal Resistance, θ_{JA} Junction-to-Ambient (No Heat Sink)	NDS (TO-3) Package			-			39		°C/W
	NDE (TO-220) Package			50			50		
	KTT (TO-263) Package [3]			-			50		
	DCY (SOT-223) Package [3]			140			140		
	NDT (TO) Package			186			186		
	NDP (TO-252) Package [3]			103			103		

(1) $I_{MAX} = 1.5A$ for the NDS (TO-3), NDE (TO-220), and KTT (TO-263) packages. $I_{MAX} = 1.0A$ for the DCY (SOT-223) package. $I_{MAX} = 0.5A$ for the NDT (TO) and NDP (TO-252) packages. Device power dissipation (P_D) is limited by ambient temperature (T_A), device maximum junction temperature (T_J), and package thermal resistance (θ_{JA}). The maximum allowable power dissipation at any temperature is : $P_{D(MAX)} = ((T_{J(MAX)} - T_A)/\theta_{JA})$. All Min. and Max. limits are ensured to TI's Average Outgoing Quality Level (AOQL).
(2) 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.
(3) When surface mount packages are used (TO-263, SOT-223, TO-252), the junction to ambient thermal resistance can be reduced by increasing the PC board copper area that is thermally connected to the package. See the APPLICATION HINTS section for heatsink techniques.

LM117 ELECTRICAL CHARACTERISTICS(1)

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.

Parameter	Conditions		LM117 (2) Min	Typ	Max	Units
Reference Voltage	3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V, 10 mA ≤ I_{OUT} ≤ I_{MAX} (1)		**1.20**	**1.25**	**1.30**	V
Line Regulation	3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V (3)			0.01 **0.02**	0.02 **0.05**	%/V
Load Regulation	10 mA ≤ I_{OUT} ≤ I_{MAX} (1) (3)			0.1 **0.3**	0.3 **1**	%
Thermal Regulation	20 ms Pulse			0.03	0.07	%/W
Adjustment Pin Current				**50**	**100**	μA
Adjustment Pin Current Change	10 mA ≤ I_{OUT} ≤ I_{MAX} (1) 3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V			**0.2**	**5**	μA
Temperature Stability	T_{MIN} ≤ T_J ≤ T_{MAX}			**1**		%
Minimum Load Current	($V_{IN} - V_{OUT}$) = 40V			**3.5**	**5**	mA
Current Limit	($V_{IN} - V_{OUT}$) ≤ 15V	NDS Package	**1.5**	**2.2**	**3.4**	A
		NDT Package	**0.5**	**0.8**	**1.8**	
	($V_{IN} - V_{OUT}$) = 40V	NDS Package	0.3	0.4		A
		NDT Package	0.15	0.20		
RMS Output Noise, % of V_{OUT}	10 Hz ≤ f ≤ 10 kHz			0.003		%
Ripple Rejection Ratio	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 0 μF			**65**		dB
	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 10 μF		**66**	**80**		dB
Long-Term Stability	T_J = 125°C, 1000 hrs			0.3	1	%
Thermal Resistance, θ_{JC} Junction-to-Case	NDS (TO-3) Package			2		°C/W
	NDT (TO) Package			21		
Thermal Resistance, θ_{JA} Junction-to-Ambient (No Heat Sink)	NDS (TO-3) Package			39		°C/W
	NDT (TO) Package			186		

(1) I_{MAX} = 1.5A for the NDS (TO-3), NDE (TO-220), and KTT (TO-263) packages. I_{MAX} = 1.0A for the DCY (SOT-223) package. I_{MAX} = 0.5A for the NDT (TO) and NDP (TO-252) packages. Device power dissipation (P_D) is limited by ambient temperature (T_A), device maximum junction temperature (T_J), and package thermal resistance (θ_{JA}). The maximum allowable power dissipation at any temperature is : $P_{D(MAX)} = ((T_{J(MAX)} - T_A)/\theta_{JA})$. All Min. and Max. limits are ensured to TI's Average Outgoing Quality Level (AOQL).

(2) Specifications and availability for military and space grades of LM117/883 can be found in the LM117QML datasheet (SNVS356). Specifications and availability for military and space grades of LM117/JAN can be found in the LM117JAN datasheet (SNVS365).

(3) 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.

TYPICAL PERFORMANCE CHARACTERISTICS

Output Capacitor = 0 µF unless otherwise noted

Load Regulation

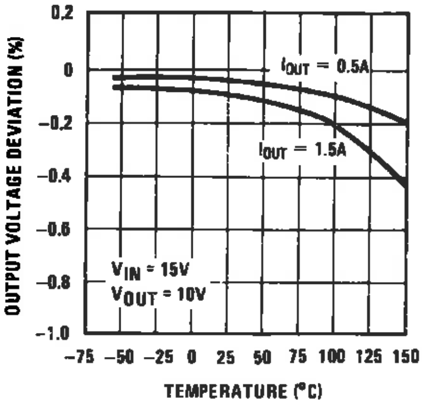


Figure 9.

Current Limit

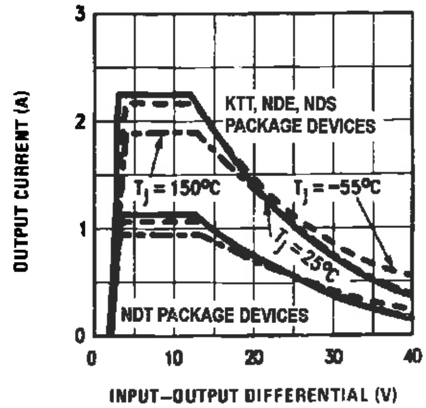


Figure 10.

Adjustment Current

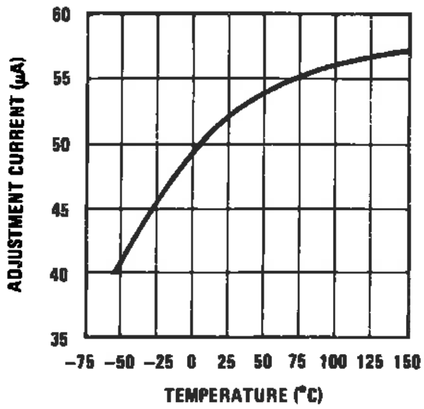


Figure 11.

Dropout Voltage

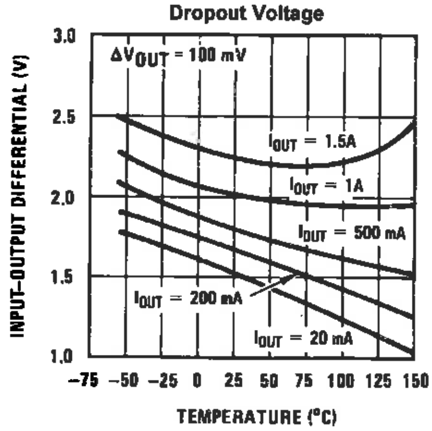


Figure 12.

V_{OUT} vs V_{IN}, V_{OUT} = V_{REF}

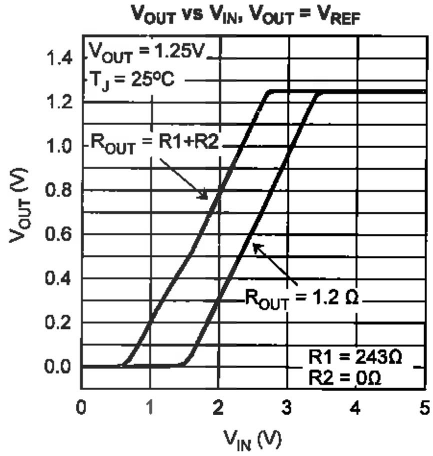


Figure 13.

V_{OUT} vs V_{IN}, V_{OUT} = 5V

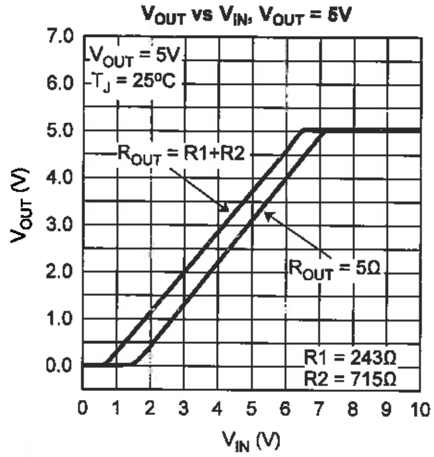


Figure 14.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Capacitor = 0 μF unless otherwise noted

Temperature Stability

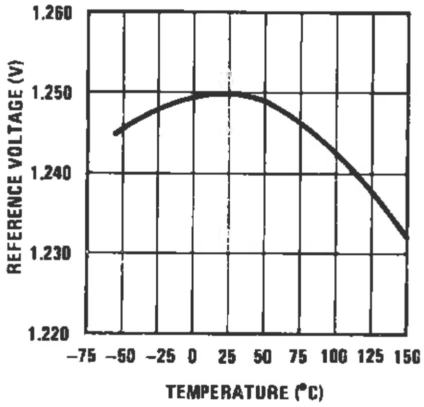


Figure 15.

Minimum Operating Current

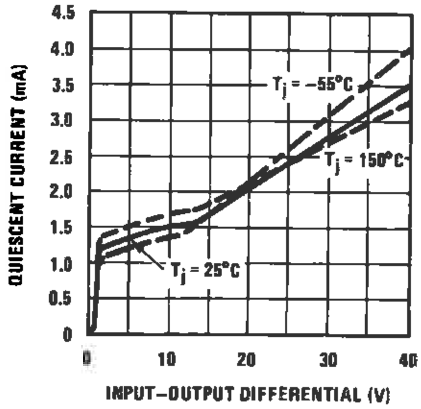


Figure 16.

Ripple Rejection

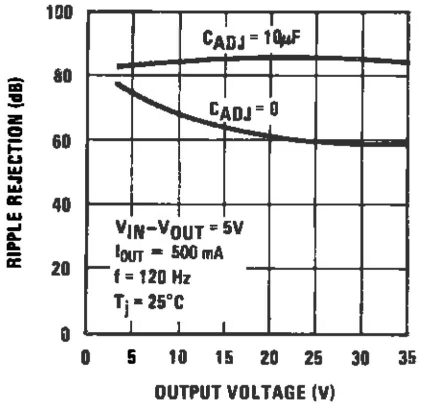


Figure 17.

Ripple Rejection

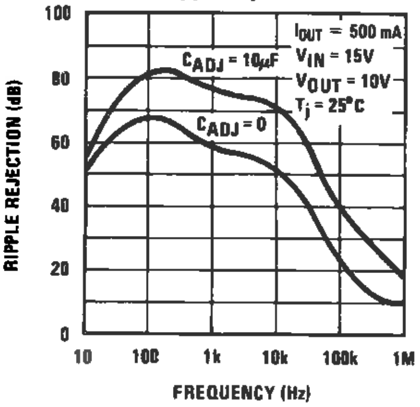


Figure 18.

Ripple Rejection

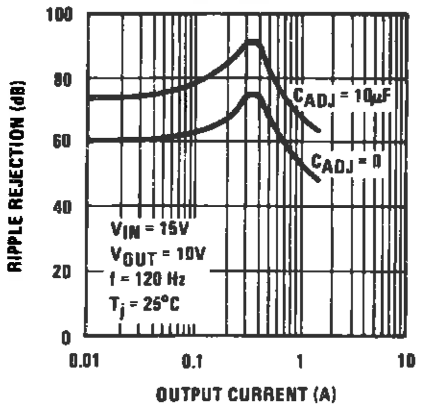


Figure 19.

Output Impedance

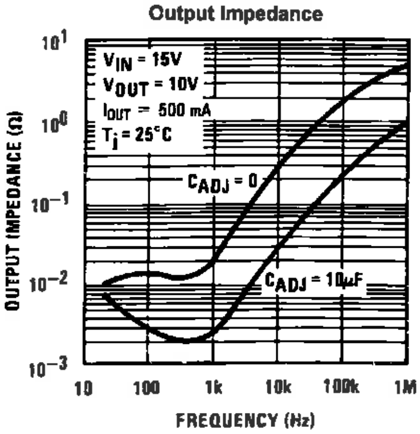


Figure 20.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Capacitor = 0 µF unless otherwise noted

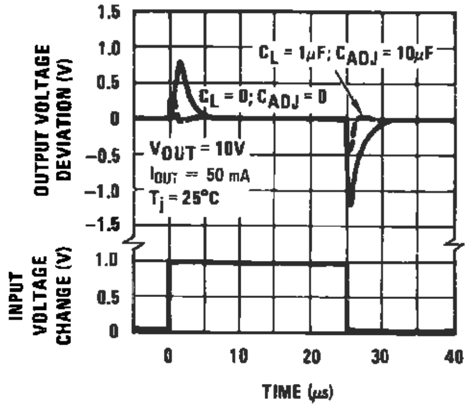


Figure 21.

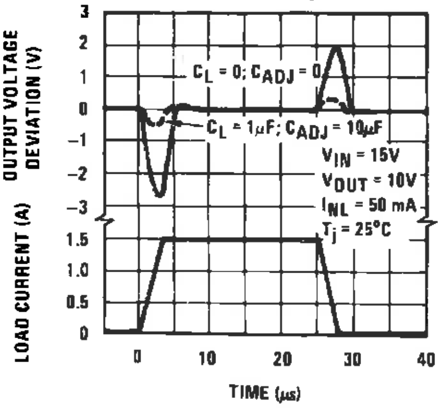
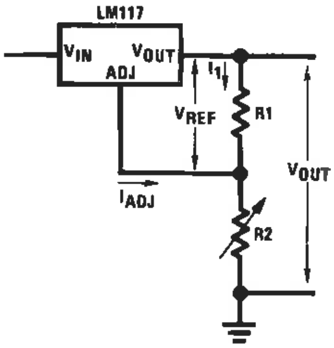


Figure 22.

APPLICATION HINTS

In operation, the LM117 develops a nominal 1.25V reference voltage, V_{REF}, between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2 \quad (1)$$



Since the 100 µA current from the adjustment terminal represents an error term, the LM117 was designed to minimize I_{ADJ} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

External Capacitors

An input bypass capacitor is recommended. A 0.1 µF disc or 1µF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM117 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 µF bypass capacitor 80 dB ripple rejection is obtainable at any output level. Increases over 10 µF do not appreciably improve the ripple rejection at frequencies above 120 Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use is solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 µF in aluminum electrolytic to equal 1µF solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5 MHz. For this reason, 0.01 µF disc may seem to work better than a 0.1 µF disc as a bypass.

Although the LM117 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1 µF solid tantalum (or 25 µF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10 µF will merely improve the loop stability and output impedance.

Load Regulation

The LM117 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240Ω) should be tied directly to the output (case) of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05Ω × I_L. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 23 shows the effect of resistance between the regulator and 240Ω set resistor.

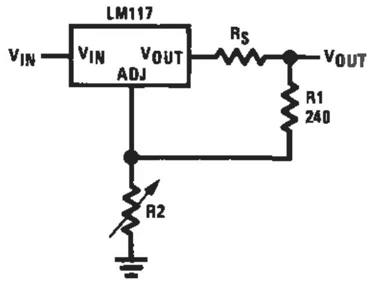


Figure 23. Regulator with Line Resistance in Output Lead

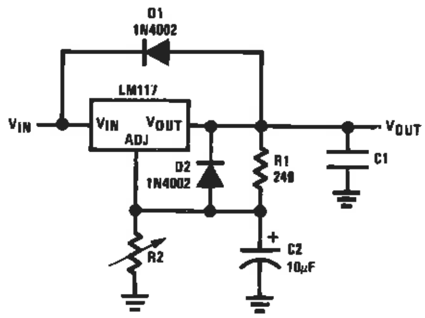
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO-39 package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

Protection Diodes

When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10 µF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN}. In the LM117, this discharge path is through a large junction that is able to sustain 15A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25 µF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when *either* the input, or the output, is shorted. Internal to the LM117 is a 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10 µF capacitance. *Figure 24* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



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

D1 protects against C1
D2 protects against C2

Figure 24. Regulator with Protection Diodes

Heatsink Requirements

The LM317-N regulators have internal thermal shutdown to protect the device from over-heating. Under all operating conditions, the junction temperature of the LM317-N should not exceed the rated maximum junction temperature (T_J) of 150°C for the LM117, or 125°C for the LM317A and LM317-N. A heatsink may be required depending on the maximum device power dissipation and the maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$$P_D = ((V_{IN} - V_{OUT}) \times I_L) + (V_{IN} \times I_G) \quad (2)$$

Figure 25 shows the voltage and currents which are present in the circuit.

The next parameter which must be calculated is the maximum allowable temperature rise, $T_{R(MAX)}$:

$$T_{R(MAX)} = T_{J(MAX)} - T_{A(MAX)} \quad (3)$$

where $T_{J(MAX)}$ is the maximum allowable junction temperature (150°C for the LM117, or 125°C for the LM317A/LM317-N), and $T_{A(MAX)}$ is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for $T_{R(MAX)}$ and P_D, the maximum allowable value for the junction-to-ambient thermal resistance (θ_{JA}) can be calculated:

$$\theta_{JA} = (T_{R(MAX)} / P_D) \quad (4)$$

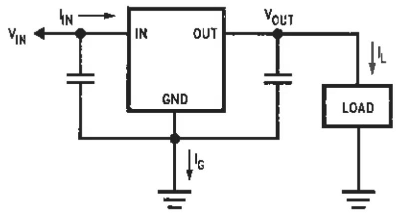


Figure 25. Power Dissipation Diagram

If the calculated maximum allowable thermal resistance is higher than the actual package rating, then no additional work is needed. If the calculated maximum allowable thermal resistance is lower than the actual package rating either the power dissipation (P_D) needs to be reduced, the maximum ambient temperature $T_{A(MAX)}$ needs to be reduced, the thermal resistance (θ_{JA}) must be lowered by adding a heatsink, or some combination of these.

If a heatsink is needed, the value can be calculated from the formula:

$$\theta_{HA} \leq (\theta_{JA} - (\theta_{CH} + \theta_{JC})) \quad (5)$$

where (θ_{CH} is the thermal resistance of the contact area between the device case and the heatsink surface, and θ_{JC} is thermal resistance from the junction of the die to surface of the package case.

When a value for $\theta_{(H-A)}$ is found using the equation shown, a heatsink must be selected that has a value that is less than, or equal to, this number.

The $\theta_{(H-A)}$ rating is specified numerically by the heatsink manufacturer in the catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

Heatsinking Surface Mount Packages

The TO-263 (KTT), SOT-223 (DCY) and TO-252 (NDP) packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

Heatsinking the SOT-223 (DCY) Package

Figure 26 and Figure 27 show the information for the SOT-223 package. Figure 27 assumes a $\theta_{(J-A)}$ of 74°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C. Please see AN-1028 (literature number SNVA036) for thermal enhancement techniques to be used with SOT-223 and TO-252 packages.

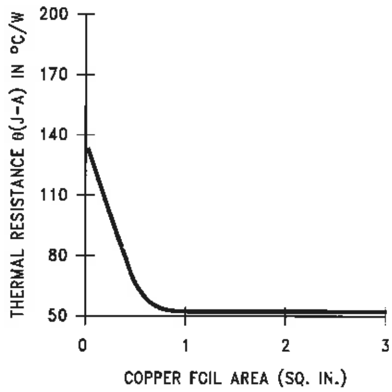


Figure 26. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

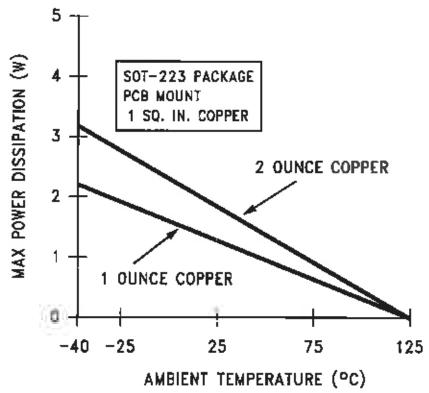


Figure 27. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

Heatsinking the TO-263 (KTT) Package

Figure 28 shows for the TO-263 the measured values of $\theta_{(J-A)}$ for different copper area sizes using a typical PCB with 1 ounce copper and no solder mask over the copper area used for heatsinking.

As shown in Figure 28, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(J-A)}$ for the TO-263 package mounted to a PCB is 32°C/W.

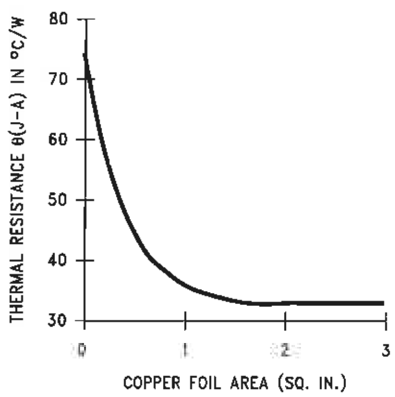


Figure 28. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package

As a design aid, Figure 29 shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming $\theta_{(J-A)}$ is 35°C/W and the maximum junction temperature is 125°C).

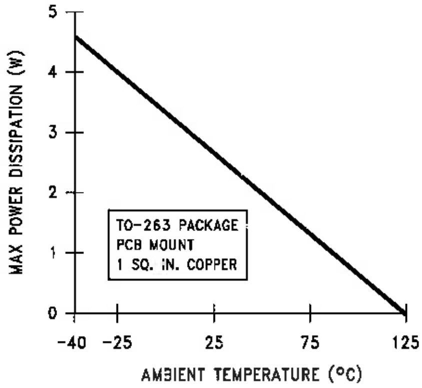


Figure 29. Maximum Power Dissipation vs T_{AMB} for the TO-263 Package

Heatsinking the TO-252 (NDP) Package

If the maximum allowable value for θ_{JA} is found to be ≥103°C/W (Typical Rated Value) for the TO-252 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} falls below these limits, a heatsink is required.

As a design aid, Table 1 shows the value of the θ_{JA} of NDP the package for different heatsink area. The copper patterns that we used to measure these θ_{JA}s are shown in Figure 34. Figure 30 reflects the same test results as what are in Table 1.

Figure 31 shows the maximum allowable power dissipation vs. ambient temperature for the TO-252 device. Figure 32 shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN-1028 (literature number SNVA036) for thermal enhancement techniques to be used with SOT-223 and TO-252 packages.

Table 1. θ_{JA} Different Heatsink Area

Layout	Copper Area		Thermal Resistance
	Top Side (in^2)(1)	Bottom Side (in^2)	(θ_{JA}°C/W) TO-252
1	0.0123	0	103
2	0.066	0	87
3	0.3	0	60
4	0.53	0	54
5	0.76	0	52
6	1.0	0	47
7	0.066	0.2	84
8	0.066	0.4	70
9	0.066	0.6	63
10	0.066	0.8	57
11	0.066	1.0	57
12	0.066	0.066	89
13	0.175	0.175	72
14	0.284	0.284	61
15	0.392	0.392	55
16	0.5	0.5	53

(1) Tab of device attached to topside of copper.

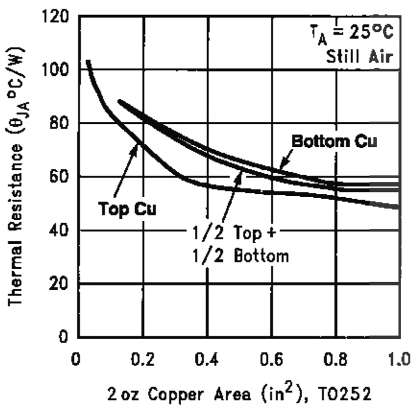


Figure 30. θ_{JA} vs 2oz Copper Area for TO-252

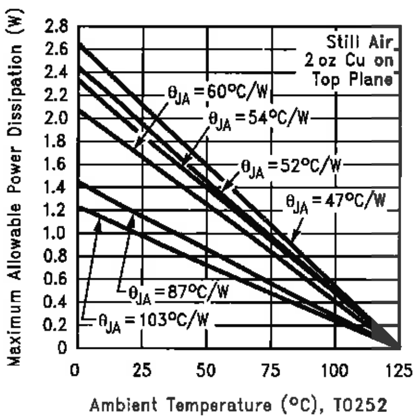


Figure 31. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

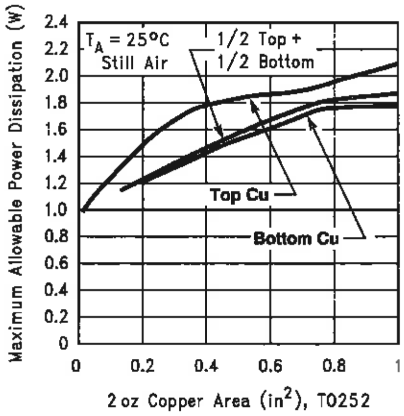


Figure 32. Maximum Allowable Power Dissipation vs. 2oz Copper Area for TO-252

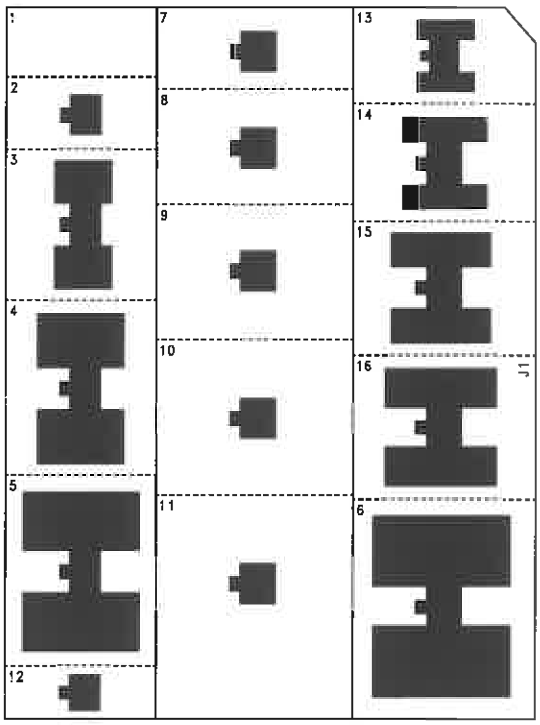


Figure 33. Top View of the Thermal Test Pattern in Actual Scale

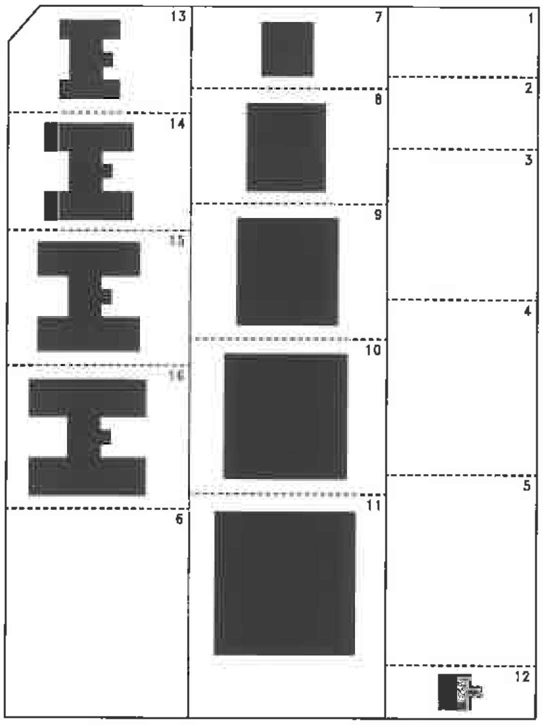
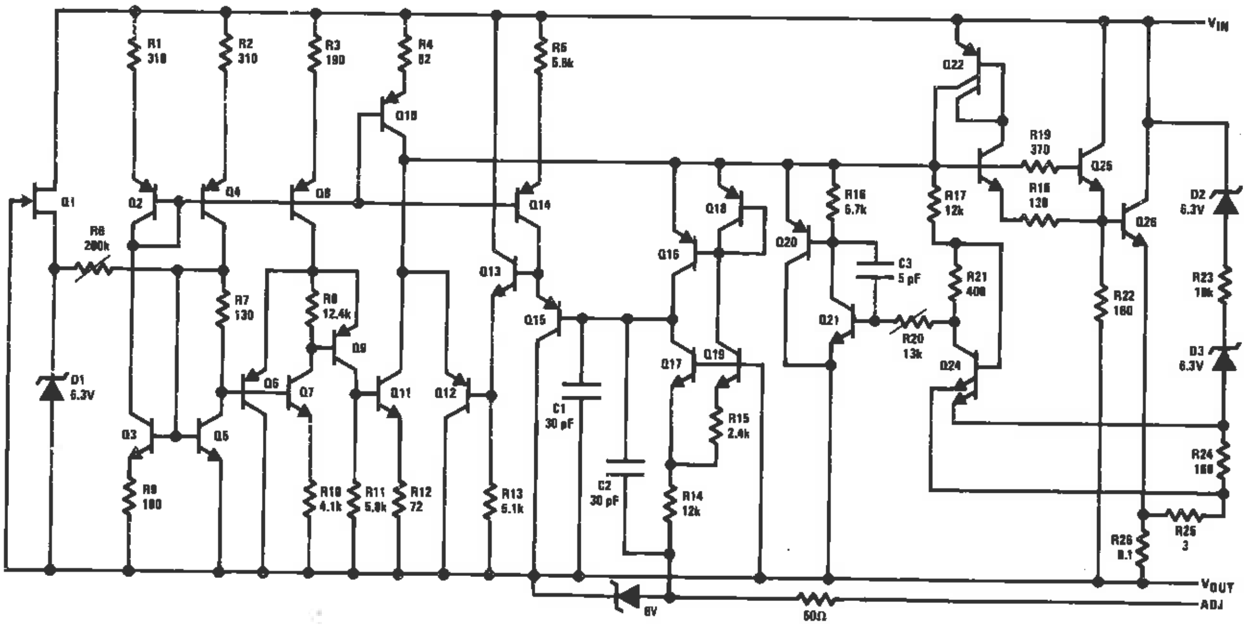


Figure 34. Bottom View of the Thermal Test Pattern in Actual Scale

Schematic Diagram



OPTOACOBLADOR

TOSHIBA Photocoupler GaAℓAs Ired & Photo IC

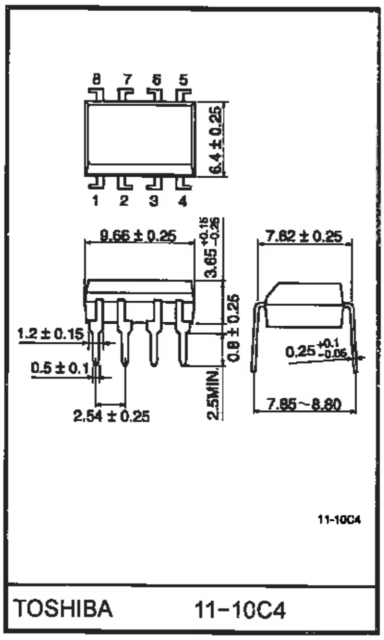
6N138, 6N139

Current Loop Driver.
Low Input Current Line Receiver.
CMOS Logic Interface.

The TOSHIBA 6N138 and 6N139 consists of a GaAℓAs infrared
emitting diode coupled with a split-Darlington output configuration.
A high speed GaAℓAs Ired manufactured with an unique LPE junction, has the virtue of fast rise and fall time at low drive current.

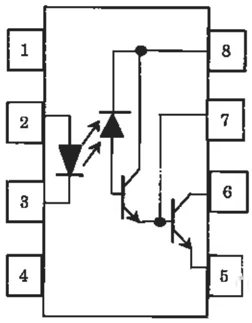
- Isolation voltage: 2500Vrms (min.)
- Current transfer ratio
  : 6N138 – 300% (min.) (I_F=1.6mA)
  : 6N139 – 400% (min.) (I_F=0.5mA)
- Switching time: 6N138 – t_{PHL}=10μs (max.)
  – t_{PLH}=35μs (max.)
  6N139 – t_{PHL}=1μs (max.)
  – t_{PLH}=7μs (max.)
- UL recognized: UL1577, file no. E67349

Unit in mm



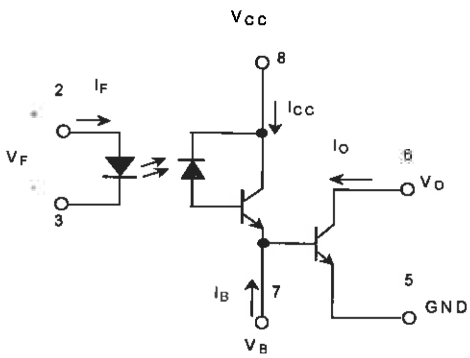
Weight: 0.54 g

Pin Configuration (top view)



1 : N.C.
2 : Anode
3 : Cathode
4 : N.C.
5 : Gnd
6 : Output
7 : Output Base
8 : Vcc

Schematic



Maximum Ratings (*) (Ta = 0°C to + 70°C)

	Characteristic	Symbol	Rating	Unit
LED	Forward current (Note 1)	I_F	20	mA
	Pulse forward current	I_{FP}(*1)	40	mA
	Total pulse forward current	I_{FP}(*2)	1	A
	Reverse voltage	V_R	5	V
	Diode power dissipation (Note 2)	P_D	35	mW
Detector	Output current (Note 3)	I_O	60	mA
	Emitter–base reverse voltage	V_{EB}	0.5	V
	Supply voltage	V_{CC}(*3)	–0.5 to 18	V
	Output voltage	V_O(*3)	–0.5 to 18	V
	Output power dissipation (Note 4)	P_O	100	mW
Operating temperature range		T_{opr}	0 to 70	°C
Storage temperature range		T_{stg}	–55 to 125	°C
Lead solder temperature (10s) (*4)		T_{sol}	260	°C
Isolation voltage (1min., R.H.≤ 60%)		BV_S(**)	2500	V_{rms}
			3540	V_{dc}

(*) JEDEC registered data
(**) Not registered JEDEC
(*1) 50% duty cycle, 1ms pulse width
(*2) Pulse width 1μs, 300pps
(*3) 6N138··· –0.5 to 7V
(*4) 1.6mm below seating plane

Electrical Characteristics
Over Recommended Temperature (Ta = 0°C to 70°C, unless otherwise noted)

Characteristic		Symbol	Test Condition	Min.	(*5)Typ.	Max.	Unit
Current transfer ratio (Note 5, 6)	6N139	CTR(*)	I_F=0.5mA, V_O=0.4V V_{CC}=4.5V	400	800	—	%
	6N139		I_F=1.6mA, V_O=0.4V V_{CC}=4.5V	500	900	—	
	6N138			300	600	—	
Logic low output voltage (Note 6)	6N139	V_{OL}	I_F=1.6mA, I_O=6.4mA V_{CC}=4.5V	—	0.1	0.4	V
			I_F=5mA, I_O=15mA V_{CC}=4.5V	—	0.1	0.4	
			I_F=12mA, I_O=24mA V_{CC}=4.5V	—	0.2	0.4	
	6N138		I_F=1.6mA, I_O=4.8mA V_{CC}=4.5V	—	0.1	0.4	
Logic high output current (Note 6)	6N139	I_{OH}(*)	I_F=0mA, V_O=V_{CC}=18V	—	0.05	100	μA
	6N138		I_F=0mA, V_O=V_{CC}=7V	—	0.05	250	
Logic low supply current (Note 6)		I_{CCL}	I_F=1.6mA, V_O=Open V_{CC}=5V	—	0.2	—	mA
Logic high supply current (Note 6)		I_{CCH}	I_F=0mA, V_O=Open, V_{CC}=5V	—	10	—	nA
Input forward voltage		V_F(*)	I_F=1.6mA, Ta=25°C	—	1.65	1.7	V
Input reverse breakdown voltage		BV_R(*)	I_R=10μA, Ta=25°C	5	—	—	V
Temperature coefficient of forward voltage		$\Delta V_F / \Delta Ta$	I_F=1.6mA	—	−1.9	—	mV / °C
Input capacitance		C_{IN}	f=1MHz, V_F=0	—	60	—	pF
Resistance (input−output)		R_{I-O}	V_{I-O}=500V (Note 7), R.H.≤ 60%	—	10^{12}	—	Ω
Capacitance (input−output)		C_{I-O}	f=1MHz (Note 7)	—	0.6	—	pF

(**) JEDEC registered data.
(*5) All typicals at Ta=25°C and V_{CC}=5V, unless otherwise noted.

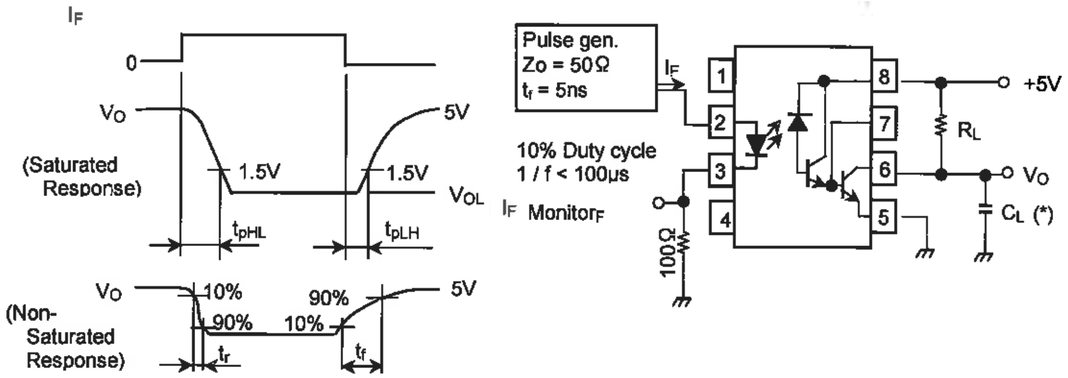
Switching Specifications (Ta=25°C, V_{CC}=5V, unless otherwise specified)

Characteristic		Symbol	Test Circuit	Test Condition	Min.	Typ.	Max.	Unit
Propagation delay time to logic low at output (Note 6, 8)	6N139	t_{pHL}(*)	1	I_F=0.5mA, R_L=4.7kΩ	—	5	25	μs
				I_F=12mA, R_L=270Ω	—	0.2	1	
	6N138			I_F=1.6mA, R_L=2.2kΩ	—	1	10	
Propagation delay time to logic high at output (Note 6, 8)	6N139	t_{pLH}(*)	1	I_F=0.5mA, R_L=4.7kΩ	—	5	60	μs
				I_F=12mA, R_L=270Ω	—	1	7	
	6N138			I_F=1.6mA, R_L=2.2kΩ	—	4	35	
Common mode transient immunity at logic high level output (Note 9)		CM_H	2	I_F=0mA, R_L=2.2kΩ V_{CM}=400V_{p-p}	—	500	—	V / μs
Common mode transient immunity at logic low level output (Note 9)		CM_L	2	I_F=1.6mA R_L=2.2kΩ V_{CM}=400V_{p-p}	—	–500	—	V / μs

(*)JEDEC registered data.

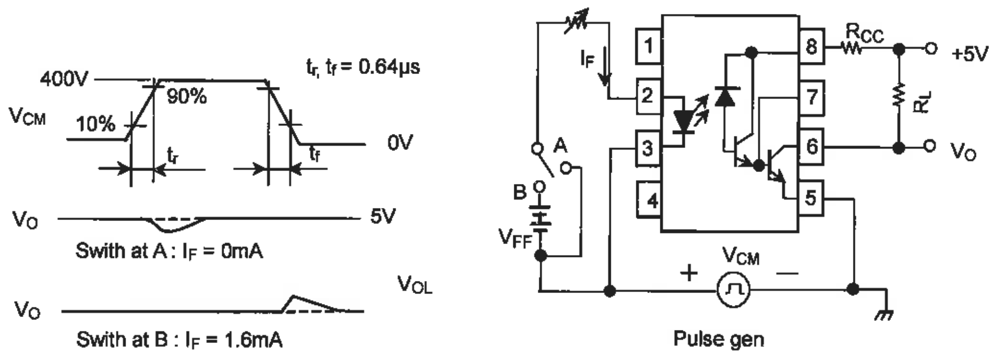
(Note 1): Derate linearly above 50°C free–air temperature at a rate of 0.4mA / °C
(Note 2): Derate linearly above 50°C free–air temperature at a rate of 0.7mW / °C
(Note 3): Derate linearly above 25°C free–air temperature at a rate of 0.7mA / °C
(Note 4): Derate linearly above 25°C free–air temperature at a rate of 2.0mW / °C
(Note 5): DC CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
(Note 6): Pin 7 open.
(Note 7): Device considered a two–terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7 and 8 shorted together.
(Note 8): Use of a resistor between pin 5 and 7 will decrease gain and delay time.
(Note 9): Common mode transient immunity in logic high level is the maximum tolerable (positive) dv_{CM} / dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a logic high state (i.e., V_O > 2.0V).
Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dv_{CM} / dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a logic low state (i.e., V_O < 0.8V).

Test Circuit 1.



(*)C_L is approximately 15pF which includes probe and stray wiring capacitance.

Test Circuit 2.



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000707EBC

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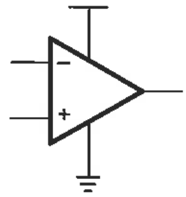
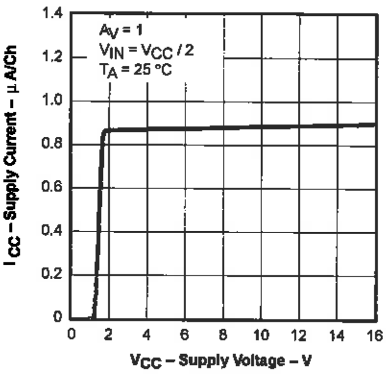
AMPLIFICADOR OPERACIONAL

- **Micro-Power Operation . . . < 1 μA/Channel**
- **Input Common-Mode Range Exceeds the Rails . . . –0.1 V to V_{CC} + 5 V**
- **Reverse Battery Protection Up To 18 V**
- **Rail-to-Rail Input/Output**
- **Gain Bandwidth Product . . . 5.5 kHz**
- **Supply Voltage Range . . . 2.5 V to 16 V**
- **Specified Temperature Range**
  - **T_A = 0°C to 70°C . . . Commercial Grade**
  - **T_A = –40°C to 125°C . . . Industrial Grade**
- **Ultrasmall Packaging**
  - **5-Pin SOT-23 (TLV2401)**
  - **8-Pin MSOP (TLV2402)**
- **Universal OpAmp EVM (Refer to the EVM Selection Guide SLOU060)**

Operational Amplifier



SUPPLY CURRENT vs SUPPLY VOLTAGE



description

The TLV240x family of single-supply operational amplifiers has the lowest supply current available today at only 880 nA per channel. Reverse battery protection guards the amplifier from an over-current condition due to improper battery installation. For harsh environments, the inputs can be taken 5 V above the positive supply rail without damage to the device.

The low supply current is coupled with extremely low input bias currents enabling them to be used with mega-Ω resistors making them ideal for portable, long active life, applications. DC accuracy is ensured with a low typical offset voltage as low as 390 μV, CMRR of 120 dB and minimum open loop gain of 130 V/mV at 2.7 V.

The maximum recommended supply voltage is as high as 16 V and ensured operation down to 2.5 V, with electrical characteristics specified at 2.7 V, 5 V and 15 V. The 2.5-V operation makes it compatible with Li-Ion battery-powered systems and many micro-power microcontrollers available today including TI's MSP430.

All members are available in PDIP and SOIC with the singles in the small SOT-23 package, duals in the MSOP, and quads in TSSOP.

SELECTION OF SINGLE SUPPLY OPERATIONAL AMPLIFIER PRODUCTS†

DEVICE	V_{CC} (V)	V_{IO} (mV)	BW (MHz)	SLEW RATE (V/μs)	I_{CC}/ch (μA)	RAIL-TO-RAIL
TLV240x‡	2.5–16	0.390	0.005	0.002	0.880	I/O
TLV224x	2.5–12	0.600	0.005	0.002	1	I/O
TLV2211	2.7–10	0.450	0.065	0.025	13	O
TLV245x	2.7–6	0.020	0.22	0.110	23	I/O
TLV225x	2.7–8	0.200	0.2	0.12	35	O

† All specifications are typical values measured at 5 V.
‡ This device also offers 18-V reverse battery protection and 5-V over-the-rail operation on the inputs.

TLV2401 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES			
		SMALL OUTLINE† (D)	SOT-23† (DBV)	SYMBOLS	PLASTIC DIP (P)
0°C to 70°C	1500 μV	TLV2401CD	TLV2401CDBV	VAWC	—
–40°C to 125°C		TLV2401ID	TLV2401IDBV	VAWI	TLV2401IP

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2401CDR).

TLV2402 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES			
		SMALL OUTLINE† (D)	MSOP† (DGK)	SYMBOLS	PLASTIC DIP (P)
0°C to 70°C	1500 μV	TLV2402CD	TLV2402CDGK	xxTIAIX	—
–40°C to 125°C		TLV2402ID	TLV2402IDGK	xxTIAIY	TLV2402IP

† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2402CDR).

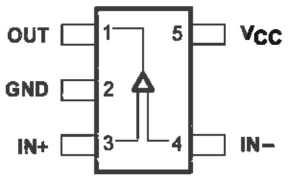
TLV2404 AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE† (D)	PLASTIC DIP (N)	TSSOP (PW)
0°C to 70°C	1500 μV	TLV2404CD	TLV2404CN	TLV2404CPW
–40°C to 125°C		TLV2404ID	TLV2404IN	TLV2404IPW

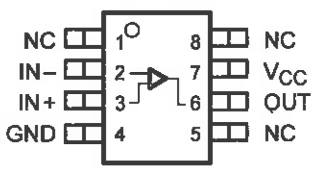
† This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2404CDR).

TLV240x PACKAGE PINOUTS

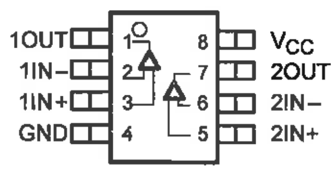
TLV2401
DBV PACKAGE
(TOP VIEW)



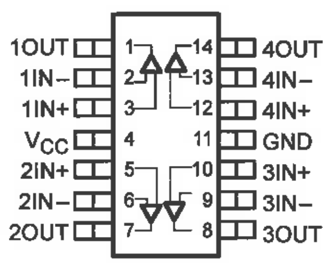
TLV2401
D OR P PACKAGE
(TOP VIEW)



TLV2402
D, DGK, OR P PACKAGE
(TOP VIEW)



TLV2404
D, N, OR PW PACKAGE
(TOP VIEW)



NC – No internal connection

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

Supply voltage, V_{CC} (see Note 1) .... 17 V
Differential input voltage range, V_{ID} .... ±20 V
Input current range, I_I (any input) .... ±10 mA
Output current range, I_O .... ±10 mA
Continuous total power dissipation .... See Dissipation Rating Table
Operating free-air temperature range, T_A: C suffix .... 0°C to 70°C
I suffix .... −40°C to 125°C
Maximum junction temperature, T_J .... 150°C
Storage temperature range, T_{stg} .... −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds .... 260°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values, except differential voltages, are with respect to GND

DISSIPATION RATING TABLE

PACKAGE	Θ_{JC} (°C/W)	Θ_{JA} (°C/W)	$T_A \le 25°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D (8)	38.3	176	710 mW	142 mW
D (14)	26.9	122.6	1022 mW	204.4 mW
DBV (5)	55	324.1	385 mW	77.1 mW
DGK (8)	54.2	259.9	481 mW	96.2 mW
N (14)	32	78	1600 mW	320.5 mW
P (8)	41	104	1200 mW	240.4 mW
PW (14)	29.3	173.6	720 mW	144 mW

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{CC}	Single supply	2.5	16	V
	Split supply	±1.25	±8	
Common-mode input voltage range, V_{ICR}		−0.1	V_{CC}+5	V
Operating free-air temperature, T_A	C-suffix	0	70	°C
	I-suffix	−40	125	

electrical characteristics at recommended operating conditions, V_{CC} = 2.7, 5 V, and 15 V (unless otherwise noted)

dc performance

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_O = V_{CC}/2$ V, $V_{IC} = V_{CC}/2$ V, $R_S = 50\ \Omega$		25°C		390	1200	µV
				Full range			1500	
α_{VIO}	Offset voltage draft			25°C		3		µV/°C
CMRR	Common-mode rejection ratio	V_{IC} = 0 to V_{CC}, $R_S = 50\ \Omega$	V_{CC} = 2.7 V	25°C	63	120		dB
				Full range	60			
			V_{CC} = 5 V	25°C	70	120		
				Full range	63			
			V_{CC} = 15 V	25°C	80	120		
				Full range	75			
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 2.7 V, $V_{O(pp)}$ = 1 V, R_L = 500 kΩ		25°C	130	400		V/mV
				Full range	30			
		V_{CC} = 5 V, $V_{O(pp)}$ = 3 V, R_L = 500 kΩ		25°C	300	1000		
				Full range	100			
		V_{CC} = 15 V, $V_{O(pp)}$ = 6 V, R_L = 500 kΩ		25°C	1000	1800		
				Full range	120			

† Full range is 0°C to 70°C for the C suffix and –40°C to 125°C for the I suffix. If not specified, full range is –40°C to 125°C.

input characteristics

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
I_{IO}	Input offset current	$V_O = V_{CC}/2$ V, $V_{IC} = V_{CC}/2$ V, $R_S = 50\ \Omega$		25°C		25	250	pA
			TLV240xC	Full range			300	
			TLV240xI				400	
I_{IB}	Input bias current			25°C		100	300	pA
			TLV240xC	Full range			350	
			TLV240xI				900	
$r_{i(d)}$	Differential input resistance			25°C		300		MΩ
$C_{i(c)}$	Common-mode input capacitance	f = 100 kHz		25°C		3		pF

† Full range is 0°C to 70°C for the C suffix and –40°C to 125°C for the I suffix. If not specified, full range is –40°C to 125°C.

electrical characteristics at recommended operating conditions, V_{CC} = 2.7, 5 V, and 15 V (unless otherwise noted) (continued)

output characteristics

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage	$V_{IC} = V_{CC}/2$, I_{OH} = –2 µA	V_{CC} = 2.7 V	25°C	2.65	2.68		V
				Full range	2.63			
			V_{CC} = 5 V	25°C	4.95	4.98		
				Full range	4.93			
			V_{CC} = 15 V	25°C	14.95	14.98		
				Full range	14.93			
		$V_{IC} = V_{CC}/2$, I_{OH} = –50 µA	V_{CC} = 2.7 V	25°C	2.62	2.65		
				Full range	2.6			
			V_{CC} = 5 V	25°C	4.92	4.95		
				Full range	4.9			
			V_{CC} = 15 V	25°C	14.92	14.95		
				Full range	14.9			
V_{OL}	Low-level output voltage	$V_{IC} = V_{CC}/2$, I_{OL} = 2 µA		25°C		90	150	mV
				Full range			180	
		$V_{IC} = V_{CC}/2$, I_{OL} = 50 µA		25°C		180	230	
				Full range			260	
I_O	Output current	V_O = 0.5 V from rail		25°C		±200		µA

† Full range is 0°C to 70°C for the C suffix and –40°C to 125°C for the I suffix. If not specified, full range is –40°C to 125°C.

power supply

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
I_{CC}	Supply current (per channel)	$V_O = V_{CC}/2$	V_{CC} = 2.7 V or 5 V	25°C		880	950	nA
				Full range			1290	
			V_{CC} = 15 V	25°C		900	990	
				Full range			1350	
	Reverse supply current	V_{CC} = –18 V, V_{IN} = 0 V, V_O = Open circuit		25°C		50		nA
PSRR	Power supply rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	V_{CC} = 2.7 to 5 V, $V_{IC} = V_{CC}/2$ V, No load,		25°C	100	120		dB
			TLV240xC	Full range	96			
			TLV240xI	Full range	85			dB
		V_{CC} = 5 to 15 V, $V_{IC} = V_{CC}/2$ V, No load		25°C	100	120		dB
				Full range	100			

† Full range is 0°C to 70°C for the C suffix and –40°C to 125°C for the I suffix. If not specified, full range is –40°C to 125°C.

electrical characteristics at recommended operating conditions, V_{CC} = 2.7, 5 V, and 15 V (unless otherwise noted) (continued)

dynamic performance

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
UGBW	Unity gain bandwidth	R_L = 500 kΩ, C_L = 100 pF		25°C		5.5		kHz
SR	Slew rate at unity gain	$V_{O(pp)}$ = 0.8 V, R_L = 500 kΩ, C_L = 100 pF		25°C		2.5		V/ms
ϕM	Phase margin	R_L = 500 kΩ, C_L = 100 pF		25°C		60°		
	Gain margin					15		dB
t_s	Settling time	V_{CC} = 2.7 or 5 V, $V_{(STEP)PP}$ = 1 V, C_L = 100 pF, A_V = –1, R_L = 100 kΩ	0.1%	25°C		1.84		ms
		V_{CC} = 15 V, $V_{(STEP)PP}$ = 1 V, C_L = 100 pF, A_V = –1, R_L = 100 kΩ	0.1%			6.1		
			0.01%			32		

noise/distortion performance

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		800		nV/√Hz
		f = 100 Hz			500		
I_n	Equivalent input noise current	f = 100 Hz			8		fA/√Hz

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input Offset Voltage	vs Common-mode input voltage	1, 2, 3
I_{IB}	Input Bias Current	vs Free-air temperature	4, 6, 8
		vs Common-mode input voltage	5, 7, 9
I_{IO}	Input Offset Current	vs Free-air temperature	4, 6, 8
		vs Common-mode input voltage	5, 7, 9
CMRR	Common-mode rejection ratio	vs Frequency	10
V_{OH}	High-level output voltage	vs High-level output current	11, 13, 15
V_{OL}	Low-level output voltage	vs Low-level output current	12, 14, 16
$V_{O(PP)}$	Output voltage peak-to-peak	vs Frequency	17
Z_o	Output impedance	vs Frequency	18
I_{CC}	Supply current	vs Supply voltage	19
PSRR	Power supply rejection ratio	vs Frequency	20
A_{VD}	Differential voltage gain	vs Frequency	21
	Phase	vs Frequency	21
	Gain-bandwidth product	vs Supply voltage	22
SR	Slew rate	vs Free-air temperature	23
ϕ_m	Phase margin	vs Capacitive load	24
	Gain margin	vs Capacitive load	25
	Supply current	vs Reverse voltage	26
	Voltage noise over a 10 Second Period		27
	Large signal follower pulse response		28, 29, 30
	Small signal follower pulse response		31
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	Small signal inverting pulse response		35
	Crosstalk	vs Frequency	36

TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

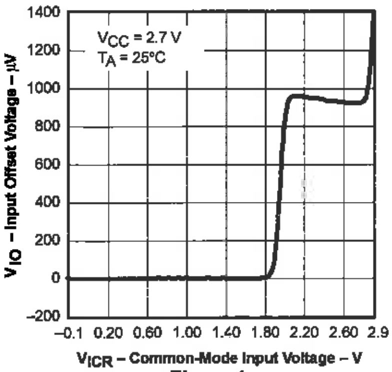


Figure 1

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

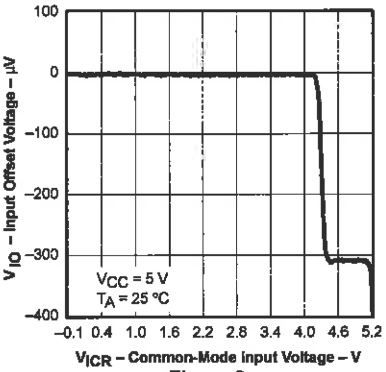


Figure 2

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

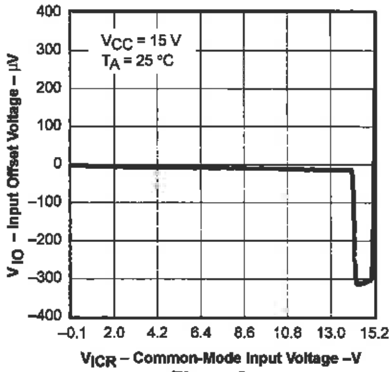


Figure 3

INPUT BIAS / OFFSET CURRENT vs FREE-AIR TEMPERATURE

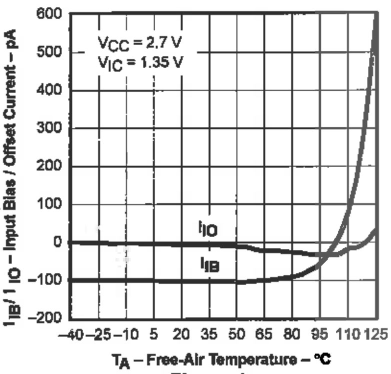


Figure 4

INPUT BIAS / OFFSET CURRENT vs COMMON MODE INPUT VOLTAGE

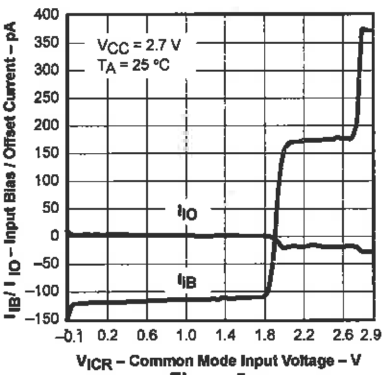


Figure 5

INPUT BIAS / OFFSET CURRENT vs FREE-AIR TEMPERATURE

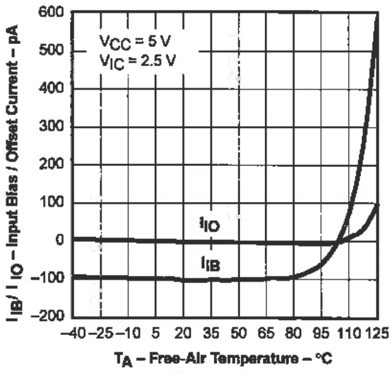


Figure 6

INPUT BIAS / OFFSET CURRENT vs COMMON-MODE INPUT VOLTAGE

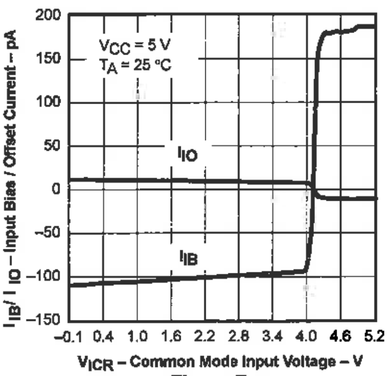


Figure 7

INPUT BIAS / OFFSET CURRENT vs FREE-AIR TEMPERATURE

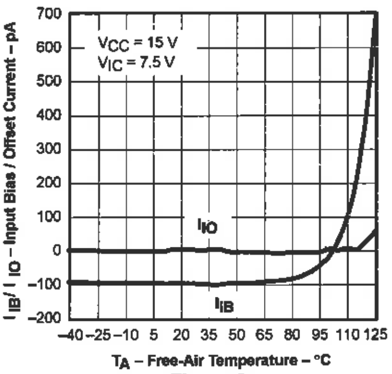


Figure 8

INPUT BIAS / OFFSET CURRENT vs COMMON-MODE INPUT VOLTAGE

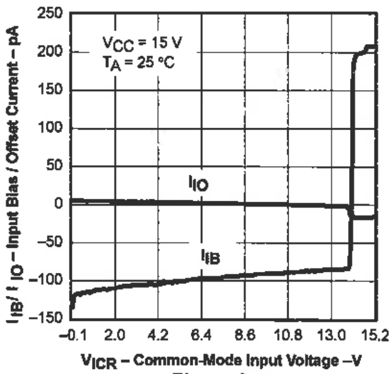


Figure 9

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO vs FREQUENCY

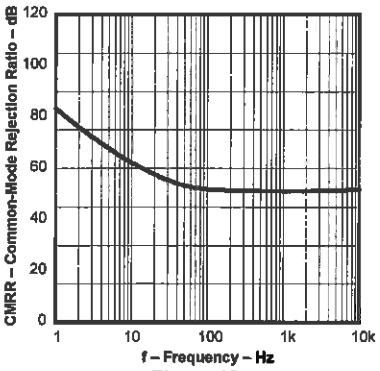


Figure 10

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

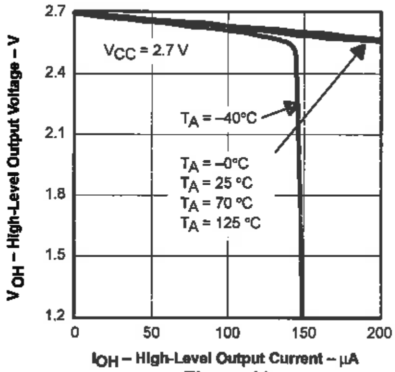


Figure 11

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

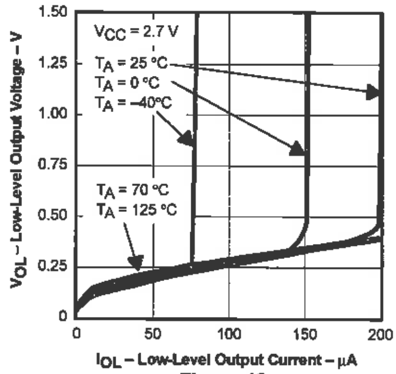


Figure 12

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

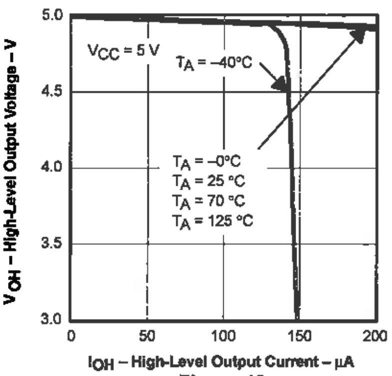


Figure 13

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

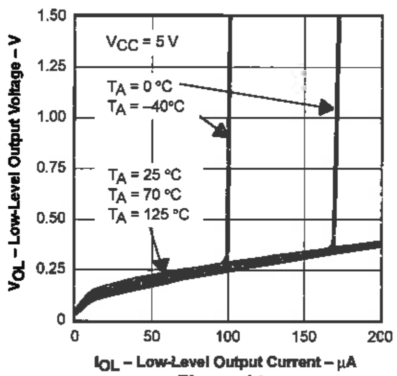


Figure 14

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

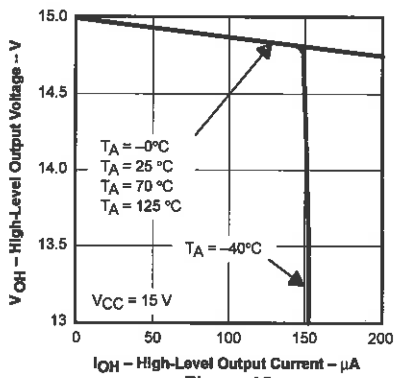


Figure 15

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

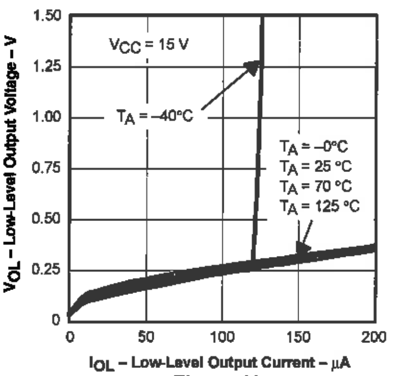


Figure 16

OUTPUT VOLTAGE PEAK-TO-PEAK vs FREQUENCY

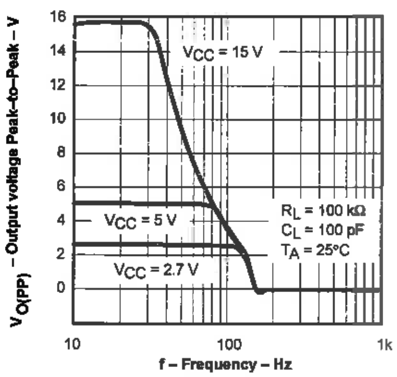


Figure 17

OUTPUT IMPEDANCE vs FREQUENCY

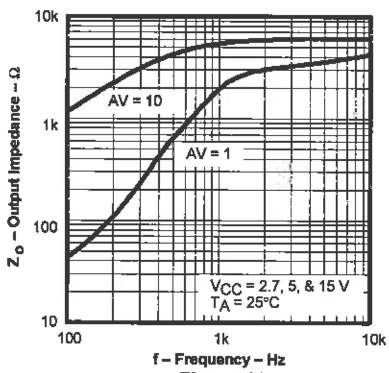


Figure 18

TYPICAL CHARACTERISTICS

SUPPLY CURRENT vs SUPPLY VOLTAGE

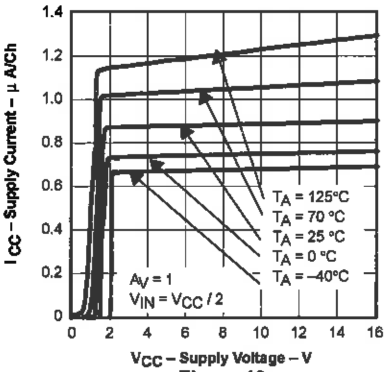


Figure 19

POWER SUPPLY REJECTION RATIO vs FREQUENCY

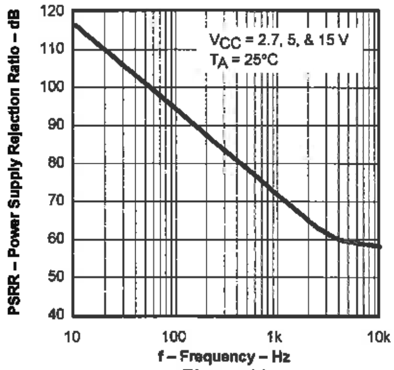


Figure 20

DIFFERENTIAL VOLTAGE GAIN AND PHASE vs FREQUENCY

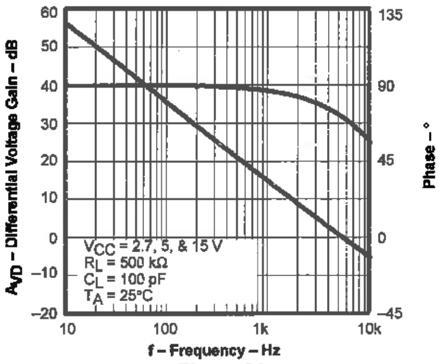


Figure 21

GAIN BANDWIDTH PRODUCT vs SUPPLY VOLTAGE

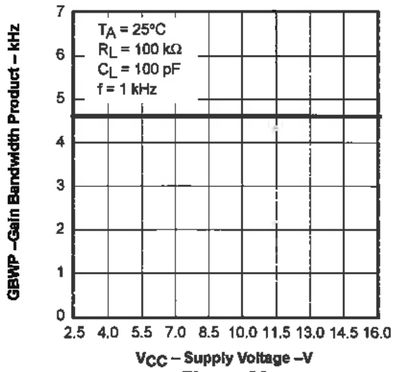


Figure 22

SLEW RATE vs FREE-AIR TEMPERATURE

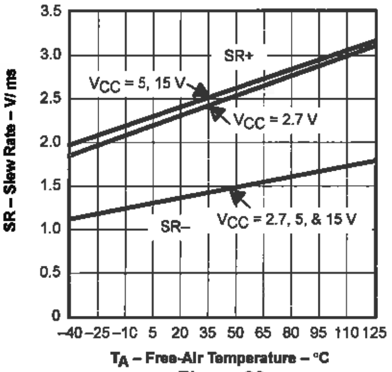


Figure 23

PHASE MARGIN vs CAPACITIVE LOAD

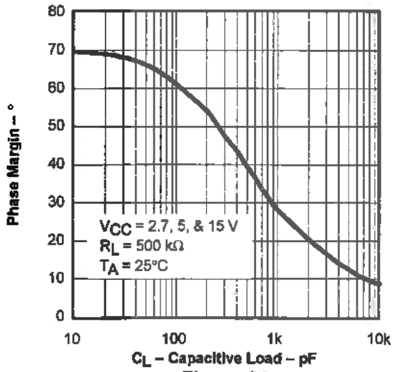


Figure 24

TYPICAL CHARACTERISTICS

GAIN MARGIN
vs
CAPACITIVE LOAD

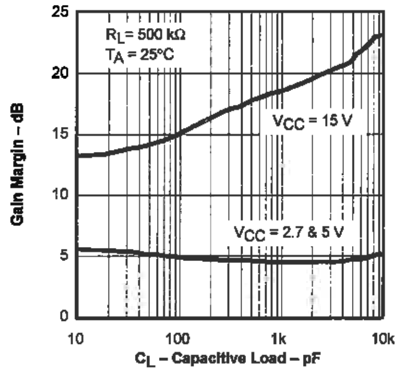


Figure 25

SUPPLY CURRENT
vs
REVERSE VOLTAGE

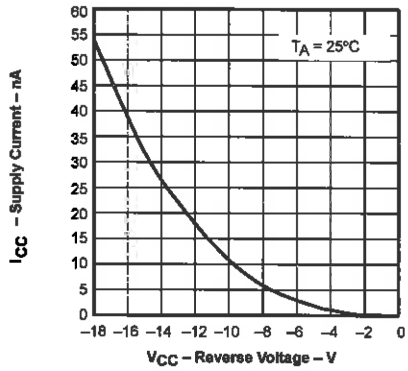


Figure 26

VOLTAGE NOISE
OVER A 10 SECOND PERIOD

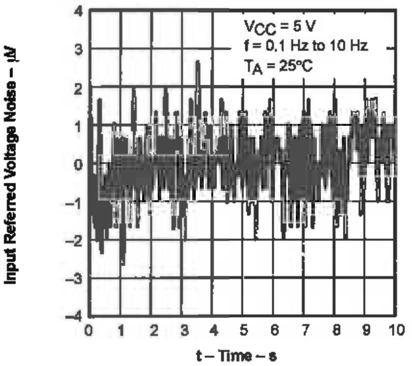


Figure 27

LARGE SIGNAL FOLLOWER
PULSE RESPONSE

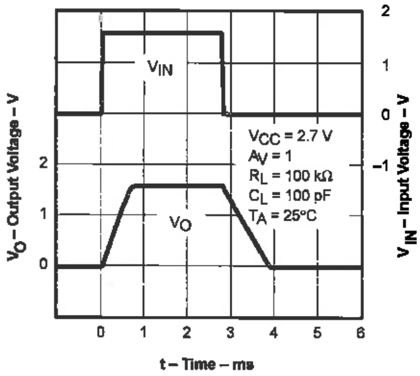


Figure 28

LARGE SIGNAL FOLLOWER
PULSE RESPONSE

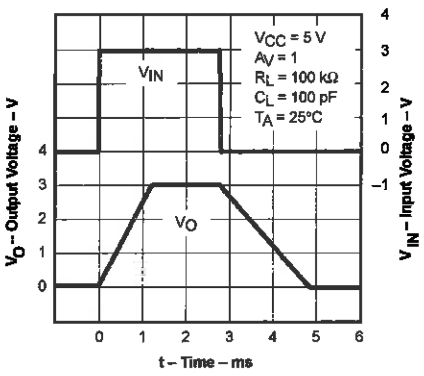


Figure 29

LARGE SIGNAL FOLLOWER
PULSE RESPONSE

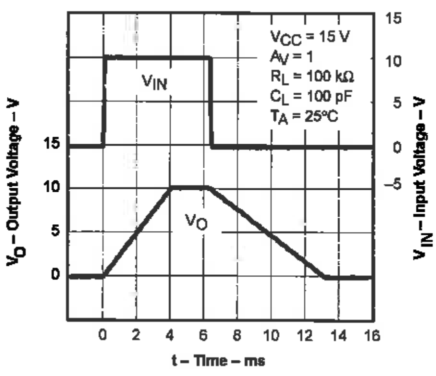


Figure 30

TYPICAL CHARACTERISTICS

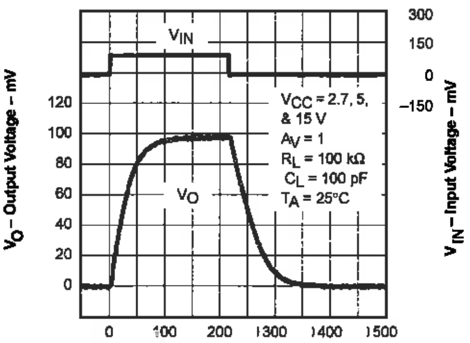


Figure 31

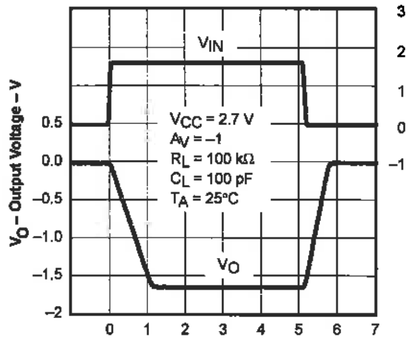


Figure 32

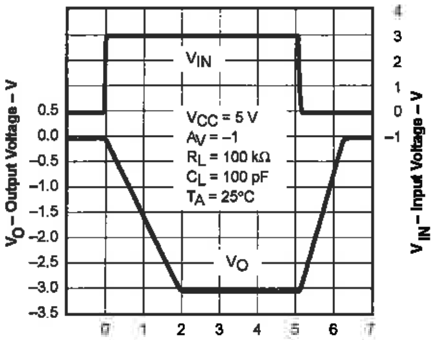


Figure 33

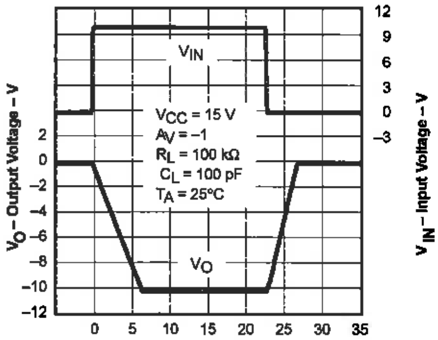


Figure 34

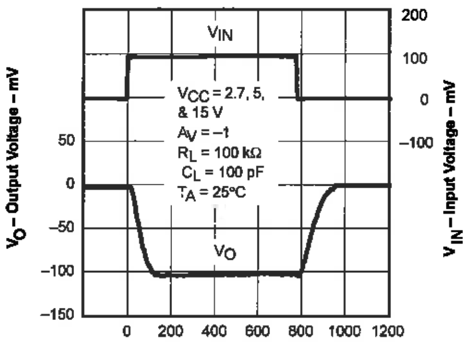


Figure 35

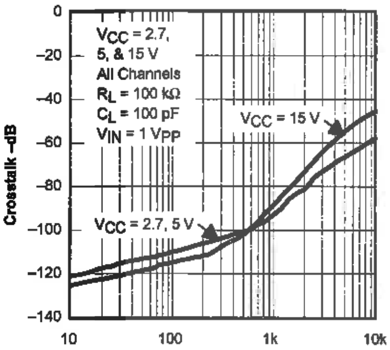
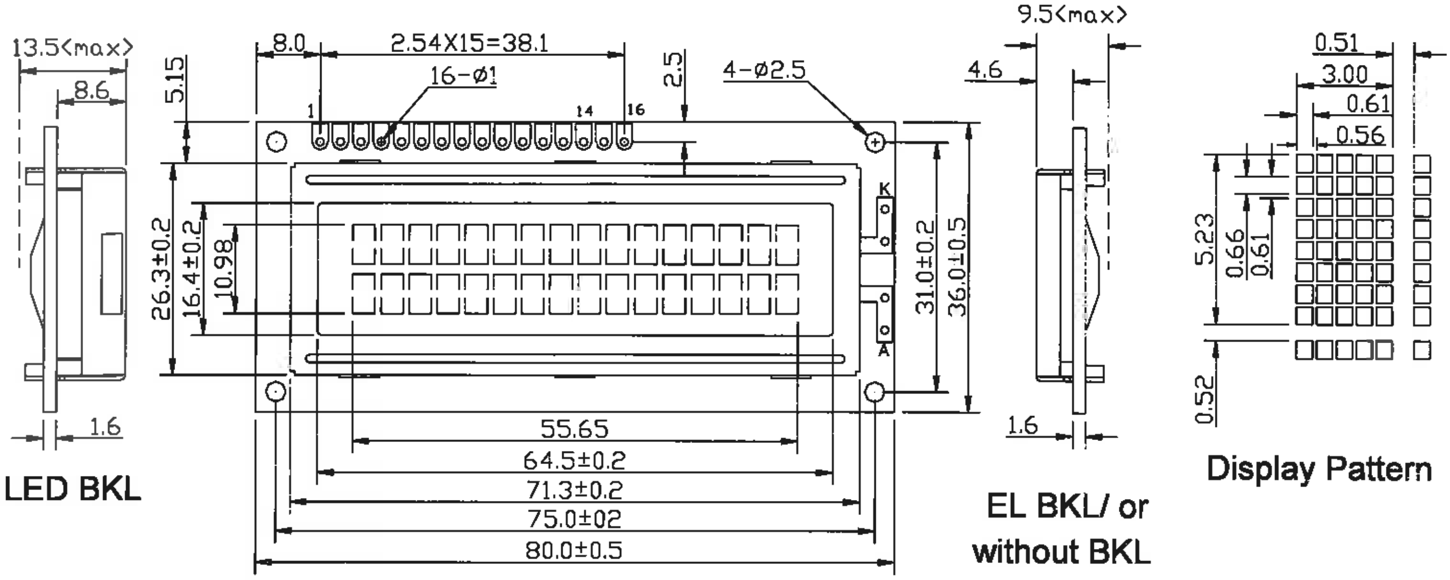


Figure 36

LCD GDM1602K



Feature

1. 5X8 dots with cursor
2. Built-in controller (KS0066U or Equivalent)
3. +5V power supply(Also available for +3.0V)
4. 1/16 duty
5. BKL to be driven by pin1,pin2,or pin15,pin16,or A,K
6. N.V.optional

PIN NO	Symbol	Fuction
1	VSS	GND
2	VDD	+5V
3	V0	Contrast adjustment
4	RS	H/L Register select signal
5	R/W	H/L Read/Write signal
6	E	H/L Enable signal
7	DB0	H/L Data bus line
8	DB1	H/L Data bus line
9	DB2	H/L Data bus line
10	DB3	H/L Data bus line
11	DB4	H/L Data bus line
12	DB5	H/L Data bus line
13	DB6	H/L Data bus line
14	DB7	H/L Data bus line
15	A	+4.2V for LED
16	K	Power supply for BKL(0V)

Mechanical Data

Item	Standard	Unit
Module dimension	80.0x36.0	mm
Viewing area	64.5x16.4	mm
Dot size	0.56x0.61	mm
Character size	3.00x5.23	mm

Absolute Maximum Rating

Item	Symbol	Standard			Unit
		Min	Typ	Max	
Power supply	VDD-VSS	-0.3	-------	5.5	V
Input voltage	VI	-0.3	-------	VDD	

Electronical characteristics

Item	Symbol	Condition	Standard			Unit
			Min	Typ	Max	
Input voltage	VDD	+5V	4.7	5.0	5.5	V
		+3.3V	2.7	3.0	5.3	V
Supply current	IDD	VDD=5V	-----	1.5	4	mA
Recommended LCD riling voltage for normal temp version module	VDD-V0	-20°C	-----	-----	-----	V
		0 °C	4.7	5.0	5.5	
		25°C	4.3	4.5	4.7	
		50°C	4.1	4.3	4.5	
		70°C	-----	------	-----	
LED forward voltage	VF	25°C	-----	4.2	4.6	V
LED forward current	IF	25°C	-----	120	160	mA
EL power supply current	IEL	VEL=110V AC 400Hz	-----	------	-----	mA

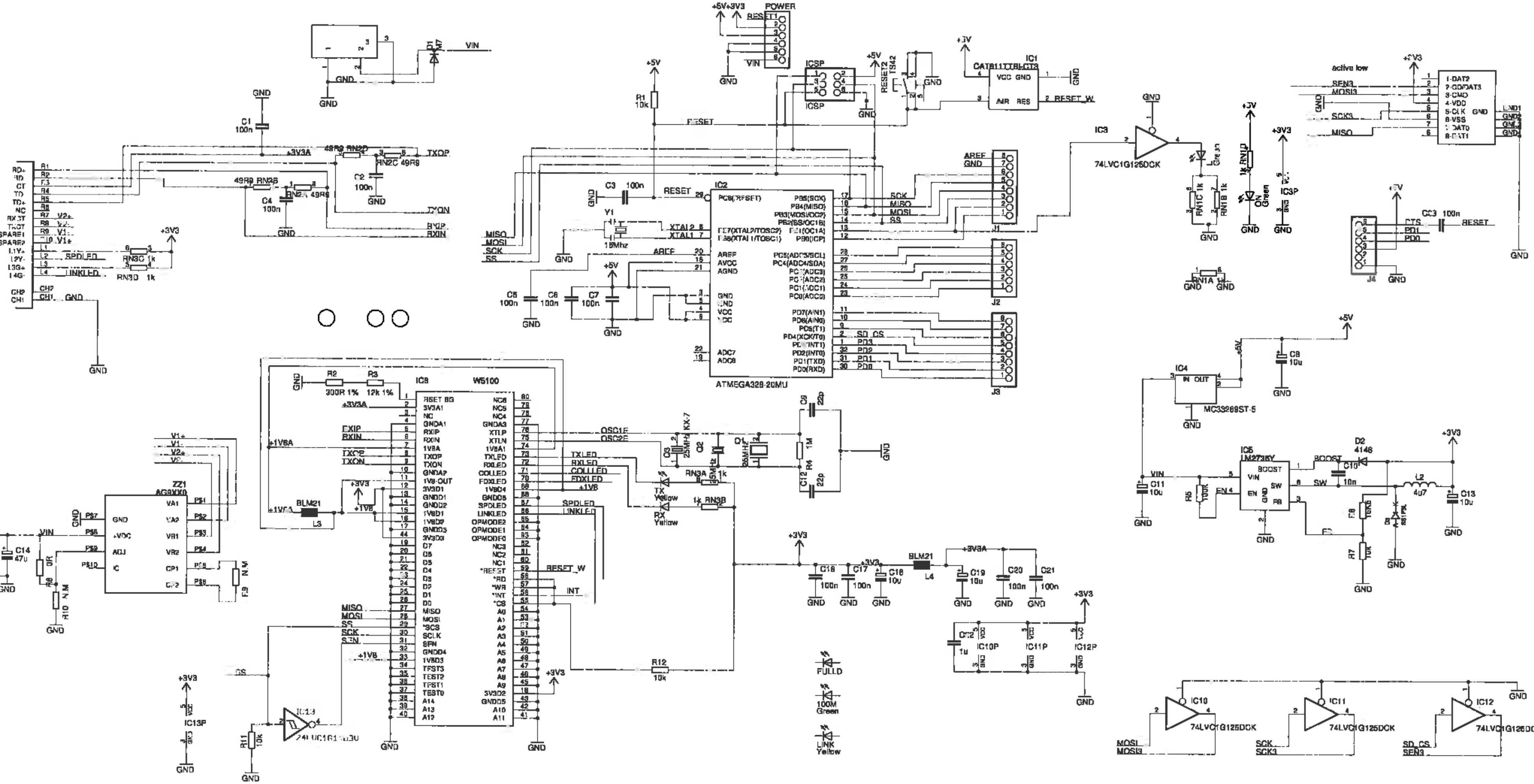
Display character address code:

Display position

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DDRAM address	00	01	02	—	—	—	—	—								0FH
DDRAM address	40	41	42	—	—	—	—	—								4FH

ARDUINO ETHERNET

ARDUINO ETH Rev 8d



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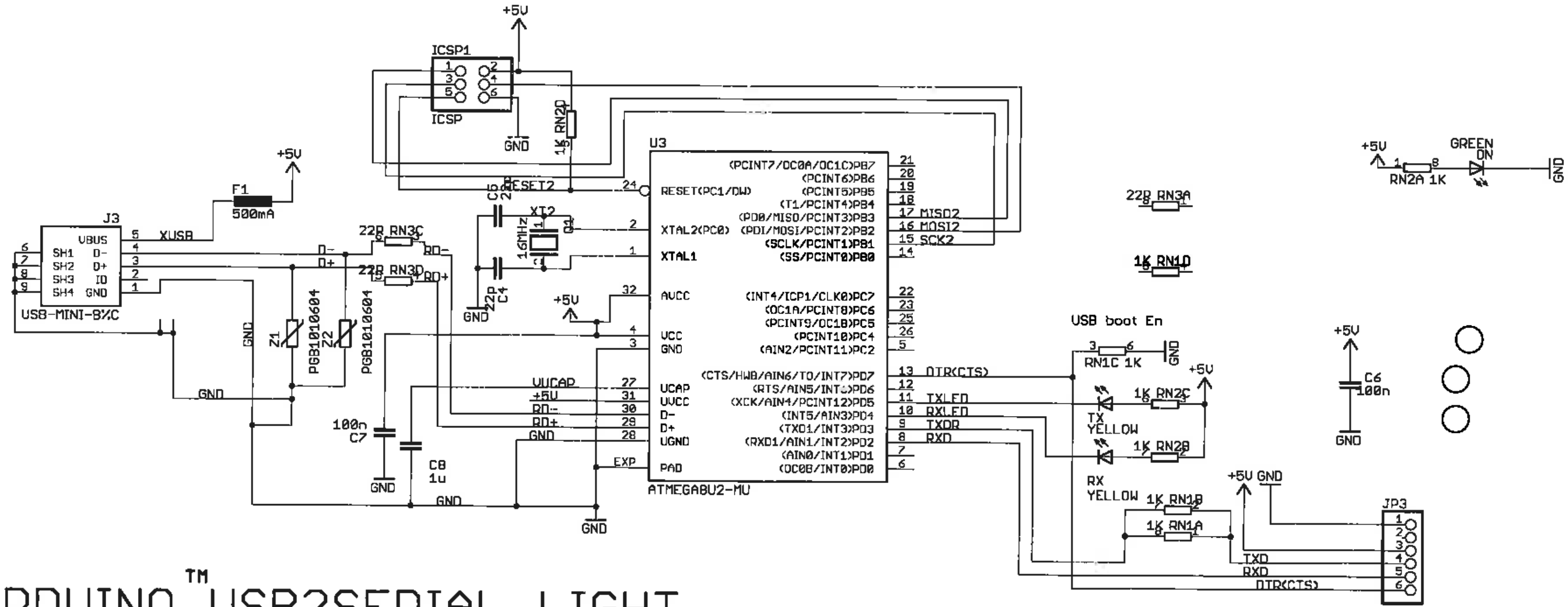
ARDUINO USB2SERIAL



ARDUINO™ USB2SERIAL LIGHT

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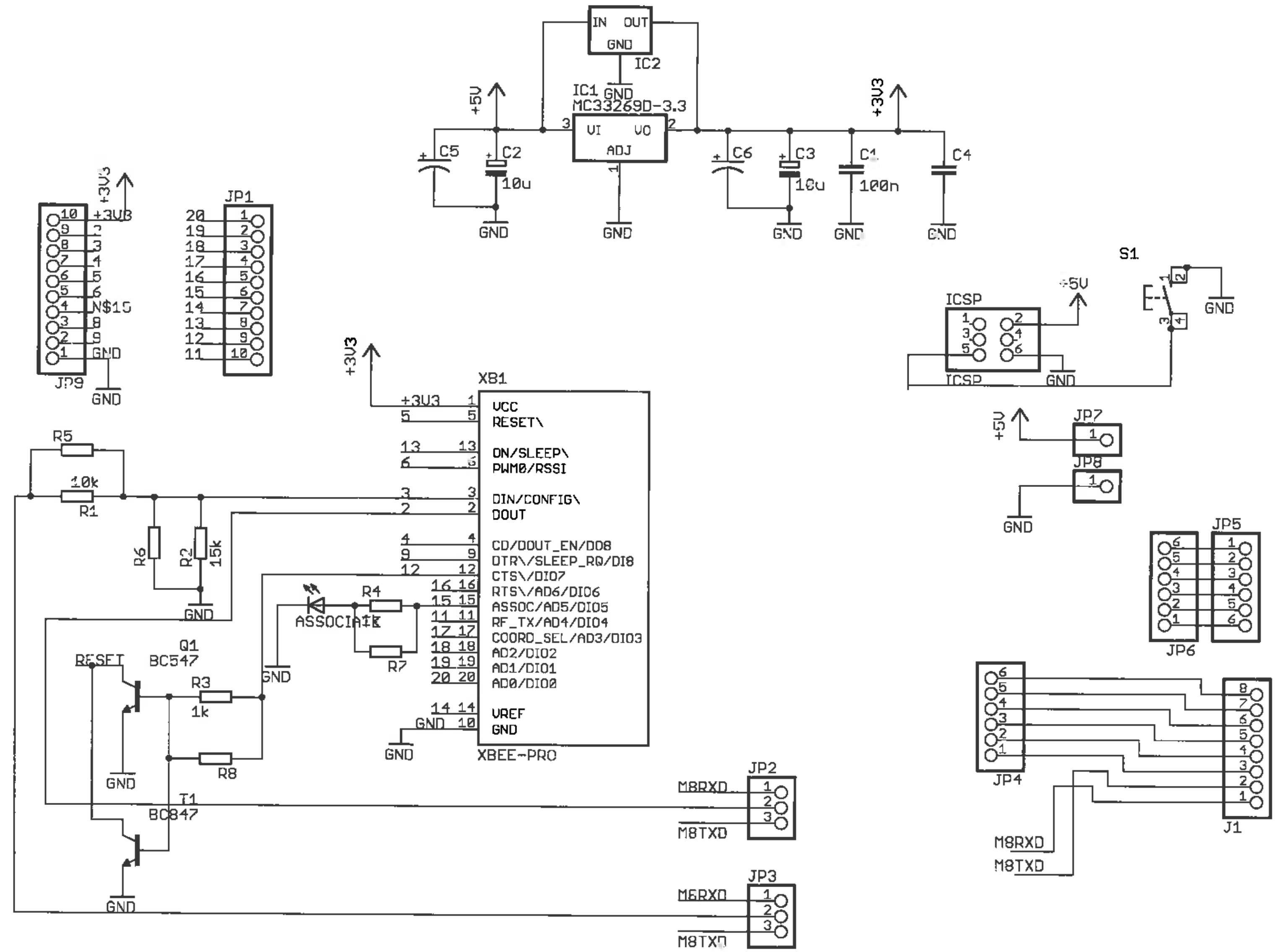
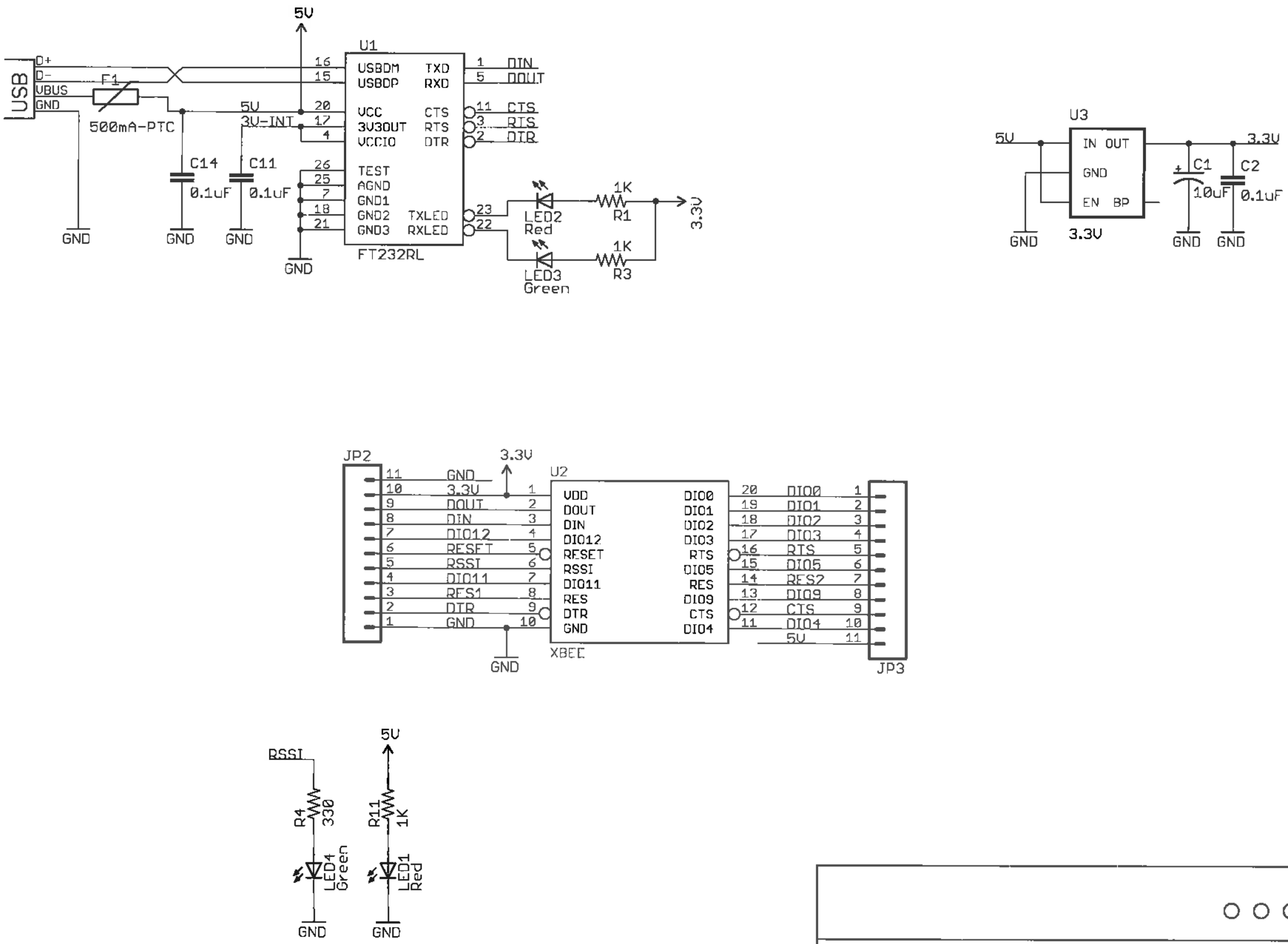
XBEE SHIELD


IC2
IN
OUT
GND
IC1
MC33269D-3.3
VI
VO
ADJ
+5V
+3V3
C5
C2
10u
C6
C3
10u
C1
100n
C4
GND
JP9
JP1
N$15
+3V3
S1
ICSP
JP7
JP8
JP5
JP6
JP4
J1
XB1
XBEE-PRO
VCC
RESET\
ON/SLEEP\
PWM0/RSSI
DIN/CONFIG\
DOUT
CD/DOUT_EN/DO8
DTR\/SLEEP_RQ/DI8
CTS\/DIO7
RTS\/AD6/DIO6
ASSOC/AD5/DIO5
RF_TX/AD4/DIO4
COORD_SEL/AD3/DIO3
AD2/DIO2
AD1/DIO1
AD0/DIO0
VREF
R5
R1
10k
R6
R2
15k
R4
R7
R3
1k
R8
ASSOCIATE
RESET
Q1
BC547
T1
BC847
JP2
JP3
M8RXD
M8TXD

XBEE EXPLORER



SFE

TITLE: XBee-Explorer-v12

Document Number:

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Date: 6/3/2008 2:30:07 PM

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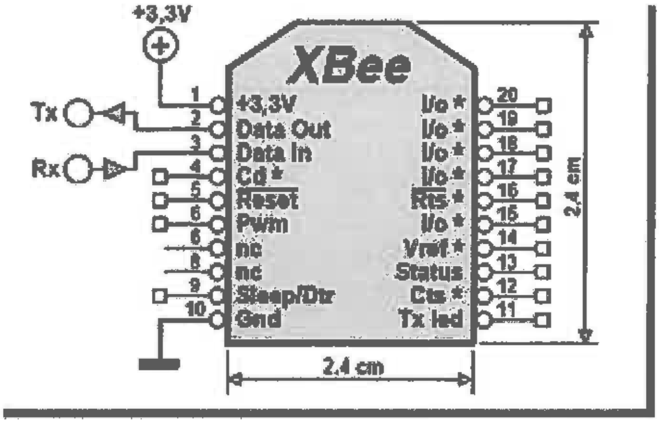
XBEE


+3,3V
XBee
Tx
Rx
1 +3,3V
2 Data Out
3 Data In
4 Cd *
5 Reset
6 Pwm
6 nc
8 nc
9 Sleep/Dtr
10 Gnd
I/o * 20
I/o * 19
I/o * 18
I/o * 17
Rts * 16
I/o * 15
Vref * 14
Status 13
Cts * 12
Tx led 11
2,4 cm
2,4 cm