LM324S, LM2902S

Single Supply Quad Operational Amplifiers

The LM324S and LM2902S are low−cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

Features

- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

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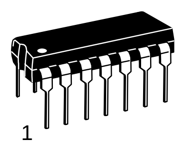
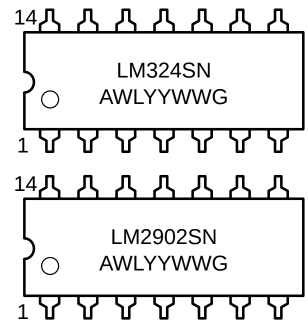
MARKING DIAGRAMS

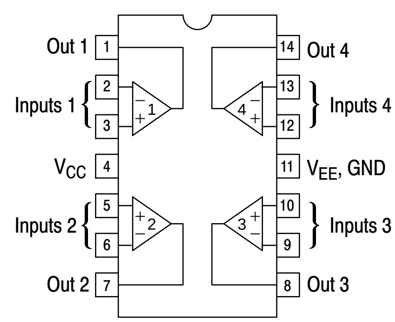


PDIP−14
N SUFFIX
CASE 646



LMxxxx = Specific Device Code
A = Assembly Location
WL = Wafer Lot
Y, YY = Year
WW = Work Week
G = Pb−Free Package

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

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

Rating		Symbol	Value	Unit
Power Supply Voltages				Vdc
	Single Supply	V_{CC}	32	
	Split Supplies	V_{CC}, V_{EE}	±16	
Input Differential Voltage Range (Note 1)		V_{IDR}	±32	Vdc
Input Common Mode Voltage Range (Note 2)		V_{ICR}	−0.3 to 32	Vdc
Output Short Circuit Duration		t_{SC}	Continuous	
Junction Temperature		T_J	150	°C
Thermal Resistance, Junction−to−Air (Note 3)	Case 646	$R_{\theta JA}$	118	°C/W
Storage Temperature Range		T_{stg}	−65 to +150	°C
Operating Ambient Temperature Range		T_A		°C
	LM324S		0 to +70	
	LM2902S		−40 to +105	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Split Power Supplies.
2. For supply voltages less than 32 V, the absolute maximum input voltage is equal to the supply voltage.
3. All $R_{\theta JA}$ measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = GND, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	LM324S Min	LM324S Typ	LM324S Max	LM2902S Min	LM2902S Typ	LM2902S Max	Unit
Input Offset Voltage	V_{IO}							mV
V_{CC} = 5.0 V to 30 V, V_{ICR} = 0 V to V_{CC} −1.7 V, V_O = 1.4 V, R_S = 0 Ω								
T_A = 25°C		−	2.0	7.0	−	2.0	7.0	
T_A = T_{high} (Note 4)		−	−	9.0	−	−	10	
T_A = T_{low} (Note 4)		−	−	9.0	−	−	10	
Average Temperature Coefficient of Input Offset Voltage	$\Delta V_{IO}/\Delta T$	−	7.0	−	−	7.0	−	μV/°C
T_A = T_{high} to T_{low} (Notes 4 and 6)								
Input Offset Current	I_{IO}	−	5.0	50	−	5.0	50	nA
T_A = T_{high} to T_{low} (Note 4)		−	−	150	−	−	200	
Average Temperature Coefficient of Input Offset Current T_A = T_{high} to T_{low} (Notes 4 and 6)	$\Delta I_{IO}/\Delta T$	−	10	−	−	10	−	pA/°C
Input Bias Current	I_{IB}	−	−90	−250	−	−90	−250	nA
T_A = T_{high} to T_{low} (Note 4)		−	−	−500	−	−	−500	
Input Common Mode Voltage Range (Note 5)	V_{ICR}							V
V_{CC} = 30 V								
T_A = +25°C		0	−	28.3	0	−	28.3	
T_A = T_{high} to T_{low} (Note 4)		0	−	28	0	−	28	
Differential Input Voltage Range	V_{IDR}	−	−	V_{CC}	−	−	V_{CC}	V
Large Signal Open Loop Voltage Gain	A_{VOL}							V/mV
R_L = 2.0 kΩ, V_{CC} = 15 V, for Large V_O Swing		25	100	−	25	100	−	
T_A = T_{high} to T_{low} (Note 4)		15	−	−	15	−	−	
Channel Separation 10 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	−	−120	−	−	−120	−	dB
Common Mode Rejection, R_S ≤ 10 kΩ	CMR	65	70	−	50	70	−	dB
Power Supply Rejection	PSR	65	100	−	50	100	−	dB

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. LM324S: T_{low} = 0°C, T_{high} = +70°C
   LM2902S: T_{low} = −40°C, T_{high} = +105°C
5. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} −1.7 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V_{CC}.
6. Guaranteed by design.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = GND, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	LM324S			LM2902S			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage − High Limit	V_{OH}							V
V_{CC} = 5.0 V, R_L = 2.0 kΩ, T_A = 25°C		3.3	3.5	−	3.3	3.5	−	
V_{CC} = 30 V, R_L = 2.0 kΩ, (T_A = $T_{high\ to}$ T_{low}) (Note 7)		26	−	−	26	−	−	
V_{CC} = 30 V, R_L = 10 kΩ, (T_A = $T_{high\ to}$ T_{low}) (Note 7)		27	28	−	27	28	−	
Output Voltage − Low Limit, V_{CC} = 5.0 V, R_L = 10 kΩ, T_A = T_{high} to T_{low} (Note 7)	V_{OL}	−	5.0	20	−	5.0	100	mV
Output Source Current (V_{ID} = +1.0 V, V_{CC} = 15 V)	I_O +							mA
T_A = 25°C		20	40	−	20	40	−	
T_A = T_{high} to T_{low} (Note 7)		10	20	−	10	20	−	
Output Sink Current	I_O −							mA
V_{ID} = −1.0 V, V_{CC} = 15 V, T_A = 25°C		10	20	−	10	20	−	
T_A = T_{high} to T_{low} (Note 7)		5.0	8.0	−	5.0	8.0	−	
V_{ID} = −1.0 V, V_O = 200 mV, T_A = 25°C		12	50	−	−	−	−	μA
Output Short Circuit to Ground (Note 8)	I_{SC}	−	40	60	−	40	60	mA
Power Supply Current (T_A = T_{high} to T_{low}) (Note 7)	I_{CC}							mA
V_{CC} = 30 V V_O = 0 V, R_L = ∞		−	−	3.0	−	−	3.0	
V_{CC} = 5.0 V, V_O = 0 V, R_L = ∞		−	−	1.2	−	−	1.2	

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

7. LM324S: T_{low} = 0°C, T_{high} = +70°C
   LM2902S: T_{low} = −40°C, T_{high} = +105°C
8. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} −1.7 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V_{CC}.

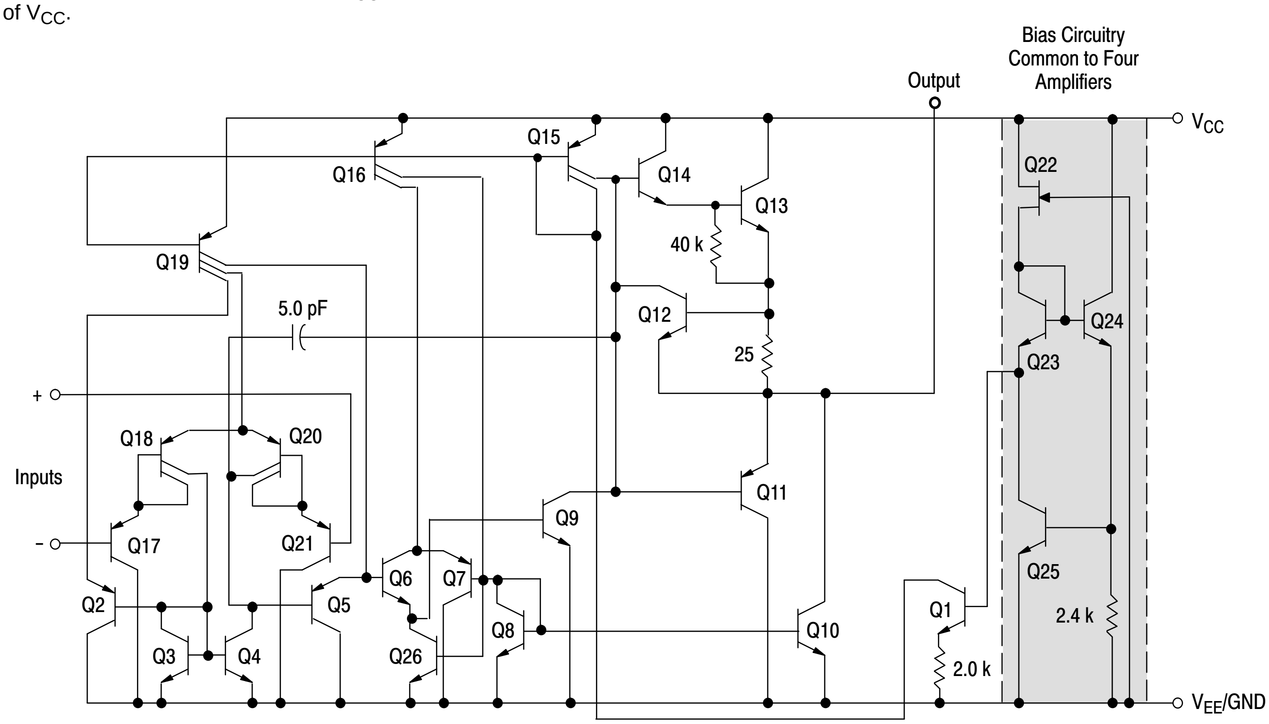
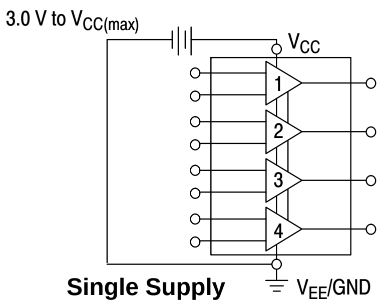


Figure 1. Representative Circuit Diagram
(One−Fourth of Circuit Shown)

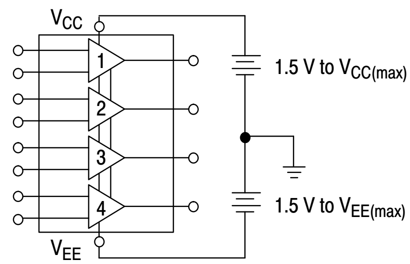
CIRCUIT DESCRIPTION

The LM324S and LM2902S are made using four internally compensated, two−stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single−ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal−voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

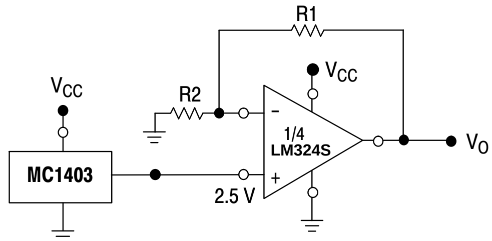


Single Supply



Split Supplies

Figure 2.



$$V_O = 2.5\ V \left(1 + \frac{R1}{R2}\right)$$

Figure 3. Voltage Reference

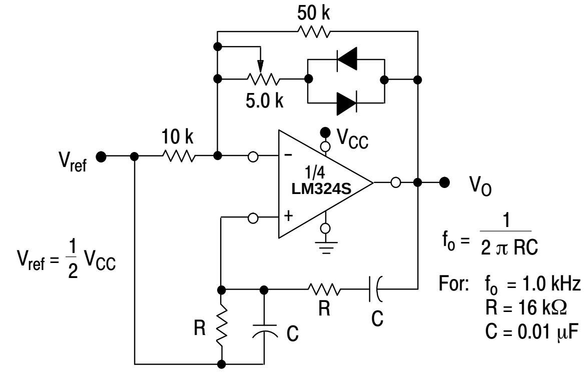
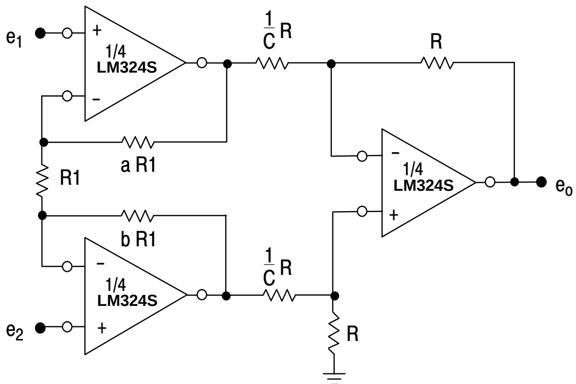
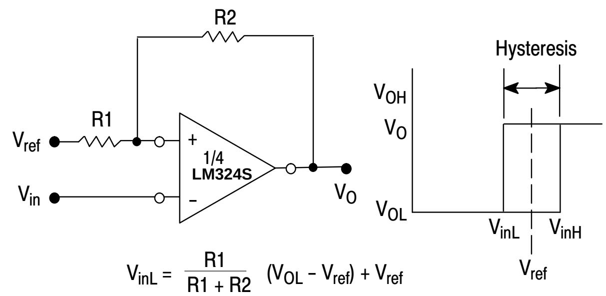


Figure 4. Wien Bridge Oscillator



$$e_o = C\ (1 + a + b)\ (e_2 - e_1)$$

Figure 5. High Impedance Differential Amplifier



$$V_{inL} = \frac{R1}{R1 + R2}\ (V_{OL} - V_{ref}) + V_{ref}$$

$$V_{inH} = \frac{R1}{R1 + R2}\ (V_{OH} - V_{ref}) + V_{ref}$$

$$H = \frac{R1}{R1 + R2}\ (V_{OH} - V_{OL})$$

Figure 6. Comparator with Hysteresis

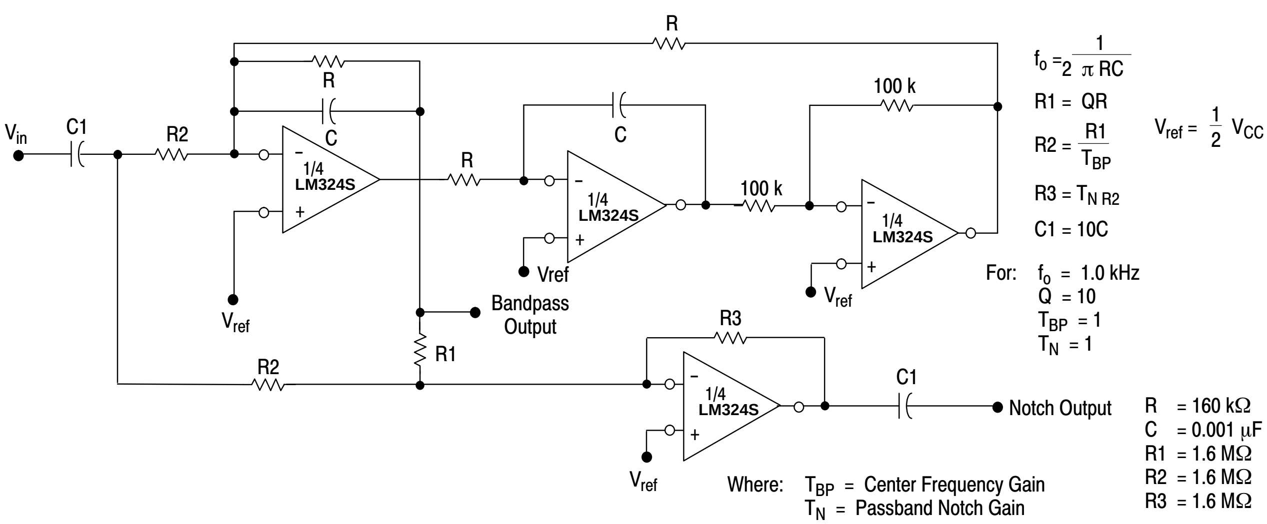
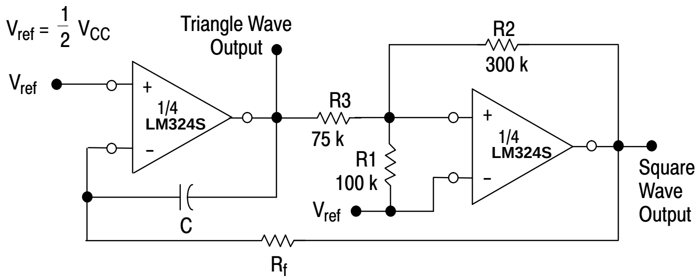


Figure 7. Bi−Quad Filter



$$f = \frac{R1 + R_C}{4\ CR_f\ R1} \quad \text{if} \quad R3 = \frac{R2\ R1}{R2 + R1}$$

Figure 8. Function Generator

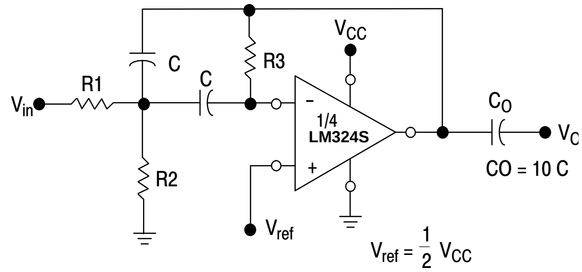


Figure 9. Multiple Feedback Bandpass Filter

Given: f_o = center frequency

$A(f_o)$ = gain at center frequency

Choose value f_o, C

Then: $R3 = \frac{Q}{\pi f_o C}$

$R1 = \frac{R3}{2\ A(f_o)}$

$R2 = \frac{R1\ R3}{4Q^2 R1 - R3}$

For less than 10% error from operational amplifier, $\frac{Q_o f_o}{BW} < 0.1$

where f_o and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

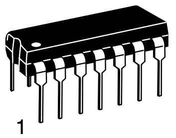
ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping†
LM324SNG	0°C to +70°C	PDIP−14 (Pb−Free)	25 Units / Rail
LM2902SNG	−40°C to +105°C	PDIP−14 (Pb−Free)	25 Units / Rail

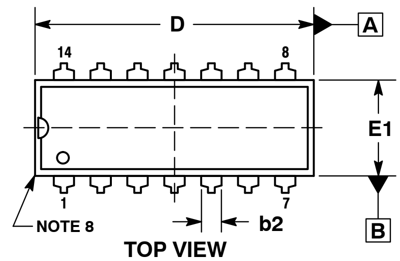
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

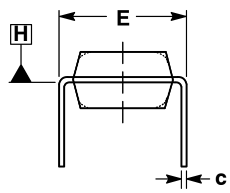
PDIP−14
CASE 646−06
ISSUE S

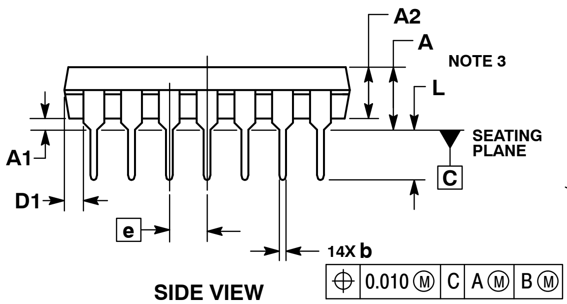
DATE 22 APR 2015

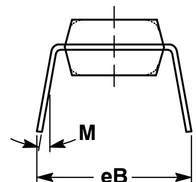


SCALE 1:1





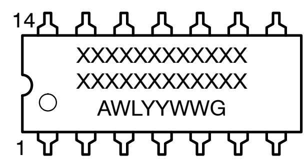




NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS−3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	----	0.210	---	5.33
A1	0.015	----	0.38	---
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP		1.52 TYP	
C	0.008	0.014	0.20	0.36
D	0.735	0.775	18.67	19.69
D1	0.005	----	0.13	---
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
eB	----	0.430	---	10.92
L	0.115	0.150	2.92	3.81
M	----	10°	---	10°

GENERIC MARKING DIAGRAM*



STYLES ON PAGE 2

XXXXX = Specific Device Code
A = Assembly Location
WL = Wafer Lot
YY = Year
WW = Work Week
G = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “ ▪”, may or may not be present.

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CASE 646−06
ISSUE S

DATE 22 APR 2015

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NO CONNECTION
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NO CONNECTION
12. EMITTER
13. BASE
14. COLLECTOR

STYLE 2:
CANCELLED

STYLE 3:
CANCELLED

STYLE 4:
PIN 1. DRAIN
2. SOURCE
3. GATE
4. NO CONNECTION
5. GATE
6. SOURCE
7. DRAIN
8. DRAIN
9. SOURCE
10. GATE
11. NO CONNECTION
12. GATE
13. SOURCE
14. DRAIN

STYLE 5:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. NO CONNECTION
5. SOURCE
6. DRAIN
7. GATE
8. GATE
9. DRAIN
10. SOURCE
11. NO CONNECTION
12. SOURCE
13. DRAIN
14. GATE

STYLE 6:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. NO CONNECTION
5. ANODE/CATHODE
6. NO CONNECTION
7. ANODE/CATHODE
8. ANODE/CATHODE
9. ANODE/CATHODE
10. NO CONNECTION
11. ANODE/CATHODE
12. ANODE/CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 7:
PIN 1. NO CONNECTION
2. ANODE
3. ANODE
4. NO CONNECTION
5. ANODE
6. NO CONNECTION
7. ANODE
8. ANODE
9. ANODE
10. NO CONNECTION
11. ANODE
12. ANODE
13. NO CONNECTION
14. COMMON CATHODE

STYLE 8:
PIN 1. NO CONNECTION
2. CATHODE
3. CATHODE
4. NO CONNECTION
5. CATHODE
6. NO CONNECTION
7. CATHODE
8. CATHODE
9. CATHODE
10. NO CONNECTION
11. CATHODE
12. CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 9:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. NO CONNECTION
5. ANODE/CATHODE
6. ANODE/CATHODE
7. COMMON ANODE
8. COMMON ANODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. NO CONNECTION
12. ANODE/CATHODE
13. ANODE/CATHODE
14. COMMON CATHODE

STYLE 10:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE
6. NO CONNECTION
7. COMMON ANODE
8. COMMON CATHODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. ANODE/CATHODE
12. ANODE/CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 11:
PIN 1. CATHODE
2. CATHODE
3. CATHODE
4. CATHODE
5. CATHODE
6. CATHODE
7. CATHODE
8. ANODE
9. ANODE
10. ANODE
11. ANODE
12. ANODE
13. ANODE
14. ANODE

STYLE 12:
PIN 1. COMMON CATHODE
2. COMMON ANODE
3. ANODE/CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE
6. COMMON ANODE
7. COMMON CATHODE
8. ANODE/CATHODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. ANODE/CATHODE
12. ANODE/CATHODE
13. ANODE/CATHODE
14. ANODE/CATHODE

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