LM111, LM211, LM311
DIFFERENTIAL COMPARATORS WITH STROBES

T-73-53

D1312, SEPTEMBER 1973—REVISED MARCH 1988

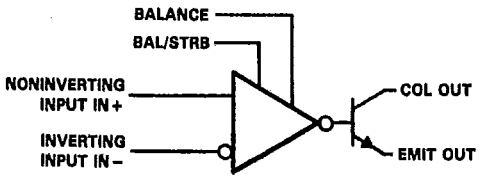
- **Fast Response Times**
- **Strobe Capability**
- **Designed to be Interchangeable with National Semiconductor LM111, LM211, and LM311**
- **Maximum Input Bias Current . . . 300 nA**
- **Maximum Input Offset Current . . . 70 nA**
- **Can Operate from Single 5-V Supply**

description

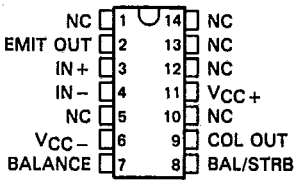
The LM111, LM211, and LM311 are single high-speed voltage comparators. These devices are designed to operate from a wide range of power supply voltage, including ±15-V supplies for operational amplifiers and 5-V supplies for logic systems. The output levels are compatible with most TTL and MOS circuits.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

The LM111 is characterized for operation over the full military range of −55°C to 125°C. The LM211 is characterized for operation from −25°C to 85°C, and the LM311 is characterized for operation from 0°C to 70°C.

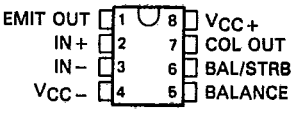
functional block diagram



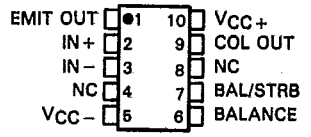
LM111 . . . J PACKAGE
(TOP VIEW)



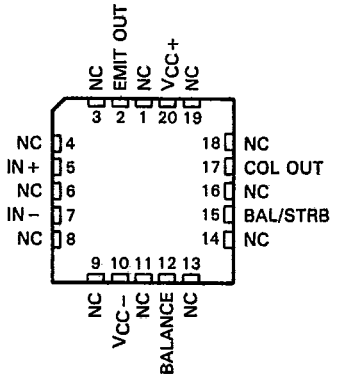
LM111 . . . JG PACKAGE
LM211, LM311 . . . D, JG, OR P PACKAGE
(TOP VIEW)



LM111 . . . U FLAT PACKAGE
(TOP VIEW)



LM111 . . . FK CHIP CARRIER PACKAGE
(TOP VIEW)



NC—No internal connection

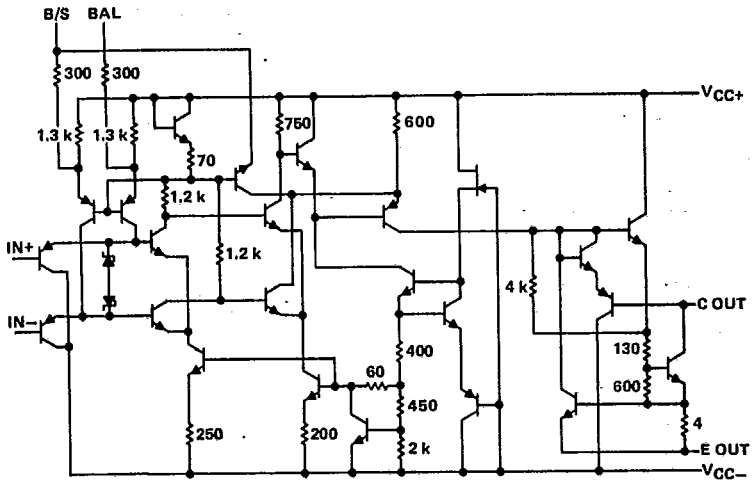
3 Voltage Comparators

AVAILABLE OPTIONS

OPERATING TEMPERATURE RANGE	V_{IO} MAX AT T_A = 25°C	PACKAGE					
		D SMALL OUTLINE	FK CERAMIC CHIP CARRIER	J CERAMIC DIP	JG CERAMIC DIP	P PLASTIC DIP	U FLATPACK
−55°C to 125°C	3 mV		LM111FK	LM111J			LM111U
−40°C to 85°C	3 mV	LM211D			LM211JG	LM211P	
0°C to 70°C	7.5 mV	LM311D			LM311JG	LM311P	

The D package is available in tape and reel. Add an R suffix when ordering, e.g., LM311DR.

schematic



BAL	Balance
B/S	Balance/Strobe
C OUT	Collector Output
E OUT	Emitter Output
IN+	Noninverting Input
IN−	Inverting Input
NC	No Internal Connection
V_{CC+}	Positive Supply Voltage
V_{CC-}	Negative Supply Voltage

Resistor values shown are nominal and in ohms.

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

	LM111	LM211	LM311	UNIT
Supply voltage, V_{CC+} (see Note 1)	18	18	18	V
Supply voltage, V_{CC-} (see Note 1)	−18	−18	−18	V
Differential input voltage (see Note 2)	±30	±30	±30	V
Input voltage (either input, see Notes 1 and 3)	±15	±15	±15	V
Voltage from emitter output to V_{CC-}	30	30	30	V
Voltage from collector output to V_{CC-}	50	50	40	V
Duration of output short-circuit (see Note 4)	10	10	10	s
Continuous total dissipation	See Dissipation Rating Table			
Operating free-air temperature range	−55 to 125	−25 to 85	0 to 70	°C
Storage temperature range	−65 to 150	−65 to 150	−65 to 150	°C
Case temperature for 60 seconds: FK Package	260			°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J, JG, or U package	300	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D or P package		260	260	°C

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D	500 mW	5.8 mW/°C	64°C	464 mW	377 mW	—
FK	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
J (LM111)	500 mW	11.0 mW/°C	105°C	500 mW	500 mW	275 mW
J	500 mW	8.2 mW/°C	89°C	500 mW	500 mW	—
JG (LM111)	500 mW	8.4 mW/°C	90°C	500 mW	500 mW	210 mW
JG	500 mW	6.6 mW/°C	74°C	500 mW	429 mW	—
P	500 mW	8.0 mW/°C	88°C	500 mW	500 mW	—
U	500 mW	5.4 mW/°C	57°C	432 mW	351 mW	135 mW

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

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

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

†Unless otherwise noted, all characteristics are measured with the balance and balance/strobe terminals open and the emitter output grounded. Full range for LM111 is −55°C to 125°C, for LM211 is −25°C to 85°C, and for LM311 is 0°C to 70°C.
‡All typical values are at T_A = 25°C.

NOTES: 5. The offset voltages and offset currents given are the maximum values required to drive the collector output up to 14 V or down to 1 V with a pull-up resistor of 7.5 kΩ to V_{CC+}. Thus these parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.
6. The strobe should not be shorted to ground; it should be current driven at −3 to −5 mA, e.g., see Figures 13 and 27.

switching characteristics, V_{CC+} = 15 V, V_{CC-} = −15 V, T_A = 25°C

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

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

TYPICAL CHARACTERISTICS

INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE

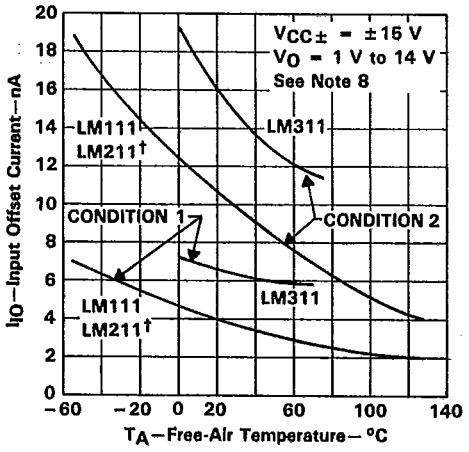


FIGURE 1

INPUT BIAS CURRENT
vs
FREE-AIR TEMPERATURE

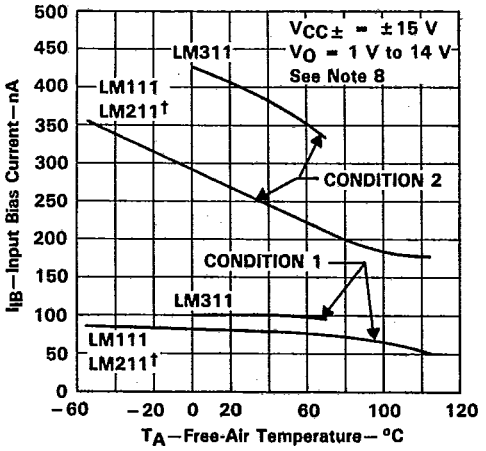


FIGURE 2

VOLTAGE TRANSFER CHARACTERISTICS

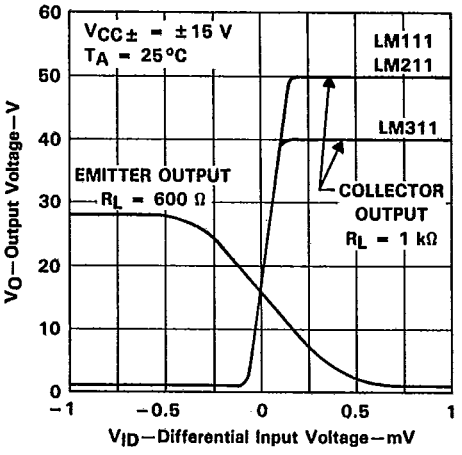
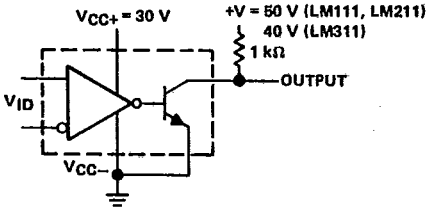
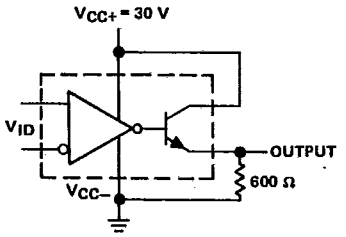


FIGURE 3



COLLECTOR OUTPUT TRANSFER CHARACTERISTIC
TEST CIRCUIT FOR FIGURE 3



EMITTER OUTPUT TRANSFER CHARACTERISTIC
TEST CIRCUIT FOR FIGURE 3

†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

NOTE 8: Condition 1 is with the balance and balance/strobe terminals open. Condition 2 is with the balance and balance/strobe terminals connected to V_{CC+}.

LM111, LM211, LM311
DIFFERENTIAL COMPARATORS WITH STROBES

TYPICAL CHARACTERISTICS

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

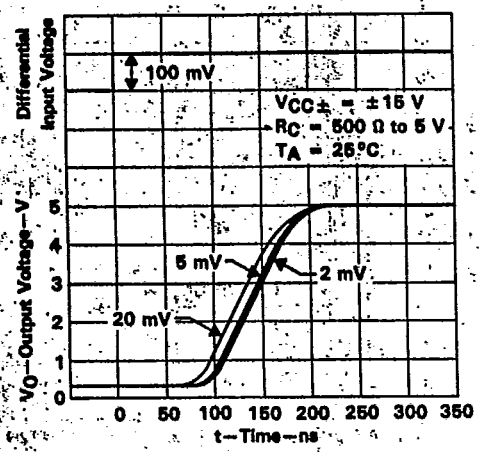


FIGURE 4

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

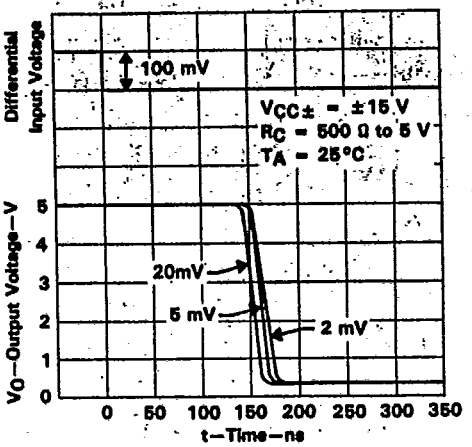
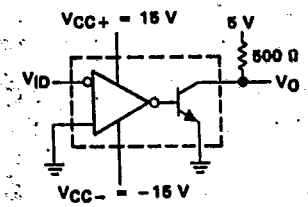


FIGURE 5



TEST CIRCUIT FOR FIGURES 4 AND 5

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TYPICAL CHARACTERISTICS

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

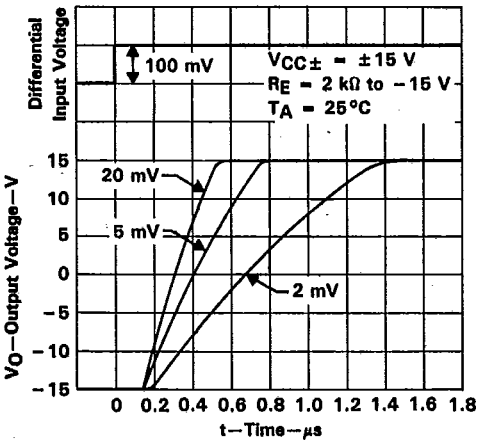


FIGURE 6

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

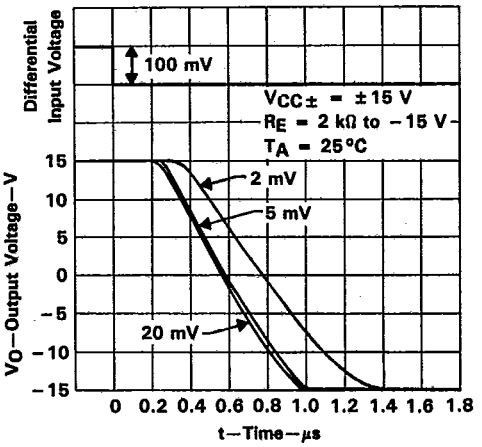
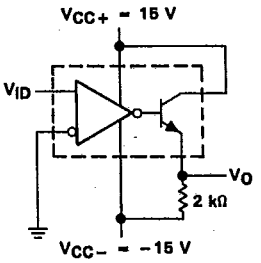


FIGURE 7



TEST CIRCUIT FOR FIGURES 6 AND 7

3 Voltage Comparators

TYPICAL CHARACTERISTICS

OUTPUT CURRENT and DISSIPATION
vs
OUPUT VOLTAGE

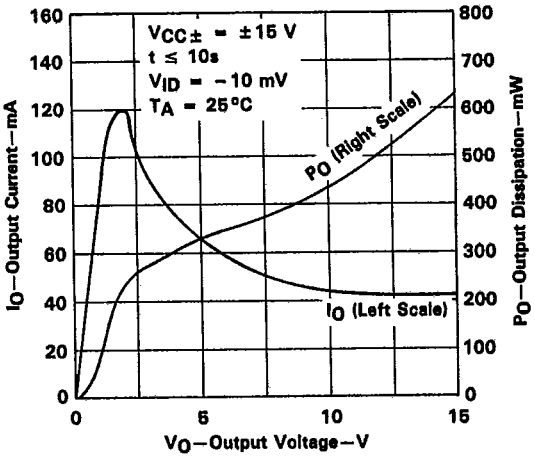


FIGURE 8

SUPPLY CURRENT FROM V_{CC+}
vs
SUPPLY VOLTAGE V_{CC+}

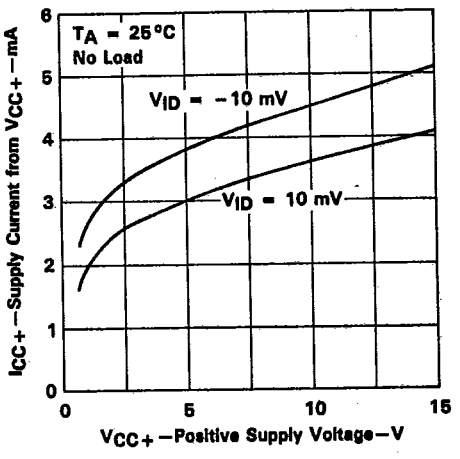


FIGURE 9

SUPPLY CURRENT FROM V_{CC-}
vs
SUPPLY VOLTAGE V_{CC-}

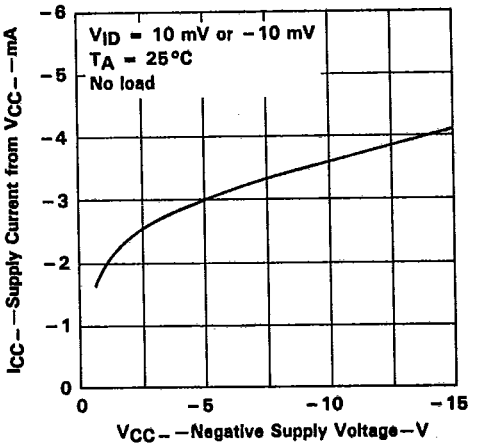


FIGURE 10

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TYPICAL APPLICATION DATA

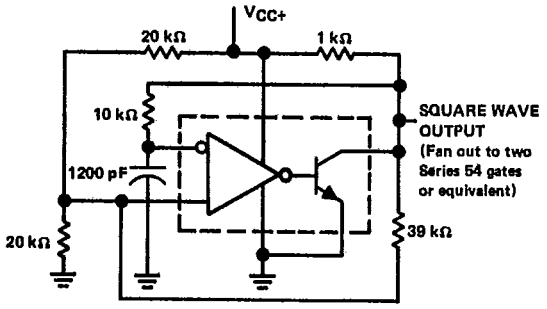


FIGURE 11. 100 kHz FREE-RUNNING MULTIVIBRATOR

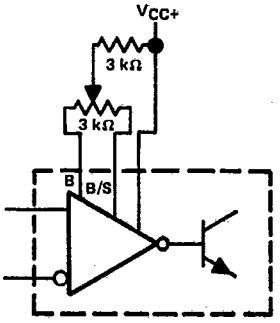


FIGURE 12. OFFSET BALANCING

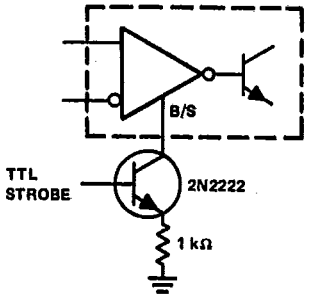


FIGURE 13. STROBING

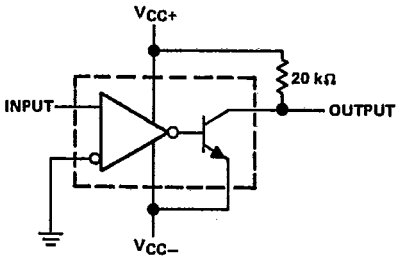
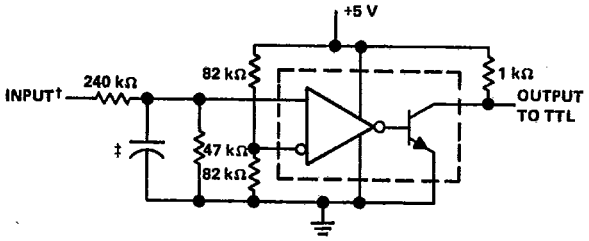


FIGURE 14. ZERO-CROSSING DETECTOR



†Resistor values shown are for a 0-to-30-V logic swing and a 15-V threshold.
‡May be added to control speed and reduce susceptibility to noise spikes.

FIGURE 15. TTL INTERFACE WITH HIGH-LEVEL LOGIC

TYPICAL APPLICATION DATA

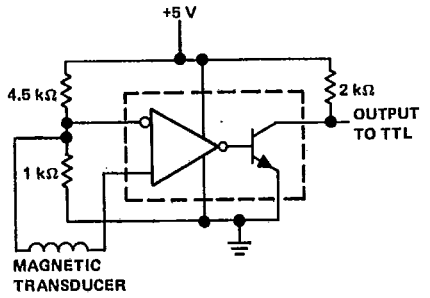


FIGURE 16. DETECTOR FOR MAGNETIC TRANSDUCER

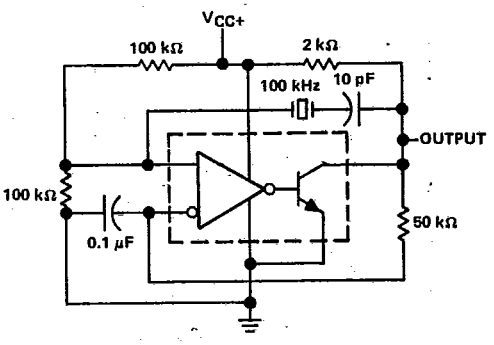


FIGURE 17. 100 kHz CRYSTAL OSCILLATOR

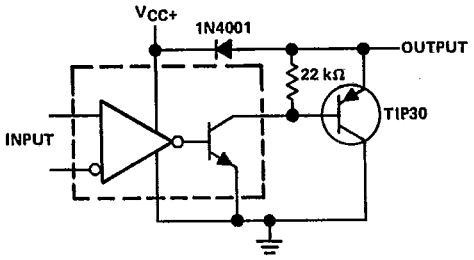
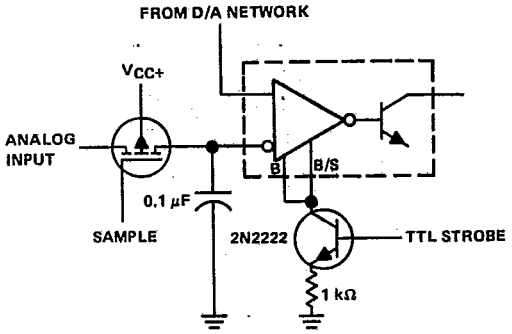


FIGURE 18. COMPARATOR AND SOLENOID DRIVER



Typical input current is 50 pA with inputs strobed off.

FIGURE 19. STROBING BOTH INPUT AND OUTPUT STAGES SIMULTANEOUSLY

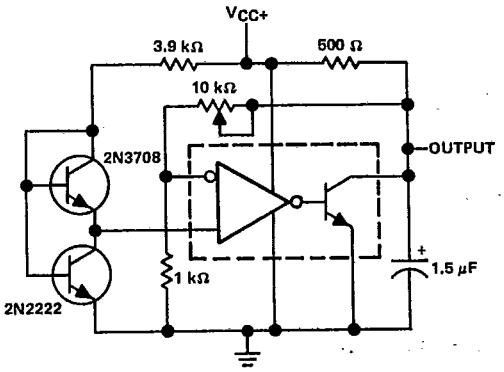


FIGURE 20. LOW-VOLTAGE ADJUSTABLE REFERENCE SUPPLY

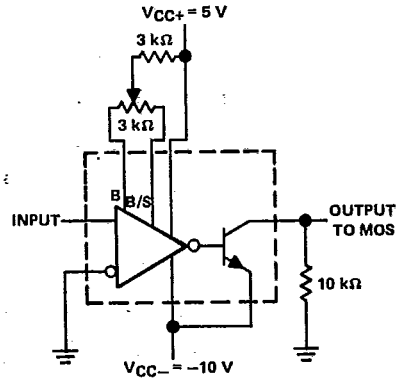


FIGURE 21. ZERO-CROSSING DETECTOR DRIVING MOS LOGIC

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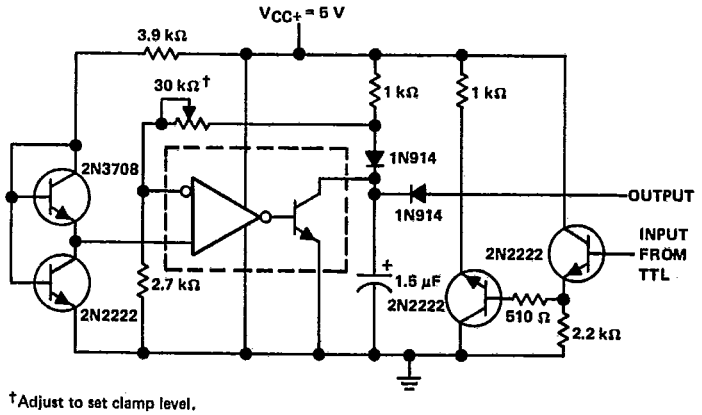
TYPICAL APPLICATION DATA



†Adjust to set clamp level.

FIGURE 22. PRECISION SQUARER

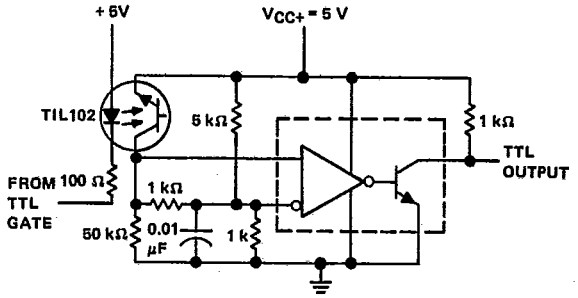


FIGURE 23. DIGITAL TRANSMISSION ISOLATOR

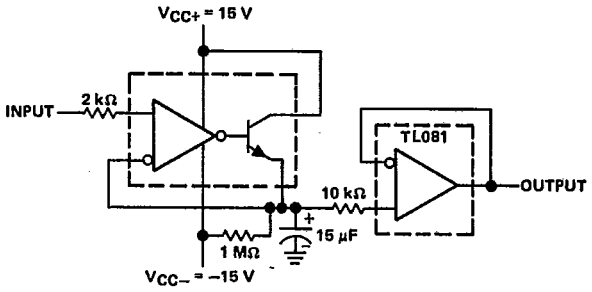


FIGURE 24. POSITIVE-PEAK DETECTOR

TYPICAL APPLICATION DATA

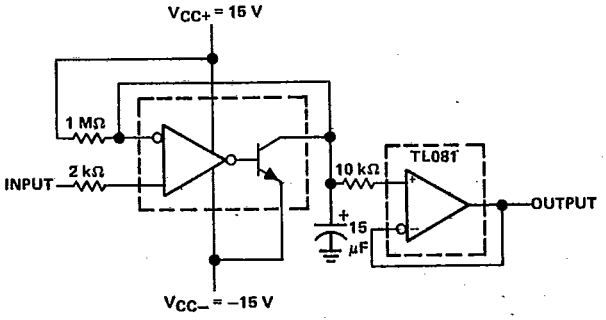
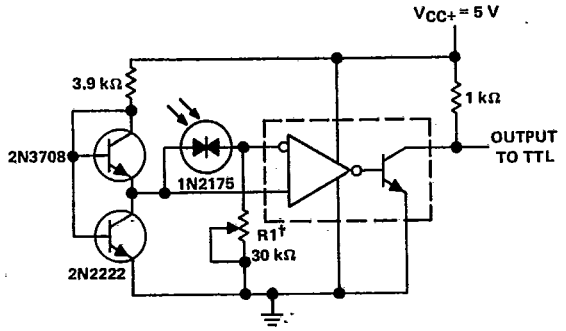
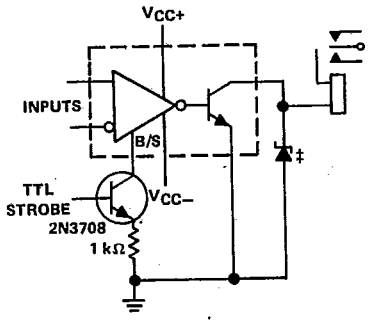


FIGURE 25. NEGATIVE-PEAK DETECTOR



†R1 sets the comparison level. At comparison, the photodiode has less than 5 mV across it decreasing dark current by an order of magnitude.

FIGURE 26. PRECISION PHOTODIODE COMPARATOR



‡Transient voltage and inductive kickback protection

FIGURE 27. RELAY DRIVER WITH STROBE

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TYPICAL APPLICATION DATA

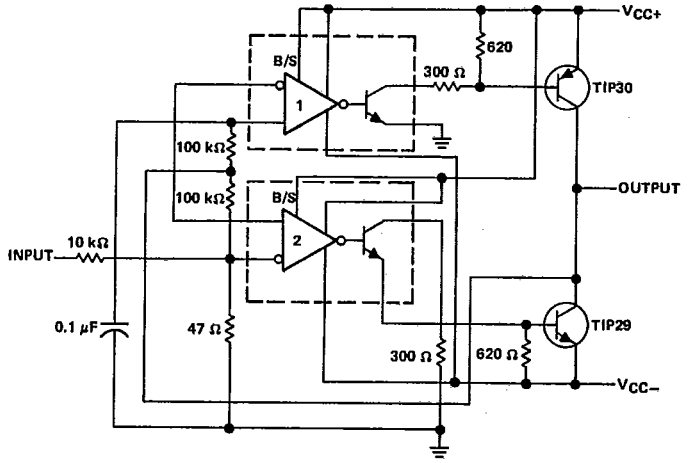

FIGURE 28. SWITCHING POWER AMPLIFIER

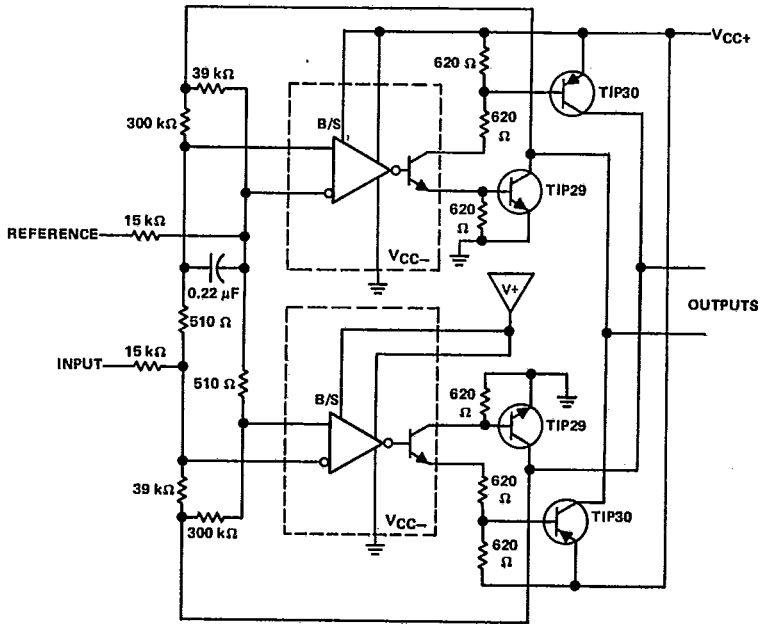

FIGURE 29. SWITCHING POWER AMPLIFIERS

3 Voltage Comparators