Dot/Bar Display Driver

General Description

LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a mov- ing dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V.

The circuit contains its own adjustable reference and accu-rate 10-step voltage divider.The low-bias-current input buffer accepts signals down to ground, or V⁻, yet needs no protection against inputs of 35V above or below ground.The buffer drives 10 individual comparators referenced to the precision divider. Indication non-linearity can thus be held typically to ½%, even over a wide temperature range.

Versatility was designed into the LM3914 so that controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914 be "chained" to form displays of 20 to over 100 seg- ments. Both ends of the voltage divider are externally avail- able so that 2 drivers can be made into a zero-center meter.

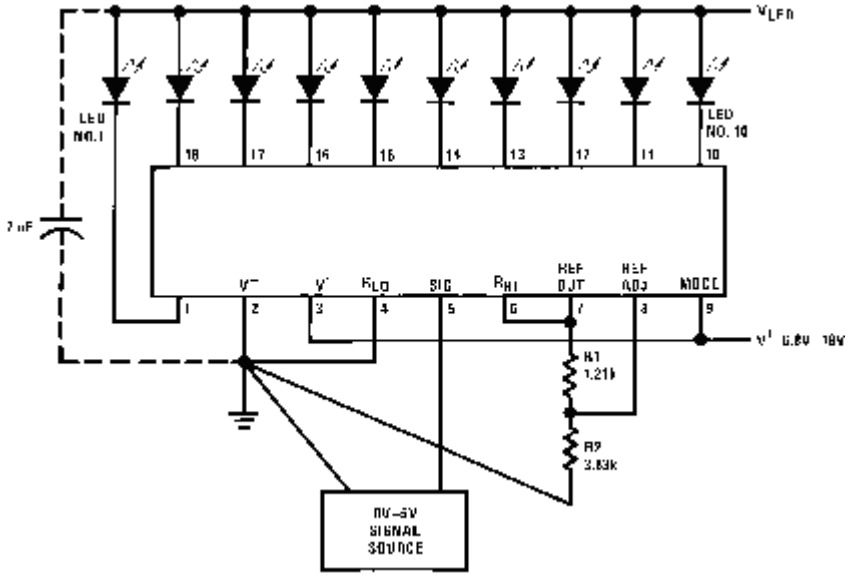
LM3914 is very easy to apply as an analog meter circuit. A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control. The simplified block diagram illustrates this extremely simple ex- ternal circuitry.

When in the dot mode, there is a small amount of overlap or"fade" (about 1 mV) between segments. This assures that aMuch of the display flexibility derives from the fact that all outputs are individual, DC regulated currents. Various effects can be achieved by modulating these currents. The indi- vidual outputs can drive a transistor as well as a LED at the same time, so controller functions including "staging" control can be performed. The can also act as a program- mer, or sequencer. The YT3914 is rated for operation from 0˚C to +70˚C. The YT3914N is available in an 18-lead molded (N) package. The following typical application illustrates adjusting of the reference to a desired value, and proper grounding for accu-rate operation, and avoiding oscillations.

FEATURES

- Drives LEDs, LCDs or vacuum fluorescents
- Bar or dot display mode externally selectable by user
- Expandable to displays of 100 steps
- Internal voltage reference from 1.2V to 12V n Operates with single supply of less than 3V n Inputs operate down to ground
- Output current programmable from 2 mA to 30 mA
- No multiplex switching or interaction between outputs
- Input withstands ±35V without damage or false outputs
- LED driver outputs are current regulated, open-collectors
- Outputs can interface with TTL or CMOS logic
- The internal 10-step divider is floating and can be referenced to a wide range of voltages

Typical Applications



$$\text{Ref Out V} = 1.25\left(1 + \frac{R2}{R1}\right)$$

$$I_{LED} \cong \frac{12.5}{R1}$$

Absolute Maximum Ratings (Note 1)

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

Power Dissipation (Note 6) Molded DIP (N)	1365 mW
Supply Voltage	25V
Voltage on Output Drivers	25V
Input Signal Overvoltage (Note 4)	±35V
Reference Load Current	10 mA
Storage Temperature Range	−55˚C to +150˚C Soldering Information
Dual-In-Line Package Soldering (10 seconds)	260˚C
Plastic Chip Carrier Package Vapor Phase (60 seconds)	215˚C
Infrared (15 seconds)	220˚C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

Electrical Characteristics (Notes 2, 4)

Parameter	Conditions (Note 2)		Min	Typ	Max	Units
COMPARATOR						
Offset Voltage, Buffer and Firs Comparato	$0V \le V_{RLO} = V_{RHI} \le 12V$,			3	10	mV
Offset Voltage, Buffer and Any OtherComparato	$0V \le V_{RLO} = V_{RHI} \le 12V$, I_{LED} = 1 mA			3	15	mV
Gain ($\Delta I_{LED}/\Delta V_{IN}$)	$I_{L(REF)}$ = 2 mA, I_{LED} = 10 mA		3	8		mA/mV
Input Bias Current (at Pin 5)	$0V \le V_{IN} \le V^+ - 1.5V$			25	100	nA
Input Signal Overvoltage	No Change in Display		-35		35	V
VOLTAGE-DIVIDER						
Divider Resistance	Total, Pin 6 to 4		8	12	17	kΩ
Accuracy	(Note 3)			0.5	2	%
VOLTAGE REFERENCE						
Output Voltage	$0.1\ mA \le I_{L(REF)} \le 4\ mA, V^+ = V_{LED} = 5V$		1.2	1.28	1.34	V
Line Regulation	$3V \le V^+ \le 18V$			0.01	0.03	%/V
Load Regulation	$0.1\ mA \le I_{L(REF)} \le 4\ mA, V^+ = V_{LED} = 5V$			0.4	2	%
Output Voltage Change with Temperature	$0˚C \le T_A \le +70˚C$, $I_{L(REF)}$ = 1 mA, $V^+ = 5V$			1		%
Adjust Pin Current				75	120	uA
OUTPUT DRIVERS						
LED Current	$V^+ = V_{LED} = 5V$, $I_{L(REF)}$ = 1 mA		7	10	13	mA
LED Current Difference (Between Largest and Smallest LED Currents)	V_{LED} = 5V	I_{LED} = 2 mA		0.12	0.4	mA
		I_{LED} = 20mA		1.2	3	
LED Current Regulation	$2V \le V_{LED} \le 17V$	I_{LED} = 2 mA		0.1	0.25	mA
		I_{LED} = 20mA		1	3	
Dropout Voltage	$I_{LED(ON)}$ = 20 mA, V_{LED} = 5V, ΔI_{LED} = 2 mA				1.5	V
Saturation Voltage	I_{LED} = 2.0 mA, $I_{L(REF)}$ = 0.4 mA			0.15	0.4	V
Output Leakage, Each Collector	(Bar Mode) (Note 5)			0.1	10	uA
Output Leakage	(Dot Mode)(Note 5)	Pins 10–18		0.1	10	uA
		Pin 1	60	150	450	uA
SUPPLY CURRENT						
Standby Supply Current(All Outputs Off)	V^+ = 5V, $I_{L(REF)}$ = 0.2 mA			2.4	4.2	mA
	V^+ = 20V, $I_{L(REF)}$ = 1.0 mA			6.1	9.2	mA

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guar- antee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Electrical Characteristics (Notes 2, 4) (Continued)

Note 2: Unless otherwise stated, all specifications apply with the following conditions:

$3\ V_{DC} \le V^+ \le 20\ V_{DC}$ $V_{REF}, V_{RHI}, V_{RLO} \le (V^+ - 1.5V)$

$3\ V_{DC} \le V_{LED} \le V^+$ $0V \le V_{IN} \le V^+ - 1.5V$

$-0.015V \le V_{RLO} \le 12\ V_{DC}$ $T_A = +25^\circ C$, $I_{L(REF)} = 0.2$ mA, $V_{LED} = 3.0V$, pin 9 connected to pin 3 (Bar Mode).

$-0.015V \le V_{RHI} \le 12\ V_{DC}$

For higher power dissipations, pulse testing is used.

Note 3: Accuracy is measured referred to +10.000 V_{DC} at pin 6, with 0.000 V_{DC} at pin 4. At lower full-scale voltages, buffer and comparator offset voltage may add significant error.

Note 4: Pin 5 input current must be limited to ±3 mA. The addition of a 39k resistor in series with pin 5 allows ±100V signals without damage.

Note 5: Bar mode results when pin 9 is within 20 mV of V^+. Dot mode results when pin 9 is pulled at least 200 mV below V^+ or left open circuit. LED No. 10 (pin 10 output current) is disabled if pin 9 is pulled 0.9V or more below V_{LED}.

Note 6: The maximum junction temperature of the LM3914 is 100˚C. Devices must be derated for operation at elevated temperatures. Junction to ambient thermal resistance is 55˚C/W for the molded DIP (N package).

Definition of Terms

Accuracy: The difference between the observed threshold voltage and the ideal threshold voltage for each comparator. Specified and tested with 10V across the internal voltage di- vider so that resistor ratio matching error predominates over comparator offset voltage.

Adjust Pin Current: Current flowing out of the reference ad- just pin when the reference amplifier is in the linear region.

Comparator Gain: The ratio of the change in output current (I_{LED}) to the change in input voltage (V_{IN}) required to pro- duce it for a comparator in the linear region.

Dropout Voltage: The voltage measured at the current source outputs required to make the output current fall by 10%.

Input Bias Current: Current flowing out of the signal input when the input buffer is in the linear region.

LED Current Regulation: The change in output current over the specified range of LED supply voltage (V_{LED}) as measured at the current source outputs. As the forward volt- age of an LED does not change significantly with a small change in forward current, this is equivalent to changing the voltage at the LED anodes by the same amount.

Line Regulation: The average change in reference output voltage over the specified range of supply voltage (V^+).

Load Regulation: The change in reference output voltage (V_{REF}) over the specified range of load current ($I_{L(REF)}$). **Offset Voltage:** The differential input voltage which must be applied to each comparator to bias the output in the linear re- gion. Most significant error when the voltage across the in- ternal voltage divider is small. Specified and tested with pin

6 voltage (V_{RHI}) equal to pin 4 voltage (V_{RLO}).

Typical Performance Characteristics

Supply Current vs

Temperature