Data Sheet

LED driver ICs and bargraph modules

RS stock numbers LM 3914N 308-174, 3914 module (lin) 304-611, LM 3915 308-865, 3915 module (log) 304-605

RS 3914 and RS 3915 ICs are designed to drive 10 external LED's directly in response to an analogue voltage input. The RS 3914 has a linear relationship between the input voltage and number of LED's illuminated whilst the RS 3915 follows a logarithmic law where each LED represents a 3dB change in input voltage level

3914 and 3915 Bargraph modules house the above ICs in die form on a panel mounting PCB complete with an integral 10 element red LED display. Connections are brought out onto solder pads.

Features

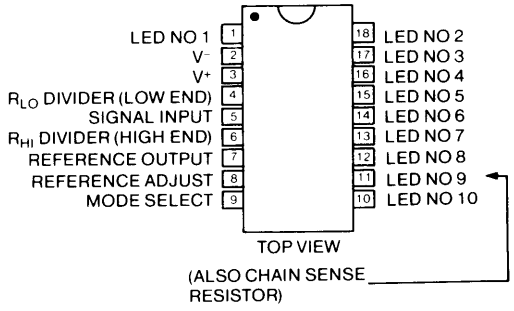
- Bar or dot display externally selectable
- Slow fade on bar or dot display (improves resolution)
- Internal voltage reference from 1.2V to 12V
- Operates with single supply of 3V to 18V
- Inputs operate down to ground
- LED drive current programmable from 2 to 30mA
- No multiplex switching or interaction between outputs
- Input withstands ±35V without damage or false outputs
- LED driver outputs are current regulated, open-collectors (ICs only)
- Outputs can interface with TTL or C-MOS logic (ICs only).

Absolute maximum ratings (Notes 5 and 8)

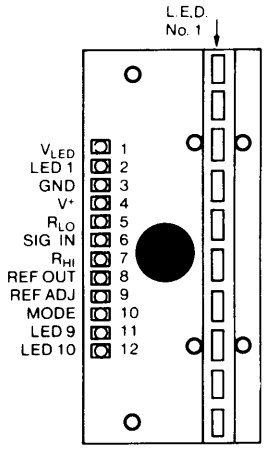
Power dissipation	RS 3914 IC	660mW
	RS 3915 IC	625mW
	3914 module (Note 7)	500mW
	3915 module (Note 7)	500mW
V^+ voltage	ICs	25V
	modules	24V
LED collector output voltage	ICs only	25V
	modules	24V
Voltage on resistor string		–100mV to V^+
Reference load current		10mA
Signal input current (with over voltage applied)		±3mA
Signal input over voltage (Note 6)		±35V
Operating temperature range		0°C to +70°C

Figure 1 **Pin connections**

RS 3914 and 3915 ICs



3914 and 3915 modules



Electrical characteristics

RS 3914 and 3915 IC characteristics

Parameter	Conditions	Min.	Typ.	Max.	Min.	Typ.	Max.	Units
COMPARATORS								
Offset buffer and first comparator	R_{LO} and R_{HI} at 0V and 12V. (Note 2)		3	10		3	10	mV
Offset buffer and any other comparator	R_{LO} and R_{HI} at 0V and 12V (Note 2)		5	15		3	15	mV
Turn ON voltage change	10% to 90% of a 20mA LED Drive		2	6	—	—	—	mV
Input bias current (at Pin 5)			10	50		10	50	nA
Gain (Δ_{LED} / ΔV_{IN})	I_{LREF} = 2mA, I_{LED} = 10mA	—	—	—	3	8		mA/mV
COMPARATOR-VOLTAGE-DIVIDER								
Divider resistance	Total, Pin 6 to 4	6.5	10	15	15	22	30	kΩ
Divider non-linearity	Deviation from straight line through first and last threshold points (Note 3)		0.5	2	—	—	—	%
Relative accuracy (input change between any two Threshold points)	(Note 4)	—	—	—	2.0	3.0	4.0	dB
Absolute accuracy at each threshold point	(Note 4)							
	V_{IN} = –3, –6dB	—	—	—	-0.5		+0.5	dB
	V_{IN} = -9dB	—	—	—	-0.5		+0.65	dB
	V_{IN} = 12, –15, –18dB	—	—	—	-0.5		+1.0	dB
	V_{IN} = –21, –24, –27dB	—	—	—	-0.5		+1.5	dB
VOLTAGE REFERENCE								
Load regulations (ΔVREF)	I_{LREF} = 0.1mA to 4mA at V^+ = 5V and V_{LED} = 5V			2		0.4	2	%
Line regulation	3V≤V^+≤18V		0.01	0.03		0.01	0.03	%/V
Output voltage	1mA Load V^+ = 5V = V_{LED}	1.2	1.25	1.34	1.2	1.25	1.34	V
Output voltage change with temperature	T_A = 0°C to +70°C I_{LREF} = 1mA, V^+ = 5V = V_{LED}		1			1		%
Adjust pin current			75	120		75	120	µA
LED CURRENT REGULATION								
LED current	V^+ and V_{LED} = 5V, I_{LREF} = 1mA	7	10	13	7	10	13	mA
LED current difference (between largest and smallest LED currents)	V_{LED} = 5V, = I_{LED} = 2mA		0.12	0.4		0.12	0.4	mA
	V_{LED}, 5V, I_{LED} = 20mA		1.2	3		1.2	3	mA
Current change with supply	I_{LED} = 2mA 2V≤V^+_{LED}≤17V		0.1	0.25		0.1	0.25	mA
Voltage (as measured at LED cathodes)	I_{LED} = 20mA		1	3		1	3	mA
Current regulation - dropout Voltage (at device pins)	I_{LED} = 20mA at V^+_{LED} = 5V Causing 10% I_{LED} decrease			1.5			1.5	V
Output saturation of LED drive Collectors	I_{LED} = 1.6mA I_{LREF} = 0.32mA		0.25	0.4	—	—	—	V
Ditto	I_{LED} = 2.0mA, I_{LREF} = 0.4mA	—	—	—		0.15	0.4	V

RS 3914 and 3915 module characteristics

(Other electrical characteristics not stated here are as per the respective IC characteristic)
(Notes 7 and 9)

Parameter		Conditions	Min.	Typ.	Max.	Units
LED segment intensity		V+ 12.0V, V_{LED} = 4.5V IL_{REF} = 1.0mA	0.10	0.20		mcd
LED intensity matching (all segments on)		V_{IN} ≥ 10V, V+ = 12.0V. V_{LED} = 3.0V IL_{REF} = 1.0mA		±33		%
LED current/segment		V+ = 12.0V, V_{LED} = 4.5V IL_{REF} = 1.0mA		10		mA
Peak wavelength	Red LED			660		nm
	Green LED			565		nm
Voltage reference output		0.10mA≤IL_{REF}≤4.0mA V+ = 12.0V, V_{LED} = 4.5V	1.2	1.25	1.34	V
Signal input bias current				10	100	nA
Supply current (V+ lead)		V+ = 5V to 20V IL_{REF} = 1.0mA		6	10	mA
Absolute accuracy at each threshold point	3914 module	Deviation from straight line through first and last threshold point (Note 3)	-5		5	%
	3915 module	V_{IN} = -3 to -18dB (Note 4)	-1		1.5	dB
		V_{IN} = -21 to -27dB (Note 4)	-2		2	dB

Comparator threshold switching voltages

RS 3914 IC and module (Note 4)

	VOLTS		
LED output	Min.	Typ.	Max.
1	0.980	1	1.020
2	1.960	2	2.040
3	2.940	3	3.060
4	3.920	4	4.080
5	4.900	5	5.100
6	5.880	6	6.120
7	6.860	7	7.140
8	7.840	8	8.160
9	8.820	9	9.180
10	9.800	10	10.200

RS 3915 IC and module (Note 4)

		VOLTS		
LED output	dB	Min.	Typ.	Max.
1	–27	0.422	0.447	0.531
2	–24	0.596	0.631	0.750
3	–21	0.841	0.891	1.059
4	–18	1.189	1.259	1.413
5	–15	1.679	1.778	1.995
6	–12	2.372	2.512	2.819
7	–9	3.350	3.548	3.825
8	–6	4.732	5.012	5.309
9	–3	6.683	7.079	7.498
10	0	9.985	10	10.015

Typical resistor string values

(Figures 2 and 3)

Resistor	NSM3914	NSM3915
R1	1.00k	1.0k
R2	1.00k	0.41k
R3	1.00k	0.59k
R4	1.00k	0.83k
R5	1.00k	1.17k
R6	1.00k	1.66k
R7	1.00k	2.34k
R8	1.00k	3.31k
R9	1.00k	4.69k
R10	1.00k	6.63k
Total	10k	22.6k

Notes:

1. Unless otherwise stated, all characteristics apply with the following conditions to **RS** 3914 and **RS** 3915 ICs.

T_A = 25°C	$-0.15V \le R_{LO} \le 12V_{DC}$
$I_{L(REF)}$ = 0.2 mA (For higher power conditions, pulse testing is used)	$0V \le V_{IN} \le (V^+ - 1.5V)$
	$V_{REF}, V_{RHI}, V_{RLO} \le (V^+ - 1.5V)$
	$3V_{DC} \le V^+ \le 18V_{DC}$ (RS 3914)
Pin 9 connected to pin 3 (bar mode)	$3V_{DC} \le V^+ \le 20V_{DC}$ (RS 3915)
	$3VDC \le VLED \le V^+$
	$-0.015 \le V_{RHI} \le 12\ V_{DC}$

2. **RS** 3914 and **RS** 3915 comparator threshold is measured when the first 1mA flows in the associated LED output pin. When measuring 'overlap' a LED is considered to be extinguishing when its current falls below 1 mA.
3. **RS** 3914 IC and module divider non-linearity is measured with R_{LO} at 0.000 V, and R_{HI} at 10.000 V_{DC}. (At lower divider voltages, buffer and comparator offset voltages add significant error.)
4. **RS** 3915 IC and module accuracy is measured referred to 0dB = + 10.000 V_{DC} at signal input, with +10.000 V_{DC} at RHI, and 0.000 V_{DC} at R_{LO}. (At lower full scale voltages, buffer and comparator offset voltage may add significant error.) See table for threshold voltages.
5. For **RS** 3914 and 3915 ICs only. Although the following situations will not lead to circuit damage, they can result in *incorrect operation*: (a) LED No. 9 (pin 11) collector voltage exceeding V+ voltage on pin 3, or becoming more than 14V below applied V^+, (additionally being limited to less than 200mV below V^-); (b) signal and comparator voltage-divider becoming higher than the limits of Note 1, above: (c) reference load capacitance above 47nF; (d) reference current loading above 5mA.
6. The addition of a 39k resistor in series with pin 5 allows ±100V signals without damage.
7. Unless otherwise stated these values apply with the following conditions, V^+ (supply) 3V to 20V. Input signal range 0.015V to V^+ –1.5V with a maximum of 12V_{DC}. (Comparator divider voltages, same limits.) T_A = 25°C. Reference load current, 80µA minimum.
8. For **RS** 3914 and 3915 modules only. Driver dissipation is given by $P_{DR} = (V_{LED} - 1.7\ V)\ I_{LED}$ (Total) + ($V^+ \times$ 10mA), where V_{LED} is the LED supply voltage. 1.7V is the nominal individual LED voltage drop, and 10mA is the maximum current of the V^+ supply.
9. The following situations can lead to incorrect operation (a) V_{LED} exceeding V^+ or more than 14V below V^+; (b) signal and comparator voltage divider becoming higher than the limits of Note 8; (c) reference load capacitance above 47nF; (d) reference current loading above 5mA.

Functional description

The block diagrams in Figures 2 and 3 illustrate the simplest circuit configuration for the modules and ICs respectively.

A positive signal applied to the signal input pin is fed to a high input-impedance buffer. The buffer output signal is presented to a series of 10 comparators, each of which is biased to a different threshold voltage level by the resistor divider network R1 to R10.

Figure 2 Block diagram of **RS** 3914 and 3915 modules

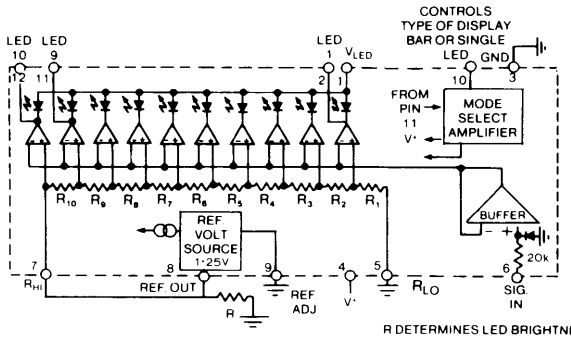
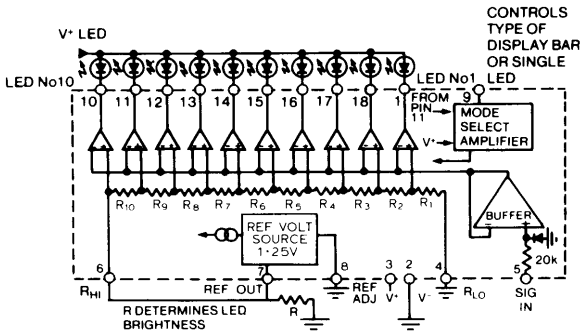


Figure 3 Block diagram of **RS** 3914 and **RS** 3915 ICs



Resistor divider network

In the block diagram the high end R_{HI} of the resistor string is connected to the internal 1.25V reference voltage. In the case of the **RS** 3914, for each 125mV that the input signal increases, a comparator will switch on another indicating LED, similarly for the nonlinear **RS** 3915 this resistor divider network can be connected between any 2 voltages, providing that they are 1.5V below V+ and no less than V–.

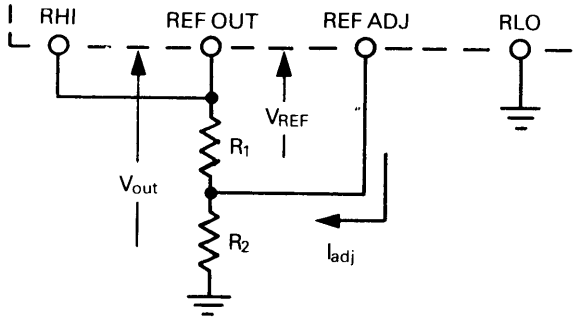
Internal voltage reference

The internal voltage reference may be used to impress a fixed voltage across the resistor divider network.

The reference is designed to be adjustable and develops a nominal 1.25V between REF OUT and REF ADJ. The reference voltage V_{ref} is impressed across programme resistor R_1 and since the voltage is constant, a constant current then flows through the outputs set resistor R_2 giving an output voltage of:

$$V_{OUT} = V_{ref}(1 + R_2/R_1) + I_{adj}R_2$$

Figure 4 Internal voltage reference



The 120µA current (max.) I_{adj} from the reference adjust pin represents an error term, the reference was designed to minimise changes of this current with V+ and load changes. For correct operation, reference load current should be between 80µA and 5mA. (Load capacitance should be less than 47nF.)

Current programming

A feature not completely illustrated by the schematic diagram is the LED brightness control. The current drawn out of the reference output determines the LED current. Approximately ten times this current will be drawn through each illuminated LED, and this current will be relatively constant despite supply voltage and temperature changes. Current drawn by the external current and voltage setting divider, as well as the internal 10-step resistor network, should be included in calculating the LED drive current.

Mode selection

The mode select input pin is used to control the bar and dot modes of operation. It is also employed in display control of multiple chaining of ICs and modules (see below).

Bargraph display

Wire mode select pin directly to V+ pin. (The bargraph display is selected if mode select pin is within 20mV of V+.)

Dot display

Leave the mode select pin open circuit.

Dot display, 20 or more LEDs

Connect Mode Select pin of the first driver in the series (ie. the one with the lowest input voltage comparison points) to LED No. 1 of the next highest IC or module. Continue connecting the Mode Select pin of the lower input drivers to LED No. 1 of the next highest drivers for 30, 40 or more LED displays. The last bar driver in the chain may have the Mode Select pin connected to pin 11, or left open circuit. All previous drivers should have a 20kΩ resistor in parallel with LED No.9.

In order for the display to make sense when multiple devices are cascaded in dot mode, special circuitry has been included to shut off LED No. 10 of the first device when LED No. 1 of the second device comes on. The connection for cascading in dot mode is depicted in Figures 11 and 12 (shown for 3915 IC and module).

As long as the input signal voltage is below the threshold of the second driver IC LED No. 11 is off. The Mode Select pin of driver No. 1 thus sees effectively an open circuit so the chip is in dot mode. As soon as the input voltage reaches the threshold of LED No. 11, the Mode Select pin of driver No. 1 is depressed by one LED voltage drop (1.5V or more) below V_{LED}. This condition is sensed by a comparator referenced 600mV below V_{LED}. This forces the output low, which shuts off the output transistor, extinguishing LED No. 10.

V_{LED} is sensed via the 20k resistor connected to pin 11. The very small current (less than 100µA) that is diverted from LED No. 9 does not noticeably affect its intensity.

An auxiliary current source at pin 2 keeps at least 100µA flowing through LED No. 11 even is the input voltage rises high enough to extinguish the LED. This ensures that the Mode Select pin of driver No. 1 is held low enough to force LED No. 10 off when any higher LED is illuminated. While 100µA does not normally produce significant LED illumination, it may be noticeable when using high-efficiency LED's in a dark environment. If this is bothersome, the simple cure is to shunt LED No. 11 with a 10k resistor. The 1V drop is more than the 900mV worst case required to hold off LED No. 10 yet small enough that LED No. 11 does not conduct significantly.

Application notes

Three of the most commonly needed precautions when using the Dot/Bar driver ICs are shown in the first application drawing (Figures 5 and 6) showing a 0V to 5V bargraph meter. The most difficult problem occurs when large LED currents are being drawn, especially in bargraph mode. These currents flowing out of the ground pin cause voltage drops in external wiring, and thus errors and oscillations. Bringing the return wires from the signal source, reference ground and bottom of the resistor string (as illustrated) to a single point close to V^- or GND pin is the best solution.

Long wires from the LED supply to the LED anode common rail (3914 and 3915 ICs) or V_{LED} (3914 and 3915 modules) can cause oscillations. Depending on the severity of the problem a 47nF to 2µ2F decoupling capacitor from the LED anode rail to V^- or GND will damp the circuit.

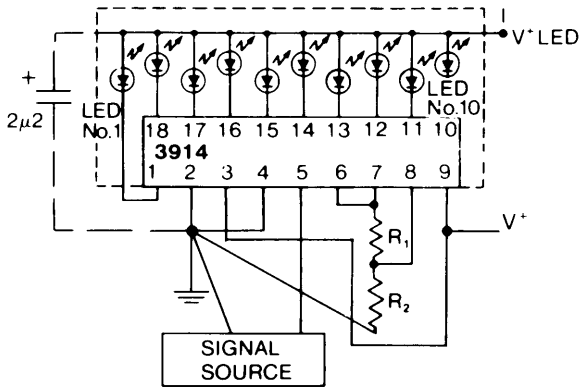
If LED turn-on seems slow (bar mode) or several LED's light (dot mode), oscillations or excessive noise is usually the problem. In cases where proper wiring and by-passing fail to stop oscillations, the V^+ voltage is usually below suggested limits (Note 2, Figures 5 and 6). Expanded scale meter applications may have one or both ends of the internal voltage divider terminated at relatively high value resistors. These high-impedance ends should be by-passed to V^- or GND with at least a 1nF capacitor, or up to 100nF in noisy environments.

Power dissipation, especially in the bar mode should be given consideration. For example, with a 5V supply and all LED's programmed to 20mA, the driver will dissipate more than maximum power rating of both devices. In this case a 7r5 resistor in series with the LED supply will cut device heating by half. The negative end of the resistor should be by-passed to V^- or GND by a 2µ2F solid tantalum capacitor.

Typical applications
RS 3914 IC and module

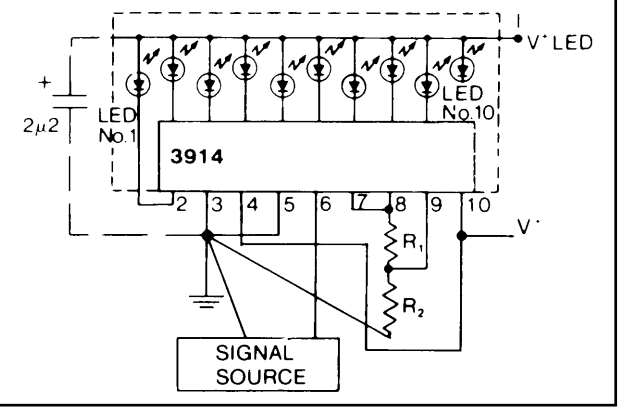
IC pin connections

Figure 5: 0V to 5V bargraph meter



Module pin connections

Figure 6: 0V to 5V bargraph meter



Note 1: Grounding method is typical of all uses. The 2µ2 capacitor is needed if leads to the LED supply are 150mm or longer.

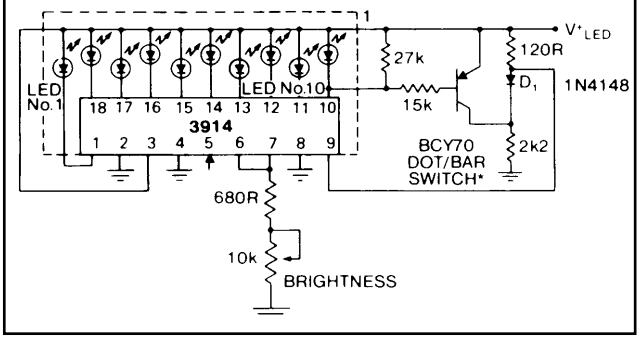
Note 2: Supply voltage V^+ is recommended to be 1.8V above high signal input and 1.5V above V_{Out} for correct operation at 25°C.

$$V_{Out} = 1.25 \left[1 + \frac{R_2}{R_1}\right]$$

$$I_{LED} \triangleq 10\left(\frac{1.25V}{R_1} + \frac{V_{FS}}{R_{DIVIDER}}\right)$$

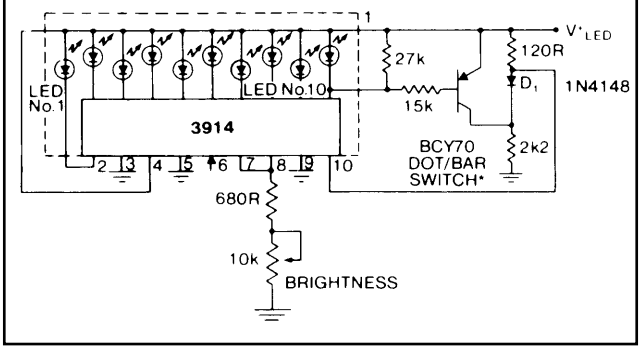
IC pin connections

Figure 7 Indicator and alarm, full scale changes from dot to bar



Module pin connections

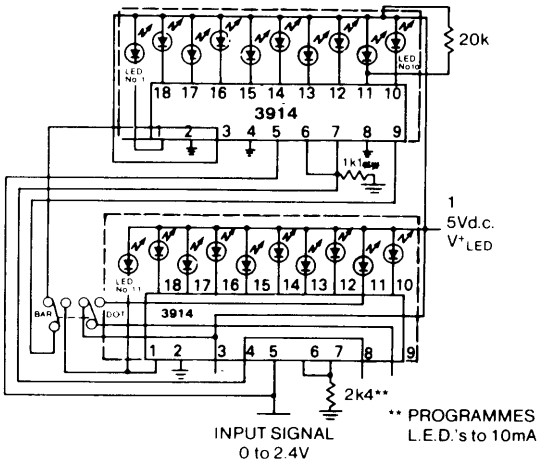
Figure 8 Indicator and alarm, full scale changes from dot to bar



*The input to the Dot/Bar switch may be taken from cathodes of other LED's (LED Nos. 1, 9 or 10 only on module). Display will change to bar as soon as the LED so selected begins to light.

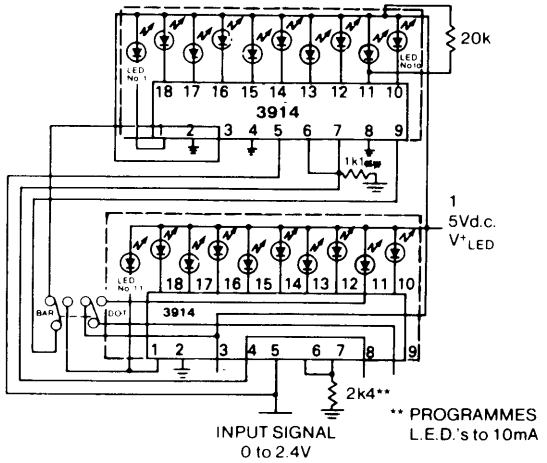
IC pin connections

Figure 9 Segment meter with mode switch



Module pin connections

Figure 10 Segment meter with mode switch



The exact wiring arrangement of this schematic shows the need for Mode Select pin to sense the V^+ voltage exactly as it appears on V^+ pin.

RS 3915 IC and module

The device, used in the circuits described previously could be directly substituted by the 3915 IC or module to give dB meter indication.

The following circuits are specifically intended for the 3915 type parts.

In order to display signals of 60 or 90dB dynamic range multiple devices can be cascaded.

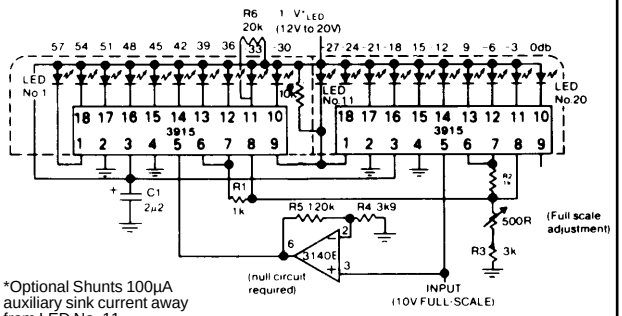
One approach would be to set the reference voltage of the two drivers 30dB apart. The disadvantage of this method is that in many applications the threshold level of LED No. 1 could be comparable to the offset voltage of the driver, hence poor accuracy on the lower scale range would result.

A better approach shown in Figure 8 is to keep the reference at 10V for both devices and amplify the input signal to the lower device by 30dB. Since two 2% resistors can set the amplifier gain within 0.35dB, a gain trim is unnecessary. However, an op amp offset voltage of 5mV will shift the first LED threshold as much as 4dB, so that an offset trim may be required. Alternatively, instead of amplifying, input signals of sufficient amplitude can be fed directly to drive the second device.

To extend this approach to get a 90dB display, another 30dB amplification must be placed in the signal path, ahead of the lowest part. Extreme care is required as the lowest driver displays input signals down to 0.5mV. Several offset nulls may be required. High currents should not share the same path as the low level signal. Also power line wiring should be kept away from signal lines.

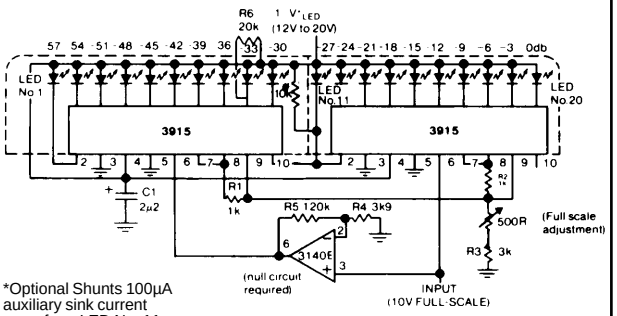
IC pin connections

Figure 11 60dB dot mode display



Module pin connections

Figure 12 60dB dot mode display

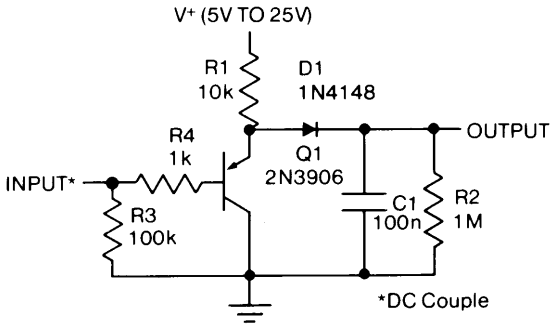


ac signal inputs

The simplest way to display an ac signal using the 3915 IC or module is to apply it directly to the signal input pin unrectified. Since the LED illuminated represents the instantaneous value of the ac waveform, one can readily discern both peak and average values of audio signals in this manner. The device will respond to positive half-cycles only but will not be damaged by signals up to ±35V or up to ±100V, (if a 39k resistor is in series with the input). It is recommended to use dot mode and to run the LEDs at 30mA for high enough average intensity.

True average or peak detection required rectification. If an IC or module is set up with 10V full scale across its voltage divider, the turn-on point for the first LED is only 450mV. A simple silicon diode rectifier will not work well at the low end due to the 600mV diode threshold. The half-wave peak detector in Figure 9 uses a PNP emitter-follower in front of the diode. Now, the transistor's base-emitter voltage cancels out the diode offset, within above 100mV. This approach is usually satisfactory when a single device is used for a 30dB display.

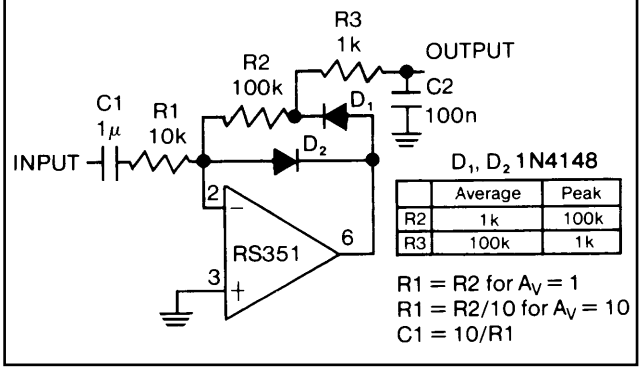
Figure 13 Half-wave peak detector



Display circuits using two or more ICs or modules for a dynamic range of 60dB or greater require more accurate detection. In the precision half-wave rectifier of Figure 14 the effective diode offset is reduced by a factor equal to the open-loop gain of the op amp. Filter capacitor C2 charges through R3 and discharges through R2 and R3, so that appropriate selection of these values results in either a peak or an average detector. The circuit has a gain equal to R2/R1.

It is best to capacitively couple the input. Audio sources frequently have a small dc offset that can cause significant error at the low end of the log display. Op amps that slew quickly, such as the RS 351, or RS 353, are needed to faithfully respond to sudden transients. It may be necessary to trim out the op amp dc offset voltage to accurately cover a 60dB range. Best results are obtained if the circuit is adjusted for the correct output when a low-level ac signal (10 to 20mV) is applied, rather than adjusting for zero output with zero input.

Figure 14 Precision half-wave rectifier



	Average	Peak
R2	1k	100k
R3	100k	1k

For precision full-wave averaging use the circuit in Figure 15. Using 2% resistors for R1 through R4, gain for positive and negative signal differs by only 1dB worst case. Substituting 5% resistors increases this to 2dB worst case. (A 2dB gain difference means that the display may have a ±1dB error when the input is a non-symmetrical transient.) The averaging time constant is R5-C2. A simple modification results in the precision full-wave peak detector of Figure 16. Since the filter capacitor is not buffered, this circuit can drive only high impedance loads such as the input of a 3915 IC or module.

Figure 15 Precision full-wave average detector

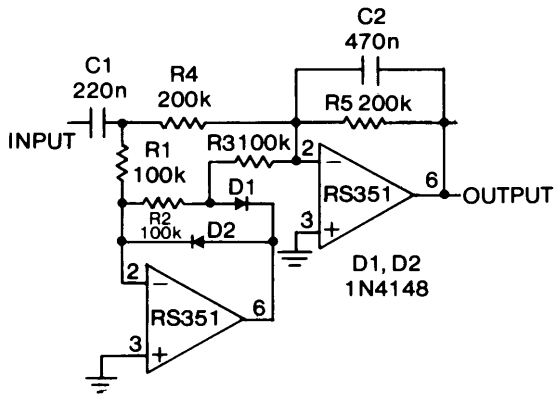
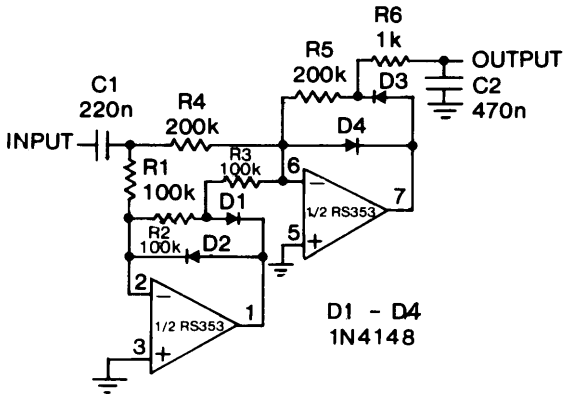
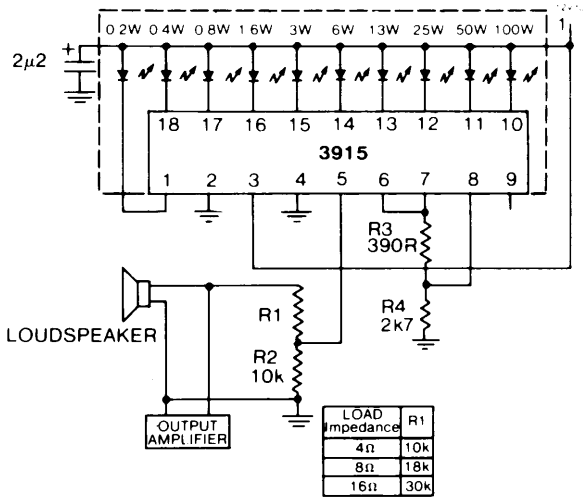


Figure 16 Precision full-wave peak detector



IC pin connections

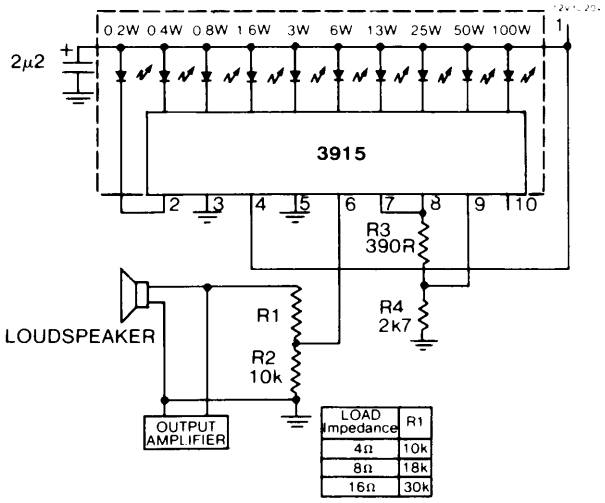
Figure 17 Audio power meter



See earlier for optional Peak or average Detector

Module pin connections

Figure 18 Audio power meter



See earlier for optional Peak or Average Detector

Figures 17 and 18 show an audio power meter employing wether the RS 3915 IC or modules suitable for power measurement from 0.2W to 100W for speaker loads of 4, 8 or 16Ω.