VU/Peak Meter with LCD bargraphs

Use it as a recording level indicator or simply as a signal level display

This easy-to-build bargraph VU meter makes it easy to record audio signals at the correct level. It shows both the average signal and peak levels in stereo on an LCD, and you can adjust both the display range and number of steps. A digital display option is also available.

By JOHN CLARKE

IF YOU ARE SERIOUS about making quality recordings, then you need to accurately monitor the audio signal level being fed into the recording device. This is to ensure that the signal level is within a range that the recorder can accept.

In particular, correct audio signal levels are quite important for modern digital recorders. These do not tolerate any amount of excess signal level and will severely distort such signals.

Dynamic range

Any audio signal, be it speech or music, varies constantly in level, and the difference between the highest and lowest levels is called the 'dynamic range'.

When recording, it's important that the lowest signal levels must be sufficiently above the 'noise floor' of the recording equipment, to prevent them from being buried in noise. On the other hand, the highest signal levels must be kept low enough to prevent signal overload and the inevitable distortion that accompanies this.

Ensuring that an audio signal stays within these bounds can be quite difficult unless its level is accurately monitored using a meter. This meter must respond not only to the average signal level, but also to peak levels as well.

Fig.1 illustrates why it is so important to get the signal levels correct. Note that each waveform shown is not the audio signal itself, but the instantaneous signal level plotted against time. These signal level variations occur constantly in music and speech. In music, for example, the

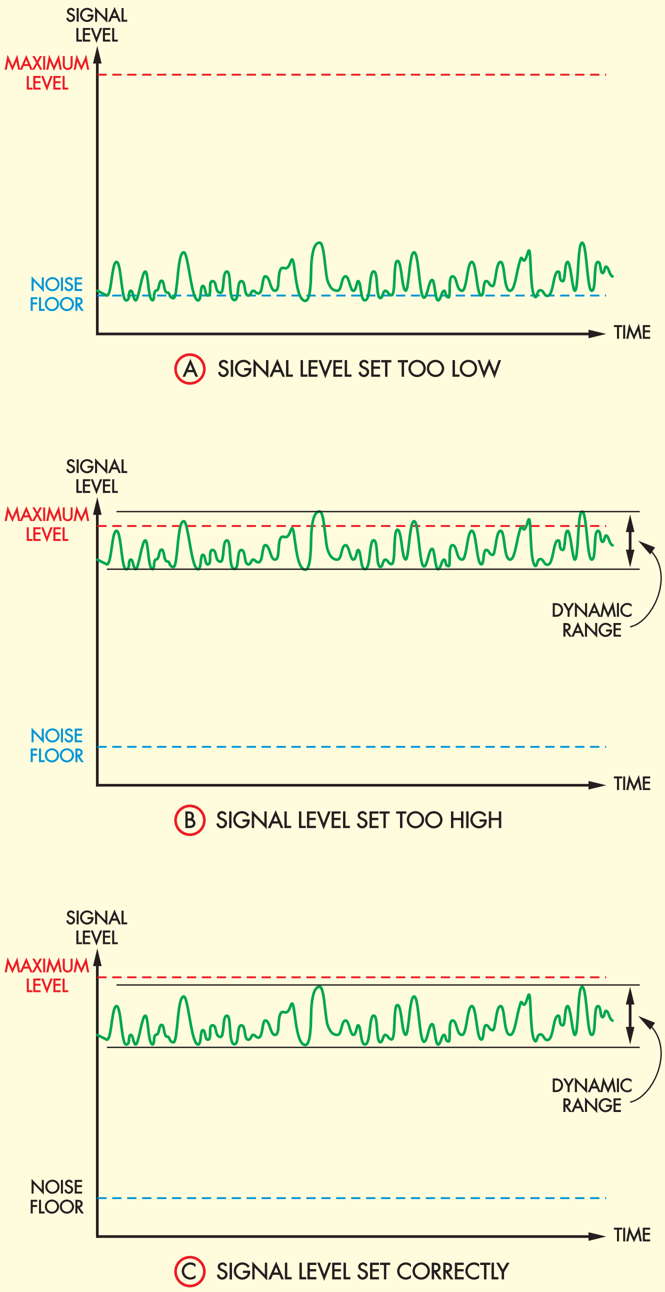


Fig.1: this diagram shows why it is important to set the correct signal level for recording. In A, the average signal level has been set too low, resulting in lots of background noise. In B, the level is too high and the recording system will overload and distort. Diagram C shows the correct level – ie, well above the noise floor but with the peaks below the maximum recording level.

level may range from soft passages to quite loud passages.

Fig.1(a) shows an example of a recording that's been made with the signal level set too low. What happens here is that lowest signal levels are lost within the noise and so only noise signals will be heard at these levels. The higher signal levels are above the noise floor, but the overall sound quality will be rather poor, with lots of background noise.

Conversely, Fig.1(b) shows what happens if the average signal level is too high. Here, the upper levels go above the maximum level that the recording device can handle without distortion.

For magnetic tape recording, some degree of signal peaking above the maximum level can be tolerated. That's because magnetic tape compresses the signal rather than severely clipping it. However, as previously indicated, this is not true for digital recordings, where any signal that goes above the maximum is simply clipped.

The ideal recording level is shown in Fig.1(c). This is where the signal levels are well above the noise floor but do not exceed the maximum level. By doing this, we ensure both low distortion and the best possible signal-to-noise ratio.

VU meter

In the past, audio signal levels were commonly measured using a 'Volume Unit' or VU meter. In fact, these have been used since broadcasting began, and are still widely used by the recording industry.

In practice, a VU meter displays the average signal level and is calibrated to show the true RMS value for a sine-wave signal. The true RMS value is simply the DC equivalent value of the AC waveform.

One drawback of conventional VU meters is that they are rather slow to react to signal variations. Typically, they take some 300ms to respond fully to a signal, and this means that they are unable to respond to the fast transients that often occur in speech and music.

As a result, many modern VU meters also include 'peak displays' that show the levels of any sudden transients. However, they only show transients that are sustained for a defined time and this assumes that any short duration transients that are clipped are inaudible.

VU/Peak meter

The unit described here falls into the latter category. It includes stereo (left and right channel) VU and peak level displays and employs an LCD readout (rather than a conventional meter) for a fast response.

As shown in the photos, the meter is housed in a small plastic utility case with a clear lid. It includes four RCA phono sockets (two input and two output) so that you can connect the unit in-line between the signal source and the recorder.

Both the Stereo VU/Peak Meter and the recorder must be set up so that the meter indicates the correct levels for recording. In practice, this means that the level control on the recorder is fixed in position. Any

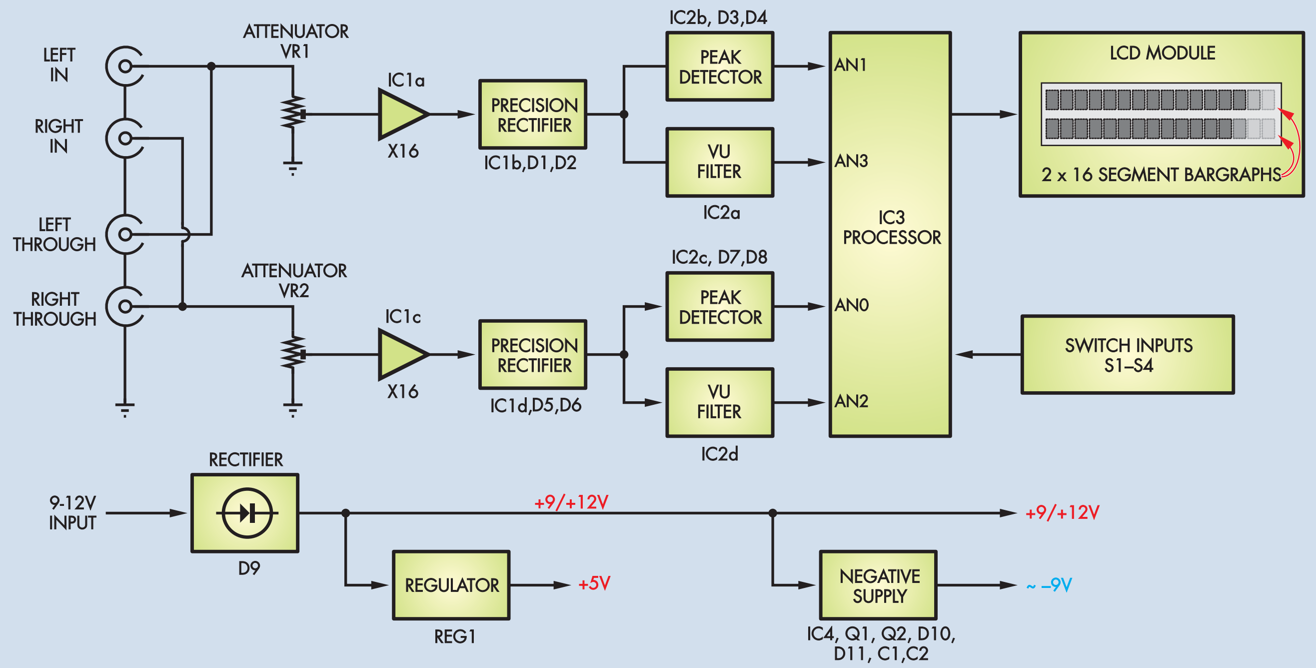


Fig.2: the block diagram of the digital Stereo VU/Peak Meter. The incoming signals are first amplified by IC1a and IC1c and then fed to precision rectifier stages. From there, they go to the peak detector and VU filter (averaging) stages before being fed to microcontroller IC3. IC3 converts the analogue peak and VU signal levels to digital values and drives the LCD module.

level changes are then made at the signal source – ie, prior to the VU meter – so that both the VU meter and recorder receive the same signal level.

Alternatively, the VU/Peak Meter could be installed within the recorder itself and the signal for it derived after the recorder's level control.

The LCD readout used consists of two 16-block bargraphs (one for each channel). These bargraphs are used here for VU indication and increase in length to the right with increasing signal level.

Main Features

- Stereo bargraph with VU and peak displays
- 15-segment bargraph for each channel
- Adjustable thresholds for each segment
- Signal level adjustment for calibration
- Digital display option
- Programmable VU and peak display options
- 9V to 12V DC power supply

A vertical thin line that travels ahead of each VU bargraph indicates the peak level for that channel.

Display options

As well as the bargraphs, there are several display options to choose from (ain't microcontrollers grand!).

These display options include choosing between either full 15-block bargraphs or 10-block bargraphs with digital readouts in the first six block positions. In each case, the display indicates the channel, with the top bargraph having an 'L' (left) and the lower bargraph an 'R' (right).

The initial pre-programmed settings are for a traditional VU meter covering the range from –28dB to +3dB as follows: –28dB, –25dB, –22dB, –19dB, –16dB, –13dB, –10dB, –7dB, –5dB, –3dB, –2dB, –1dB, 0dB, +1dB, +2dB and +3dB. These settings are the same for both channels. Note, however, that the –28dB block is not indicated because the 'L' and 'R' channel designations are shown here instead.

In addition, this programmed location is used when the digital format display option is selected.

The use of a microcontroller also makes it possible to change the bargraph settings to cover a wider or narrower range. In practice, each block position can be set from between –48dB through to a maximum of +16dB.

Note, however, that the overall range should be 48dB. This means that if the uppermost block in the bar is set at +16dB, the lowermost block should be set to a minimum of –32dB.

When used with a digital recorder, the uppermost bar should be set at 0dB. This would be the absolute maximum level that the digital recorder can handle before clipping.

Mode switch

Pressing the Mode switch for the first time changes the display to show the far lefthand block on the top line and the 'SET VALUE' (eg, –28dB) on the second line. Basically, the block on the top line shows the bargraph position that has the indicated set value.

Pressing the Mode switch again causes the display to show the next block in the bargraph and its value. This step can then be repeated, with each subsequent pressing of the Mode switch showing the next block in the bargraph (and its value).

The displayed values can be changed using the Up and Down switches, which are located behind the front panel. Note that it is important that these values are set to increase in value from left to right. So a sequence of –22, –19, –16, etc is correct but –22, –23, –24 is incorrect.

Specifications

Display graph: 15-block bargraph or 10-block bargraph with digital display

Display range: 48dB (0 to –48dB) or value variations from +16dB maximum to –32dB

Signal levels: requires 440mV RMS to over-range on VU scale

Accuracy: within 1dB for signals above –40dB

Display resolution selectable to a minimum of 1dB

Input impedance: 100kΩ

Supply voltage: 9V to 15V DC maximum.

Supply current: 108mA with backlit display; 68mA with non-backlit display

Options switch

The Options switch invokes the various display selections. These can be toggled using the Up and Down switches to select one of the following display options:
(1) Bar, VU On, Peak On
(2) Bar, VU Off, Peak On
(3) Bar, VU On, Peak Off
(4) Digital and Bar, VU On, Peak On
(5) Digital and Bar, VU Off, Peak On
(6) Digital and Bar, VU On, Peak Off

This means that you can select the full 15-block bargraph with both the peak and VU displays shown, or you can have either peak or VU only shown. Similarly, you could choose the digital display for the first six blocks (DIGITAL selection) and then choose to show either the VU or peak readings, or both.

Note that when the DIGITAL selection is made, the digital reading will show the VU value unless the Peak display only is selected. If Peak only is selected, then the Digital display shows the peak readings.

As indicated above, the DIGITAL display uses 'L' and 'R' designations to indicate the left and right channel bargraphs. The digital values that are displayed will only be in steps of the actual programmed values for each block in the bargraph.

The digital display indicates these values (and the 'L' and 'R' designations) within the first six blocks of the displays (ie, the bargraphs no longer occupy these first six blocks). However, if the signal goes below the minimum block setting, then the digital display will show blanks instead of the numbers.

Once the display mode and other settings have been entered, the setup is saved simply by switching the power off and on again.

Block diagram

Refer now to Fig.2 for a block diagram of the Stereo VU/Peak Meter.

As shown, both the Left In and Left Through sockets are paralleled, as are the Right In and Right Through sockets. This allows the audio source signals to be fed into the VU meter and also fed straight back out to the recording device.

Following the L and R input sockets, the audio signal is fed to trimpots VR1 and VR2, which act as level attenuators. The left and right channel signals are then amplified by op amps IC1a and IC1c, which operate with gains of 16. From there, the signals are then precision rectified and fed to the peak detector and VU filter stages.

The outputs from these stages are fed to the AN0 to AN3 inputs of microcontroller IC3. This processes the input signal levels and drives the LCD module according to the settings and values entered using switches S1 to S4.

In operation, IC3 converts the analogue voltages from the peak detector and VU stages to digital values ranging from 1 to 1024. A value of 1024 represents the maximum analogue signal level, which is 5V.

Normally, the unit is set up so that the far righthand block of the bargraph turns on when signal value goes above 1024. This is set to occur when the righthand block is set at 0dB or higher. However, if the far righthand block is set at a minus dB value, then the signal value is reduced to coincide with that dB setting.

The remaining blocks in the bargraph are then calculated to show the lower signal levels. For example, a signal that is at –6dB (or half the 0dB signal level) will have a digital value of 1024/2 or 512 when converted by IC3. Similarly, a –12dB signal will have a digital value of 256. And a signal that is 48dB below the 1024 maximum level will have a digital value of 4 (ie, 251 times less).

These values are all calculated using the following equation:

Attenuation (dB) = 20log(the signal ratio)

For example, if the signal level is half the maximum, then the log of this is –0.3 and 20 times this is –6dB.

Note that IC3 only indirectly uses this equation because it uses a look-up table that already has the values programmed into it.

Power source

Power for the meter comes from an external 9V to 12V DC supply and this is fed in via reverse polarity protection diode D9. The resulting 9V to 12V rail, together with a –9V rail generated by the 'negative supply' block, is used to power the op amps that form the input amplifiers, precision rectifiers, peak detectors and VU filters.

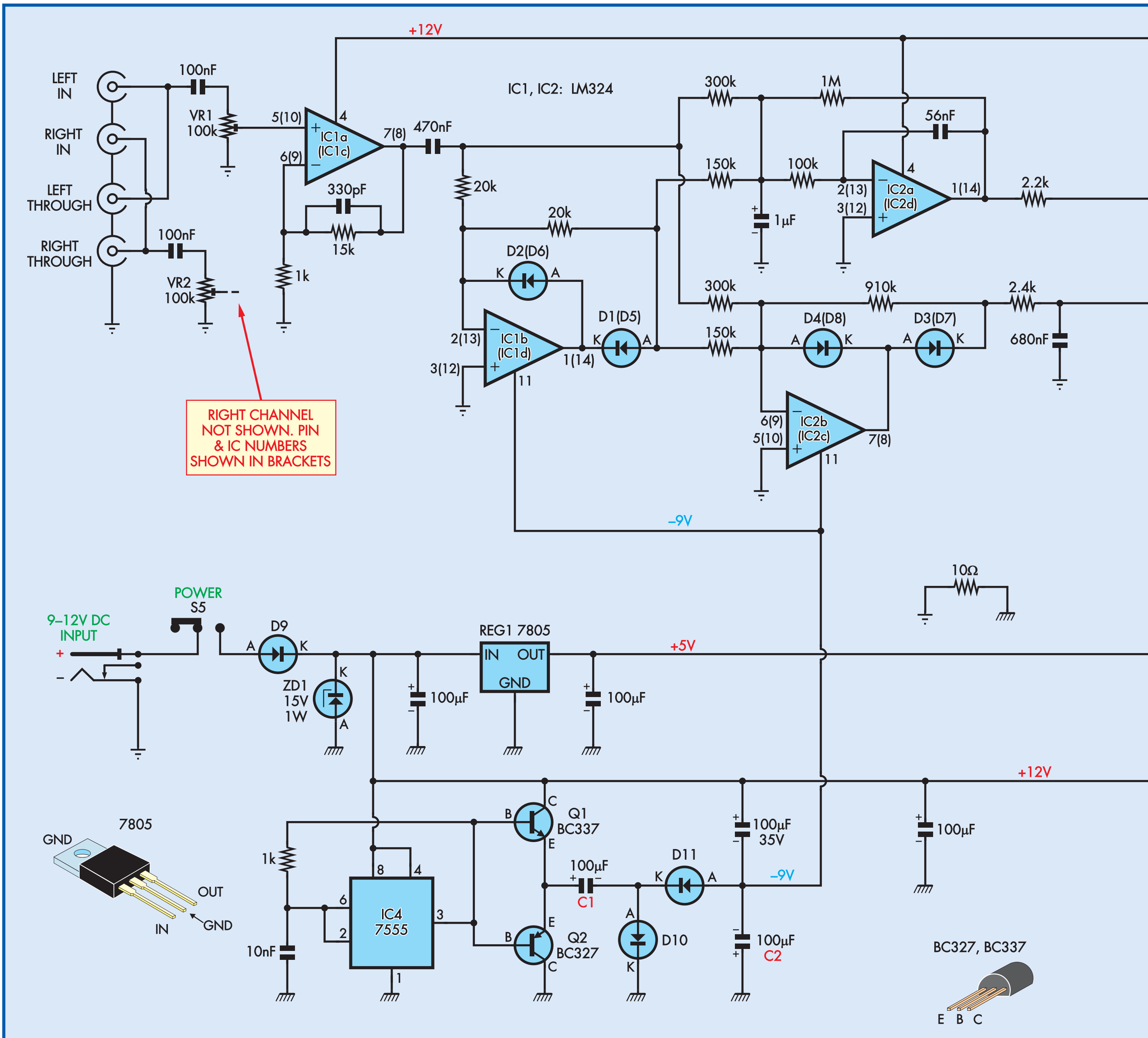
Finally, regulator REG1 produces a +5V rail, which is used to power microcontroller IC3 and the LCD.

Circuit details

Fig.3 shows the Digital Stereo VU/Peak Meter circuit details, but note that only the lefthand channel circuitry before IC3 has been depicted for the sake of clarity. The righthand channel is identical, so we'll describe lefthand channel operation only.

As before, the incoming left-channel audio signal is attenuated via trimpot VR1, which sets the display sensitivity. The signal at the wiper (moving contact) is then applied to op amp IC1a, which operates with a gain of 16 (ie, it amplifies the signal by a factor of 16). This is done to boost the signal level to at least 5V peak-to-peak, so that it is suitable for the following level display circuitry.

IC1a's output is fed via a 470nF capacitor to the full-wave precision rectifier. For the VU signal path, this stage is based on op amp IC1b, diodes D1 and D2 and op amp IC2a. Similarly, for the peak detector, the precision rectifier uses IC1b, D1 and D2 and op amp IC2b. It operates as follows.



DIGITAL STEREO VU/PEAK METER

When the input signal goes positive, pin 1 of IC1b goes low and forward biases diode D1. The resulting gain of the signal appearing at the anode of D1 is –1, as set by the 20kΩ input resistor and 20kΩ feedback resistor.

This inverted signal at D1's anode is applied to the inverting input (pin 2) of IC2a via 150kΩ and 100kΩ resistors. IC2a operates with a gain of –6.66 on this signal, as set by the ratio of the 1MΩ feedback resistor and the 150kΩ input resistor (the 100kΩ resistor in series with the input is inside the feedback loop).

As a result, the overall gain for the signal path between pin 2 of IC1b and pin 1 of IC2a is –1 x –6.66, or +6.66 (ie, IC1b's gain x IC2a's gain).

At the same time, the positive-going signal from IC1a is applied via a second path to IC2a via a 300kΩ resistor. In this case, IC2a operates with a gain of –3.33 due to the ratio of the 1MΩ feedback resistor and the 300kΩ input resistor. Thus, the overall signal gain at the output of IC2a is 6.66 – 3.33 = 3.33.

Now let's consider what happens when IC1a's output swings negative. When this occurs, diode D2 is forward biased and so IC1b's output is clamped at 0.6V above the pin 2 input signal and no signal flows through D1. IC1b is therefore effectively taken out of circuit and IC2a now simply amplifies the signal from IC1a (applied via the 300kΩ resistor) on its own.

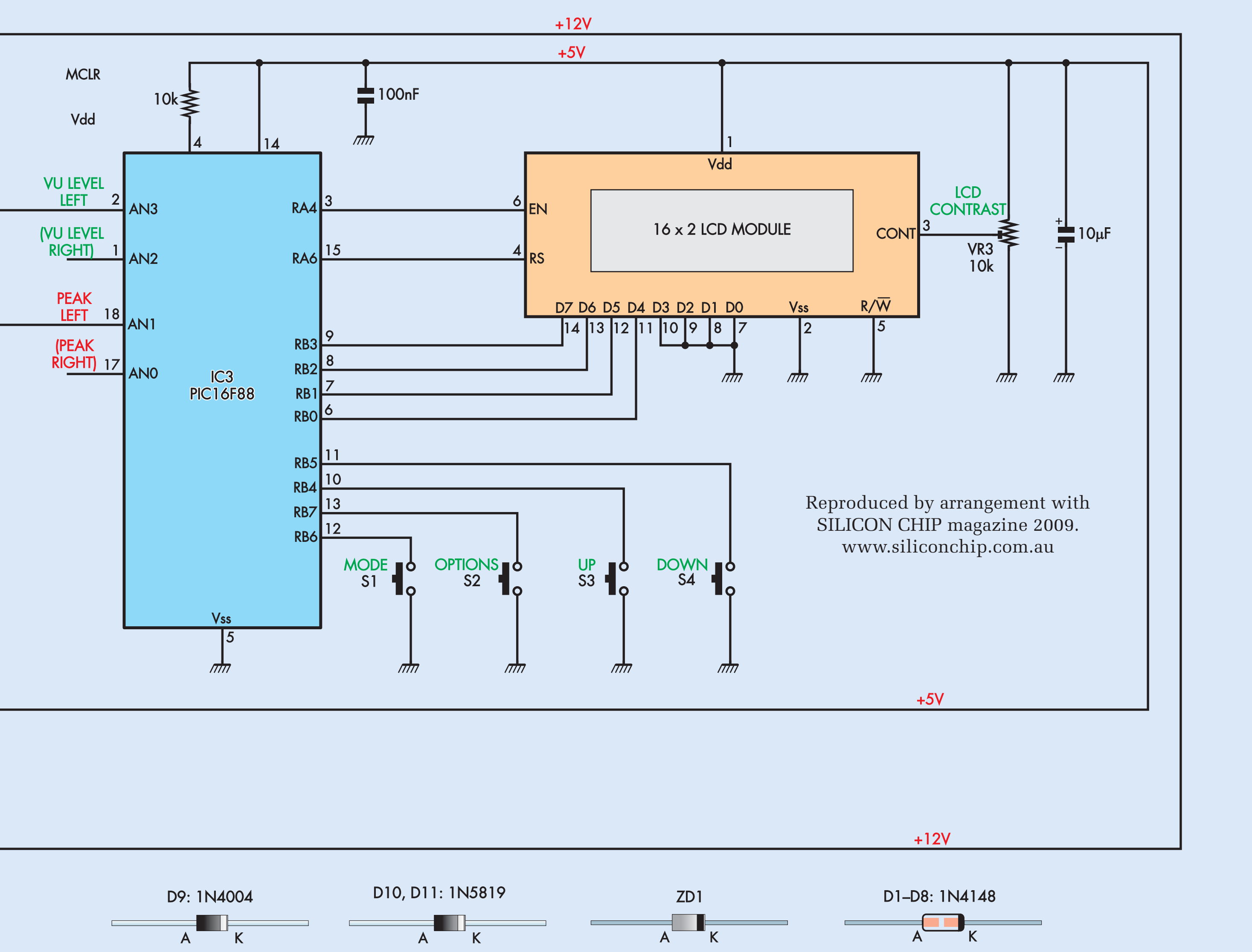


Fig.3: the parts shown in this circuit diagram can be directly related to the block diagram shown in Fig.1. Note that only the lefthand channel circuitry before IC3 has been shown for the sake of clarity – the righthand channel is identical. IC1a is the input amplifier, IC1b, D1, D2 and IC2a form the precision rectifier and VU filter stages; and IC2b, D3 and D4 function as the peak detector. IC4, transistors Q1 and Q2, diodes D10 and D11 and capacitors C1 and C2 make up a diode charge pump, which provides the required –9V rail.

As before, it operates with a gain of –3.33 for this signal path. Since the input signal is negative, the output at pin 1 is positive – ie, it inverts and amplifies the negative input signal.

The precision rectifier therefore provides a positive output with gain of 3.33 for both positive and negative going inputs.

VU response

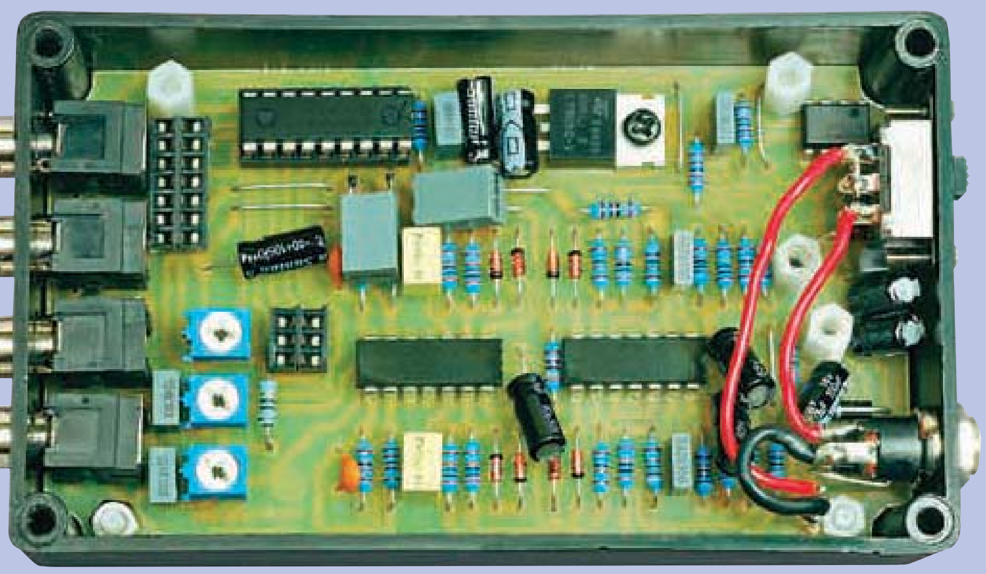
IC2a also provides low-pass filtering of the rectified signal so that its response is relatively slow. This filtering conforms to VU (volume unit) standards, so that the output reaches the input level after 300ms and overshoots by about 1.5%.

The filtering is carried out using the 100kΩ and 1MΩ resistors, the 56nF and 1μF capacitors and the parallel combination of the 300kΩ and 150kΩ input resistors. Together, these provide the 2.1Hz roll-off frequency and a Q (quality factor) of 0.62.

Peak level detector

IC2b and its associated components comprise the peak level detector. This stage is also fed via two signal paths: (1) directly from the output of IC1a via the 470nF capacitor and a 300kΩ resistor; and (2) from diode D1 in the precision rectifier circuitry (and a series 150kΩ resistor).

How this works is again best explained in two steps – ie, when the signal from IC1a swings positive and when the signal swings negative.



The main PC board is secured inside the case using four M3 nylon screws, two tapped nylon spacers and two nylon nuts. Two additional tapped nylon spacers are also fitted to the PC board (centre, right) to support the bottom righthand corner of the LCD module and the righthand end of the switch PC board. Note that the capacitors that go under the LCD module and switch board must be mounted horizontally, to provide the necessary clearance.

As we know from the precision rectifier explanation, when the input signal goes positive, pin 1 of IC1b swings low and forward biases D1. The resulting gain of the signal at the anode of D1 is –1, as set by IC1b's 20kΩ input and 20kΩ feedback resistors.

This amplified signal is applied to pin 6 of IC2b via the 150kΩ resistor. As a result, IC2b's output swings high and forward biases D3. This diode is in series with a 910kΩ resistor in the feedback loop.

The signal at D3's cathode is thus amplified by –910kΩ/150kΩ or –6.066, which means that the output signal is positive and the overall gain from the output of IC1a for this signal path is +6.066 (ie, –1 × –6.066).

For the second signal path (ie, via the 300kΩ resistor), IC2b operates with a gain of –910kΩ/300kΩ or –3.033. This means that the overall gain of the signal from IC1a is 6.066 – 3.033, or +3.033.

When the signal goes negative, D2 is forward biased and IC1b's output is clamped as before. IC2b now operates on its own and amplifies the signal applied to it via the 300kΩ resistor with a gain of –3.033 (ie, –910kΩ/300kΩ).

As a result, IC2b delivers a positive output signal on both positive and negative output signal swings from IC1a. And in both cases, the absolute signal gain is the same at 3.033.

Note that a 910kΩ feedback resistor is used for IC2b instead of a 1MΩ resistor (as used for IC2a in the VU filter). That's because the peak value must be 3dB higher than the VU value.

How The Diode Charge Pump Works

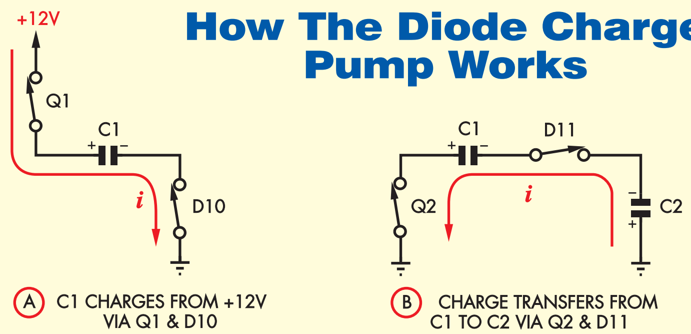


Fig.4: how the diode charge pump works. Capacitor C1 charges towards the +12V rail when transistor Q1 turns on and then transfers its charge to C2 when Q1 switches off and Q2 turns on.

This 3dB figure comes about because the peak of a sinewave is 1.414 times the RMS value (ie, 3dB greater). Another way of saying this is that the RMS value of a sinewave is 0.7071 of the peak value.

In our case, the VU signal is the average level of the full-wave rectified signal, and this is only 0.637 of the input signal's peak level. The 910kΩ resistor is therefore used to provide a peak output that is 0.91 (approximately 0.637/0.7071) of the peak signal, or about 3dB higher than the VU signal.

Diode D4 ensures that IC2b's output does not swing negative by more than about 0.7V, so that its response to signals is not compromised. In normal operation, diode D3 is forward biased and D4 does not conduct. However, when the signal is at 0V, IC2b's output tends to switch positive and negative to maintain control. That is when D4 comes into operation.

The peak signal level at D3's cathode is filtered using a 2.4kΩ resistor and a 680nF capacitor. This filtering slows the peak signal level response so that it is not instantaneous but instead conforms to an audio standard. This ensures that only peaks that are wide enough to be audible are displayed.

The standard we picked is IEC60268-10, which has a 1.7ms response time to peak signals. This means that the measured signal level will be 1dB lower than it otherwise would be for a 10ms signal burst and 4dB lower for a 3ms burst (compared to an instantaneous measurement).

In practice, the 2.4kΩ resistor and the 680nF capacitor in the filter circuit set the time constant at 1.63ms.

The decay time constant specified in the IEC standard is –20dB in 1.5s (equivalent to a 650ms decay time constant). In this circuit, the 910kΩ resistor and the 680nF capacitor set the decay rate at 619ms which is near enough.

Microcontroller

The left-channel VU and peak level signals are respectively applied to analogue inputs AN3 and AN1 of microcontroller IC3. Similarly, the right-channel signals are applied to inputs AN2 and AN0.

Note that the VU input signal is fed via a 2.2kΩ resistor to limit the current flow when IC2a's output goes above 5V. The 2.4kΩ resistor in the output filter circuit for IC2b does the same job.

IC3 is a PIC16F88 microcontroller. It measures the incoming VU and peak signal levels for the left and right channels and drives the 2-line 16-segment LCD module accordingly.

In operation, the signal levels at the AN inputs of the microcontroller are converted to 10-bit digital values using an internal A/D (analogue-to-digital) converter. Outputs RB0 to RB3 then drive the LCD's D4 to D7 data lines, while outputs RA4 and RA6 drive the enable (EN) and register select (RS) lines on the LCD.

Switches S1 to S4 are used to enter data into the microcontroller. Normally, inputs RB4 to RB7 are held high via internal pull-up resistors. Closing a switch pulls the associated input to ground and this is detected and processed by the microcontroller.

IC3 operates at a frequency of 8MHz, as set by an internal oscillator. It is powered from a regulated +5V supply rail, with the reset input at pin 4 tied high via a 10kΩ resistor. The 100nF capacitor and a 100µF filter capacitor provide supply rail decoupling.

The LCD module also runs from the +5V supply rail and a 10µF capacitor decouples its supply. The lower four data lines (D0 to D3) are tied to ground and the LCD module is driven using the upper four bits (D4 to D7). Preset VR3 provides display contrast adjustment.

Software

The software files are available for download via the *EPE* Library site, access via **www.epemag.com**. Pre-programmed PICs are available from Magenta Electronics – see their advert in this issue for contact details.

Power supply

The +5V supply rail for the circuit is derived from a 9V to 12V DC plugpack via diode D9 (which provides reverse polarity protection) and 3-terminal regulator REG1. This regulator has its input and output terminals bypassed using 100µF electrolytic capacitors. Zener diode ZD1 clamps any transients from the plugpack that go above 15V.

The positive supply rail for op amps IC1 and IC2 is derived immediately following D9 (ie, before REG1). This rail is typically 9V to 12V. By contrast, the negative supply rail for these op amps is generated using a diode charge pump. This comprises a 7555 oscillator (IC4), transistors Q1 and Q2 and diodes D10 and D11.

In operation, IC4 oscillates at about 75kHz, with the 10nF capacitor on pin 6 charged and discharged via a 1kΩ resistor connected to the pin 3 output. Pins 2 and 6 are the lower and upper threshold inputs and these monitor the capacitor voltage.

The pin 3 output drives the bases of transistors Q1 and Q2. When pin 3 is high, transistor Q1 switches on

Parts List – Digital Stereo VU/Peak Meter

1 PC board, code 702 (Main), size 116 × 65mm
1 PC board, code 703 (Switch), size 81 × 19mm
(Both boards are available as a set from the *EPE PCB Service*)
1 LCD module with back lighting (Jaycar QP-5516 or equivalent)
1 120 × 70 × 30mm box with clear lid (Jaycar HB-6082 or equivalent)
4 SPST micro tactile switches (S1-S4)
1 DPDT slider switch (S5)
1 8-pin IC socket cut to 2 × 3-way strips
1 14–pin IC socket cut to 2 × 7-way strips
2 14-pin IC sockets for IC1 and IC2 (optional)
1 18-pin IC socket for IC3
4 PC mount right-angle RCA phono sockets
1 20-way DIL header strip
1 2.5mm DC bulkhead socket
4 M3 × 10mm nylon screws
2 M3 × 6mm nylon screws
4 M3 × 6mm screws
1 M3 × 10mm metal screw
4 M3 tapped × 15mm nylon stand-offs (cut to 11mm)
2 M3 nylon nuts
1 M3 metal nut
2 M2 × 8mm screws for S5
2 PC stakes
1 100mm length of red hookup wire
1 50mm length of black hookup wire
1 200mm length of 0.7mm tinned copper wire

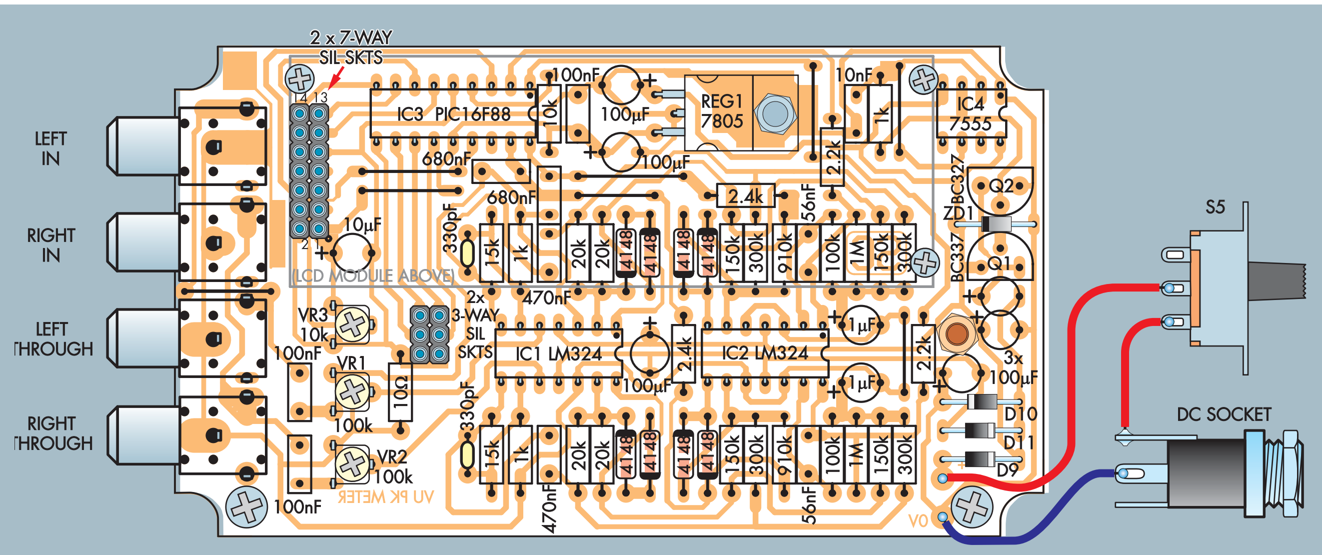
Semiconductors
2 LM324 quad op amps (IC1,IC2)
1 PIC16F88-I/P microcontroller (IC3) programmed with VUPEAK.hex
1 7555 CMOS timer (IC4)
1 LM340T5, 7805 5V regulator (REG1)
1 BC337 *NPN* transistor (Q1)
1 BC327 *PNP* transistor (Q2)
8 1N4148 diodes (D1-D8)
1 IN4004 diode (D9)
2 1N5819 Schottky diodes (D10,D11)
1 15V, 1W Zener diode (ZD1)

Capacitors
1 100mF 35V PC electrolytic
5 100mF 16V PC electrolytic
1 10mF 16V PC electrolytic
2 1mF 16V PC electrolytic
2 680nF MKT polyester
2 470n MKT polyester
3 100n MKT polyester
2 56nF MKT polyester
1 10nF MKT polyester
2 330pF ceramic

Potentiometers
2 100kΩ horizontal trimpots with 2.5mm pin spacing (VR1, VR2) (Code 104)
1 10kΩ horizontal trimpot with 2.5mm pin spacing (VR3) (Code 103)

Resistors (0.25W 1% carbon film)

2 1MΩ	2 15kΩ
2 910kΩ	1 10k
4 300kΩ	2 2.4kΩ
4 150kΩ	2 2.2kΩ
2 100kΩ	3 1kΩ
4 20kΩ	1 10Ω



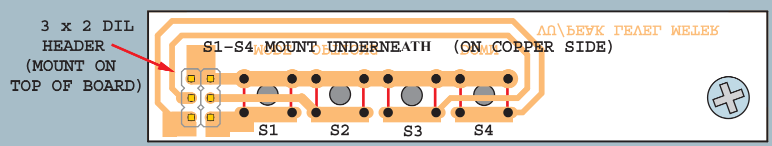


Fig.5: assemble the two PC boards as shown here. Note that most of the capacitors on the main board must be mounted horizontally, so that they don't foul the LCD module and switch PC board when these are installed (see photos).

and Q2 is off. Conversely, when pin 3 is low, transistor Q2 switches on and Q1 turns off.

Basically, the transistors act as current buffers which drive the following voltage converter circuitry without loading IC4's output.

Diodes D10 and D11, along with capacitors C1 and C2 (both 100µF), act as a 'diode charge pump' converter to derive the negative (–9V) supply. Fig.4 shows a more simplified arrangement of how this works.

When transistor Q1 switches on, C1 charges towards the 12V supply rail via diode D10. Subsequently, when Q1 switches off and Q2 turns on, the positive terminal of C1 is connected to ground and the negative side of the capacitor is pulled below ground by an amount equal to the voltage across it.

The 6-way pin header is mounted on the top side of the switch PC board. The four switches are mounted on the track side.

Capacitor C2 now quickly charges towards this negative voltage via diode D11. As a result, it reaches a negative voltage that is close in value to the 12V supply, minus the voltage drops across the diodes and the saturation voltages of transistors Q1 and Q2.

In practice, this is about –9V and this rail is bypassed using another 100µF capacitor (to the positive rail) to minimise the supply impedance.

Note that the diodes used are Schottky types, which have a lower voltage drop than standard diodes. In addition, these diodes are better suited for high-frequency operation and produce less losses at 75kHz.

Construction

The Stereo VU/Peak Level Meter is built on two PC boards – see Fig.5. The main board is coded 702, and carries all the input metering circuitry, the microcontroller and the LCD module, which is connected via a pin header.

The second, smaller board is coded 703, and carries switches S1 to S4 to allow the display values and options to be changed from the preprogrammed settings. Both printed circuit boards are available as a set from the *EPE PCB Service.*

Begin construction by checking the PC board for any faults. These could include bridges between tracks, breaks in the copper and incorrect hole sizes. In addition, make sure that the various mounting holes are all the correct size, including those for the RCA phono sockets.

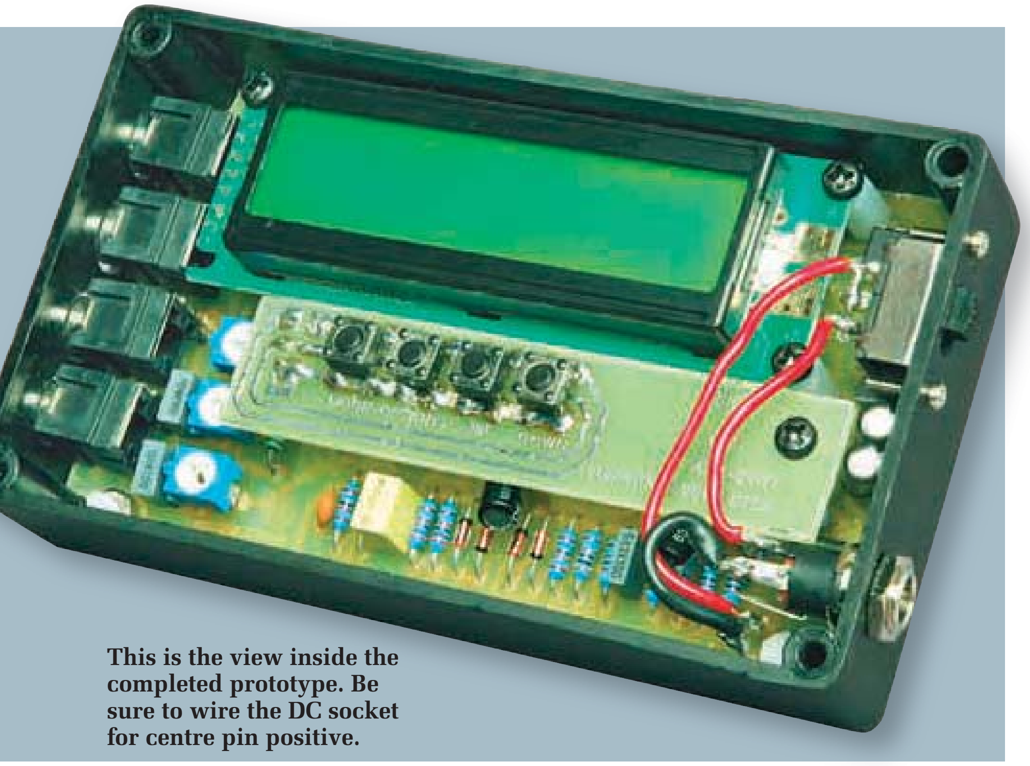
Start the assembly by installing PC stakes at the two supply terminals (ie, the bottom right connections to the DC socket and switch S5), then install the eight wire links. In particular, note the link situated between the two central phono sockets – don't leave it out.

The resistors can go in next. Table 1 shows the resistor colour codes, but you should also use a digital multimeter to confirm their values (some colours can be difficult to decipher).

Next on the list are the diodes. Several different types are used in this circuit, so be careful not to mix them up. Once they're in, transistors Q1 and Q2 can be installed. Note that Q1 is a BC337 (*NPN*), while Q2 is a BC327 (*PNP*) – be sure to install them in their correct locations.

Note also that the tops of the transistors must be no more than 9mm above the PC board, to allow clearance for switch S5 when the unit is mounted inside its case.

Now for regulator REG1. As shown, this is installed flat against the board (just bend its leads down at right angles) and secure its metal tab using an M3 × 10mm metal screw and nut. Be sure to tighten the nut before soldering REG1's leads. Doing this the other



This is the view inside the completed prototype. Be sure to wire the DC socket for centre pin positive.

way around could place undue stress on the soldered joints.

IC1, IC2 and IC4 can now be installed, taking care to ensure they are all correctly oriented (ie, pin 1 at top, right). Note that IC4 is a CMOS device, so observe the usual static precautions (ie, discharge yourself by touching an earthed metal object, avoid touching its pins and earth the barrel of your soldering iron using a clip lead).

An 18-pin socket is used for IC3. Don't plug IC3 in yet, though – that step comes later.

Trimpots VR1, VR2 and VR3 are next on the list. Note that VR3 is 10kΩ (code 103), while VR1 and VR2 are both 100kΩ (code 104). Once they're in, the four RCA phono sockets can be installed.

Installing the capacitors

Take a careful look at the photos before installing the capacitors. In particular, note that all the electrolytic types, except for the two 100µF units just below transistor Q2, must be installed horizontally (ie, laid over on their sides). This is necessary to allow clearance for the LCD module and the switch carrier PC board.

In practice, its just a matter of bending their leads down at right angles before installing them. Make sure they all go in with the correct polarity.

Depending on the brand, it may also be necessary to mount some of the polyester capacitors in this fashion.

Header sockets

The main board assembly can now be completed by installing two 7-way SIL (single-in-line) sockets (for the LCD header) and two 3-way SIL sockets (for the switch board header).

In both cases, these socket strips are made by cutting down IC sockets – ie, a 14-pin IC socket and an 8-pin IC socket, respectively. Use side cutters to split the sockets in half and a file to clean up the edges.

Once these are in, a matching 14-way pin header (which is cut from a 20-way header) can be soldered to the LCD module. Note that this header must be inserted from the underside of the module's PC board and its pins soldered on the top side.

Switch PC board

There's nothing complicated about the switch board, since it carries just switches S1 to S4 and a 6-way pin header. Note however, that the four switches are mounted on the copper side of the board – see photo.

The 6-way header is mounted in the usual manner (ie, it is installed on the non-copper topside of the board).

Testing

The unit is now ready for testing, before final assembly into its case. This should be done without microcontroller IC3 in place and with the LCD module unplugged.

First, temporarily wire a DC socket to the +12V and 0V terminals on the main PC board (the +12V lead goes to the centre terminal of the socket). That done, connect a 9V to 12V DC power supply to the unit and switch on (**warning:** do not apply more than 15V to the unit, otherwise Zener diode

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	1MΩ	brown black green brown	brown black black yellow brown
❏	2	910kΩ	white brown yellow brown	white brown black orange brown
❏	4	300kΩ	orange black yellow brown	orange black black orange brown
❏	4	150kΩ	brown green yellow brown	brown green black orange brown
❏	2	100kΩ	brown black yellow brown	brown black black orange brown
❏	4	20kΩ	red black orange brown	red black black red brown
❏	2	15kΩ	brown green orange brown	brown green black red brown
❏	2	2.4kΩ	red yellow red brown	red yellow black brown brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	3	1kΩ	brown black red brown	brown black black brown brown
❏	1	10Ω	brown black black brown	brown black black gold brown

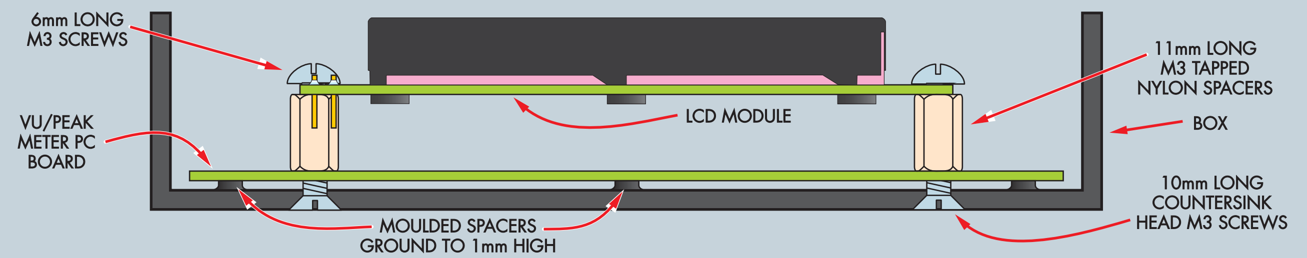


Fig.6: here's how the PC board assembly fits inside the case. Be sure to use tapped nylon spacers as specified (not metal), to prevent shorts to the PC tracks. The 10mm countersink M3 screws through the base of the case should also be nylon, again to prevent shorts on the PC board.

ZD1 will become hot and may be damaged by excess current).

Now measure the voltage between pins 5 and 14 of IC3's socket. This should be 5V (anywhere between 4.85V and 5.15V is OK). The voltage on pin 11 of both IC1 and IC2 should be anywhere from –7V to –10V, depending on the input voltage.

If you don't get the correct voltages, switch off immediately and check for wiring errors. If you don't get any voltage at all, check the supply polarity.

Assuming everything is OK, switch off and plug IC3 into its socket, making sure it is oriented correctly. That done, plug the LCD module into its header socket and temporarily support it at the other end on nylon stand-offs.

Now apply power again, and check that the display shows 'L' and 'R' to indicate the positions of the bargraphs. If there is no display or the contrast is poor, try adjusting the contrast trimpot (VR3). If there is still no display, check the connections to the module through the header and sockets.

Final assembly

Once the checkout is complete, the PC boards can be installed in a small plastic case measuring 120 × 70 × 30mm. The specified case comes with clear lid and is available from Jaycar (Cat.HB-6082).

Four countersunk holes will have to be drilled in the case base in line with the corner mounting holes of main the PC board. In addition, you will need to drill four holes at one end for the RCA phono sockets and a hole at the other end for the DC power socket – see photos. Be sure to position the latter hole so that the power socket clears the switch board.

Finally, you will need to drill two holes for switch S5 mounting screws and make a square cutout for the switch actuator. The square hole can be made by drilling a series of small holes around the inside perimeter and then knocking out the centre piece and cleaning up with a small file.

Fig.6 shows the final assembly details. First, the integral (moulded) spacers on the case base should be ground down to a height of 1mm. That done, secure an M3 × 11mm tapped nylon spacer (cut it down from a 15mm spacer) to the PC board immediately to the left of transistor Q1 (this spacer supports the lower righthand corner of the LCD module).

A second similar spacer is also fitted just below this (to the right of the 2.2kΩ resistor) to support the righthand end of the switch PC board.

The main board can now be installed in the case by sitting it on the 1mm moulded spacers. Secure it along the top edge using two M3 × 10mm countersink screws, which go into two more M3 × 11mm tapped nylon spacers. The bottom edge of the board is then secured using M3 × 10mm countersink Nylon screws and nuts.

Once the main board is secured, the LCD module can be installed by plugging it into its header socket and securing it to its three matching nylon spacers using M3 × 6mm screws.

Similarly, the switch PC board is plugged into its header socket and secured to its matching 11mm spacer at the other end.

Finally, fit the DC socket and power switch S5 and complete the wiring as shown in Fig.5. The switch is secured using the supplied M2 screws.

Calibration

Just how you calibrate the meter depends on the application. First, VR1 and VR2 are used to set the signal level sensitivity for the left and right channels respectively.

In practice, a true VU meter will show +0dBU when the applied signal is +4dBU. Now, 0dBU is 1mW into 600Ω. Thus, when 1mW is multiplied by 600Ω

DISPLAY MODES

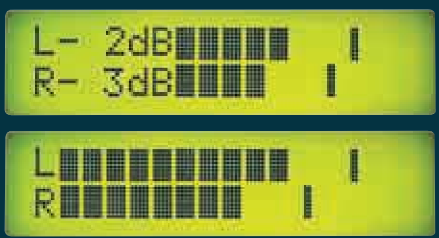


Fig.7: just two of the optional display modes that can be selected: top – Digital and Bar, VU On, Peak On; bottom – Bar, VU On, Peak On

MODE SELECTION

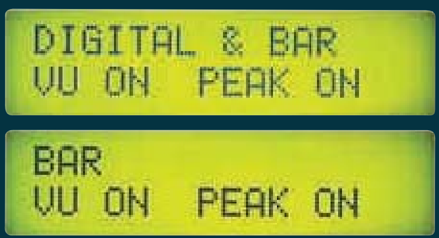
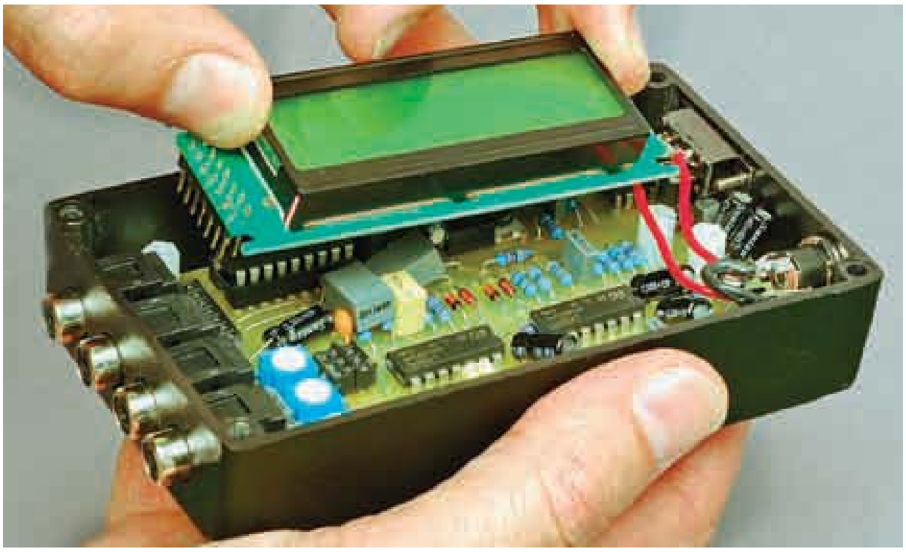


Fig.8: the display mode is selected by pressing the Options switch and then stepping through the selections using the Up and Down buttons. These two modes correspond to the displays shown in Fig.7.

SETTING THE BLOCK

Fig.9: the individual bargraph block values can be altered using the Mode switch and the Up and Down switches.



The LCD module plugs into the 2 × 7-way SIL sockets on the PC board and is secured to three of the nylon spacers. The switch PC board (not shown here) mounts in similar fashion and is secured to the fourth nylon spacer.

and the square root taken (V = square root of power × resistance), the voltage is 774mV. 4dBU is 1.584 times greater and so the 4dBU signal level is 1.23V.

The peak level will be some 3dB higher than this because the peak value of a sinewave is 1.414 times higher than its RMS value. So if you are replacing existing VU meters, the Stereo VU/Peak Meter should be calibrated to show 0VU with a 1.23V sinewave input.

For most other applications, the display readings are set according to the level that produces clipping. With digital recorders, these invariably include a clipping indication that shows whenever the signal goes above the maximum level for digital conversion.

This means that the meter should be calibrated so that the 0VU peak block is just displayed at this clipping level.

The display range may also be altered to suit your application. A digital recorder would normally use a meter display that shows 0VU at the far righthand block. The values below this can then be set according to preference.

For example, you could set each block to display in just 1dB steps, or you could use much larger steps or a combination of step sizes. Larger steps are more useful at lower signal levels, while 1dB steps are best as the signal level approaches the upper threshold. ***EPE***