QUASAR PROJECT KIT # 3002. TEMPERATURE METER

The Intersil chip 7106 is an amazing chip. We are so used to a constant stream of new and improved IC's that it is a surprise to find a chip which was launched in 1977, has remained unchanged during that time and yet sales of the chip today are actually increasing. What is the reason for this popularity?

The 7106 was the first IC to contain all the active circuitry for a 3 1/2 digit panel meter (DPM) in a single chip. It was designed to interface directly to a liquid crystal display (LCD). (The 7107 IC is intended for LED - light emitting diode - displays.) So the chip contains BCD to seven segment decoders, display drivers, clock and a reference voltage as well as the necessary analogue to digital (AD) circuitry to convert the input voltage to a digital form. The AD system also indicates the polarity of the input voltage.

Voltage is the most frequently measured electrical quantity. In temperature meters, current meters, wind speed meters and resistance meters what is actually being measured is voltage, or more correctly, the potential difference between two points. After calibrating the meter for its particular purpose then the potential difference measured will give an accurate (digital) reading of the (variable analogue) quantity being measured.

With less than 10 external passive components the 7106 chip may be made into an easy to use meter for any of these purposes especially multiple range digital volt meters. See the Kit 3127 documentation enclosed with this kit for more details.

Digital displays have many advantages over analogue meters which use a pointer and moving coil. Firstly they are easier to read especially by unskilled labour. In the majority of applications it is better hat the value displayed is exactly the value being measured, for example, 13.6V. To use an analogue display with its many graduated scales (some going up and others going down) and switches requires considerable practice. But a simple LCD which reads '13.6' can be understood by everyone.

Second, the DPM built using the 7106 is physically stronger and more robust than analogue meters because it has no moving parts. Thirdly, for the manufacturer the assembly of the complete DPM unit can be done by relatively unskilled labour. Fourthly, the 7106 by its very nature can be adapted to so many uses at such a low cost that it has actually created markets for itself. All of these factors add up to a better, cheaper product which everyone can afford.

In this kit we have supplied the 7106, the LCD and the components necessary to build it into a temperature meter. A printed circuit board (PCB) is supplied with the kit. It has a printed overlay on it so that the position of all the components is clearly indicated and construction only takes a few minutes.

The PCB has a large breadboard area so that once you have become familiar with the module and used it as a temperature meter you can easily advance to build other metering devices such as a digital voltmeter, resistance meter, current meter and even an AC voltmeter. Used with a photodiode a light meter can be built. Applications are limited only by the availability of transducers and changing the circuit slightly to convert the external signals to a 0 to 199.9 mV DC signal. Copies of some ofthe circuits to do this are provided.

The kit is constructed on a single-sided printed circuit board (PCB). A computer aided design (CAD) program is used to design the board.

CIRCUIT DESCRIPTION

The potential difference (PD) across a silicon diode is dependent on its temperature and current through it. Its temperature coefficient is negative, that is, the voltage falls with increasing temperature. This fall is approximately linear and is typically -2.2mV/oC. That is, there is the same drop in voltage when the diode cools from 88 oC to 87 oC as there is when it cools from 23 oC to 22 oC. Better sensors have better linear characteristics. In this Kit we have used a transistor as a diode (base and collector shorted together) which has a more linear temperature response over a bigger range than a diode does.

The temperature meter measures the PD across the diode after an offset voltage which is available from pins 1 and 32 of the 7106 has been added. The two 100K 10-turn trimpots are used to calibrate the sensor at two known temperatures. The calibration is easily done using water with ice in it to calibrate zero degrees Centigrade and putting the sensor in a jet of steam from a boiling water kettle to calibrate for 100 oC. The decimal point has been hard-wired on. (The enclosed literature shows you circuits of how to obtain a variable decimal point.)

ASSEMBLY INSTRUCTIONS

There are several important points to watch.

1. The LCD (liquid crystal display) is mounted on **two** 40 pin IC sockets which you must cut apart using your side cutters. This allows the LCD to sit above the 7106 chip and save space. Make sure you get the LCD and the 7106 chip around the correct way. Look for the notch at one end of the LCD and match it to the notch shown on the PCB overlay (it goes to the lefthand side of the PCB.) Similarly, match the notch on the 7106 (opposite to the LCD notch – it goes to the right.) These two components should be the last items added to the PCB. Use the filled-in IC socket (if supplied) for the 7106 IC itself.

2. Mount POT 1 and R1 in the sockets provided and not directly into the PCB. Solder the single mounting socket pins into the PCB (After breaking them apart.). The values of these two components will change when the meter is used to build other projects. For the temperature meter R1 is 1M and POT1 is 100K (104).

3. It is best to attach the battery snap on the bottom side of the PCB so that the battery is contained inside the box.

4. Note the LINK to make on top of the PCB.

The PCB has been marked on both sides to help you in using the kit to build other circuits. Abbreviations refer to the Intersil/Harris documentation.

After the kit is assembled and the battery is connected the display should show some random readings or indicate out-of-range '1'. The unit now needs to be calibrated. You will need some ice and water to adjust the Zero Adjust pot to zero degrees centigrade and a jet of steam from boiling water to adjust the Scale Adjust pot to 100 degrees centigrade. The order of calibration does not matter. You may have to adjust both pots when you do the first calibration in order to get a reading other than '1'.

If you hear a 'click, click' when you turn the trim pot then you are at one end of the winding and you should turn it the other way.

Depending on the distance of the sensor from the meter you may need to use thin shielded coaxial cable between them. The 7106 has excellent noise limiting haracteristics. The sensor attached six inches from the PCB using the hookup wire provided should not have any noise roblems. The sensor transistor may be mounted on the breadboard area of the PCB with jumper leads connected from T+ and T- to it.

WHAT TO DO IF IT DOES NOT WORK

Poor soldering is the most likely reason. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB. Thirdly, follow the track with a voltmeter to check the potential differences at various parts of the circuit.

A check list of other items includes:

- did you add the jumper LINK on top of the PCB.
- are the IC and LCD in the correct way. Check no pins are
- bent up. This is very easy to do with a 40 pin IC.
- is the battery flat.
- is POT1 and the 1M resistor properly fitted into the sockets.

WHAT TO LEARN FROM THIS KIT

The Kit shows how much of electronics today can be contained in a single chip. Commercial low cost digital volt meters are nothing more than this kit, some switches and passive components and a nice plastic case. The main reason today for the failure of meters is more likely due to switch and mechanical failure rather than failure of the electronics itself.

Our Kit 3127 uses the 7106 and is a double-sided PCB version of Kit 3002 without the breadboard area. It contains more information about how to use the 7106 in different types of meters. Get the documentation from

http://www.quasarelectronics.com/3127.htm

The data sheet for the 7106 may be downloaded from the Intersil website at

www.intersil.com

or you can get it from our website at

www.quasarelectronics.com/ds.htm (7106.pdf)

You can get the pinout information for the LCD at

www.quasarelectronics.com/ds.htm (vi302_dp.pdf)

You may download a detailed Application Note for the 7106 at

www.quasarelectronics.com/ds.htm (7106_an1.pdf)

This kit is basically the circuit shown in Figure 20 of this Application Note.

(Documentation: November 2002)

COMPONENTS

Resistors 1% metal film:	
1M brown black black yellow	2
22K red red black red	1
47K yellow violet black red	1
100K brown black black orange	3
220K red red black orange	1
Capacitors:	
100p 101 monoblok	1
220n 224 metallized	1
10n 103 mylar	1
100n 104 mylar	1
470n 474 metallized	1
BC547 or BC548	2
10 turn trimpot	2
40 pin IC socket	3
7106 IC	1
hookup wire	
9V battery snap	1
Box #2 and screws	1
LCD VI302-DP-RC	1
Kit 3002 PCB	1

QUASAR KIT 3002 – TEMPERATURE METER

CONNECTING THE BC547 AS A TEMPERATURE SENSOR

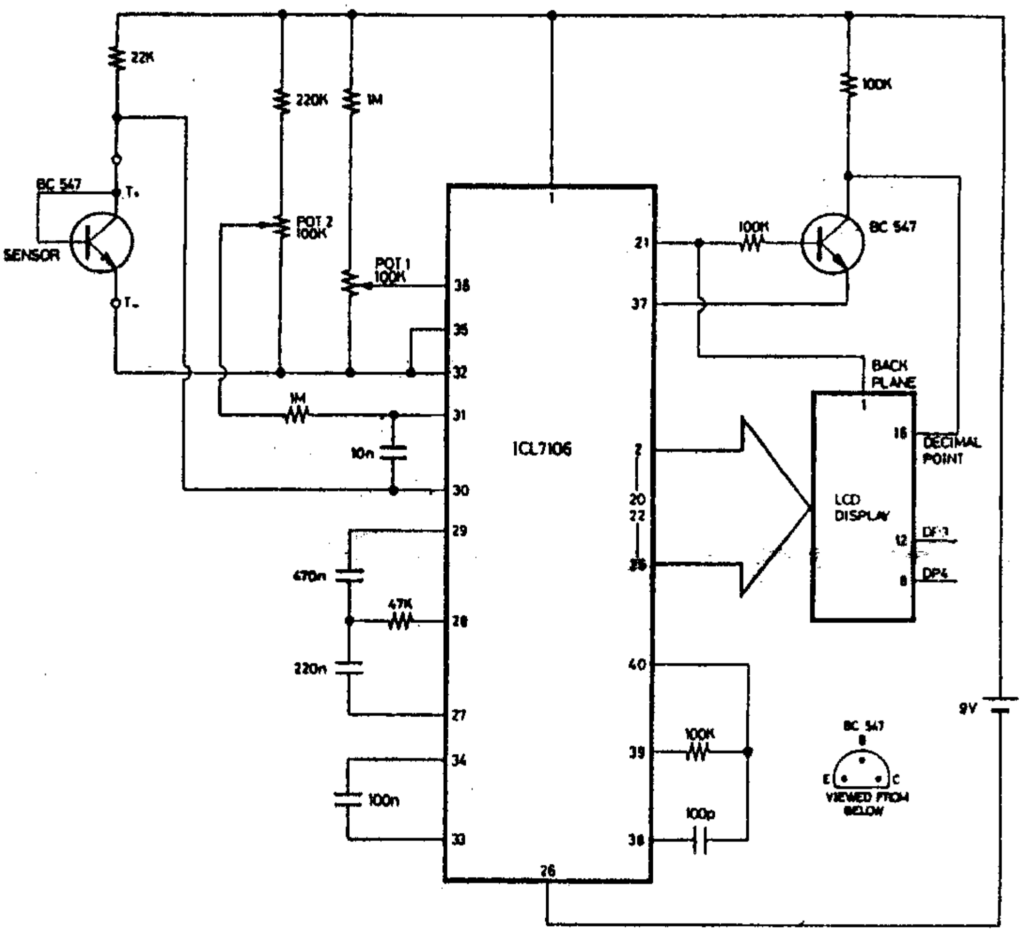
Viewed with the BC547 transistors flat silver side facing you:

1. The left leg goes to T- position on PCB
2. The centre and Right legged (connected together) go to T+ position on PCB

Use the 2-core cable provided to make the connection.

See Circuit Description section above for details of how this humble NPN transistor is used to measure temperature.

3002 Schematic



The 7106 chip is one of the long term survivors in the IC world. It was launched in 1977 yet it has remained as popular as ever.

The reason is that it contains in it all the active circuitry for a 3 1/2 digit panel meter (DPM) in a single chip. It was designed to interface directly to a liquid crystal display (LCD). (It has a sister chip, the 7107, intended for connection to light emitting diode displays.) So the chip contains BCD to seven segment decoders, display drivers, clock and a reference voltage as well as the necessary analogue to digital (a/d) circuitry to convert the input voltage to a digital form. The a/d system also indicates the polarity of the input voltage.

Voltage is the most frequently measured electrical quantity. In temperature meters, current meters, wind speed meters and resistance meters what is actually being measured is voltage, or more correctly, the potential difference between two points. After calibrating the meter for its particular purpose then the potential difference measured will give an accurate digital reading of the analogue quantity being measured.

With a few additional external passive components the 7106 chip may be made into an easy to use meter for any of these purposes especially multiple range digital volt meters.

Digital meters have many advantages over analogue meters that use a pointer and moving coil.

1. They are easier to read. In the majority of applications it is better that the value displayed is exactly the value being measured, for example, 13.6V. To use an analogue display with its many graduated scales (some going up and others going down) and switches requires considerable practice. But a simple LCD which reads '13.6' can be understood by everyone.
2. DPMs built using the 7106 are physically stronger and more robust than analogue meters because they have no moving parts.
3. The 7106 by its very nature can be adapted to so many uses at such a low cost that it has actually created markets for itself.

All of these factors add up to a better, cheaper product which everyone can afford.

In this Kit we have supplied the 7106, the LCD and the essential components and information necessary for you to custom build it into a panel meter of your choice. The PCB has a printed overlay on it so that the position of all the components is clearly indicated and construction only takes a few minutes.

The kit is constructed on a double-sided, through hole plated printed circuit board (PCB). Protel Autotrax and Schematic were used to design it.

ASSEMBLY INSTRUCTIONS

Assembly is generally straightforward. Follow the overlay to tell you where to put the components. Leave resistors RA and RB until last.

Start by inserting all the resistors first, followed by the capacitors. Capacitors C1, C4 and C5 are mounted under the IC so make sure they are pushed down close to the PCB. Next comes the 40 pin IC socket for the 7106. Once again be sure it is pushed right down before soldering.

The LCD is mounted on **two** 20 pin socket strips. These are made by cutting apart a 40 pin IC socket using your side cutters. This allows the LCD to sit above the 7106 chip. Take care that these strips are at right angles to the PCB otherwise inserting the LCD will be difficult.

Trimpot P1 can be fitted to either side of the PCB. Putting it on the rear (solder side) of the PCB makes it easier to adjust if the meter is mounted on a panel.

Lastly insert the 7106 into its socket, followed by the LCD. Make sure you get them round the correct way. A small triangle on the overlay marks pin 1 of each part.

All that remains is to determine the values of RA and RB (described later) and soldering them in, along with a link for the decimal point position if required. For the moment just solder a link for RB.

CALIBRATION

Connect 9V to the kit. All that remains is calibration. This is easy. Connect a multimeter between pins 35 and 36 of the 7106. Use alligator clips on the solder side of the board. Use trimpot P1 to adjusted VREF measured between these pins to 100mV.

(You can also do this another way by applying a known voltage to the input terminals and adjusting VREF for the this reading so that VIN = 2 x VREF. This requires that RA and RB are installed.)

Now decide the input voltage range you want to measure according to the table on the next page.

WHAT TO DO IF IT DOES NOT WORK

Poor soldering is the most likely reason. Check all solder joints carefully under a good light. Check that all components are in their correct position on the PCB.

Are the IC and LCD in the correct way. Check no pins are bent up. This is very easy to do with a 40 pin IC and the LCD display.

Is the battery flat?

CIRCUIT DESCRIPTION

The heart of the meter is the A/D converter built into the 7106. It uses a dual slope conversion technique. It relies on the charging and discharging of an integrating capacitor and having a counter count when the capacitor voltage is above a set value. Since the capacitor discharge is linear the counter reading is proportional to the input voltage. There are three phases to the process:

Phase 1 - Auto Zero.
The auto zero capacitor is charged to the integrator's offset voltage. This voltage is subtracted from the input signal during phase 2. The integrator thus appears to have zero offset voltage.

Phase 2 - Signal Integrate.
The signal input is averaged for 1000 clock pulses.

Phase 3 - Reference Integrate.
VREF is averaged back to zero volts. The number of clock pulses counted to return to zero is a digital measure of VIN.

The Reference Voltage supplied to the 7106 at pins 35 and 36 should be between 100mV and 1V for most purposes. This corresponds to a full scale reading of 199.9mV and 1.999V respectively. **In this kit VREF is set to 100mV but is adjustable from 89 - 107mV**.

Let us discuss parts of the circuit in more detail and investigate how to customize the meter for your purpose.

Decimal Point. A jumper selects the decimal point position in the LCD. Displays are driven by applying a symmetrical square wave to the back plane (BP.) To turn on a segment a waveform 180° out of phase with the BP (but of equal amplitude) is applied to that segment. To get the decimal point the external circuit inverts the BP output (pin 21) with a transistor and applies it to the required decimal via a jumper. Pin 37 is used as the negative supply for these externally generated segment drivers.

Analogue Section. C1 is the reference capacitor and is unchanged for all ranges measured. INLO is tied to the analogue COMMON pin 32.

The integration capacitor C5 is suitable for VREF values but the value of the integration resistor R1 should be increased to 470K for a VREF of 1V.

System Timing. This is determined by the components connected to pins 38, 39 & 40. Values are unchanged for all ranges measured. The internal oscillator runs at 48kHz, or 3 readings per second.

Auto-Zero Capacitor. This is C4 connected to pin 29. It has some influence on the noise of the system and recovery from overload input. For 200mV full scale a 0.47uF capacitor is recommended.

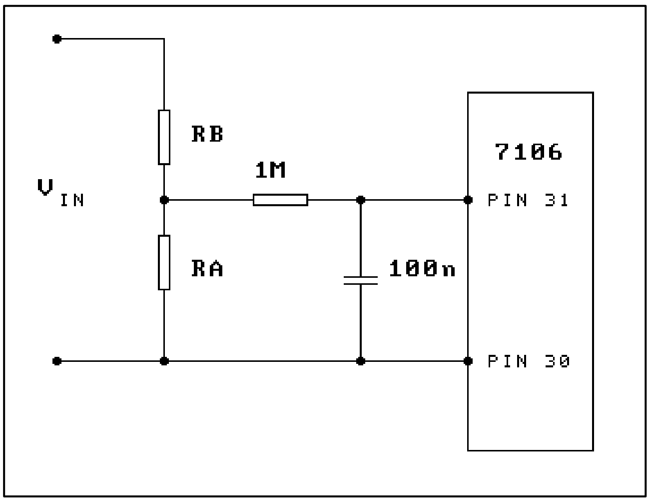
Reference Voltage. The analogue input required to generate a full scale output of 2000 counts is

VIN = 2 x VREF

Thus to set the meter to read from 0 - 199.9mV VREF is set to 100.0mV.

VREF is measured between pins 35 & 36. The trimpot, P1, is adjusted to get the correct reference voltage.

To measure voltage greater than 200mV an input voltage divider is required (see Figure 4). The general relation for full scale sensitivity is now:



VIN (full scale) = 2 x VREF x RA / (RA + RB)

Figure 4. Input Attenuation for VIN > 200mV

For example, a 0 - 20V range can be obtained using a 100:1 voltage divider. This can be done by making RA = 300K and RB = 2.7M. The decimal point jumper is placed at position '2' so a full scale display of 19.99V is available. The following table shows the resistor values to use for different voltage ranges and the position of the decimal point jumper.

Range	RA	RB	DP jumper
200mV	10M	Wire Link	2
2V	300K	2.7M	4
20V	100K	10M	3
200V	10K	10M	2

Note: For the 20V and 200V range RB should be 9.9M and 9.99M respectively. This introduces a slight error that can be corrected by adjusting VREF slightly (CALIBRATION method 2).

The 200mV range does not require a voltage divider on the input but a 10M resistor is used for RA anyway. The input resistance of the 7106 is so high that this resistor is necessary to short out any static charge accumulating on the input terminals.

Putting this all together we can construct a multi range voltmeter as shown in Figure 5.

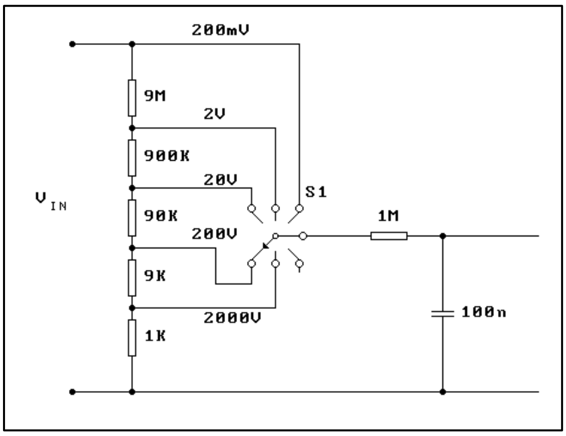


Figure 5. Multi range Voltmeter

Non-standard Voltage Input. In many applications it is required that the output of a transducer is converted by a scale factor into some meaningful result. For example, a load cell of a weighing system may have an output voltage of 0.682V when it has 2.0 Kg weight on it. You want the meter to read the range 0 - 1.99 Kg directly.

Set the meter (RA and RB) to have a 2V input range. This gives a maximum input voltage of 68.2mV. Then adjust VREF to 34.1mV (half the input voltage), put the decimal point in the correct position by moving the jumper and the panel meter now reads off 0 - 1.99 Kg directly from the display.

Voltages Below 200mV. On the 200mV scale the least significant digit represents 100 micro volts. To resolve smaller signals it is necessary to use an op-amp prior to the voltage input to amplify the DC voltage.

Current Measurement. The current must be converted into a voltage using a shunt resistor. The voltage divider resistors RA and RB are not used. The principal is shown in Figure 6.

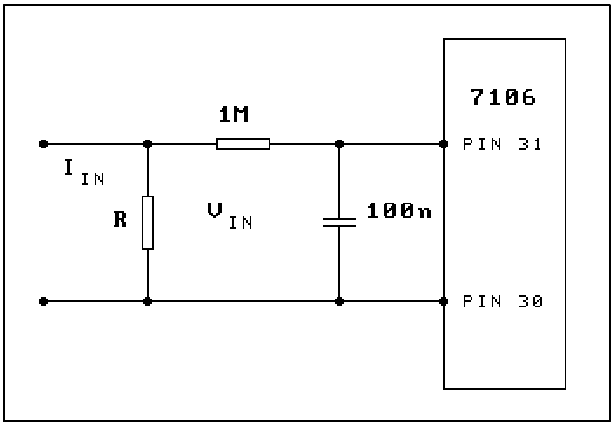


Figure 6. Principle of Current Measurement

If R = 0.1 ohms then 200mV will be developed when the current through it is 2A. This voltage is applied to the meter which is set up for the 200mV range. Power dissipation at the maximum reading is I^2R.

To measure a full scale of 200mA then R should be 1.0 ohms in order to generate 200mV input to the meter. For a 20 mA meter then R = 10 ohms.

A general multi range current meter is shown in Fig. 7.

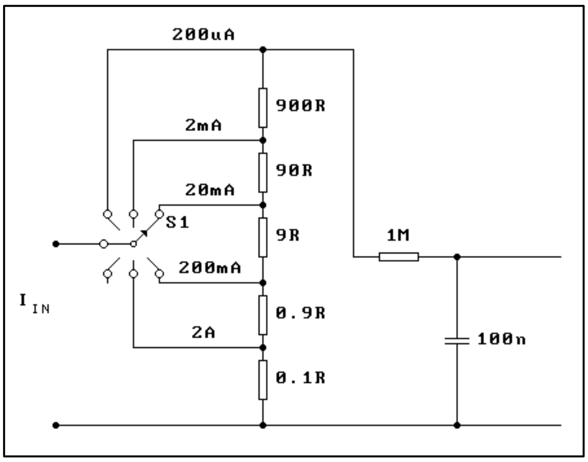


Figure 7. Multi range Current Meter

Resistance Measurement. The kit is not specifically designed for this purpose, however, with some changes to the board this function can be carried out. The principle is shown in Fig. 8. The unknown resistance is put in series with a known resistance and a current is passed through the pair as shown. If they are of equal value the integration and de-integration ramps will be of equal slope and the display will read 1000. The maximum readable ratio is 1.999. Since a ratio is being measured the reference resistor need not be exact.

Displayed reading = Runknown / Rstandard x 1000

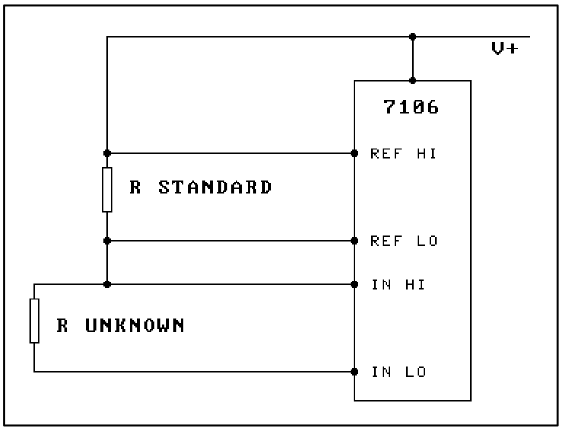


Figure 8. Measuring Resistance

QUASAR PROJECT KIT # 3127 - 3 ½ Digit LCD Digital Panel Meter

WHAT TO LEARN FROM THIS KIT

The Kit shows how much of electronics today can be contained in a single chip. Commercial low to medium cost digital multimeters are nothing more than this kit, some switches and passive components and a plastic case. The main reason today for the failure of meters is more likely due to switch contact and mechnical failure rather than failure of the electronics itself.

Web Address & Email

You can email us at **sales@quasarelectronics.com** if you have any problems/requests. See our Web page at:

http://www.quasarelectronics.com

PARTS LIST – 3127

Resistors (0.25W carbon)		
820 grey red brown	R3	1
27K red violet orange	R2,5,6	3
47K yellow violet orange	R1	1
100K brown black yellow	R4	1
1M brown black green	R7	1
Capacitors		
100pF 101 ceramic	C3	1
100nF 104 monobloc	C1,2	2
220nF 224 monobloc	C5	1
470nF 474 monobloc	C4	1
Semiconductors		
BC547, NPN transistor	Q1	1
7106 IC 3 ½ Digit LCD A/D converter	IC1	1
Miscellaneous		
Trimpot, 200Ω	P1	1
Liquid Crystal Display 3 ½ digit, VI302-DP-RC, or S5018C	LCD	1
IC socket, 40 pin For mounting IC1 and LCD		2
9V battery snap		1
PCB, 3127		1