Construction Project:

General-purpose digital panel meter

This updated version of the popular digital meter described in June 1990 features a single polarity DC supply, audible over-range indicator and very high stability.

by JEFF MONEGAL

A general purpose digital panel meter like the one presented here has many uses. Replacing the analog meters in your workbench power supply is a typical and useful example. But unlike many similar modules, because it can be powered directly from a 12V DC source, this project can be used in a car as an indicator of battery/alternator activity. Or perhaps add a temperature probe, to measure temperature.

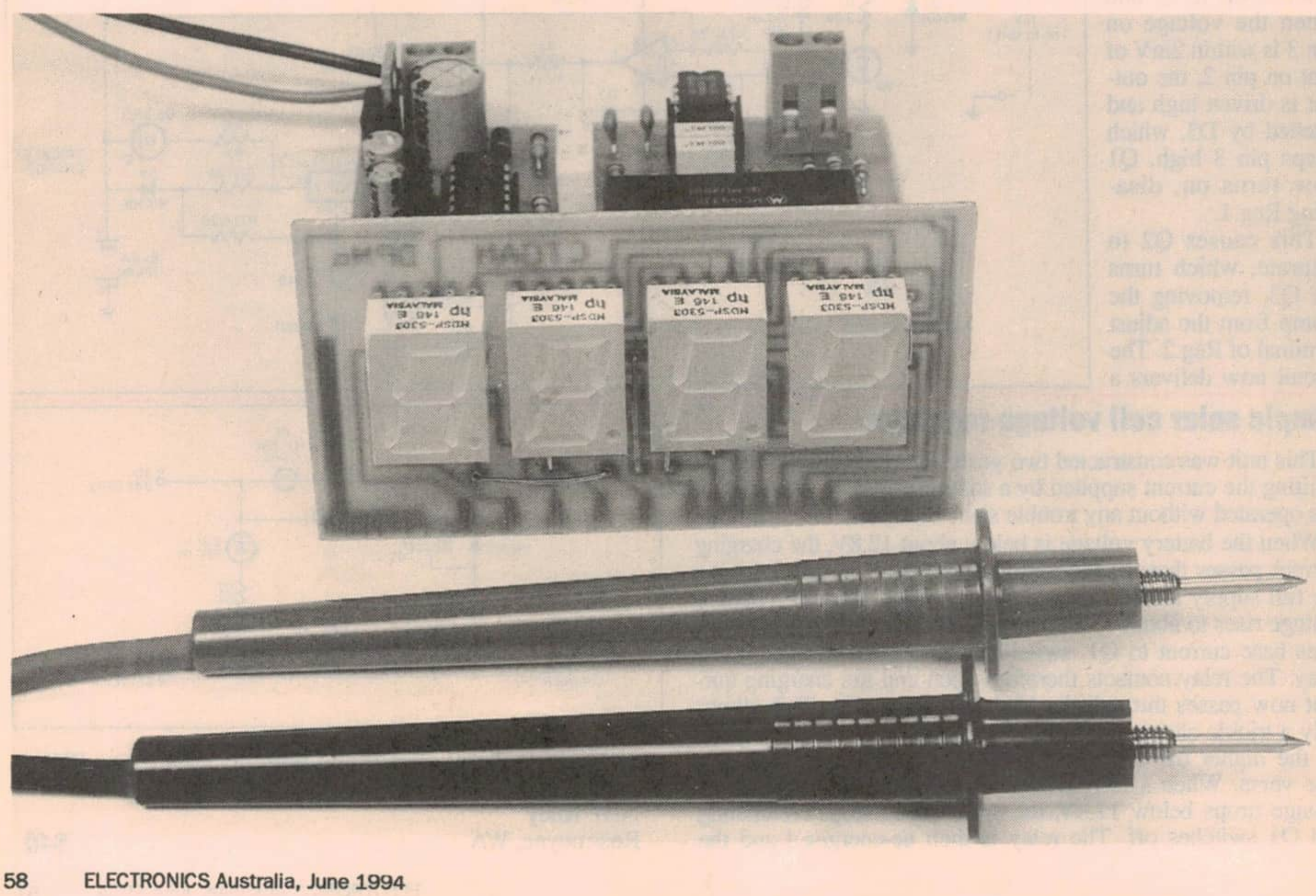
By adding scaling resistors in a voltage divider configuration, the meter can be converted to a voltmeter with ranges anywhere from 200mV to over 2000 volts. Add a few shunt resistors and the meter is an ammeter able to measure milliamps to 20A or more. The analog to digital converter IC used in this project is the Motorola MC14433, the same as in the previous design. However, the reference voltage to the ADC is a precision reference IC, type MC1403, compared to the zener diode reference used in the June 1990 version.

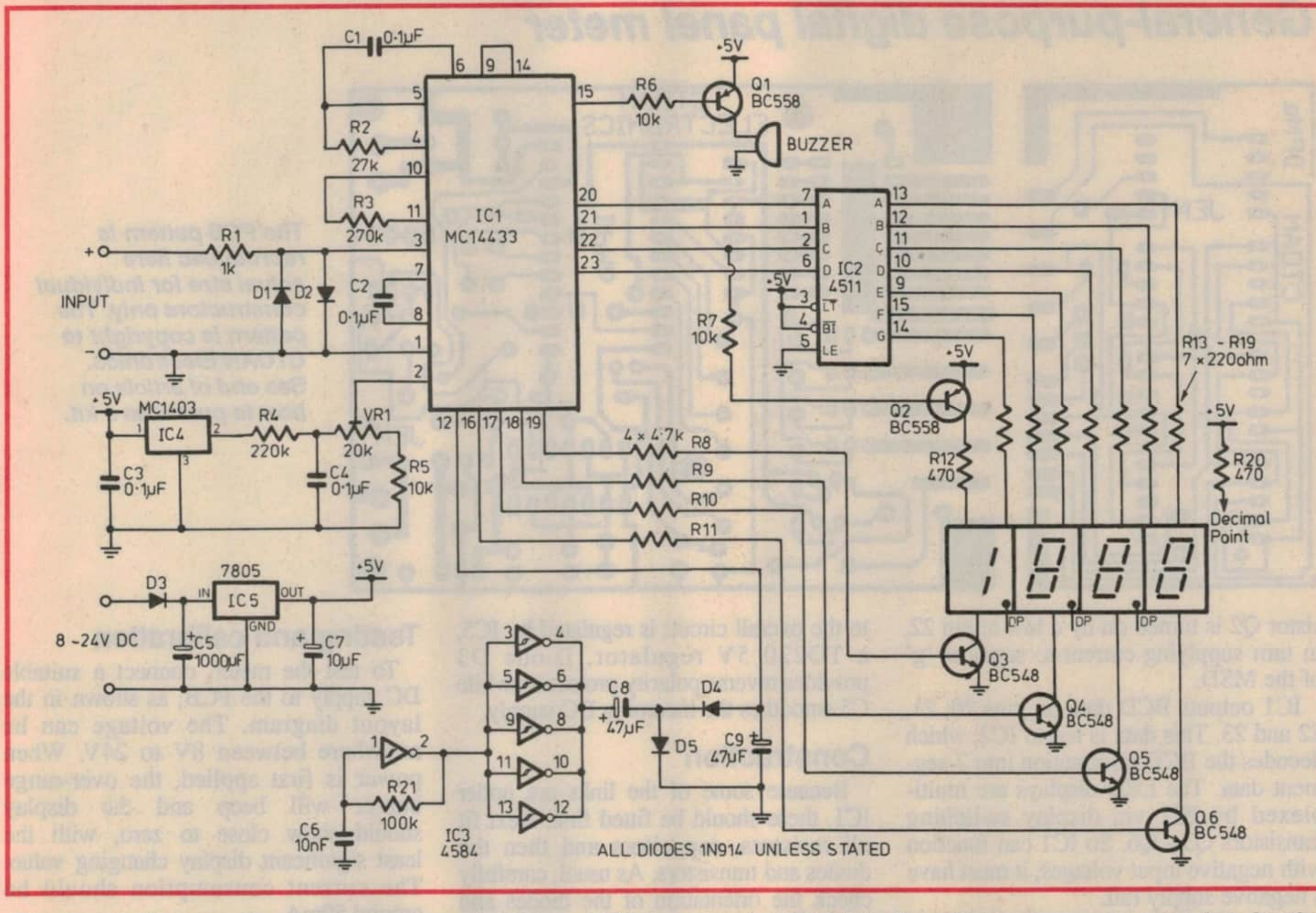
Another important addition is an onboard negative rail generator. This allows the meter to be powered directly from a single 8 - 24V DC supply.

So how does this new design perform? The MC1403 reference IC is specified as having a worst case maximum change of 4.4mV over a temperature range of 0° to +70°C. However this change is for a 2.5V output from the IC. In this project, the 2.5V is divided down to 200mV, so the actual change in the reference will be about 400 microvolts.

This doesn't take into account any change in value of the components used in the reference divider, but tests have shown that the meter reading doesn't change over the temperature range of 0° to 55°C.

The meter has auto-polarity, with segment 'g' of the most significant digit used to indicate a negative value. Over-range indication is also included, but rather than the usual flashing or blanked-out display we've used a small 'soft tone' piezo buzzer. You don't have to be watching



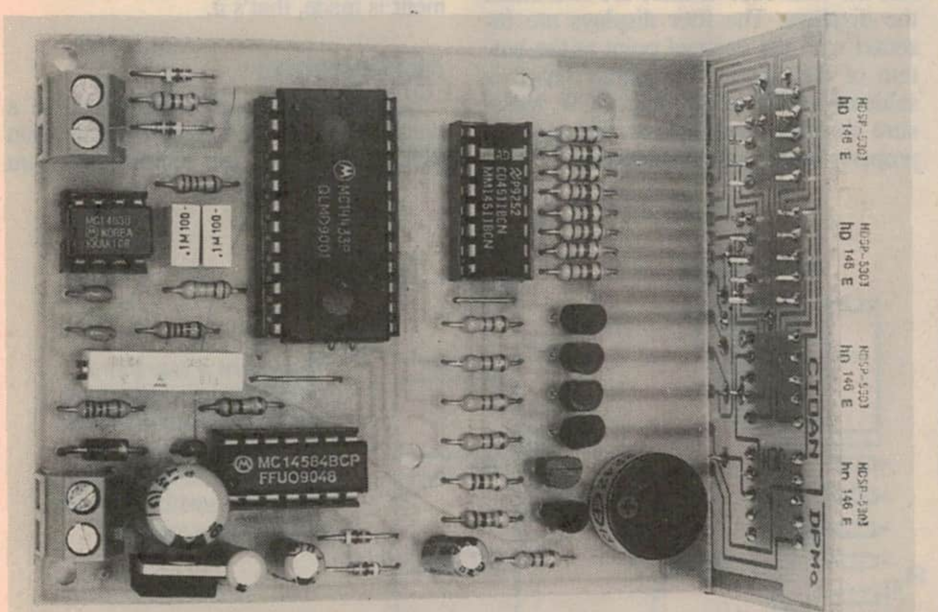


The circuit diagram. The A to D converter is IC1, and IC2 decodes the BCD data from IC1 to seven segment data for the displays. The negative power rail is developed by IC3, and the reference is IC4.

the display to know that the input voltage is over range.

How it works

Most of the work takes place inside the dual-slope analog to digital converter IC1. The integration components are C1 and R2 and with the values shown, the circuit gives about four conversions per second. Resistor R3 sets the internal clock frequency to about 66kHz. Resistor R1 together with diodes D1 and D2 ensure that the input to the ADC cannot exceed +/-600mV.



This close-up view of the main PCB shows the display board attached to the main board.

The reference for IC1 comprises IC4 and associated components. The MC1403 was chosen as it is cheap, readily available and has excellent specifications. It gives a 2.5 volt output at pin 2, with a variation of +/-25mV over the temperature range of 0° to 70°C.

Components R4, VR1 and R5 divide the 2.5 volts down to the required 200mV for the reference needed by IC1. Therefore the full-scale input voltage to the meter is 200mV; or more precisely, 199.9mV. Needless to say, R4 and R5 are 1% metal-film resistors and VR1 is a cermet multi-turn trimpot.

The over-range output of IC1 is pin 15, which goes low when the input exceeds 199.9mV. This turns on Q1, via R6, which sounds the buzzer when there's an over-range condition. Because the module has auto-polarity, segment 'g' of the most significant display (MSD) is used to indicate a negative input voltage. Under this condition, pin 22 of IC1 will be low during the on-time of the MSD display (driven on by pin 19). Tran-

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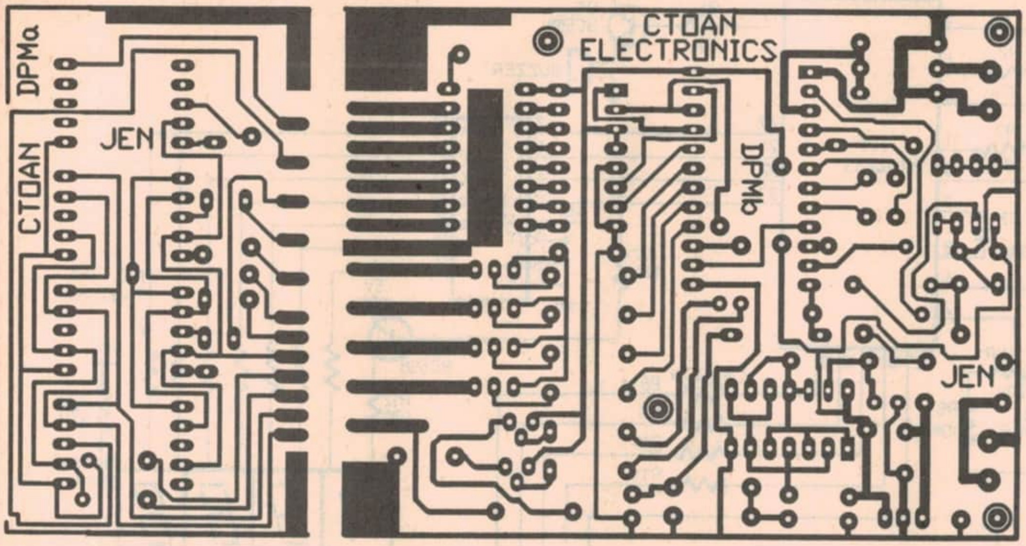


The PCB pattern is reproduced here actual size for individual constructors only. The pattern is copyright to CTOAN Electronics. See end of article on how to purchase a kit.

sistor Q2 is turned on by a low at pin 22, in turn supplying current to segment 'g' of the MSD.

IC1 outputs BCD data on pins 20, 21, 22 and 23. This data is fed to IC2, which decodes the BCD information into 7-segment data. The LED displays are multiplexed by IC1 via display switching transistors Q3 - Q6. So IC1 can function with negative input voltages, it must have a negative supply rail.

In the previous design, the negative supply had to be provided externally. In this design the negative supply is generated by IC3, a hex inverter with Schmitt trigger inputs.

IC3a is wired as a standard Schmitt relaxation oscillator and its output is buffered by the five parallel connected gates. These gates drive a charge pump circuit consisting of components C8, C9, D4 and D5. Here the AC signal developed by IC3 charges C9 in a negative direction, producing a negative voltage of about 4V which is then fed to pin 12 of IC1. Power to the overall circuit is regulated by IC5, a TO220 5V regulator. Diode D3 provides reverse polarity protection while C5 smoothes the incoming DC supply.

Construction

Because some of the links are under IC1, these should be fitted first. Next fit all resistors, capacitors and then the diodes and transistors. As usual, carefully check the orientation of the diodes and electrolytic capacitors. We used IC sockets in the prototype, and these should be fitted last, followed by the voltage regulator. Use a small soldering iron, as there are a few tracks running between IC pins.

When assembling the display PCB, insert the links first as there are two under the displays. The four displays are inserted with the decimal point at the bottom of the board. The display board is soldered at 90° to the main PCB. Make sure that the two boards are aligned properly before you solder them.

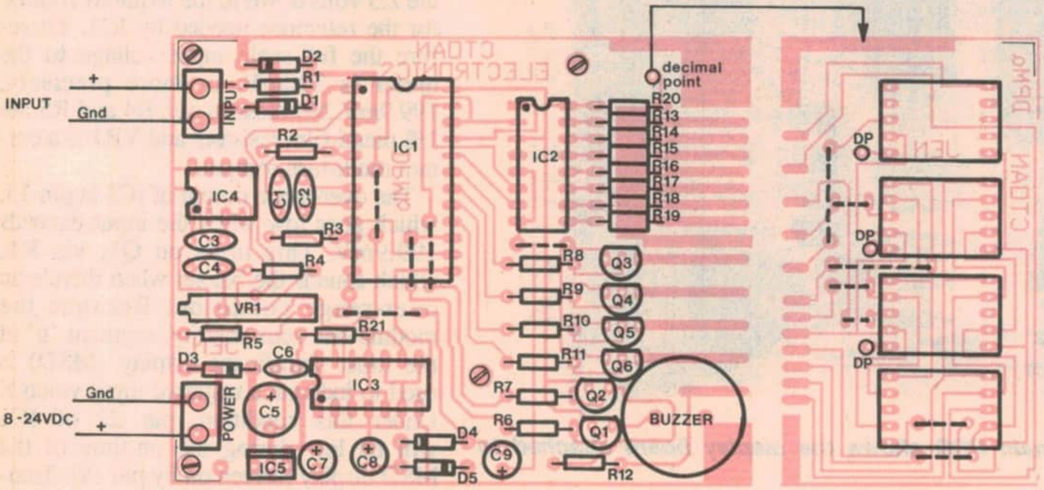
Testing and calibration

To test the meter, connect a suitable DC supply to the PCB, as shown in the layout diagram. The voltage can be anywhere between 8V to 24V. When power is first applied, the over-range buzzer will beep and the display should show close to zero, with the least significant display changing value. The current consumption should be around 50mA.

To calibrate the meter, connect a DC voltage source that can be adjusted below 200mV. Monitor this voltage with another DVM of known accuracy and adjust the voltage to say, 100mV. Then adjust the potentiometer until the display agrees with the DVM. Once this adjustment is made, that's it.

Applications

Because this meter is an update of a previously published project, rather than repeat ourselves, we recommend you



There are a few links under ICs and displays, so fit the links first. The decimal point can be fixed for a single scale meter, or switchable via a three-way switch.

PARTS LIST

Resistors

All 1/4W, 5% unless otherwise stated

R1	1k
R2	27k 1% metal film
R3	270k
R4	220k 1% metal film
R5	10k 1% metal film
R6,R7	10k
R8-11	4.7k
R12,R20	470 ohm
R13-19	220 ohm
R21	100k
VR1	20k 10-turn cermet trimpot

Capacitors

C1,C2	0.1uF mylar
C3,C4	0.1uF mono
C5	1000uF 16V electrolytic
C6	10nF mono
C7	10uF 16V electrolytic
C8,C9	47uF 16V electrolytic

Semiconductors

IC1	MC14433 3.5 digit ADC
IC2	4511 seven-segment driver
IC3	4584 hex Schmitt inverter
IC4	MC1403 precision reference
IC5	7805 T0220 5V regulator
D1,D2,D4,D5	1N914 signal diode
D3	1N4004 power diode
Q1,Q2	BC558 PNP transistor
Q3-6	BC548 NPN transistor
DIS1-4	HDSP 5303 seven-segment LED display

Miscellaneous

PCB, 90 x 70mm coded DPMb; PCB, 90 x 40mm coded DPMa; PCB-mount 'soft tone' piezo buzzer; two by two-way PCB mount terminals; IC sockets to suit if required; solder; wire for links; mounting screws as needed.

CTOAN Electronics is offering this project as a kit for $50.00, which includes all components, including buzzer, four displays and both PCBs. Postage and handling is $5.00 to anywhere in Australia. A repair service is also available for this kit. Cost of any repair, excluding IC1 replacement, is $20.00 which includes return postage. Fully built and calibrated kits are also available for $79.00 including postage.

Kits may be ordered using B/C, M/C and Visa cards as well as cheque or money order from:
CTOAN Electronics
PO Box 211
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Phone (07) 297 5421

refer to the June 1990 edition of *EA*, pages 132 to 138. (Photocopies of this article can be obtained through our Reader Services Office.)

This article gives a more expanded description of the operation of IC1, and gives more detail on how to convert the meter to a voltmeter or an ammeter. Remember that this design doesn't include space on the PCB for the scaling components. However these are easily fitted to a range switch.

As for the previous design, the full-scale input voltage is 199.9mV, so the scaling circuits given in the previous article apply to this project. ❖