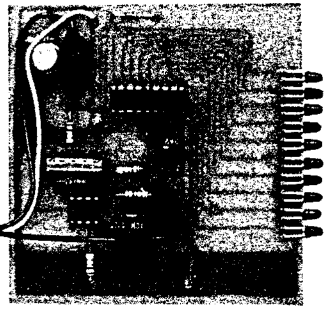
FUEL GAUGE

Moving coil meters? How passé. If Ford is prepared to spend millions of pounds on computer-aided design and robot assembly, the least you can do is fit your car with an electronic fuel gauge. Design by A. M. Smithers.



The standard petrol gauge, as fitted to most cars, is of a primitive 'hot-wire' design, the gauge responding to the heating effect of the current through it, which in turn varies with the resistance of the fuel gauge sender unit located in the fuel tank. The chief disadvantage of such a gauge is the inaccuracy of reading. Running out of petrol is advantageous only in certain circumstances and even then it would be nice to know exactly when it was going to occur!

A far more elegant, and indeed, much prettier solution would be a bargraph type display which could be accurately calibrated. With the help of the LM3914 bargraph display driver this can easily be effected. The standard sender unit in the tank is retained, but the petrol gauge is disconnected at the instrument panel and the sender unit is, instead, connected to the input. R2 provides the current source for the sender unit previously obtained from the gauge itself. Please note that considerable adjustment is provided on the circuit resulting in the value of R2 and, indeed, the resistance of the sender unit being not at all critical.

The voltage developed across the sender unit of the car in which the prototype was fitted varied from around 10 V when empty to around 2 V when full. A 741 operational amplifier is used to invert this signal by comparing it with a 5 V reference provided by R4 and R5. The output of the op-amp varies from about 0V5 when the tank is empty to about 8 V when it is full. This output is now of the correct sense to be fed to a standard LM3914 expanded scale voltmeter. The potential divider formed by R7 and PR1 provides a full scale adjustment which may be calibrated against a brimming full petrol tank. Similarly PR2 provides a zero adjustment for calibration against an empty tank.

Construction

The circuit is relatively simple and may be constructed on Veroboard or the PCB design as illustrated. IC sockets are recommended, particularly to novice constructors, as LM3914s do not come cheap and removing an 18-pin IC is no easy task in any case. The LEDs may be soldered directly to the board as shown or may be mounted remotely, for instance on the car dashboard with flying lead connections to the PCB. If mounting the LEDs on the board specified, please note that 0.125" LEDs must be used as 0.2" types will not fit!

R2, the 100R 2 W resistor is not of a critical value and to save costs, on the prototype this component was made up of 4×470R ½W resistors in parallel. Any similar combination resulting in a power handling of 1W5 or more may be used.

Provision is made on the PCB for converting the circuit to dot-mode display. Although this modification would not be advantageous for a fuel gauge, the project can of course be used for any purpose requiring a monitor with a response that is inversely proportional to a linear input.

HOW IT WORKS

A current source for the fuel gauge sender unit is provided by R2. A voltage proportional to the resistance of the sender is therefore developed between the input and ground. In a typical vehicle this voltage will vary from 2 V when full to around 9 V when empty. This variable input is inverted around a reference voltage derived from R4 and R5 by a unity gain inverter consisting of IC1, R3 and R6. C1 is deliberately larger than is normal for frequency compensation to slow down the response of the circuit, thus providing a far more static display, free from annoying flicker. A variable potential divider formed by R7 and PR1 sets the FSD of the LM3914 bargraph display driver.

PR2 serves two purposes; the *setting* of this pot adjusts the zero level of the voltmeter, while the *value* sets the LED current. A value of 2k2 was chosen to given an LED current of around 7 mA according to the formula:

$$I_{LED} = \frac{1.2\,(10 + R)}{R}$$

where R is the value of PR2 in kilohms. A current of 6 mA per LED with all LEDS illuminated corresponds to a maximum dissipation in IC2 of around 600 mW which is inside the rated maximum of 660 mW.

The components ZD1, R1 and Q1 form a simple stabilised power supply of around 10 V. This value allows for a weak battery while still maintaining accuracy.

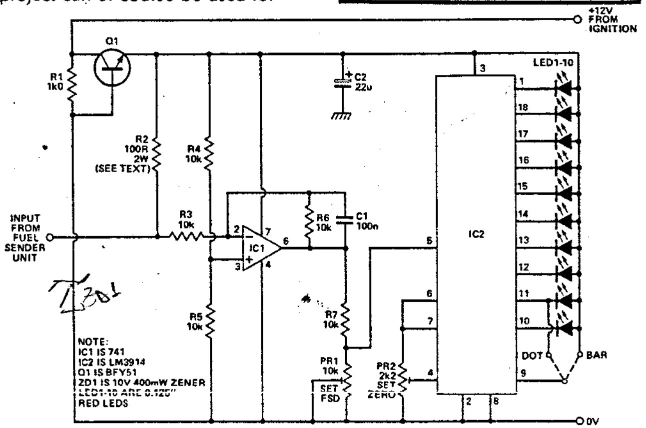


Fig. 1

Testing And Calibration

After assembly of all components, connect the unit to a 12 V supply and short the input terminal temporarily to 0 V. It should be now possible by adjustment of PR1 to obtain a full 10 LED display with adjustment to at least half FSD. With the input shorted to +10 V PR2 should adjust for no LEDs illuminated, again with considerable adjustment both ways. If the unit fails to function check for solder shorts, misfitted components, broken PCB tracks and faulty components — in that order.

To calibrate the unit it is obviously necessary to have access to the car with fuel tank full and empty; we recommend that the following procedure is adopted. Run the car until the tank is nearing empty. Drain the tank into a suitable container by disconnecting the fuel line at the pump and refill the tank with about 2–3 pints of fuel to allow a certain safety margin even when the gauge registers empty. Connect the unit temporarily to the car and after allowing the tank contents to settle, accurately measure the voltage at the input and record this value. Replace the tank contents, drive to a garage and fill the tank completely with fuel. Again accurately measure the voltage at the input.

Remove the unit to the test bench, apply power and connect a low value potentiometer between the input and ground. Now using the recorded values, the unit may be calibrated on the bench by applying the correct voltages by adjustment of the potentiometer. This method of calibration is necessary because the two adjustments are highly interactive and calibration would otherwise entail filling and draining the fuel tank several times, which would be time-consuming and possibly expensive. When calibration is complete, seal the presets with wax or nail varnish and finally install the unit in the car. Take care not to allow the track around the edge of the PCB touch the chassis when mounting the unit — this is the +10 V rail and blown fuses will result.

The display brightness is set by the *value* of PR2. This value is chosen to give a current of about 6 mA per LED which corresponds to a dissipation of around 600 mW in the LM3914 when all LEDs are illuminated. As the maximum allowable dissipation of the device is 660 mW, on no account should the value of PR2 be reduced.

A design point is that the display is of 10 LEDs and most modern cars have tank capacities of around 10 gallons. Thus an approximate direct readout of 'gallons remaining' is obtained and a fair estimation of fuel consumption may be made.

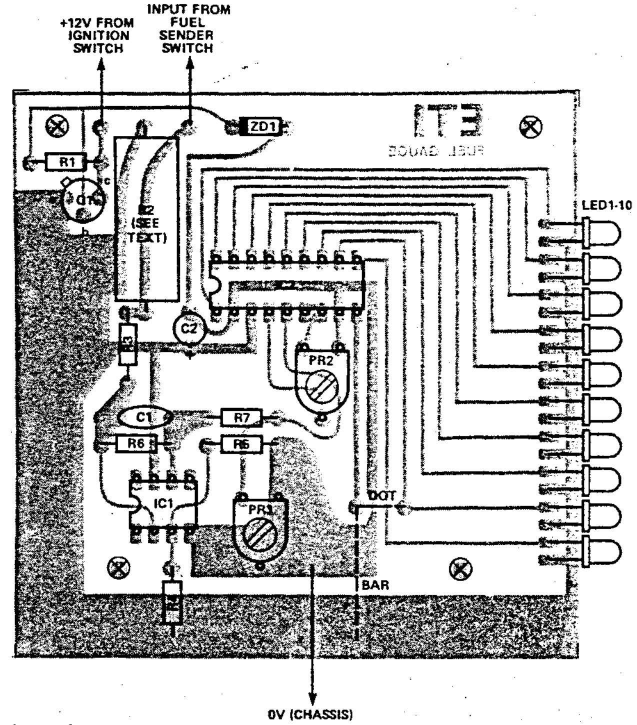
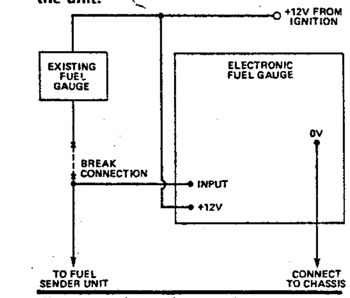


Fig. 2 (Above) Component overlay. This is slightly altered from the prototype shown.
Fig. 3 (Below) Connection details for the unit.



PARTS LIST

Resistors (all ¼W, 5% except where stated)	
R1	1k0
R2	100R 2 W (see text)
R3–7	10k
Potentiometers	
PR1	10k miniature horizontal preset
PR2	2k2 miniature horizontal preset
Capacitors	
C1	100n polyester or polycarbonate
C2	22u 16 V tantalum
Semiconductors	
IC1	741
IC2	LM3914
Q1	BFY51 or similar
ZD1	10 V 400 mW zener
LED1–10	0.125" red LEDs
Miscellaneous	
PCB (see Buylines); hardware for mounting	

BUYLINES

No problems with any of the components here; everything should be sold by everybody, and most of it could be found in your junk box. The PCB can be obtained using the PCB Service order form on page 91.