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45p

Fuel Consumption Meter

Plus... V.D.U. SYSTEM

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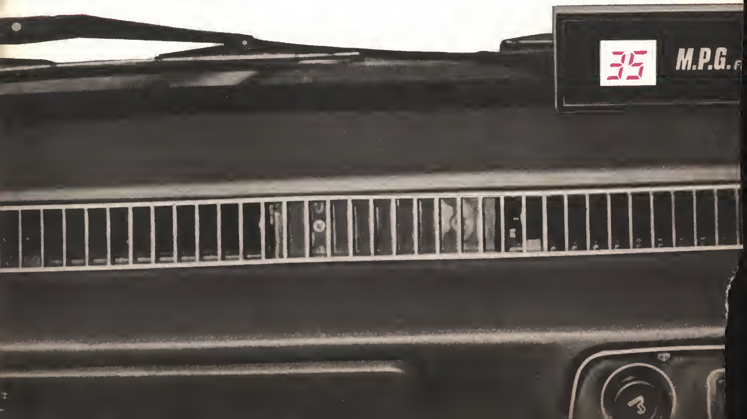
Fuel Consumption Meter

J.McCARTHY

This unit does not show the average m.p.g., but gives an instantaneous fuel consumption related factor. You can check your driving efficiency. As your foot goes down on the accelerator, down goes the m.p.g., and up it comes again when your foot does!



THIS article describes a fuel consumption meter which has been operating successfully for many months. The attributes of the system are:

(a) Two digit digital display
(b) Mainly low-price TTL
(c) Interfaces to the car via a simple connection to the SU electric fuel pump, and an easy modification to the car's speedometer.

An SU electric fuel pump may be fitted to any car using a mechanical fuel pump, provided that the former can provide the fuel at a satisfactory rate. In the author's case, a 1725cc Hillman Hunter was fitted with a fuel pump borrowed from and aged side-valve Morris Minor. The Hunter never showed any signs of fuel starvation despite very hard driving. Fig. 2 shows a simplified diagram of such a pump. As the pump operates, the voltage at point "A" alternates between +12V and 0V (for —ve earth vehicles).

The measurement system may conveniently be considered as two interconnected sections, as depicted in Fig. 1. Referring to this diagram, the distance monitor counts pulses derived from the speedometer, whilst pulses at a slower repetition rate derived from the fuel pump cause the generation of a series of internal control pulses which halt the speedometer counting process, store and display the count to date, and reset the counter. This effectively generates a measure of distance covered per operation of fuel pump, which it may be noted is of the same dimensions as miles per gallon, or for that matter, kilometres per litre, although it is clearly not in these units. Fig. 3(a) shows the counter module circuit, which utilises a total of six TTL chips which drive a pair of 3015F seven-segment displays. Its function is as follows: Provided that the reset line is kept low, pulses into the gated speedo input, or to be more specific, negative going edges, will cause the two tandemed 7490s to count. Pulses to the strobe cause the 7475s to latch their outputs to the count generated at their inputs by the 7490s. The 7475s outputs are converted by a pair of 7447s into seven-segment display code.

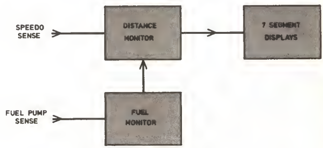
The signals applied to this module, in relation to the signal received from the vehicle sensors, relative to time, are in Fig. 4, which is not necessarily to scale. For each rotation of the speedometer cable, one pulse is applied to the gated speedo input, until the fuel pump operates, at which point the strobe and reset lines are sequentially pulsed in order to display the count since the last pump operation, and to reinitialise the counters.

Fig. 3(b) shows the second module; this circuit matches and converts the signals obtained from the speedometer and the fuel pump sensors into those suitable for TTL logic.

SPEEDOMETER SENSOR

At this point, it is necessary to describe the method of application to the speedometer of a sensor. The method used by the author, which should be applicable to the majority of cars, was to mount a photo-sensitive device in the rear of the speedo in such a way that light is reflected from the speedometer illuminating bulb via a part of the rotating mechanism, onto the photo-device. The point at

Fig. 1. Simplified block diagram of Fuel Consumption Meter



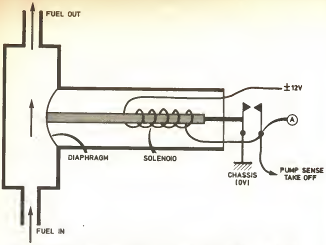


Fig. 2. Diagram shows the fundamental arrangement of an electric fuel pump, and how the sense signal is derived. One-way valves direct the flow of fuel as the diaphragm oscillates

which this is mounted has to be carefully selected, and it may be necessary to paint parts of the internal workings of the speedometer with matt-black paint. It is also necessary to make a minor change to the speedometer illumination system, entailing severing the wire connecting the speedometer bulb to the sidelight system, and connecting it instead to the ignition switch, such that it is on, whenever the ignition is on. The photo-device is then connected to the module of Fig. 3(b) *via screened cable.* This precaution has been found to be essential in view of the high impedance nature of the phototransistor, when no light is falling on it.

The current changes caused within the phototransistor due to changes in the incident light are then used to drive a p.n.p. Darlington pair, the output from which is taken to a variable Schmitt trigger comprising a 741 with adjustable positive feedback, a level-shifting n.p.n. transistor, and finally a 7413 to generate suitable TTL levels, The setting of the three variable resistors will be described later. The signals from this section of the unit are then sent to the counter module for processing.

FUEL PUMP

The pulses from the fuel pump which have additional unwanted spikes in both the positive and negative sense, are first clamped to TTL levels by a pair of diodes, one of which prevents negative pulses from entering the remainder of the circuitry, the other of which clamps the input level to less than 5V. The pulses then go to a pair of retriggerable monostables, held in one package, the 74123. The two monostable multivibrators have periods of T1 and T2 where T1 is very much greater than T2. The output of the monostable of period T2 is used to drive the subsequent circuitry, while the output of the other monostable is used to inhibit false triggering caused by contact bounce, ringing and so on.

The subsequent circuitry comprises a pulse sequence generator to generate the reset and latch strobe pulses, and to inhibit the input of speedometer derived pulses. The heart of this system comprises a divide-by-eight counter, part of a 7490 (IC8) and a clock oscillator, part of 7413 (IC9). A pulse from the monostable driver will force the counter to reset, which allows the oscillator to function. This causes the counter to count from zero to four, in so doing, generating the required control pulses. When the counter achieves a count of four, the rising of IC8 pin 9 output inhibits the function of the clock oscillator.

COMPONENTS . . .

Resistors

R1, R3	270Ω (2 off)
R2	2·2kΩ
R4	270kΩ
R5, R6	240kΩ 2% (2 off)
R7	6·2kΩ 2%
R8	27kΩ

All resistors ¼W 5% unless otherwise stated.

Potentiometers

VR1, VR3	100kΩ vertical preset (2 off)
VR2	1MΩ vertical preset

Capacitors

C1, C2, C8, C9, C10	1nF (5 off)
C3	0·01μF
C4	100μF/20V electrolytic
C5	10nF
C6	10nF
C7	22μF

Transistors and Diodes

TR1, TR2	OC200 (2 off)
TR3	2N3705
TR4	BP101, TDB7805T or equivalent
D1, D2, D3	OA202 (3 off)

Displays

X1, X2	3015F (2 off)

Integrated Circuits

IC1, IC2, IC8	7490 (3 off)
IC3, IC4	7475 (2 off)
IC5, IC6	7447 (2 off)*
IC7	7413
IC9	7400
IC10	7404
IC11	74123
IC12	741
IC13	7805 regulator

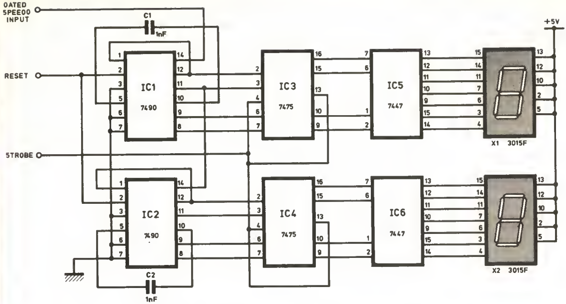
Miscellaneous

Three way plug and socket for sensor inputs. Metal case (prototype housed in box 162 × 70 × 50mm). Plug and socket for 12V input. Veroboard. On/off switch. Integrated circuit holders if desired. Polarised display filter (for digital version).

* Not needed for meter display

Constructor's Note

The BP101 is available from **Electrovalue.** OC200 transistors are available from **Watford Electronics,** and **Semiconductors Supplies, Orchard Works, Church Lane, Wellington, Surrey, SM6 7NF.**



SUPPLY PINS	0V	+5V
IC1	10	5
IC2	10	5
IC3	12	5
IC4	12	5
IC5	8	16
IC6	8	16

Fig. 3(a). Counter module circuit (built on separate board)

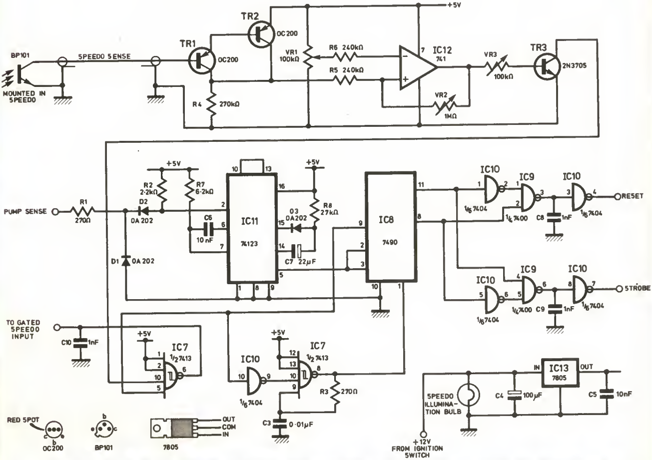


Fig. 3(b). Interfacing module circuit diagram. This part of the system matches the sense signals to the TTL

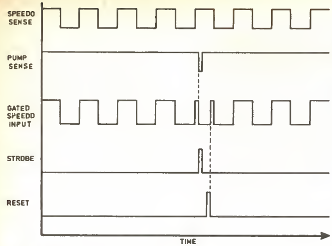
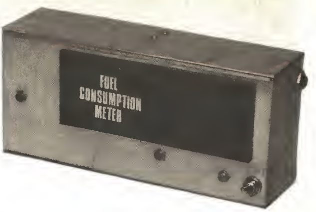


Fig. 4. Sensor and control signals relative to time. These are not to scale



The use of a metal case is advisable for effective screening; the 5V regulator can then be mounted on the rear of the unit for excellent cooling. The driver will probably be most curious about the fuel consumption reading when accelerating hard; a time when increased concentration on the road is required, and so care should be taken in the use on this instrument.

ANALOGUE DISPLAY

The author's unit employs a pair of seven-segment displays, but it might be felt preferable by some constructors to use an analogue meter display. These may easily be done by replacing the displays and their associated 7447s with the circuit of Fig. 5. In this circuit, the inverted outputs of the two 7475s are used to drive a 6-bit resistive digital to analogue converter, the resulting current from which is amplified by TR4, and used to drive a 1mA meter movement. The emitter of TR4 is set to around 2·2V below Vcc by the effect of the three diodes D3, D4 and D5 and

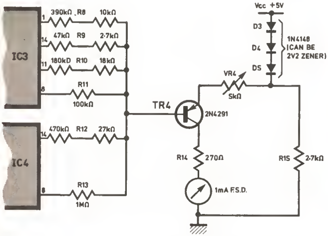


Fig. 5. Circuit diagram of meter display circuit. Devices marked with an asterisk in the main components list will not be necessary if this readout system is used

R15. This ensures minimum current flow when the outputs of the 7475s are high, thereby obviating the necessity of a set zero adjustment. VR4 is used to set the full-scale deflection value. This should be initially set to its maximum value, and when adjustment of the rest of the equipment has been made as next described, set to give the desired full-scale reading in use.

COMPONENTS . . .

FOR METER DISPLAY

Resistors

R8	390kΩ + 10kΩ
R9	47kΩ + 2·7kΩ
R10	180kΩ + 18kΩ
R11	100kΩ
R12	470kΩ + 27kΩ
R13	1MΩ (2 off)
R14	270Ω
R15	2·7kΩ

Potentiometers

VR4	5kΩ preset
D3, D4, D5	1N4148 (3 off) or 2VZ Zener (1 off)
Meter	
M1	1mA f.s.d.

CONSTRUCTION

The circuit layout is in no way critical, and in the author's case, the equipment was built on two small sheets of Veroboard, with each board corresponding to one of the modules described previously. The above having been said, it is important to observe two important rules: The decoupling capacitors on the 7490s on the counter module board are essential to the counter chips' correct operation. They should be connected as closely as possible to the chip supply pins. In view of the electrically noisy environment within a car, due to ignition, and other radiation, the equipment should be constructed within an earthed metal box; failure to do so may result in spurious operation.

The author's Fuel Consumption Meter circuit was laid out on two pieces of Veroboard mounted one behind the other. Component layout is non-critical, and this photograph shows the basic arrangement of the counter section of the prototype unit.

Interfacing section circuit board. Use Fig. 3 for interwiring. This board should be mounted so that the displays show through the front panel directly

SETTING UP

The only specific adjustment required in the system is that relating to the circuitry interfacing the speedometer to the TTL, and three preset adjustments have been found necessary.

Adjustment may most easily be done with the equipment in the car, and *both* driving wheels *securely* jacked-up clear of the road. With the engine started and idling slightly faster than normal, gently engage first gear. The three preset potentiometers should be initially set as follows:

VR1 mid-position.
VR2 maximum resistance.
VR3 maximum resistance.

A test meter should be set to around the 5V d.c. range, and connected to the output of the 741.

VR1 should be adjusted in either direction as necessary until the meter reading pulsates at a speed proportional to the speedometer reading. VR2 should then be adjusted until the pulsations just stop, and then increased by about 10 per cent. VR1 should be adjusted to the middle position of the range in which speedometer pulses are detected. So far, a centre point for the input pulses has now been determined, and by setting the positive feedback to the maximum acceptable, any rough tops to the waveform will be "ironed out". The number held by IC10 should now be checked; this should be the value 4. If this is not the case, momentarily trigger the 74123 by connecting the pump sense wire to earth for a brief period. If after a very short period of time, the 7493 does not halt in the mentioned rest state, something in this area is not in order and the circuitry should be checked. If all is well, transfer the test meter probe to the input of the 7413, and reduce the value of VR3 until the pulsations appear from the output of the 741, and then at the *output* of the 7413. The equipment is now ready for use.

INTERPRETING THE RESULTS

During normal driving, the readings presented by the equipment will fluctuate with changes in fuel consumption. It should be noted that two sources of inaccuracy can occur.

The first of these occurs because the float-chamber systems of most carburettors are gravity operated, and any violent disturbance in the car's motion, such as violent braking or cornering will affect the amount of petrol allowed into the float-chamber by the needle-valve, causing a momentary upset in the readings obtained.

Secondly, as is well known by Morris Minor, and doubtless other drivers, a marked lowering of the level of fuel in the petrol tank causes the pump to operate very rapidly as air, rather than petrol is ingested. The settings of the timing components on the 74123 is such that a cycle during which air is ingested occurs before the 74123 pulse of time T1 has finished, thus ensuring that the pulses from the pump are ignored when air is being drawn in. Accuracy is still effected by this phenomenon however, and the fuel level should not be allowed to fall this low in normal running if accurate results are required from the equipment. ★