digital rev counter

Until recently, the speed of a car engine (r.p.m.) was measured with an analogue system. It stands to reason that a digital method would do equally well. In principle this can be done with a common frequency meter. Since in this case the number of revolutions per minute (r.p.m.) is to be measured, the time base will have to be somewhat adapted.

The contact breaker in every car (except diesels) and on every engine closes and opens a certain number of times per minute. This number is determined by the following factors: the number of cylinders, the type of engine (two-stroke or four-stroke) and the number of revolutions per minute. If the first two data are known, it can be calculated how many pulses a certain contact breaker gives per second at a certain number of revolutions per minute.

A one-cylinder two-stroke engine gives one pulse per revolution. A one-cylinder four-stroke engine produces one pulse per two revolutions. So a four-stroke engine gives half the number of pulses at the same number of revolutions. This leads to the formula for the number of pulses per second any type of engine produces at a certain number of revolutions (per minute):

$$p = \frac{n \times c}{60 \times a}$$

where p = pulses per second (p.p.s.)
n = revs per minute (r.p.m.)
c = number of cylinders
a = 1 for two-stroke, 2 for four-stroke.

By means of this formula we can now set up Table 1 which immediately shows the fixed r.p.m./p.p.s. ratio for each type of engine. For instance, a most common engine is the four-cylinder four-stroke. At 6000 r.p.m. this engine produces 200 p.p.s. To express the r.p.m. in four digits will therefore take some 30 seconds. This is, of course, out of the question because within the time span of 30 seconds the number of r.p.m. is subject to variation. Consequently, the number of digits shown is reduced to two. The measuring time is then only three tenths of a second. The engine speed can thus be measured with an accuracy of $< 1\%$, which is amply sufficient. Nobody will care whether an engine makes 3418 or 3457 r.p.m.

The circuit

The pulses produced by the contact breaker are usually a bit frayed due to contact 'chatter', and the voltage produced is variable because of the resulting inductance voltages.

Since electronic circuits in general have a severe dislike of inductive voltage peaks, these voltages will have to be suppressed, or at least limited. A zener with a capacitor in parallel for the sharp peaks provides sufficient protection. This protective network is formed by R_1, C_1 and D_1 (see figure 1). Thus the inductive peaks, and to some extent also contact chatter, are suppressed. The remaining chatter is suppressed by means of a monostable multivibrator, which uses half of a 7400 IC. This one-shot responds to pulses with a width of 50 µs or more. In addition, the one-shot passes pulses wider than the characteristic pulse time for their entire length, so that spurious pulses have no effect.

The timebase is provided by a simple, yet relatively stable UJT-oscillator. Its pulse width can be adjusted over a wide range by means of potentiometers R_5 and R_6; the first is for coarse adjustment, the second for fine. In some cases the value of R_7 must be changed (larger or smaller) to enable the required pulse width to be set.

In contrast to the usual circuits, the output pulse is not used to drive a counter gate. The signal to be counted is fed continuously to the counter input of the digital counter used. This is possible because the measuring time is so long that the measuring error due to the latch- and reset time is negligible.

The signal for the buffer memory used in the counter is derived from the discharge pulse the UJT produces across R_9. The transistors T_3 and T_4 provide a level suitable for TTL circuits.

The latch signal thus obtained is a positive pulse. The negative edge of this pulse is used for triggering a one-shot, so that a reset pulse can be produced after the latch pulse. The decade counter, type 7490 (generally applied in digital counters) must be reset with a positive pulse. However, the one-shot produces a negative pulse. Moreover, the delay between latch and reset is too small to ensure optimum functioning. Therefore, the positive trailing edge of the negative pulse is used. After differentiation with C_5 and R_{15} a useful signal appears on the reset output. Diode D_2 suppresses the differentiated pulse caused by the negative flank.

So far the overall control circuit. Its layout is shown in figure 2.

In principe any digital decade counter can be used, and one that is eminently suitable is the minitron counter. This decade counter consists of a display board with several counter boards mounted at right angles to it. For this application the display board is shortened to about 5 cm, so that it can accomodate only two minitrons. The complete minitron counter with two decades is then a block of no more than 5 x 6.5 cm. The dimensions of the control circuit board are reduced correspondingly.

The diagram of the minitron counter is shown in figure 3. The 7490 is connected as a normal divide-by-ten circuit. The buffer memory, or latch, is a 7475. This IC contains four D-flipflops that store the information from the 7490 or pass it on continuously, as required. When mounting the IC on the board, pin 8 must be cut off; or, if IC sockets are used, pin 8 can be removed from the IC socket.

Via the 7475, the BCD information is fed to the 7-segment decoder 7447 which drives the minitron directly. The board is shown in figure 4. By means of soldered connections the display and counter circuit boards are joined to form a kind of block. Figure 5 shows how and where the soldered connections must be made. The width of the control board matches that of the counter boards so that that, too, can be soldered to the display board.

Supply

The rev. counter operates on the usual voltage for TTL-ICs, that is 5 V.

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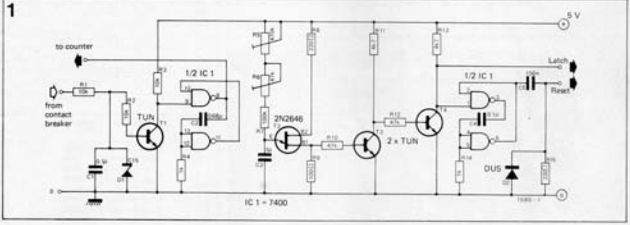

Figure 1. Circuit diagram of the control circuit.

Parts list

Resistors:
R_1, R_2, R_3 = 10 k
R_4, R_{14} = 1 k
R_5 = 470 k, trim.
R_6 = 47 k, trim.
R_7 = 100 k
R_8 = 220 Ω
R_9 = 100 Ω
R_{10}, R_{12} = 47 k
R_{11}, R_{13} = 4k7
R_{15} = 330 Ω

Capacitors:
C_1, C_4 = 0.1 μ
C_2 = 0.68 μ
C_3 = 1 μ
C_5 = 150 n

Semiconductors:
T_1, T_3, T_4 = TUN
T_2 = 2N2646 (UJT)
IC_1 = 7400
D_1 = zener 15 V, 250 mW
D_2 = DUS

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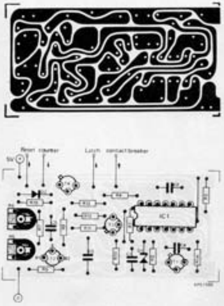

Figure 2. Printed circuit board and component lay-out for the control circuit.

Table 1.

	6000 r.p.m.	8000 r.p.m.
Engine type	Pulses per second	
1 cyl. 2-stroke	100	133
2 cyl. 2-stroke	200	267
3 cyl. 2-stroke	300	400
1 cyl. 4-stroke	50	67
2 cyl. 4-stroke	100	133
4 cyl. 4-stroke	200	267
6 cyl. 4-stroke	300	400
8 cyl. 4-stroke	400	533

Adjustment

There are several ways of adjusting the rev. counter. The most accurate method is by using the mains frequency or a crystal time base. Unfortunately, the latter will not always be available.

Another possibility is to use a tone generator. Both mains frequency - and tone generator adjustment are discussed below.

Adjustment with the tone generator

For this method of adjustment, a tone generator with calibrated tuning scale for reasonable accuracy is a first requirement. Table 1 gives the frequencies corresponding to a certain type of engine running at 6000 or 8000 r.p.m. Furthermore, each frequency corresponding to a certain engine speed can be calculated with the formula given above. So far so good.

However, the circuit responds only to square wave voltages, so the tone generator will have to produce a square-wave output, or the conventional sine-wave must be converted into a square wave.

This can be done with the simple circuit

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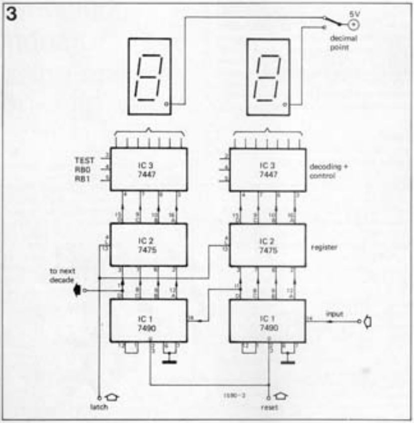

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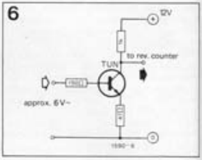

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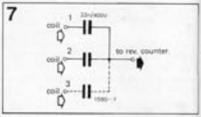

Table 2.

Engine type	rpm indication at 50 pps
1 cyl. 2-stroke	3000
2 cyl. 2-stroke	1500
3 cyl. 2-stroke	1000
1 cyl. 4-stroke	6000
2 cyl. 4-stroke	3000
4 cyl. 4-stroke	1500
6 cyl. 4-stroke	1000
8 cyl. 4-stroke	750

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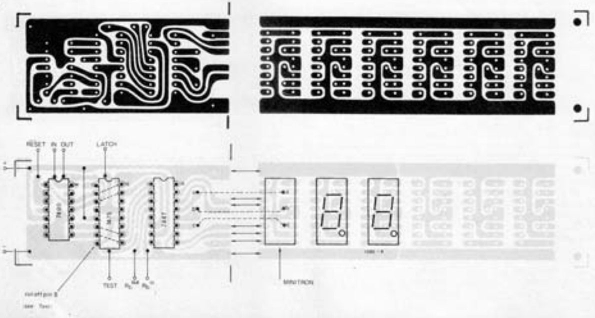


in figure 6. The output signal of this circuit is about 10 V, which is sufficient to operate the rev. counter.

Adjustment with mains frequency

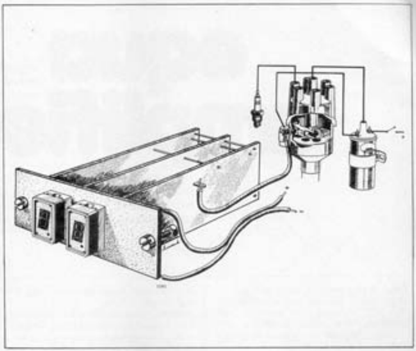
Here again the auxiliary circuit of figure 6 is used, for the mains voltage is a sine wave. A simple bell transformer, or something similar, will provide the required voltage of 6 V.

The square wave output from the circuit is applied to the input of the control circuit.

Table 2 shows what the rev. counter should indicate when used with a given type of engine, and operating on a 50 Hz input signal. While the input signal is applied, the counter can be accurately adjusted by means of R_5 and R_6. Adjustment must be such that the reading fluctuates as little as possible between various values. As is usual for most digital counters, the last digit can jump plus or minus one.

Engines with several ignition coils

Some engines have more than one ignition coil and contact breaker. In this case the various channels from the contact points should be coupled with capacitors. Figure 7 shows how this is best done. A little of experimenting may sometimes be necessary to find the best values for the capacitors.



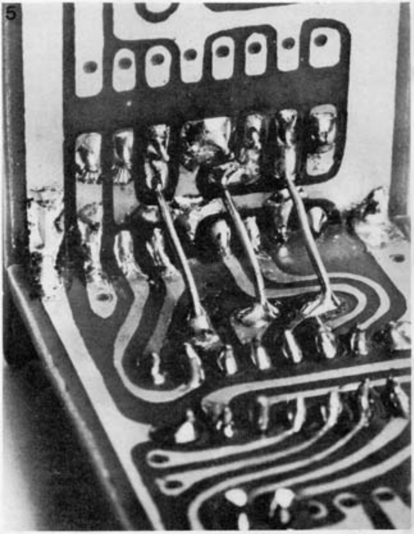


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Figure 3. Circuit diagram of the minitron decade.

Figure 4. Printed circuit board and component lay-out for counter plus display. For this particular application the display board can be shortened to about 5 cm.

Figure 5. The photograph shows clearly how the soldered connections between the two boards must be made.

Figure 6. Auxiliary circuit for adjusting the rev. counter by means of a tone generator or with the mains frequency.

Figure 7. If the engine has more than one ignition coil, this auxiliary circuit can be used to obtain a correct speed indication.