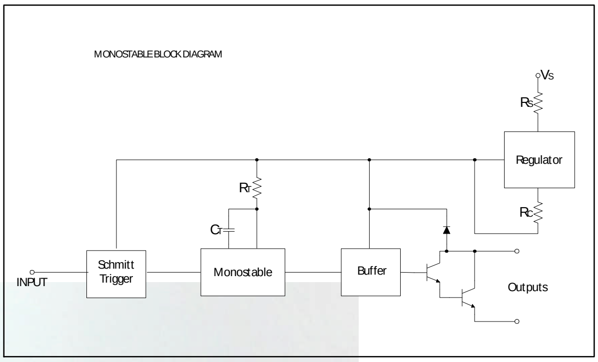
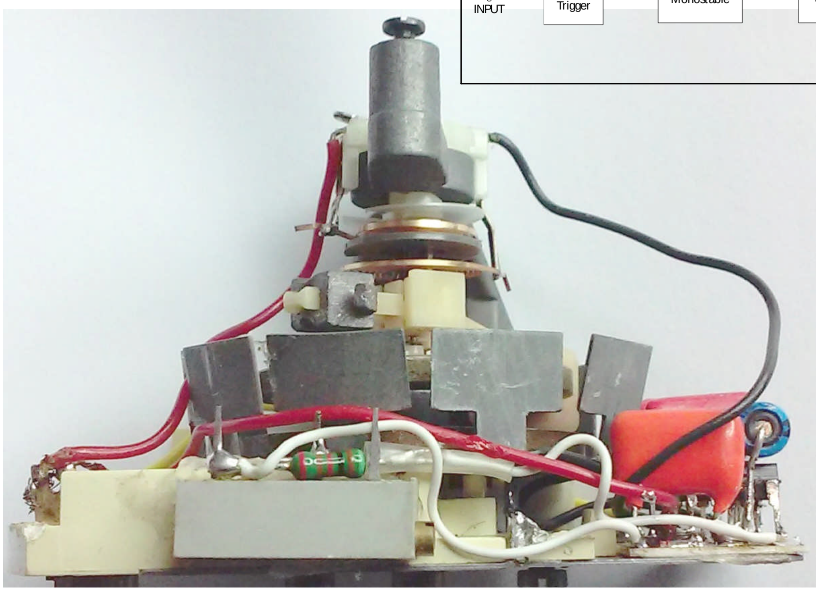
SMITHS CLASSIC

INTEGRATED CIRCUIT
(GEN-4 / "THICK FILM")

TACHOMETERS

CALIBRATION AND REPAIR





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Smiths Gen-4 RVC tachometer:

From about the early 1970s, Smiths produced their "RVC", voltage triggered, tachometer which employed an **I**ntegrated **C**ircuit (IC) as the active element. Previously, their "RVI", current-triggered, tachometers had used discrete transistor(s).

Smiths also produced a range of tachometers for Diesel engines, driven by a pulse generator attached to the engine itself. Similar circuitry to that of the ignition-triggered range for cars was used in these instruments.

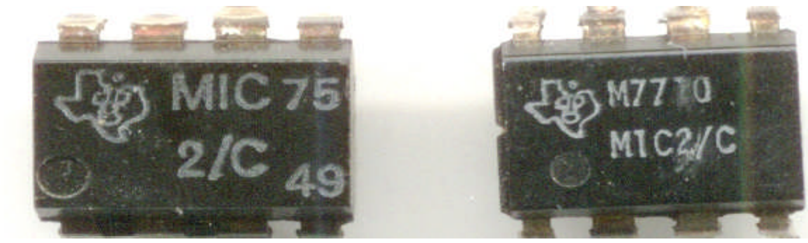
The MIC2/C Integrated circuit:

This integrated circuit for the "RVC" tachometers was provided to Smiths by Texas Instruments (TI) and was almost certainly a re-marked SN76810.

ITT made a similar IC, the SAK215, which is "pin-compatible" and performed the same function as the SN76810 though some of the parameters were slightly different. The SAK215 chip was used by other instrument manufacturers, e.g. VDO, in their tachometers.

The most significant change introduced with this IC was that the meter was now current-driven, as opposed to the earlier voltage-driven circuit. The advantage of the current-drive was that temperature compensation, for the change in meter resistance with temperature, was not now required. The same value of current was supplied as long as the current x resistance product of the meter circuit did not exceed the available voltage – about 5 Volts.

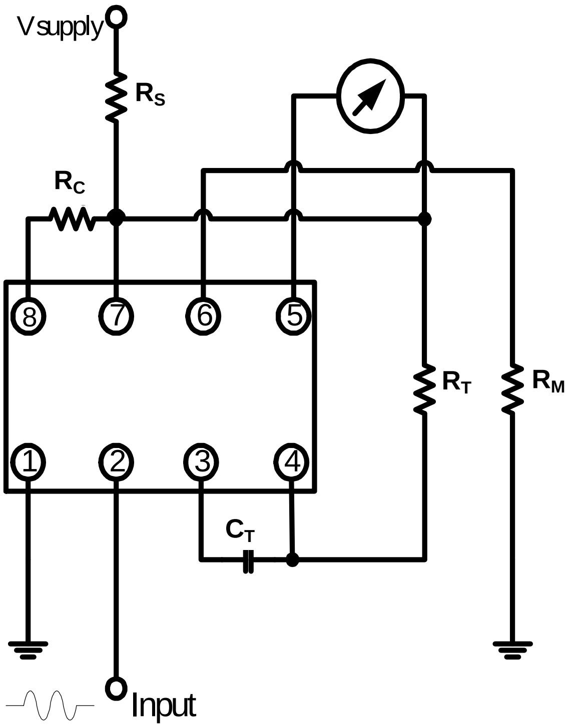
With the Gen-4 tachometers, Smiths provided no calibration adjustment as had been done for earlier model instruments. Any change in accuracy due to component ageing could not be readily corrected.



Two MIC2/C integrated circuits removed from Smiths tachometers. Pin #1 is identified by a round moulded depression near pin #1 and/or a groove or notch formed in the end of the plastic package (right-hand example).
The four digit code, sometimes prefixed by a letter, is a manufacturing date code of the form "YYWW" where "YY" indicates the year of manufacture and "WW" the week in that year. It can be seen that the IC on the left was manufactured in the 49^{th} week of 1975 and the IC on the right in the 10^{th} week of 1977. The date code prefix letter may indicate the facility at which the IC was manufactured

The circuit diagram below shows the basic circuit configuration of a tachometer using this IC. The same component designations have been used throughout this document.

TYPICAL APPLICATION OF SN76810P AS A TACHOMETER



R_M = Meter current defining resistor

R_S = Supply resistor

R_C = Regulator resistor

R_T = Timing resistor

C_T = Timing capacitor

For choice of values, refer to application notes

From the SN76810 datasheet setting out the basic tachometer circuit. Smiths often place R_S (sometimes two series resistors) in the negative supply line.

Notable differences between the SN76810 and SAK215 ICs are listed in Table 1 below.

TABLE 1: Differences in parameter values between SN76810 and SAK215 ICs		
Parameter	SN76810	SAK215
Pulse width	0.7 x R_T x C_T	0.64 x R_T x C_T
R_T value range	15 – 40 kilohms	15 – 100 kilohms
Maximum output current	60 mA	40 mA
R_M calculation	2.28V/full scale I_M	2.25V/full scale I_M

Note: Since these ICs output a pulse rather than a continuous current, the current supplied must be greater than the full scale dc current of the meter.The value used for these calculations is equal to:

$$\frac{\text{Full scale dc meter current}}{\text{Pulse duty factor (DF)}}$$

$$DF = \frac{\text{Length of output pulse}}{\text{time between trigger pulses at maximum revolutions per minute}}$$

DATASHEETS TO HAND FOR BOTH THE SN76810 AND SAK215 APPEAR AT THE END OF THIS DOCUMENT.

The Gen-4 thick film circuit board:

The first "RVC" (Gen-3) tachometers used a printed-circuit board construction as had the preceding "RVI" instruments but the later, Gen-4, models employed a thick-film construction with laser-trimmed resistors printed on a ceramic substrate to which other components are soldered. The basic circuit was the same between the two types of construction, resistor and/or timing capacitor values changed as required.

THE CERAMIC SUBSTRATE USED IN THESE INSTRUMENTS CONTAINS BERYLLIUM WHICH IS KNOWN TO BE A HEALTH HAZARD. DO NOT DRILL, GRIND OR CUT THIS MATERIAL.

Each thick-film board had an ID number. The board ID number relates to the physical board itself rather than component values which may vary from sample to sample. The Smiths part number for the board would be of the form "41-161-7nn-nn", where "n" represents any number, and component values on each board would differ depending on the number of cylinders and the maximum indicated value.

Resistor R_T and capacitor C_T set the width of the pulse driving the meter and R_M determines the value of current supplied for each pulse. Deflection of the meter is a function of both the pulse width and current. So within reason, changing either of these parameters can be used to calibrate the tachometer. Hence we find that Gen-3 instruments use a 68 Ohm meter current setting resistor where the Gen-4 use 191 Ohm or 170 Ohms, for R_M on boards to hand. (Refer to Table 2 later in document.). Indications are that either R_T or, in the case of the type 4 boards R_M were trimmed once the boards had been populated with components.
Once populated, R_T is not accessible on type 4 boards whereas R_M is. R_T is accessible on type 2 and type 5 boards whereas R_M, located beneath the MIC 2/C, is not. Trimming of these resistors after board assembly was possibly the method used to calibrate the finished assembly.

Labels for these "accessible" resistors are displayed in Green text on following thick-film board graphics.

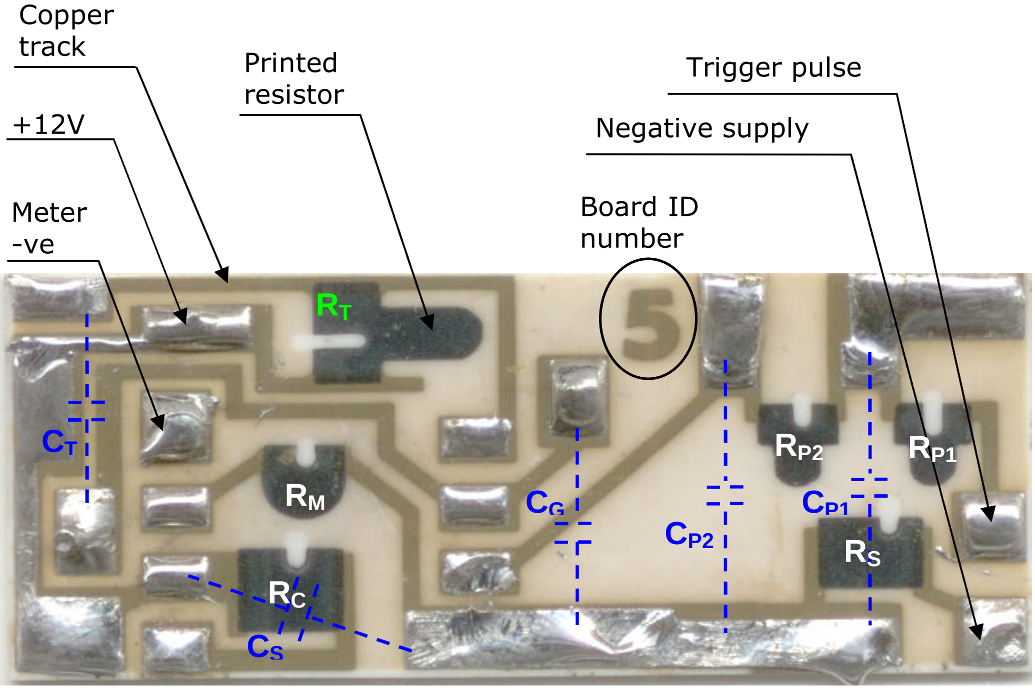
Each board was coated with a solder mask coating. Clear, Green and Red solder mask is found on boards to hand but there may be additional colours (Blue?). The significance of the solder mask colour, if any, is not known at this time.

There are quite a number of different boards used in the Gen-4 tachometers. Different boards would be required for each combination of cylinders (4/6/8/12/selectable) and for each full scale value (5500/6000/7000/8000/10000), although not all possible combinations of the above parameters would have been manufactured – tachometers with a full scale value of 10000 for an 8 or 12 cylinder engine are unlikely to have been produced.

Further variants, dependent on type of trigger signal, whether a lower voltage signal from a Lucas OPUS ignition system or triggered by the inductive spike from a coil will also add to the range of boards. Lucas OPUS ignition systems can be found as original equipment in some Jaguar and Triumph cars. Possibly other marques also.

RVC 2611/00F – Type 5 Thick-film board:

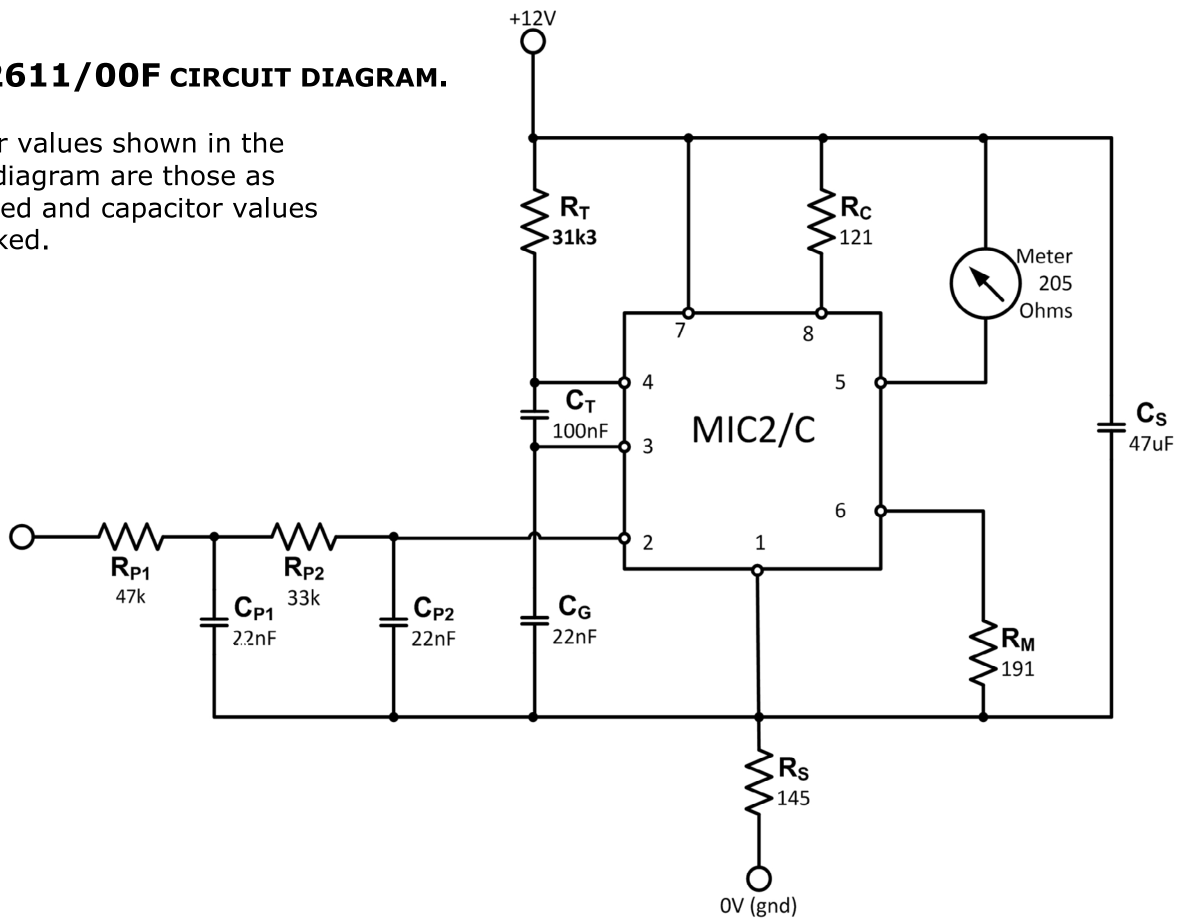
The figure below shows a thick-film board from an RVC 2611/00F tachometer as fitted to the Triumph T2500S saloon. (6 cylinder engine, full-scale value 7000 rpm.)



De-populated circuit board from a Smiths OEM RVC 2611/00F, Gen-4, tachometer. Component ID as in circuit diagram.

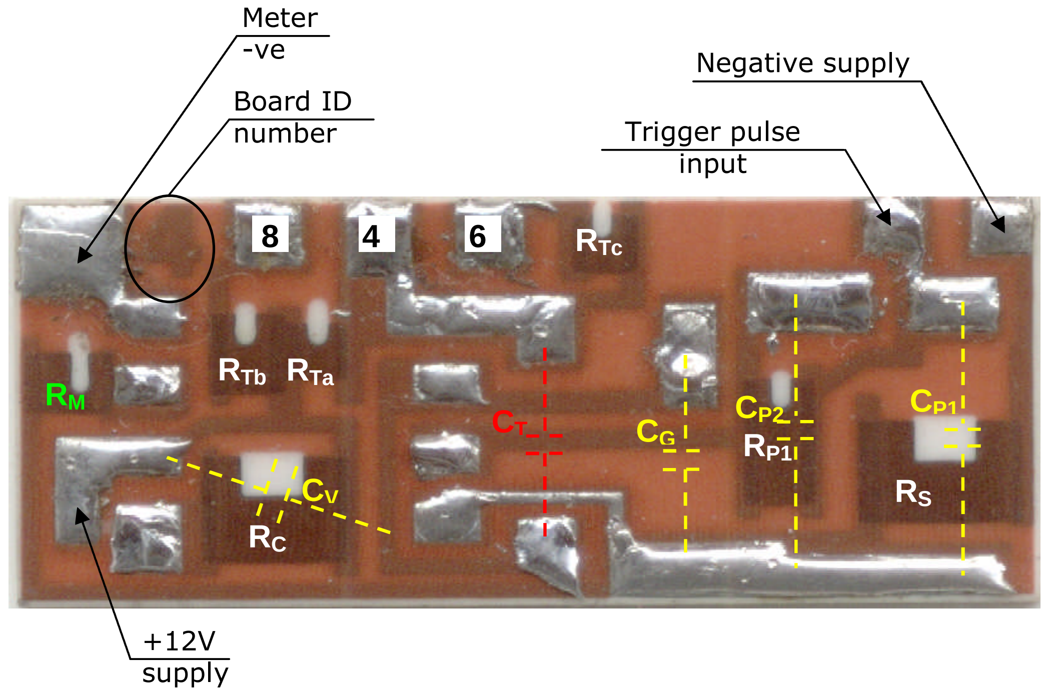
RVC 2611/00F CIRCUIT DIAGRAM.

Resistor values shown in the circuit diagram are those as measured and capacitor values as marked.



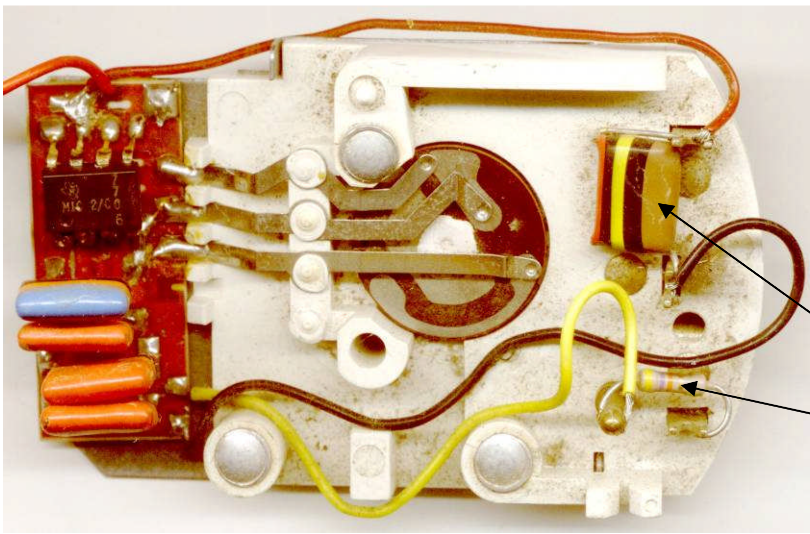
RVC 1002/00F – Type 4 Thick-film board:

Shown below are the thick film board and circuit diagram from a Gen-4 “GP” accessory tachometer. This same board is used for several tachometers, those selectable for 4, 6 or 8 cylinders and a 0 – 8000 rpm scale.



De-populated thick film circuit board type 4 from a Smiths RVC 1002/00F, Gen-4, accessory tachometer. The three numbered pads shown at the top edge of the board connect to the cylinder select switch.

The layout is quite different to that of the previous board and only one of the two trigger circuit resistors resides on the board. A 47kOhm resistor, R_{P2}, in the trigger circuit is located at the connection terminals as is the supply filter capacitor C_F.

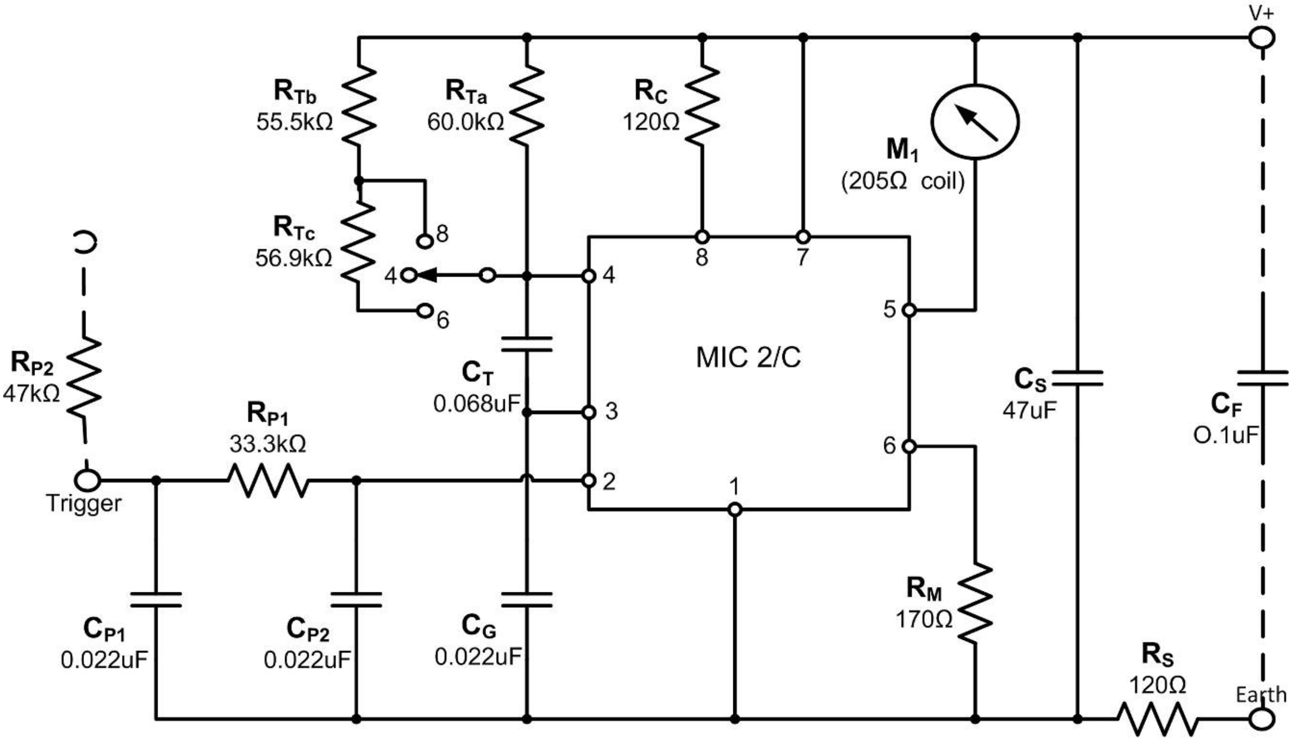


Gen-4 accessory tachometer baseplate showing the location of the two components mounted remote from the thick-film assembly. These are indicated by dashed lines in the circuit diagram.

The same base components are used in all “thick-film” tachometers, the selector switch is only present if required, mainly in accessory type instruments.

RVC 1002/00F circuit diagram

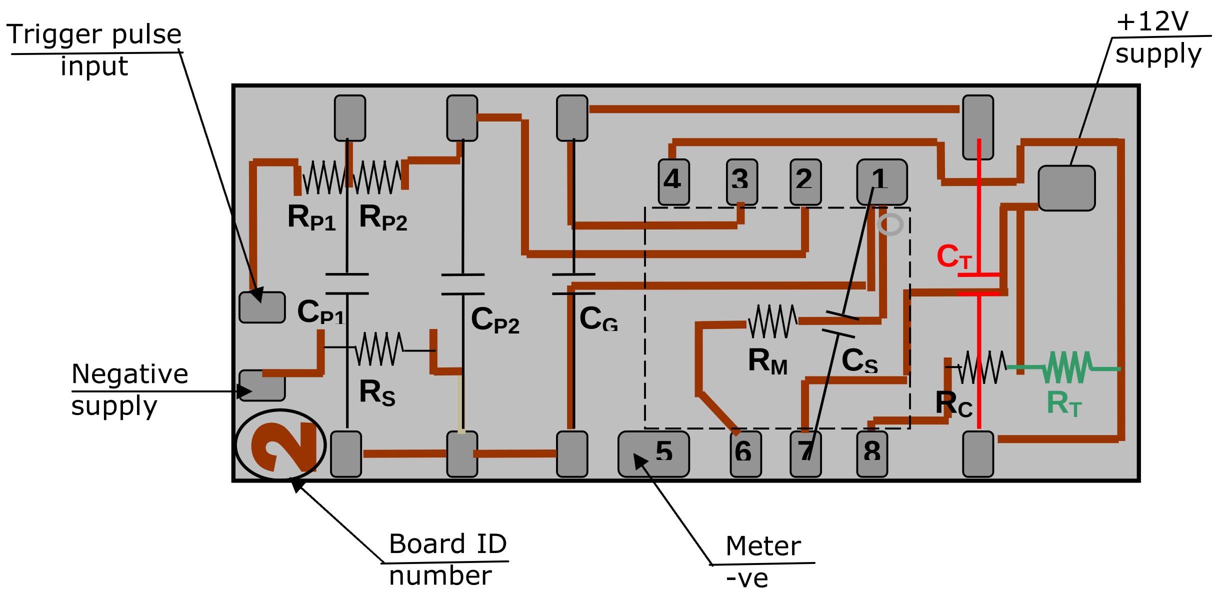
The circuit diagram below is similar to the previous diagram with the addition of a selector switch. Values for the timing capacitor (C_T), timing resistors (R_T) and meter current setting resistor (R_M) are also different.



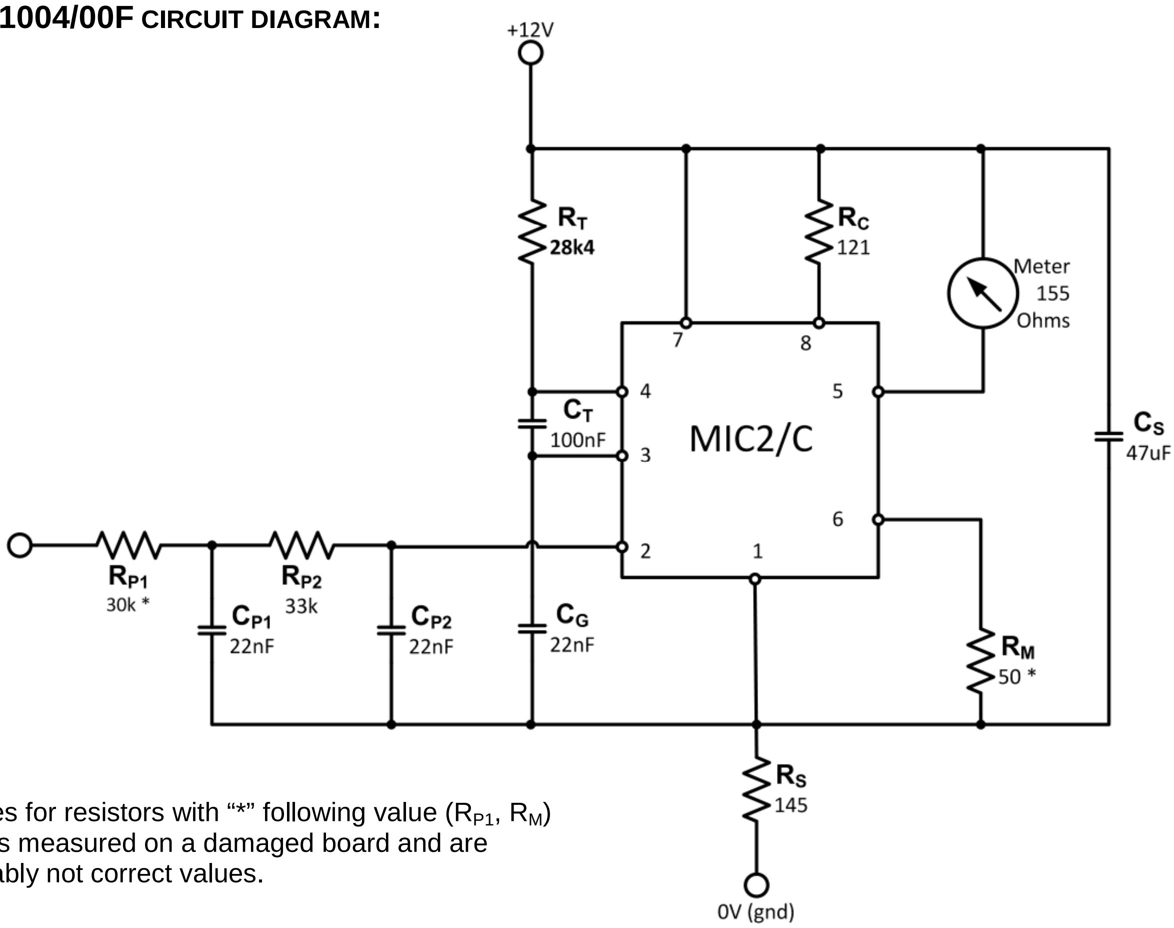
Circuit diagram of the Smiths RVC 1002/00F, Gen-4, accessory tachometer. This tachometer has a full-scale value of 8000 rpm.

RVC 1004/00F - Type 2 Thick-film board:

The sketch below shows the layout of the Type 2 thick film board. (IC pins are numbered here.) used in the RVC 1004/00F tachometer.



RVC 1004/00F CIRCUIT DIAGRAM:

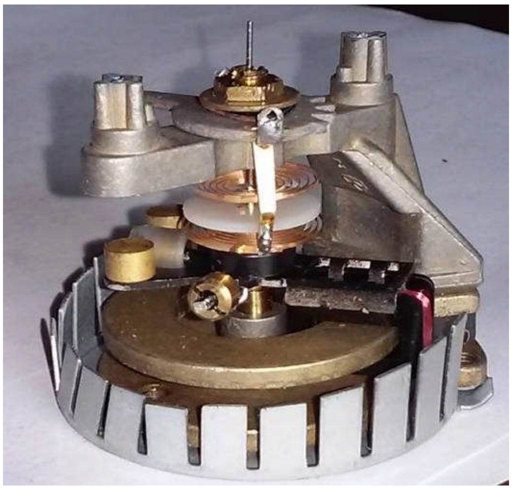


Values for resistors with "*" following value (R_{P1}, R_M) are as measured on a damaged board and are probably not correct values.

Gen-4 Meters:

The later, Gen-4, Tachometer also used a new meter which was dimensionally very different from that used in the earlier instruments.

Photographs below show two different meters used in the Gen-4 tachometer. Meters tested have a resistance of c155 (early) or c205 Ohms (late) and a full-scale current of 10.5mA and 9.5mA respectively. Metal fingers that can be bent inwards or outwards provide a small adjustment of meter span and linearity.



Showing early Gen-4 movement field plates on left and later pattern on right.

Be very careful when working with the late pattern meters. The meter terminals are simply held in place with heat-swaged plastic spigots which can melt during soldering of the meter's connecting wires, leaving the terminals hanging on the hairsprings.

This is not an issue with the early pattern meter where these terminals are retained by fingers folded over a fibre plate.

Details of meter terminal attachment: Early pattern meter at left, later pattern at right.

Early pattern meters employ threaded adjustable weights to balance the meter armature. Late pattern meters have crimped balance weights which cannot be moved.

Measured resistor values for setting meter current:

TABLE 2:- Meter current (I_M) determination:

		Meter coil	f.s. current		
R_M = 68Ω	I_M = 34mA	75Ω	24.5mA	Copper laminate	Gen-3
R_M = 170Ω	I_M = 13mA	155Ω	10.5mA	Type 4 board	Gen-4
R_M = 191Ω	I_M = 12mA	205Ω	9.5mA	Type 2 & 5 boards	Gen-4

Which looks about right as the Gen-3 meter's full-scale current is c24mA and Gen-4 meters 10.5 or 9.5mA. Refer to text on page 3.

Repairing the thick-film tachometers:

These tachometers seem to be fairly reliable and provided they have not been subject to reversed voltage supply there is little that goes wrong. Long-term drift in component values will cause these instruments to lose accuracy. In order to (re-) calibrate these meters, there is some small adjustment available in the iron field plate, or "fence", around the meter itself. Calibration drift or the fitting of an engine with a different number of cylinders to a vehicle are the most probable reason for service. The IC will die if connected to a reversed power supply.

There are four critical, in terms of accuracy, components on these thick-film boards. They are:

- MIC2/C integrated circuit
- Timing capacitor (C_T)
- Timing resistor (R_T)
- Meter current defining resistor (R_M)

In the case of a failed integrated circuit, if you can find a replacement IC, then you can get a tachometer going again but good calibration will not necessarily be achieved due to the normal device parameter spread in any semiconductor device. Replacement with a SAK215 will introduce errors that may or may not be in your favour.

The timing capacitor is a metallised polyester (Mylar) type, as are all capacitors apart from one aluminium electrolytic capacitor soldered directly to pins of the integrated circuit. The only truly critical capacitor is the timing capacitor. The manufacturing tolerance on the value of these capacitors is ±20%, so this also may be a selected component.

Both the timing resistor and meter current defining resistors are printed resistors on the thick-film board. Resistors are laser-trimmed to the desired value after the solder mask layer has been applied but before other components are soldered in place.

I have seen a proposed method of calibrating these tachometers (reducing the reading) by the addition of resistance in series with the meter. Any added resistance has to defeat the current drive circuit within the IC before any effect is seen. The meter will then be driven by voltage rather than current and this will introduce further temperature effects on the tachometers operation. A more elegant solution is to place a (high value) variable resistance in parallel with the meter coil thus bleeding some of the supplied current from the meter. This way, the current drive to the meter is not compromised. This method can only reduce the reading of the tachometer.

To increase the reading of the tachometer, four options are available.

The first is to increase the value of C_T. Due to the nature of capacitors, which usually have a large tolerance on value and readily available values available are fairly widely spaced, this of itself is unlikely to be a practical solution.

The second method is to increase the value of R_T. This is not possible without removing the existing R_T from the circuit.

The third method is to increase the drive to the meter by reducing R_M. Smiths used this method in their Gen-3 Marine tachometer.

Reducing the value of R_T and/or C_T will reduce the tachometer reading.

The fourth option, to enable a tachometer to be calibrated over a reasonable range, is to change both C_T and R_T as follows:

> Increase the value of C_T to the next "standard" value, 120nF in most cases, by replacing the existing capacitor. Or add a 22nF capacitor in parallel with the existing C_T.

Place a variable resistance, connected by flying leads, in parallel with R_T, securing it to the base plate of the tachometer.

With suitable choice of values, increasing or decreasing the tachometer reading is possible. Limitations on values are those specified for the integrated circuit used.

The above exercise was carried out on a high-reading RVC 2611/00F tachometer.

Pulse width of original board = 2.1 ms

Period between pulses @ 7000 rpm (max scale value) = 2.86 ms

Therefore, Duty Factor ≈ 0.73

Constraints on modification:

The parallel combination of existing and added resistors to be ≥ 15kΩ (From datasheet).

The maximum pulse width to be 90% or less than the period between pulses.

$DF \leq 0.9$

In the following table, R_{Tp} is the added parallel resistance and R_{tot} is the combined resistance. Resistor values in kilohms, capacitance values in nanofarads (nF).

Component	min	max
R_T	31.30	31.30
R_{Tp}	51.00	151.00
R_{tot}	19.40	25.93
Pulse width (ms)	1.63	2.18
C_T	120	120

The above values, a 51k fixed and a 100k variable resistor, provided a calibration range of ± 500 rpm at 6000 indicated rpm (300 Hz), which was sufficient for this tachometer. Using a 200k variable resistor would increase the maximum pulse width to 2.34ms; 500k to 2.49ms.

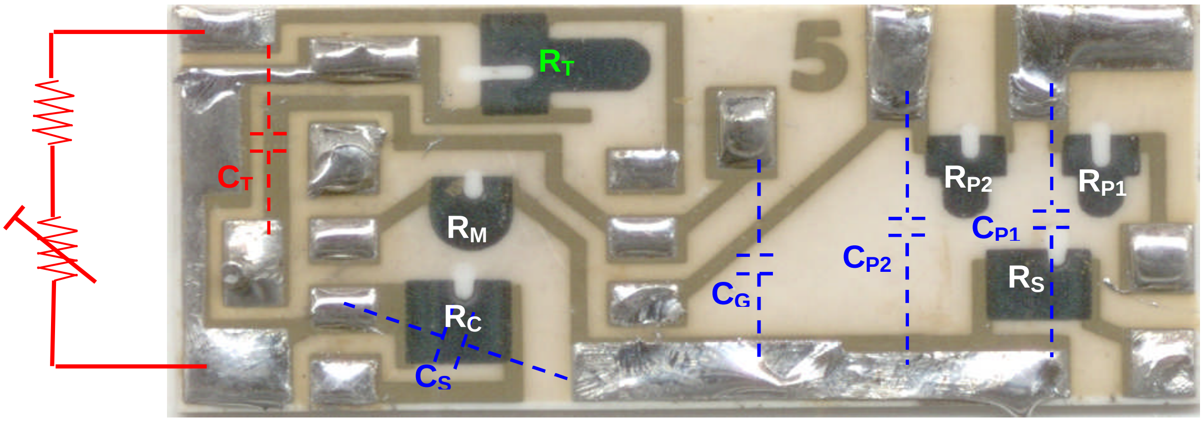
The changes to the original board are shown on the next page. A photo of the modified tachometer is shown on the cover page of this document, where the added fixed and variable resistors can be seen. The variable resistor is a 10 turn type that was to hand.

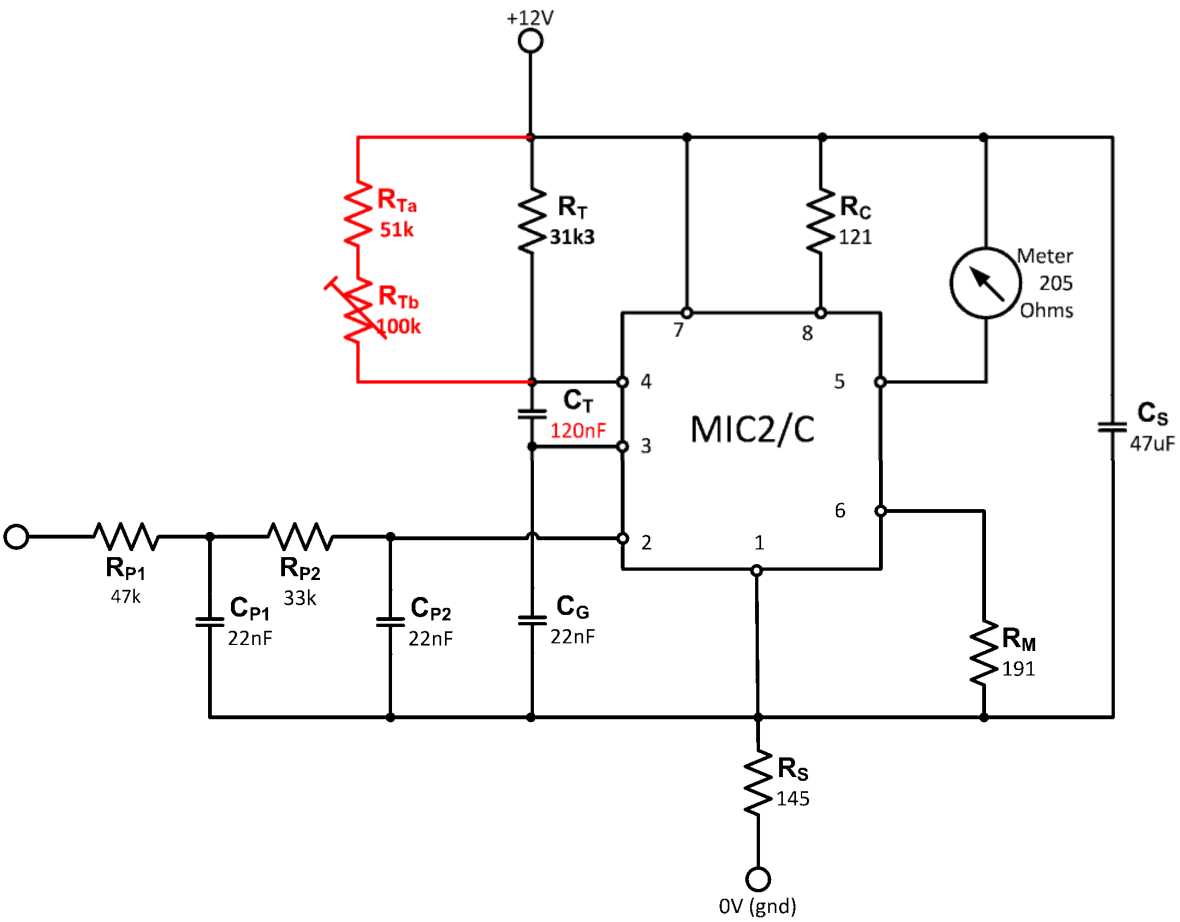
A most critical parameter is the pulse width which must be less than the full scale rpm period between pulses. For the tachometer of interest here, the duty cycle of the unmodified tachometer at maximum rpm was about 73%. Duty cycle values of 70% to 90% will be useful.

This method is not really suitable for Gen-4 accessory type tachometers that select the number of cylinders with a switch. For those, adjustment of meter current is a realistic option to calibrate the tachometer. Here the maximum meter current would be the limiting factor.

Modifications to an accessory tachometer (RVC 1002/00F) are shown later in this document.

Diagrams below show modifications to board and circuit to create a tachometer that could be readily calibrated. . Components coloured Red show the changes, which are minimal.Changes shown are for a 6 cylinder tachometer. A multi-turn potentiometer was used as the variable resistor.

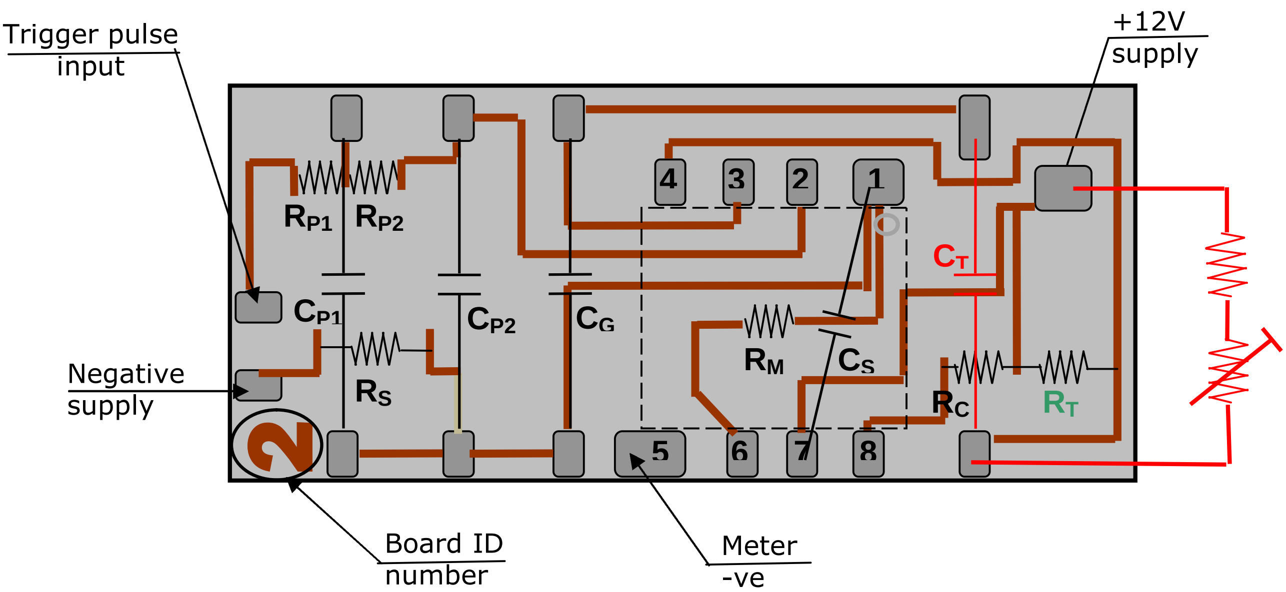




Bench-test calibration results for modified tachometer:

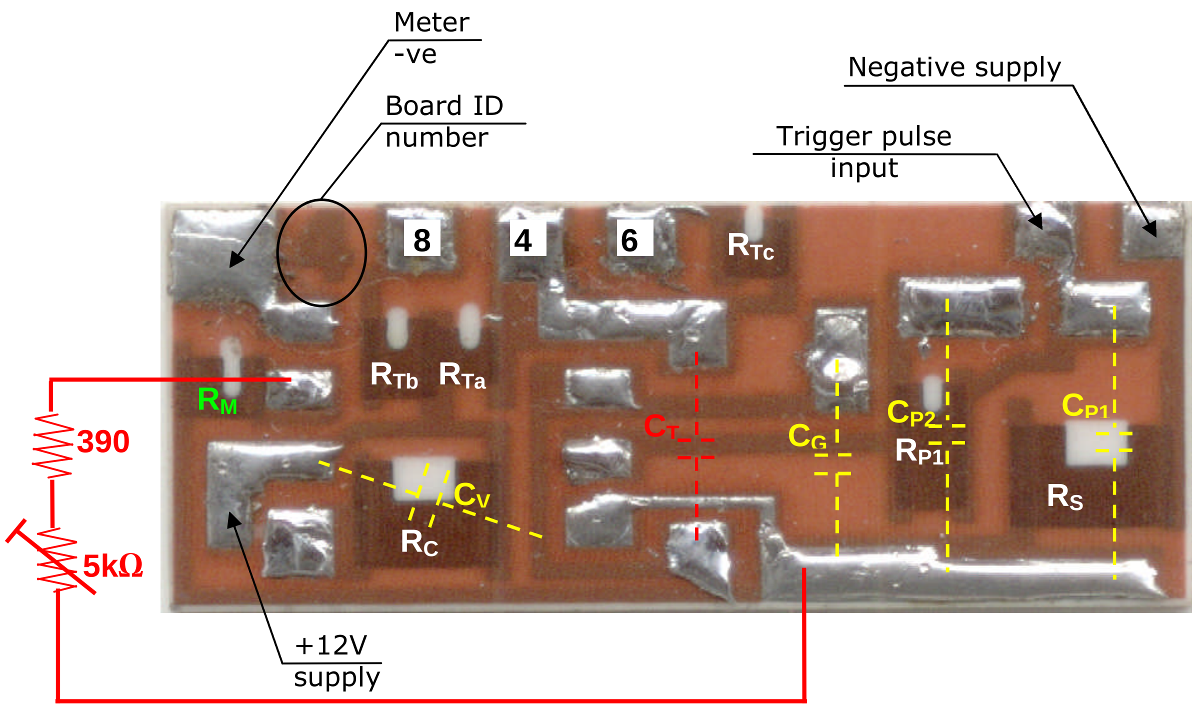
Six CYLINDER TACHOMETER		
Tachometer Part #: RVC 2611/00F		
Date:26/06/2022		
Specified RPM	**Frequency Hz**	**Indicated RPM**
1000	50.00	1000
2000	100.00	2000
3000	150.00	3000 **
4000	200.00	4000
5000	250.00	5000
6000	300.00	6000
7000	350.00	7000
** Corrected from 2900 by bending adjacent field plate		

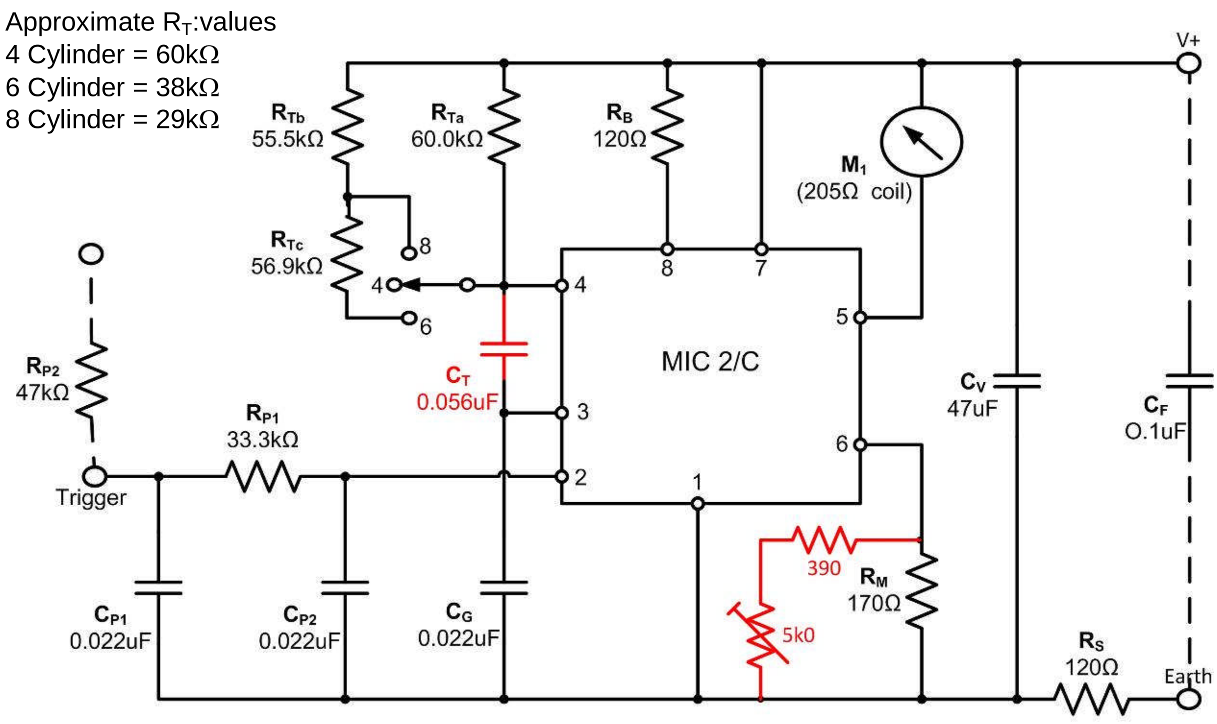
This same method is readily applied to the type 2 boards as below:



RVC 1002/00F – Type 4 Thick-film board:

Shown below are the modified thick film board and circuit diagram from a Gen-4 "GP" accessory tachometer. Again, a multi-turn potentiometer is used as the variable resistor. Red coloured elements show modifications.





Circuit diagram of the modified Smiths RVC 1002/00F, accessory tachometer.

The above modification provided an adjustment range of -500rpm and +1200rpm at 6000rpm on dial. Changing the cylinder select switch on this particular tachometer produced an accurate reading for the 6 cylinder setting but was a little high on 8 cylinders. This error may have been in reading (the meter is heavily damped) or to ageing of resistors on the board.

SN76810

AND

SAK215

DATASHEETS

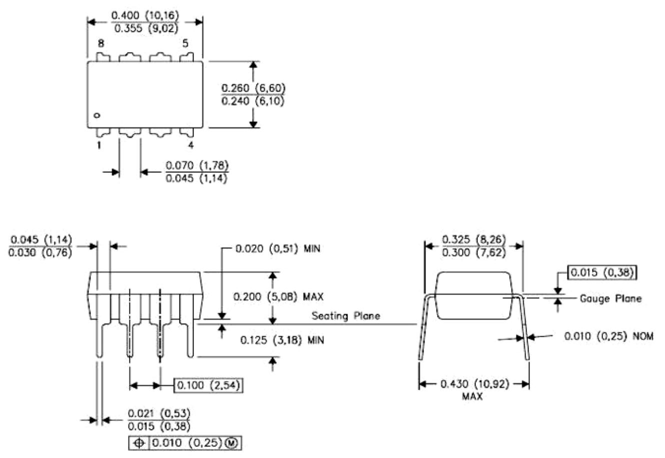
GENERAL PURPOSE MONOSTABLE/TACHO DRIVER

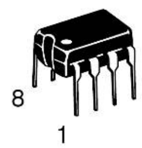
A high performance monostable with Schmitt input for general applications, ideally suited for driving a meter.
Capable of running from any D.C. voltage above 8.2V.

- Internal regulated voltage rail
- Schmitt trigger input
- Constant current output pulse
- Minimum of external components required
- Small package – eight pin D.I.L.

P-package

The dual-in-line package consists of a circuit mounted upon a 8-lead frame and encapsulated within a plastic compound. The compound will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated in high-humidity conditions. The package is intended for insertion in mounting-hole rows on 0.300” centres. Once the leads are compressed to 0.300” separation and inserted, sufficient tension is provided to secure thepackage in the board during soldering. Silver-plated leads require no additional cleaning or processing when used in soldered assembly.





Absolute maximum ratings

Supply Voltage	No Upper Limit
Package Power Dissipation	500mW
Input Voltage	12V
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-55°C to 150°C

Electrical characteristics

PARAMETER	MIN.	TYP.	MAX.	UNITS
Input voltage range for guaranteed current triggering	1.5		6.0	V
Input voltage at which triggering occurs		0.5		V
Output current at pin 5			-60	mA
Output current at pin 6			+60	mA
Output voltage at pin 6	2.07	2.26	2.44	V
Regulated voltage at I_s = 60mA	7.6	** 7.9	8.2	V
Dynamic impedance of regulator		3.0		ohms
Supply current		7.0		mA
Pulse width temperature coefficient		-0.03		%/°C
Pulse width temperature coefficient		+0.03		%/°C
Pulse width		$0.7C_TR_T$		ms
** Original datasheet gave this value as 7.0; less than the minimum. 7.0 has been changed to 7.9 here.				

SN76810 choice of external components

The values of five external components have to be chosen in order to operate the I.C.

Two resistors are required in the shunt regulator, one resistor is required to determine the output current, and a timing resistor/potentiometer and a capacitor are also needed.

1. RESISTOR VALUES FOR SHUNT REGULATOR

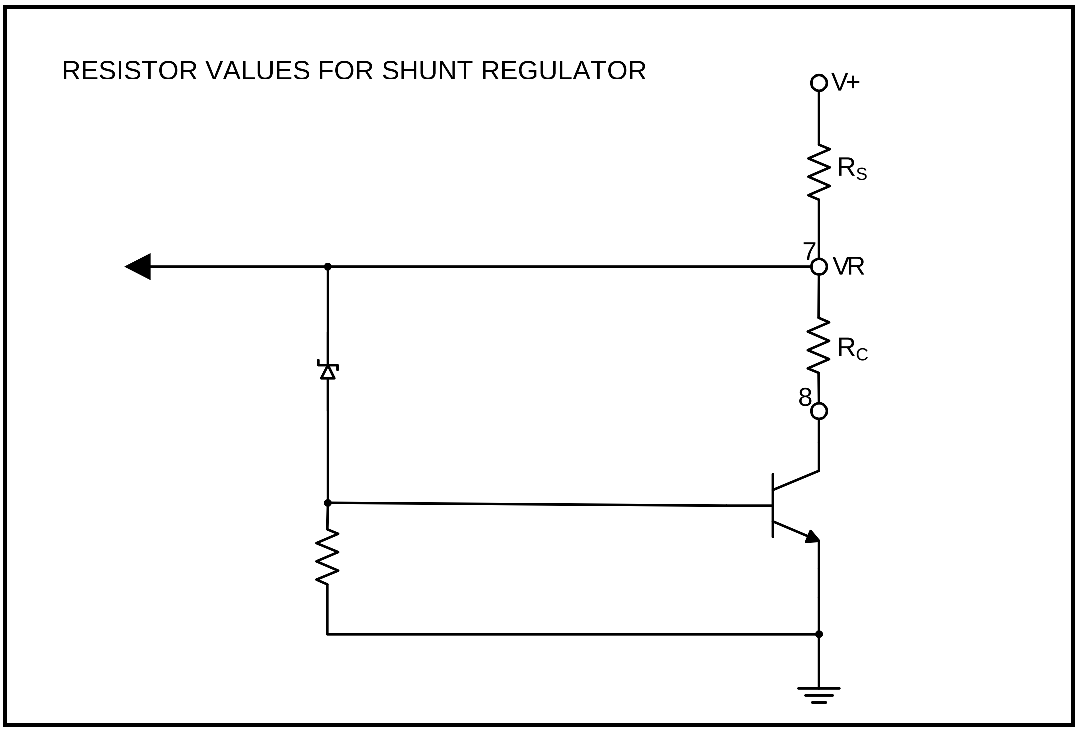


FIG. 1A

The circuit of the regulator is shown here, where V_S is the supply voltage, R_S and R_C are the external resistors, V_R is the regulated voltage.

Since V_R has a maximum value of approximately 8.2V, V_S can be any value greater than 8.2V provided R_S is low enough to supply the current demanded by the circuit.

To calculate R_S and R_C, it is necessary to know the maximum and minimum values of supply voltage V_{Smax} and V_{Smin} and the output current I_M. (See next section for calculation of output current.)

Then $$R_S = \frac{V_{Smin} - 8.2}{12 + I_M} \quad \textbf{1.1} \qquad R_C = \frac{R_S \times 6.5}{V_{Smax} - 7.5} \quad \textbf{1.2}$$

These equations are based on the assumption that with V_S at it's minimum value, R_S provides just enough current for the total circuit requirements whereas with V_S at its maximum value, the current through R_C just brings the transistor in the shunt regulator into saturation. This ensures maximum stability of the regulated voltage V_R.

Having selected a minimum value for V_S and calculated R_S, there is a limit to the maximum value of V_S that can be allowed, and hence a lower limit to R_C, which is determined by the maximum permitted power dissipation (500mW).

The worst-case power dissipation is given approximately by:

$$P_{tot} = (100 + 3.7 \times I_M \times DF + 16/R_C)\text{mW} \quad \textbf{1.3}$$

Where DF is the maximum operating mark/space ratio.

So putting P_{tot} = 500mW gives: $$R_C = \frac{16}{400 - 3.7 \times I_M \times DF} \text{ k ohms} \quad \textbf{1.4}$$

Using this value of R_C in equation 1.2 will give the maximum permitted value of V_S for the chosen values of V_S and R_S.

EXAMPLE:
V_{Smax} = 12V, V_{Smin} = 10V, I_M = 28mA, DF = 80% then;
Using eqn. 1.1 gives R_S = 45 ohms
Using eqn. 1.2 gives R_C = 65 ohms
Checking with eqn. 1.4 shows that the minimum permissible value of R_C is 50.5 ohms (corresponding to a maximum V_S of 13.3V) so the proposed conditions are acceptable.

2. OUTPUT CURRENT

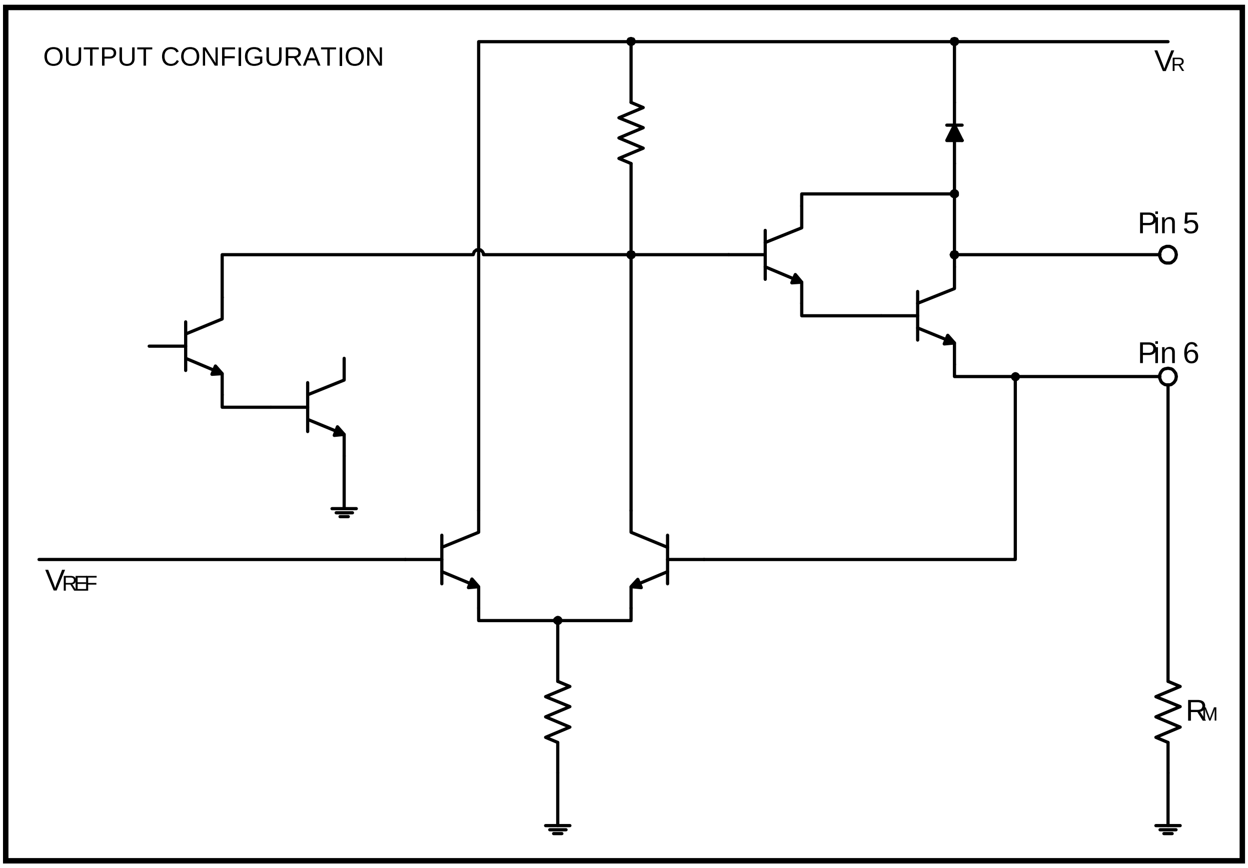


FIG. 2A

When the output is "on" the voltage on Pin 6 is V_{REF} and the output current is given by:

$$I_M = \frac{V_{REF}}{R_M} \qquad \mathbf{2.1}$$

Since V_{REF} is typically 2.28 volts, this gives

$$R_M = \frac{2.26}{I_M} \qquad \mathbf{2.2}$$

However the maximum value of I_M is 60mA and the maximum value of V_{REF} is 2.44 volts, so the minimum value of R_M is 41 ohms

3. Timing components

The timing equation is:

$T_{PW} = 0.7\ C_T R_T$

The range of R_T is 15k ohms to 40k ohms

The upper limit of C_T is governed only by capacitor leakage. With R_T = 40k ohms the charging current is approximately 150 µA.

The lower limit of C_T depends on the application, since the output pulse becomes increasingly distorted as the pulse width is decreased, if an inductive load such as a meter is being driven. A range of T_{PW} from 5 µsec to 50 msec should be achievable.

Applications of the SN76810

A. TACHOMETER DRIVER/FREQUENCY METER

Since the 76810 produces constant amplitude, constant width current pulses at the same frequency as the input signal it can be used to drive a tachometer. The output signal is integrated by the meter and gives a reading proportional to input frequency. See Fig. 3

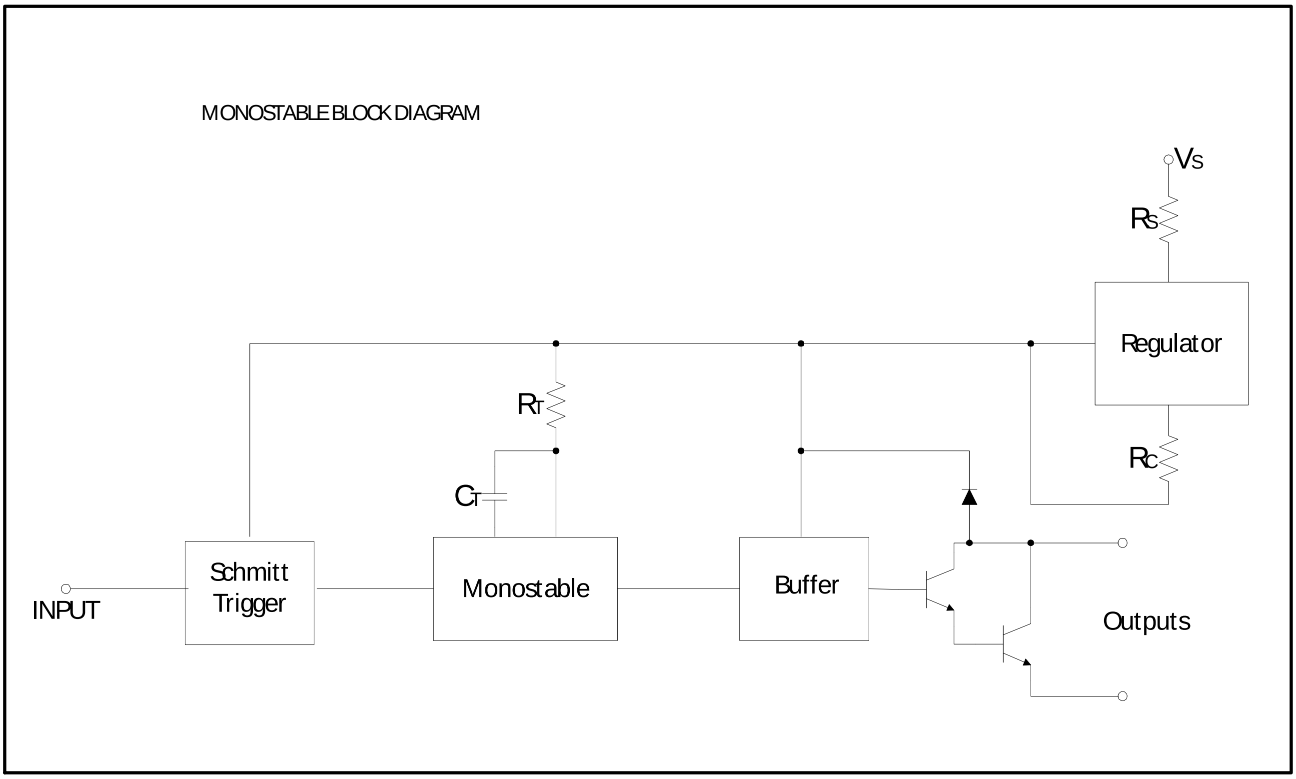
B. FREQUENCY TO VOLTAGE CONVERTER

A simple filter network on the output can be used to generate a voltage proportional to input frequency. See Fig. 4

C. MONOSTABLE INTERFACE WITH TTL (WITH PROVISION FOR GENERATION OF 5V TTL V_{CC} RAIL IF NECESSARY).

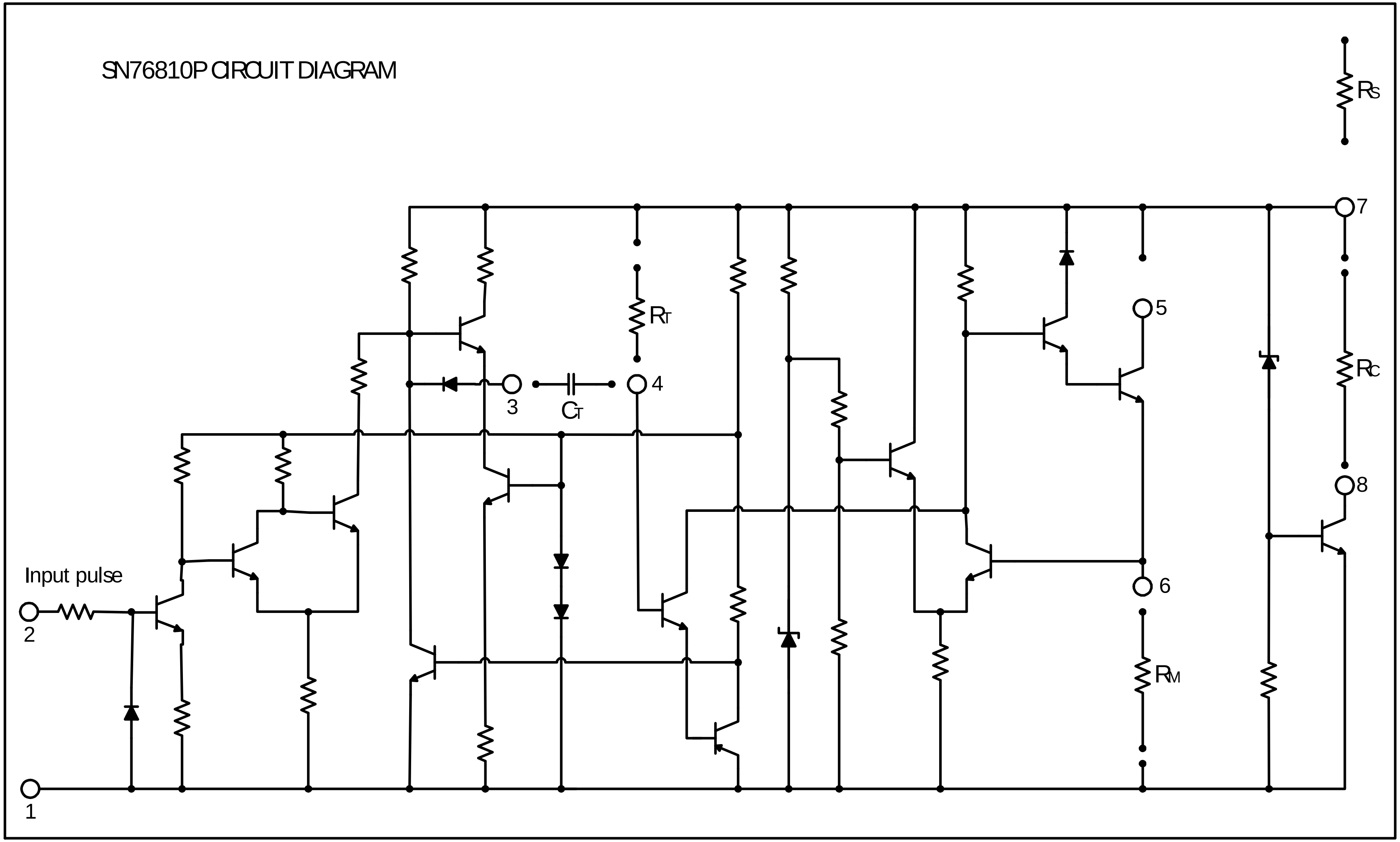
The output from Pin 6 can be used to drive TTL as the voltage level swings between 0V and a minimum of 2.07 volts. The resistor from Pin 6 to ground should be made small enough to allow the TTL gate input current to flow through it without raising the voltage above the input threshold level.

As shown in Fig. 5, a 5 volt rail can be easily generated for running TTL if necessary.



MONOSTABLE BLOCK DIAGRAM
VS
RS
Regulator
RT
RC
CT
Schmitt
Trigger
Monostable
Buffer
INPUT
Outputs

FIG. 1



SN76810P CIRCUIT DIAGRAM
RS
7
RT
5
RC
3
CT
4
8
Input pulse
2
6
RM
1

FIG. 2

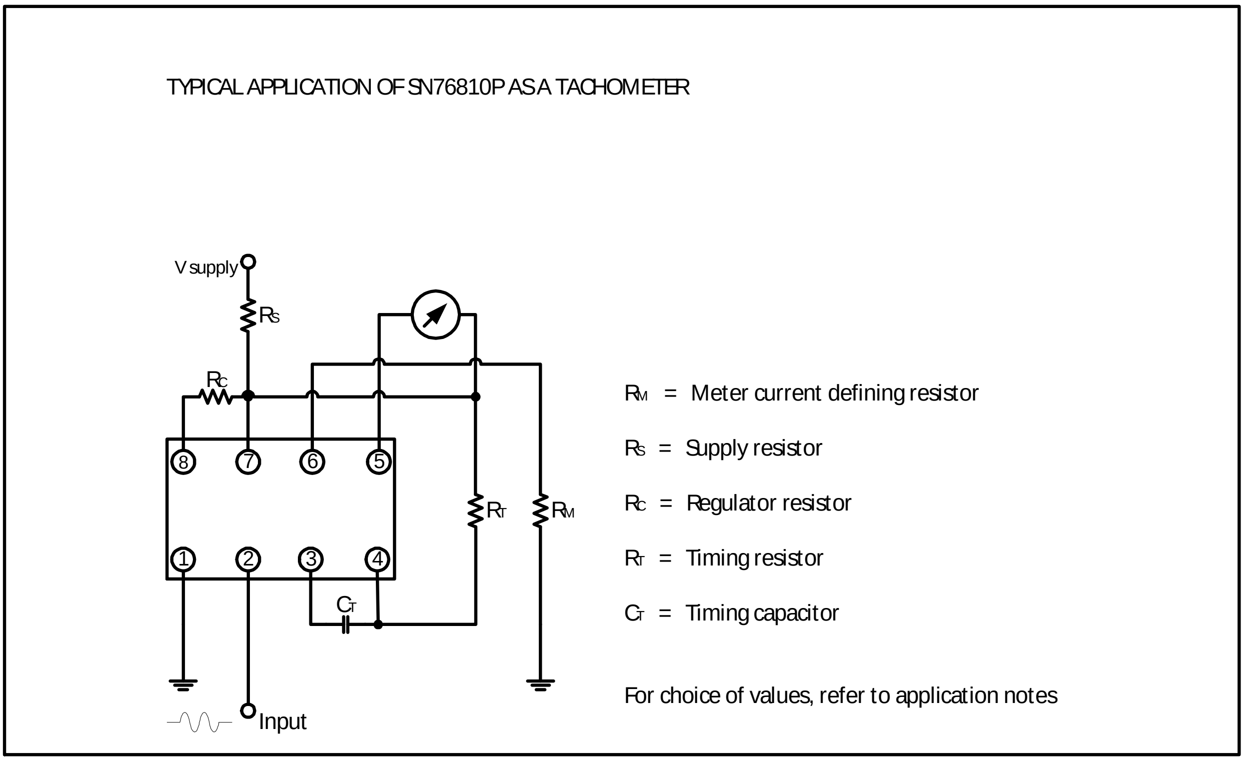

TYPICAL APPLICATION OF SN76810P AS A TACHOMETER
V supply
RS
RC
RT
RM
CT
Input
RM = Meter current defining resistor
RS = Supply resistor
RC = Regulator resistor
RT = Timing resistor
CT = Timing capacitor
For choice of values, refer to application notes

FIG. 3

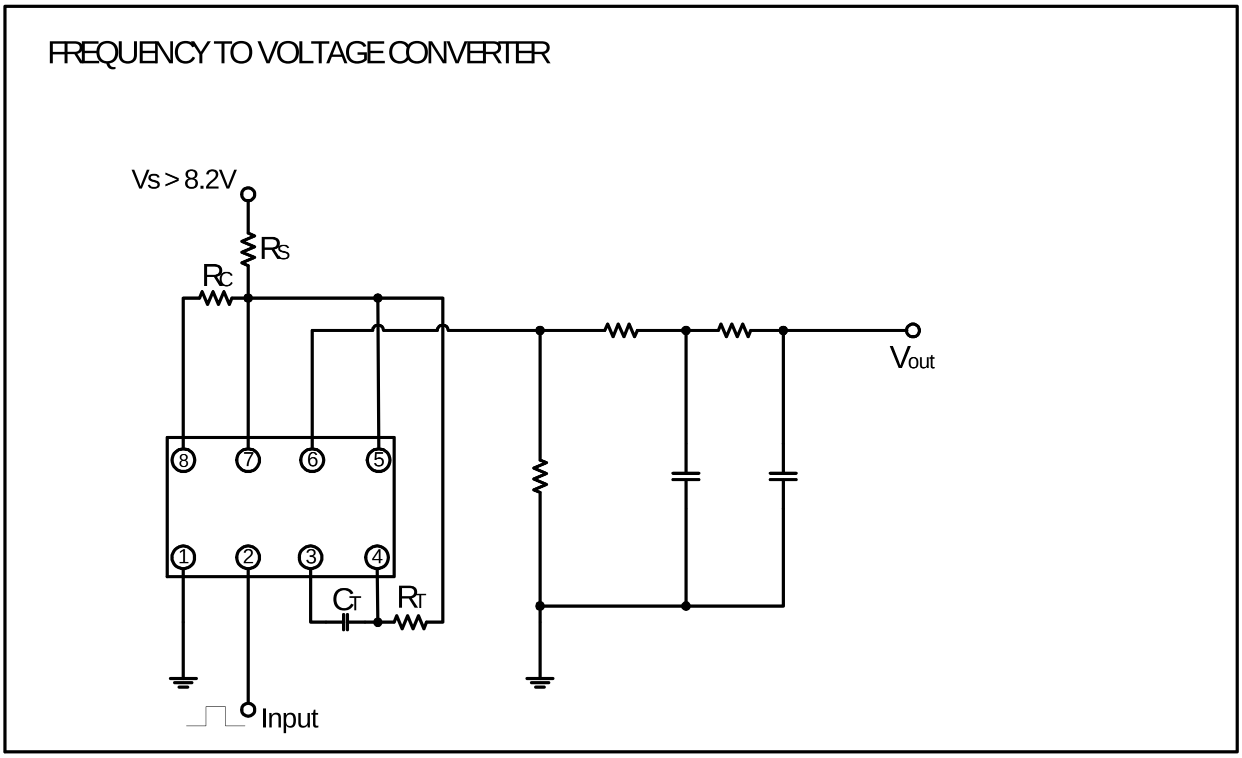
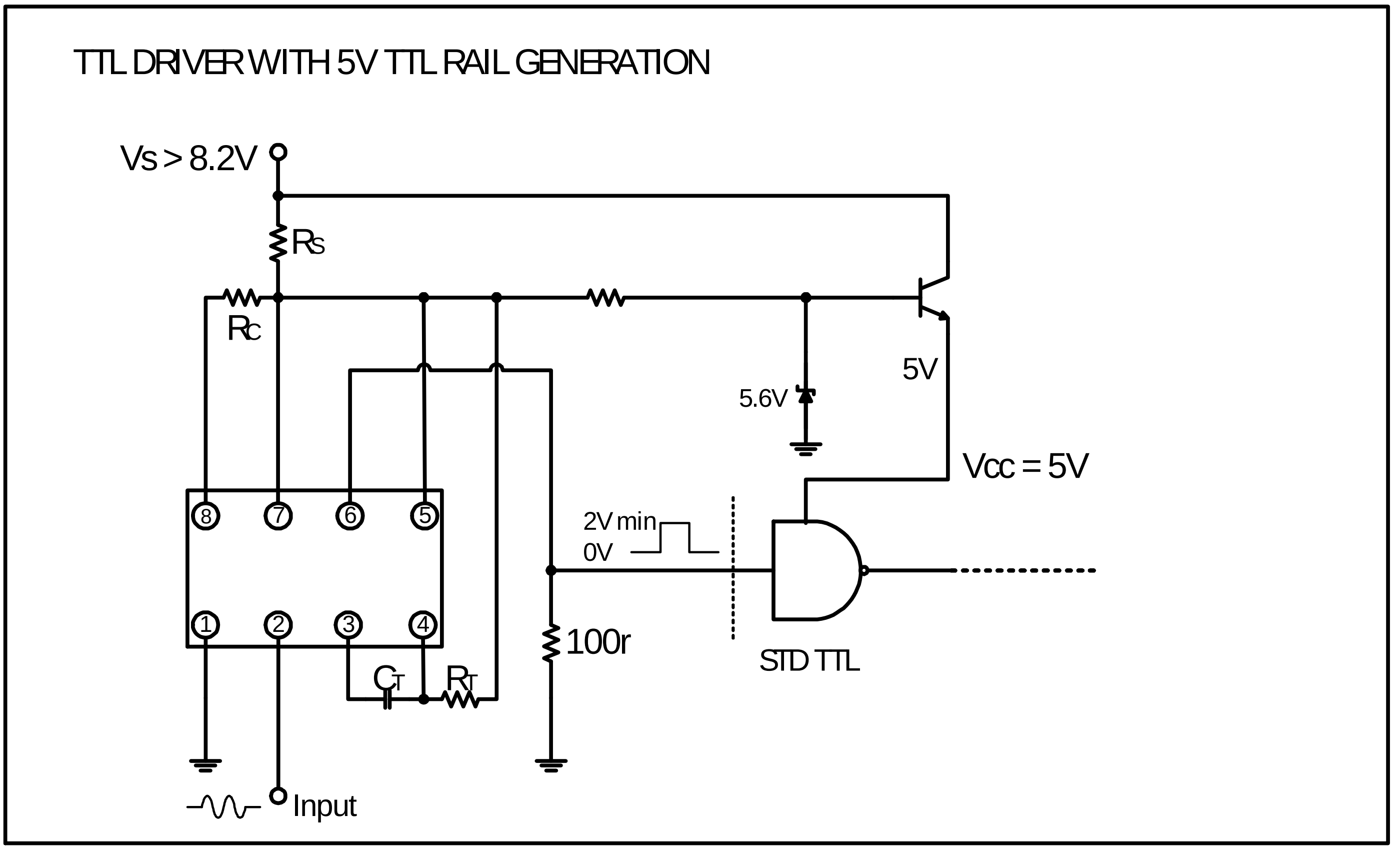

FREQUENCY TO VOLTAGE CONVERTER
Vs > 8.2V
RS
RC
CT
RT
Vout
Input

FIG. 4



TTL DRIVER WITH 5V TTL RAIL GENERATION
Vs > 8.2V
RS
RC
5.6V
5V
Vcc = 5V
8
7
6
5
1
2
3
4
2V min
0V
100r
STD TTL
CT
RT
Input

FIG. 5

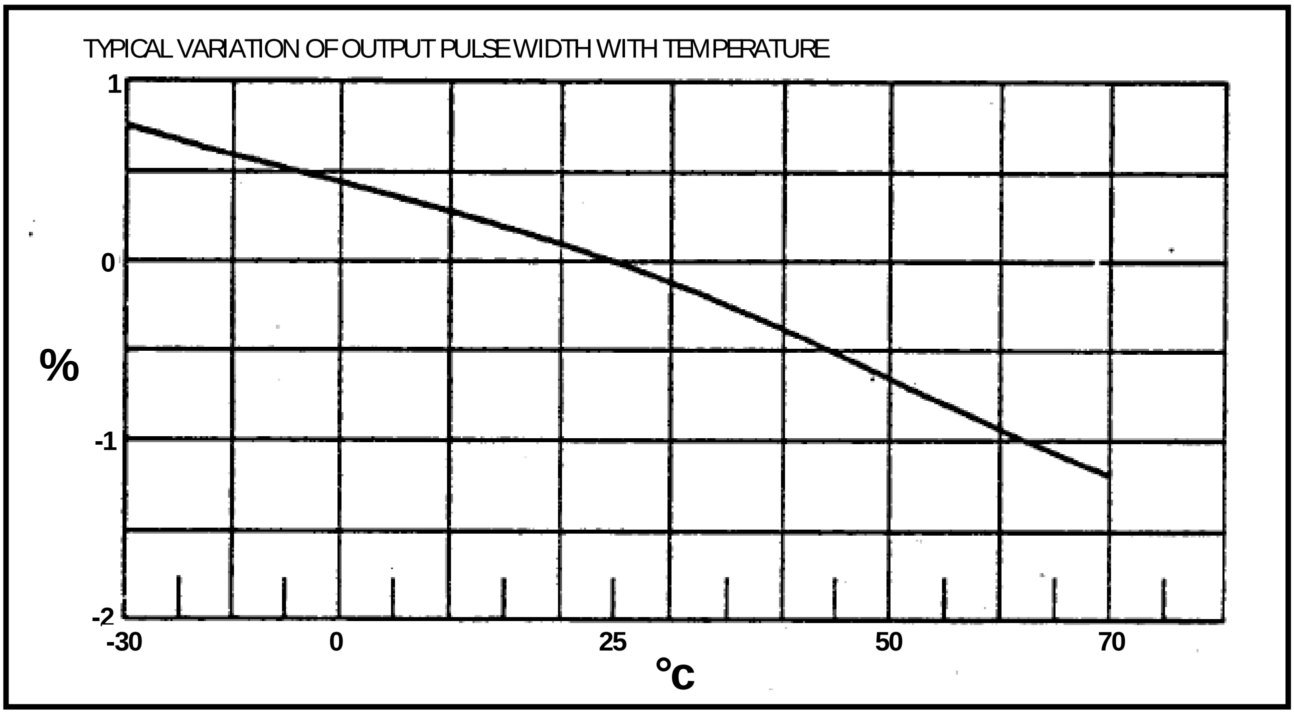

TYPICAL VARIATION OF OUTPUT PULSE WIDTH WITH TEMPERATURE
1
0
%
-1
-2
-30
0
25
50
70
°C

FIG. 6

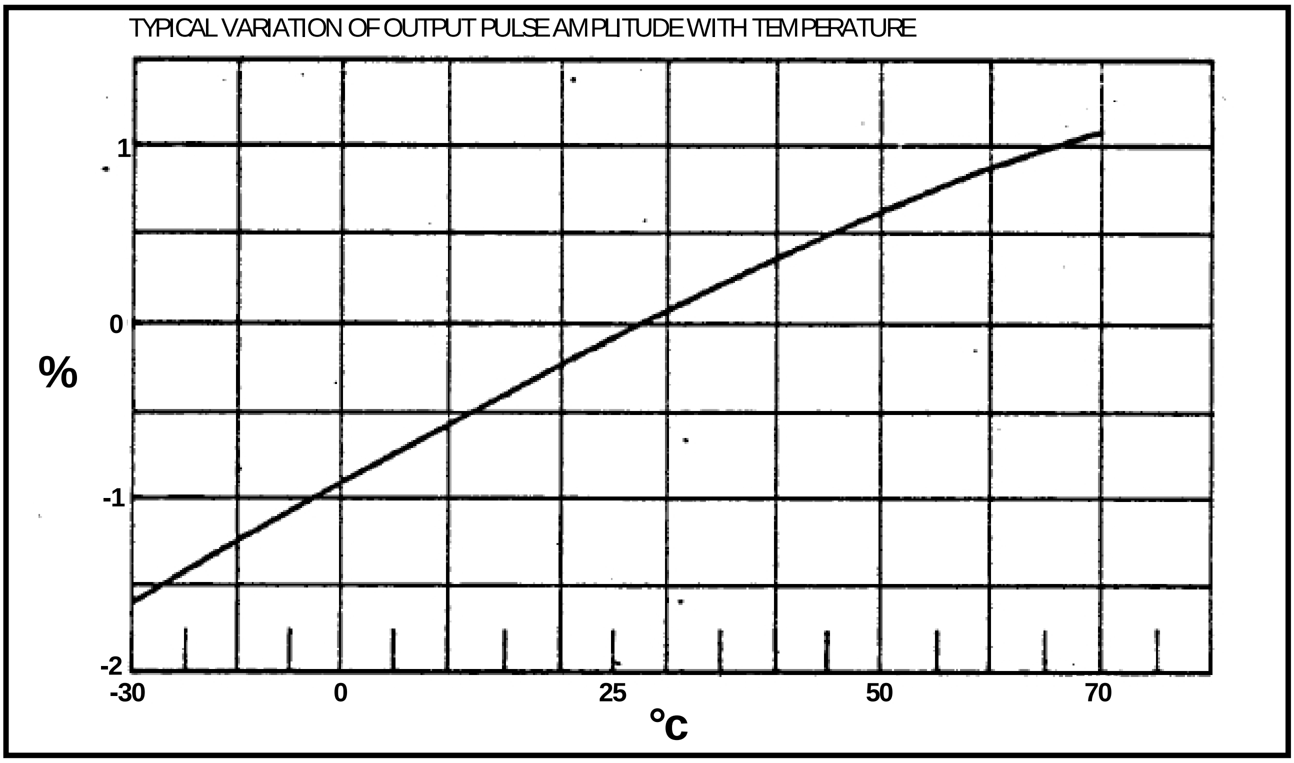

TYPICAL VARIATION OF OUTPUT PULSE AMPLITUDE WITH TEMPERATURE
1
0
%
-1
-2
-30
0
25
50
70
°C

FIG. 7

Pulse Shaper Circuit for Revolution Counters

The monolithic integrated circuit SAK215 is designed for use in revolution counters of cars and for other applications like frequency to current converters. By use of suitable external circuitry the revolution counter can be adapted to engines with two to eight cylinders. It is designed for a nominal 12 VDC supply.

Fig. 2 shows the operating circuit of a revolution counter with FSD = 6000 RPM (two ignition pulses per turn of the crank-shaft) at a nominal battery voltage of 12 V.

Dimensioning Hints

Coil resistance R_M of the indicating instrument:

The output transistor must operate in the active range.
This is ensured if

$$V_{5/6} = V_7 - V_6 - (I_{5p} \cdot R_M)$$

is above 1V. The additional inductive voltage drop at the beginning of a current pulse due to the inductance of the moving coil is ignored in this equation.

Adjustment resistor $R_{6/1}$ for the instrument current:
The peak current through the moving coil is given at a pulse duty factor of 0.7 by

$$I_{5p} = \frac{I_M}{0.7}$$

where I_M is the DC current for full scale deflection. Since the current flowing into pin 5 is equal to the sink current of pin 6 the adjustment resistor $R_{6/1}$ can be calculated as

$$R_{6/1} = \frac{V_6}{I_{5p}}$$

Series resistor R_V:

$$R_V \leq \frac{B_{min} - 8.2\ V}{12\ mA + I_{5p}}$$

Between pin 7 and pin 1 the circuit behaves like a zener diode. The resistor R_V therefore has to be chosen so that adequate current for the IC and the moving coil is available even at the lowest battery voltage:

By-pass resistor $R_{7/8}$:
In order to ensure proper function of the stabilizing circuit the voltage drop across the by-pass resistor $R_{7/8}$ must be limited to 7V at the highest battery voltage.

$$R7/8 < \frac{7\ V - Rv}{VBmax - 7.4\ V}$$

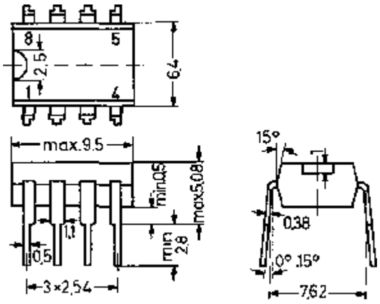


Fig. 1:
SAK215 in mini Dip
plastic package similar to TO -116
20A8 according to DIN 41866
Weight approximately 0.5 lg
Dimensions in mm

Pin connections

1 Ground, 0
2 Input
3 Feedback output
4 Feedback input
5 Output
6 Adjustment pin for output current
7 Stabilized supply voltage pin
8 Supply voltage V_B

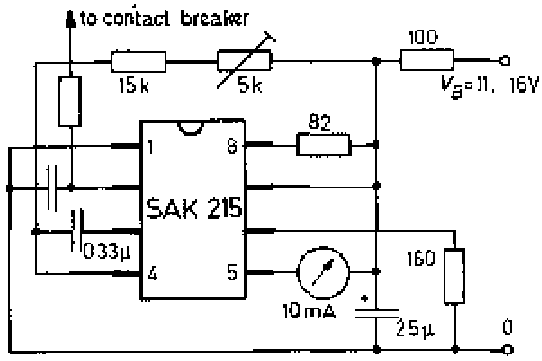


Fig.2:
Block diagram and operating circuit of the SAK215

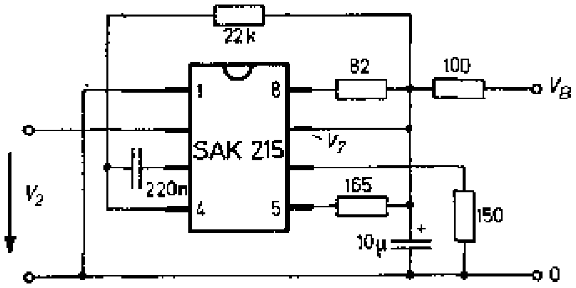


Fig. 3:
Test circuit for the characteristic

All voltages are referred to pin 1.

Absolute Maximum Ratings

	Symbol	Value	Unit
Supply Voltage	V_B	see dimensioning hints for R_v and $R_{7/8}$	
Input Voltage	V_2	±20	
Current through Instrument Coil	I_5	40	
	$-I_6$	40	
Power Dissipation at TA = 65 °C	P_{tot}	500	—
Ambient Operating Temperature Range	T_A	-25 to +65	V
Storage Temperature Range	T_S	-25 to +125	mA

Recommended Operating Conditions

.	Symbol	Min.	Typ.	Max.	Unit
Frequency of the Input Pulses	f_I	—	—	10	kHz
Pulse Duty Factor of the Output Current	t_{P5}/T_5			0.9	—
Timing Resistor	$R_{7/4}$	15	—	100	kΩ
Resistor for adjusting the Current through the Instrument Coil	$R_{6/1}$	100	—	—	Ω
Voltage Drop across Bypass Resistor	$V_{7/8}$	—	—	7	V
Voltage Drop between Pins 5 and 6	$V_{5/6}$	1	—	—	V

Test Conditions for the Characteristics (see test circuit Fig. 3)

	Symbol	Value	Unit
Supply Voltage	V_B	14	V
Ambient Operating Temperature	T_A	25	°C
Input Pulse Amplitude	V_Z	1.6	V
Input Pulse Duration	T_I	0.5	ms
Input Pulse Repetition Frequency	F_I	250	Hz

Characteristics in the Test Circuit Fig. 3

	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage (stabilized)	V_7	7.4	—	8.2	
Current Consumption	1_7	—	—	12	
Input Voltage Range without triggering the Circuit	V_2	—20	—	+0.5	
Trigger Range	V_2	1.5	—	20	
Trigger Slope	dV_2/dt		positive going		V
Input Impedance	r_{211}	—	7	—	mA
Pulse Amplitude at Pin 6	V_6	2	—	2.5	V
Output Pulse Duration	t_5		0.64 • R7/4 • C3/4		V
Output Current	1_5	—	I_6	—	