LOW CURRENT STANDBY SWITCH...

By A. THOMAS

OFTEN a situation arises where an amplifier or other electronic device can be switched on fully at the instant an input signal appears, but in the absence of such a signal, it is on "standby" and consumes very little current.

This is a factor of considerable importance in battery powered equipment; not only is the battery power important, but the amount of power that may be taken for a relatively short time. An instance where this may occur is an amplifier that has a standby current of, say, 20mA and a current of 100mA when delivering an output. In this case the battery has to stand the long term current of 20mA as well as the short term current of 100mA, and consequently has to be quite large physically in order to get a reasonable life out of it. If the standby current is very low then the peak current may be obtained when required from a much smaller battery.

Typical instances where this idea can be applied are a baby alarm amplifier or a loud speaking telephone; such devices need not be switched on manually when required, since the incoming signal can be made to perform this operation. Another possibility is radio control of models, where the battery life is very important indeed. Radio control is beyond the scope of this article, but the idea may be seeded in the minds of the enthusiast.

BASIS OF THE SWITCH

The basis of the low current standby switch is a high gain low current amplifier which feeds an electronic switch. The switch then turns on the power to the main circuit, which carries out whatever function that is required in the normal manner.

To enable the required low leakage current to be obtained, silicon transistors are essential in a design of this type. The low cost epoxy transistor type 2N2926 has been used in this instance.

The signal input to the switch is fed in parallel with the signal input to the amplifier or other apparatus it is intended to control.

PERFORMANCE SPECIFICATION

The minimum signal which may be fed into the unit to ensure reliable switching is 1mV. If a higher level of voltage input is required at a higher input impedance, then a series resistor may be put at the input, the value being calculated to provide an input current of 10μA.

The frequency range over which the unit will switch reliably is 100Hz to 100kHz. Tests have not been carried out at a higher frequency than 100kHz, but there is no reason why the unit should not handle frequencies up to about 30MHz. Modification will be suggested later for high frequency use. If a higher input level is available, then the lower frequency limit may be reduced to 10Hz. The wave form is not critical as long as the duty ratio is less than 10 to 1; that is, if impulses are applied at the input at 1kHz then the pulse width must be greater than 100μs.

The drain from the power supply is in the order of 100μA in the no-signal condition; when a signal is received, the current taken by the amplifier part of the switch is in the order of 5mA. The total current taken by the switch depends on the load applied to it.

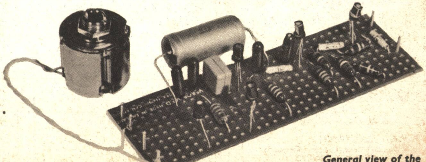
The output current from the switch depends on the output transistors used and can be up to 10A. Table 1 gives a list of output currents and suitable transistors. (The model illustrated in this article has an output rating of 50mA or 500mA, depending upon which type of transistor is used in TR5 stage.) The output voltage will be the full battery voltage less the V_{ce} saturation of the output transistor, and this can range between 300 and 700mV.

The signal modulation of the switched battery voltage is approximately 1mV at 100Hz, and this decreases as the input frequency increases and may be attenuated by the addition of a suitable capacitor at the output.

The leakage current into the load with no signal input will be very low, the measured current for a BFY50 transistor was 75nA.

Table I

Output current	TR4	TR5	TR6
20mA	2N2926	—	—
50mA	2N2926	2N2926	—
500mA	2N2926	BFY40	—
5A	2N2926	2N2926	2N2697, 2N2811, or 2N2877
7A	2N2926	BFY50	2N3230 or 2N3231



General view of the complete signal operated switch

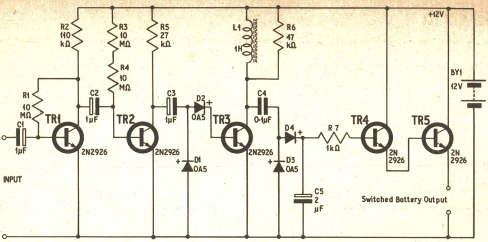


Fig. 1. Circuit diagram of signal operated switch. This arrangement is suitable for switching currents of up to 50mA. With different output transistors and an additional stage, currents of up to 7A can be switched—see Table 1 and Fig. 4

The threshold time of the switch is 75ms and the hold time, after the cessation of the signal, is 1·5 seconds.

CIRCUIT DESCRIPTION

Fig. 1 shows the complete circuit of the switch. The input signal is applied to C1 via a resistor if required as discussed earlier. TR1 is a common emitter low current high gain amplifier, the output of which is fed via C2 to TR2. The resistors R3 and R4 make-up a 20 megohm resistance feeding 500nA of base current to TR2. This small current helps overcome the V_{BE} of TR2 and puts TR2 into a partially conducting state. The signal from C2 turns the stage on with the positive half cycle, and hard off with a portion of the negative half cycle.

The output from TR2 collector is fed via C3 to a pair of diodes D1 and D2. These diodes form a voltage doubler rectifier and feed the full voltage swing from TR2 collector as a positive going signal at TR3 base.

The collector circuit of TR3 consists of an inductor of 1H with a parallel damping resistor of 47 kilohm. The input to TR3 base causes the collector to swing the full battery voltage, then, due to the inductance in the collector, to overswing the same amount, so producing a 24V peak to peak signal at C4. The damping resistor value has been chosen to suit the inductance at 100Hz to prevent ringing.

The output from TR3 collector is fed via C4 to a voltage doubler rectifier, D3, D4, and thence to a reservoir capacitor C5, which tends to charge to the peak value of the signal, 24V. This level is clamped by the base collector junction of TR4 to the battery voltage. Thus, maximum driving voltage is applied to the Darlington emitter follower TR4 and TR5. The voltage on C5 is fed via R7 current limiting resistor. The collector breakdown voltage BV_{CEO} of the 2N2926 is 18V, but in the position of TR3 the collector swings 24 volts. Six transistors have been tried in this position with no ill effects.

CONSTRUCTION

L1, the inductor in TR3 collector circuit, has an inductance of 1H. In the prototype a Mullard Vinkor core type LA2416 has been employed. This coil former is wound with 1,180 turns of 42 s.w.g. enamelled copper wire. The d.c. resistance of this winding is 110 ohms. Other forms of inductors may be used as long as they have a high *Q*.

The unit is built up on a piece of Veroboard as shown in Fig. 2 and Fig. 3.

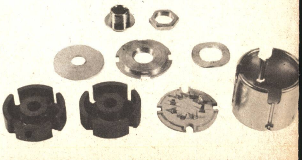
Any power transistors that are used must be mounted on a heat sink of minimum dimensions 3in × 2in made from aluminium. The heat sink may be mounted by means of spacers to the Veroboard. Fig. 4 gives the additional circuit for the power transistors referred to in Table 1.

TESTING THE UNIT

With no load on the output of the unit, and no signal input, connect the battery via an ammeter. The meter should read something in the order of 100μA.

Disconnect the ammeter and connect a voltmeter across C5. Apply a signal in the order of 1mV at a frequency greater than 100Hz. The output from a radio receiver speaker would be ideal, and should be connected via a potential divider consisting of a 120 kilohm resistor in series with a 100 ohm resistor. The 100 ohm resistor goes down to the negative battery, the 120 kilohm resistor to the speaker, and the junction to the amplifier input. The other side of the speaker also goes to the negative side of the battery.

With the radio tuned into any station with a continuous output, and the volume control set for a moderate level, approximately 1mV of suitable signal will be fed to the switch.



The items that make up the Vinkor core assembly

COMPONENTS . . .

Resistors
R1 10MΩ
R2 110kΩ
R3 10MΩ
R4 10MΩ
R5 27kΩ
R6 47kΩ
R7 1kΩ
All ½W, "Hystab" (Radiospares)

Capacitors
C1 1μF } elect. 15V
C2 1μF } sub. min.
C3 1μF }
C4 0·1μF polyester
C5 2μF polyester

Diodes
D1–4 OA5 germanium diode (4 off)

Transistors
TR1–4 2N2926 (4 off)
TR5 } see Table 1 and text
TR6 }

Miscellaneous
L1 1H inductor, high Q (see text)
BY1 12V layer type battery
Vinkor core LA2416, housing DT2418, and former DT2074 (Mullard); 42 s.w.g. enamelled wire for L1. Veroboard. Terminal pins.

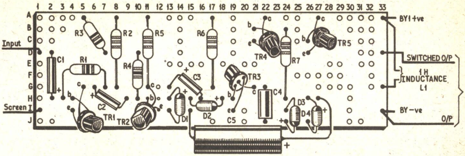


Fig. 2. Component arrangement on the Veroboard

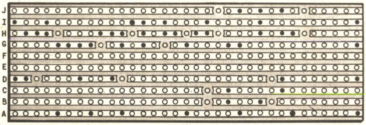


Fig. 3. Underside of the Veroboard showing breaks in the copper strips and connection points

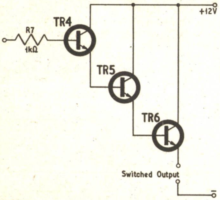


Fig. 4. Additional stage for high current operation. Transistor types are given in Table 1

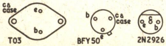


Fig. 5. Transistor base details

The voltage across C5 should be 12V when the signal is present and virtually zero two seconds after the signal has been removed. Connect the necessary load, depending on the output transistor used, and move the voltmeter connection from the top end of C5 across to the switch output. Approximately 11·5V should be present when a signal appears and zero volts when it is removed. If the unit works as above, it is now ready for use.

If a switch-on pulse is apparent in the apparatus, then the threshold time may be increased by inserting a resistor experimentally in between D4 and C5. Any instability may be removed by connecting a suitable capacitor across the output from the switch. *Warning: the output impedance of the last stage is very small, therefore the output transistor may be destroyed if a short circuit is placed across the output terminals.*

MODIFICATIONS FOR H.F. USE

For use as a high frequency switch, the bandwidth will be from 100kHz to 30MHz. The capacitor and inductor values may be reduced by a factor of 100. The germanium diodes should be of a type designed for h.f. use. The input sensitivity level may be required to be increased from 1mV to 10mV. ★