the ham notebook

solid-state vibrator replacement

With the flood of solid state vhf rigs on the market, the price of the vibrator powered units has dropped to a level where almost anyone can afford to go vhf mobile. This solid-state switch fits in a small minibox and has only two wires that connect to the vibrator socket (not counting the chassis ground). The only addition to the rig is a small spst switch mounted on the power-supply chassis. Yet this simple unit eliminates the hash and mechanical problems common to vibrators.

The schematic, **fig. 1**, shows a basic vibrator primary circuit and a secondary winding with buffer. It's basically a mechanical switch with the centertap of the primary at plus 12 Vdc. The vibrator alternately grounds point (A) then (B) creating a square wave of dc. This causes current to flow in the secondary winding. The induced currents always have some transients on their edges. These transients are bypassed by an RC combination called a buffer circuit. This is a resistor and capacitor series combination in parallel with the secondary high-voltage winding.

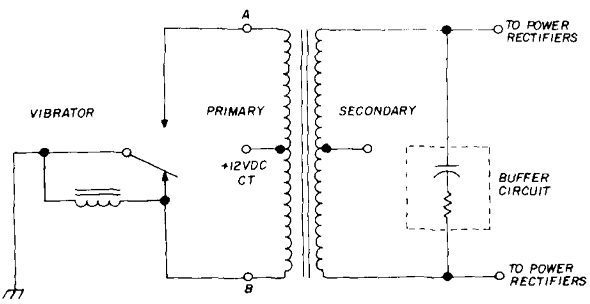


fig. 1. The basic vibrator supply.

The schematic in **fig. 2** shows the oscillator. This unit duplicates the electrical function of the vibrator and thus could be likened to a solid-state switch. With power applied, the circuit first grounds terminal A then terminal B. A brief description would indicate the toroid (similar in dimensions to an 88-mH toroid) is the heart of the circuit. Its function is to feed back current to the bases, alternately saturating Q1 and Q2. CR1 and CR2 are zeners suggested by the transformer company to protect the power transistors from transients. They could be left out but they are inexpensive insurance. The R1, R2 and R3, R4 combinations are resistive current dividers, limiting the base current to a saturated but safe level.

Construction is not critical. The transistors should be heat sinked as they do run warm under transmit condition. Other components should be mounted with care keeping vibration in mind. A short barrier strip mounted on the outside of the box would permit quick connection and testing without connection to the rig. The switch can be tested without connection to the rig by applying plus 12 Vdc to pin four of the toroid and providing a ground return. The switch will oscillate at a low frequency (you'll hear a buzz from the toroid); however, when a load is connected, the operating frequency of the switch is near 1000 Hz. If the load becomes too great, the circuit will stop oscillating and save the transistors from thermal runaway.

Since the switch has only two connections to the rig plus the chassis ground, the hookup time is minimal. The vibrator is removed from its socket. The base of an old vibrator could be used as a quick connector to the vibrator socket. The two pins to be used should be determined from the schematic of your rig. Run two heavy leads from terminals A and B to the pins that correspond to the ends of the primary. A spst switch should now be mounted on the power-supply chassis, accessible from the top side of the chassis. This switch is wired in series with the buffer circuit. Be sure to label this switch as *buffer in* in the *on* position and *buffer out* in the *off* position. The *buffer out* position is used with the solid-state switch as the reactance of the buffer at the new operation frequency (1000 Hz) is much too low and the power it would pass would burn out the resistor in short order. The rig now is ready to operate with the option of returning to vibrator with the flick of the switch to the *buffer in* position and reinstalling a vibrator.

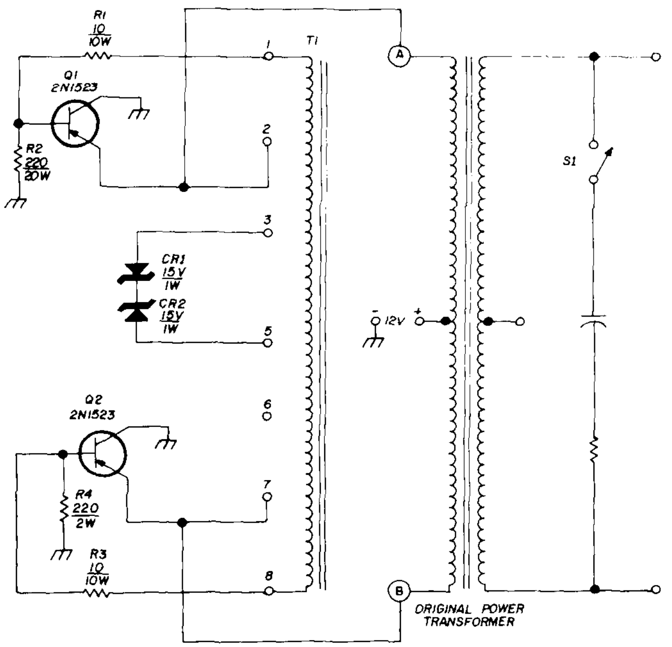
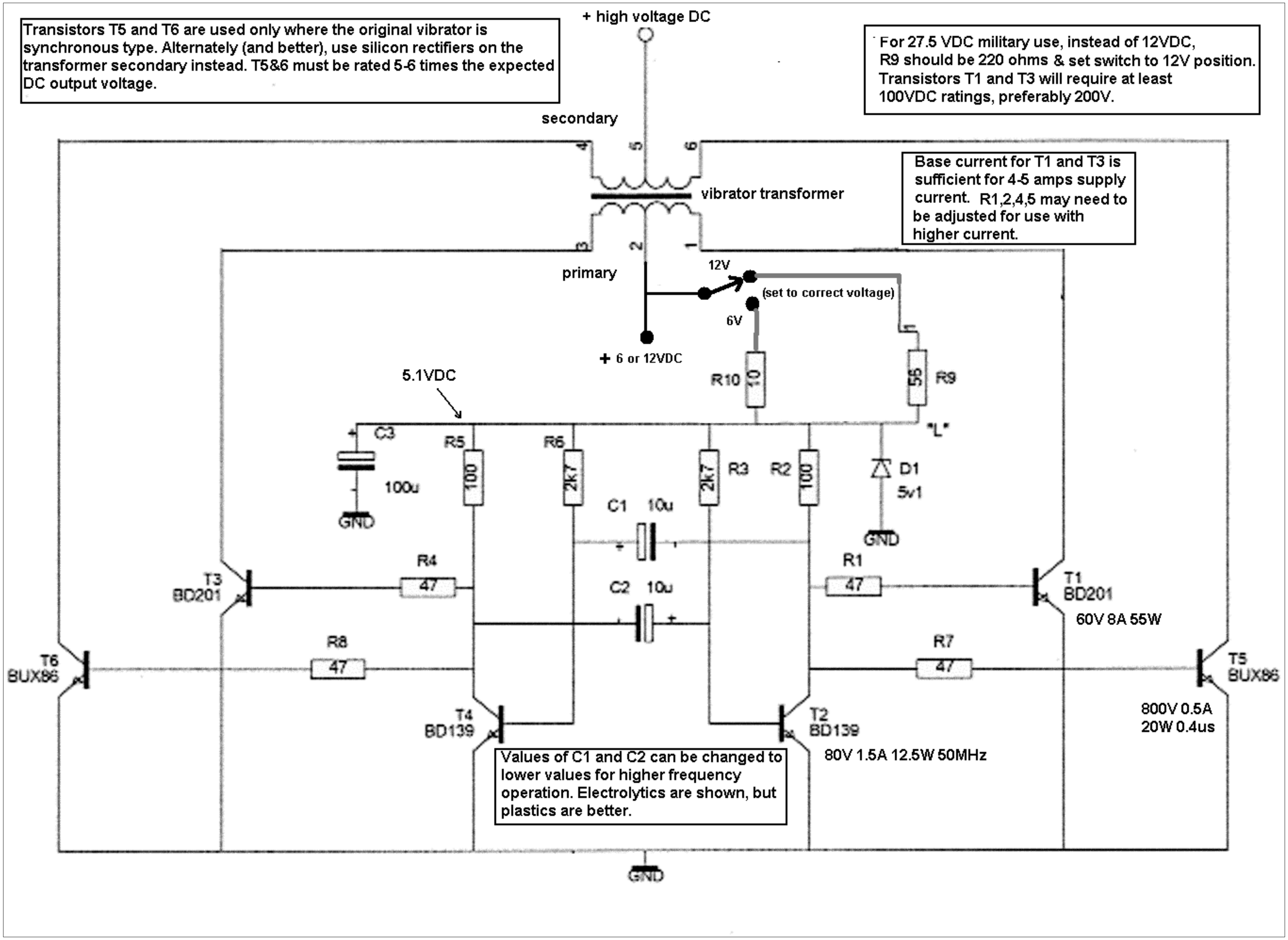


fig. 2. Transistor switch is the heart of the solidstate vibrator replacement. T1 is an Osborne 2709, available from Osborne Transformer Company, 2823 Mitchell Avenue, Detroit, Michigan 48207.

This same basic circuit appeared in the 1970 edition of *The Radio Amateur's Handbook*, page 336, as an integral part of a more complex mobile power supply.

Ray Kashubosky, K8RAY



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Solid-state "vibrator" circuit

Mobile radio telephone units, car radios and similar gear with vibrator power supplies, while still in perfect working order, may have to be discarded when the vibrator fails since there are no replacements. This article describes a solid state plug-in replacement unit which is simple to build and very reliable.

by PHILIP WATSON

Like the author, a large proportion of six metre and two metre amateur radio enthusiasts first went on the air using mobile equipment discarded by taxi companies and other commercial users; typically valve units powered by vibrator supply.

Suitably modified, and often "improved", these units performed extremely well and a good many of them are still in operation. The one big query hanging over their owners' heads is what they will do when the vibrators finally fail. For vibrators are a thing of the past. They have not been manufactured locally for something like two years now and, even when they were available, they were not by any means cheap.

Some users have simply bowed to the inevitable and decided it was time to splurge on the much more up-to-date units now available commercially. This is fine, if you can afford it, and if the kind of thing you want is readily available.

Others have sought more modern disposals units, not requiring vibrators, to serve as a mobile unit, relegating the old mobile unit to the shack where it can serve as a base unit operating from the mains. (We will have more to say about mains operation later.) This is fine too, provided you can obtain the unit you want and that you have such a place for the old one.

Another approach is to discard the vibrator supply, or at least the vibrators and transformers, and replace them with a more modern transistorised supply, using transformers wound on ferrite cores. There is no doubt this is an excellent approach, and the smaller, lighter transformer it makes possible has much to recommend it. On the other hand, it represents a fair amount of work; something which might be hard to justify if a simpler approach is possible.

Another suggestion was to add an extra winding to the existing transformers, to serve as a feedback winding, then follow conventional transistor power supply techniques. The writer tried this and found it a perfectly practical approach. A 10 turn winding, five turns each side of a centre tap, was sufficient to ensure reliable oscillation.

The main objection was the need to fit this winding. While it was achieved without removing the transformer from the chassis, by simply removing the covers, it was a rather fiddly job, better avoided if possible.

While discussing the problem on the air, Ross Mudie, VK2ZRQ, mentioned an article in "Radio Communication" for May 1970 describing a transistor circuit which would simply plug in in place of the vibrator, without the need to modify the circuit in any way.

The upshot was the unit about to be described. The work was done on an AWA MR10B; one of the most popular units to find its way onto the amateur scene. At the same time, there is no reason why the idea would not suit most other power supplies designed for vibrators.

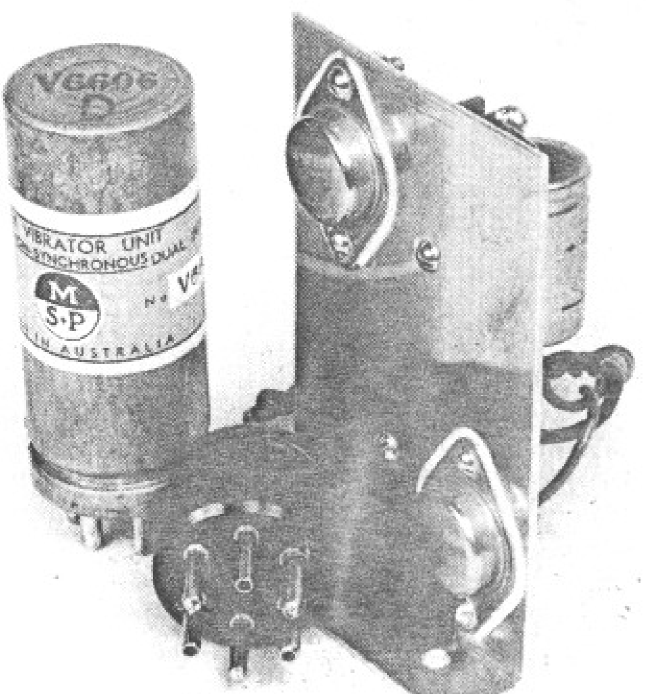
The MR10 power supply is, in effect, two separate power supplies on the one chassis. Both deliver a nominal 150V at about 75-80mA. One powers the receiver, and both supplies, connected in series, are used for the transmitter, ie, providing about 300V at 80mA. The power supply also houses the relays to control each power supply, along with the associated valve heater string, plus the fuses, etc. Bias for the transmitter comes from an extra winding on the receiver transformer.

Each circuit uses a non-synchronous, dual interrupter type vibrator in the primary circuit and a bridge type selenium rectifier in the secondary. Whether you intend to replace the vibrators or not, it is a good idea to cast a suspicious eye on these rectifiers. They are both bulky and inefficient by modern standards and, if you do plan to replace the vibrators, you will need some of the space they occupy.

More importantly, it is not generally appreciated that these rectifiers deteriorate steadily over a period of years and it is not surprising to find that, even with a good vibrator, they will deliver significantly less than the expected 150V.

They can be replaced by a bridge configuration of four silicon rectifiers, such as the EM404, or rather more conveniently, but more expensively, by a ready-made bridge, such as the MB4. As well as requiring only a tiny fraction of the space needed for the old rectifiers, these should deliver at least 15V more. (30V on transmit.) If the old rectifiers are below par, the increase may be as high as 25V.

The circuit of the transistor unit con-



The solid-state unit compared with the vibrator which it replaced. In some cases a more compact design may be possible and the factors concerned are discussed in the text. Operating frequency is from 100 to 120Hz.

sists, basically, of a pair of power transistors in a multivibrator circuit, each half of the vibrator transformer primary forming the collector load for each transistor. The collector of each transistor is cross connected to the opposite transistor base via a resistance capacitance network.

The diodes between base and emitter limit the reverse bias applied across this junction during the "off" period of the cycle for that transistor. Otherwise, the reverse bias would exceed the reverse bias breakdown voltage for the base/emitter junction.

While this breakdown may not be destructive (due to the impedance in this part of the circuit), current flow in the base emitter junction, due to any cause, will tend to "turn on" the emitter/collector circuit at a time when it should be turned off. The result, at best, would be highly inefficient operation.

The resistance capacitance network between collector and emitter is a protective circuit, rather than one which is essential to the basic operation. The circuit will work without it but can go into a spurious mode of high frequency oscillation under certain load conditions. To prevent this the capacitance is used to limit the high frequency response of the system. The resistor is simply to limit the surge current from the capacitor through the collector/emitter junction at the moment that the transistor is turned on.

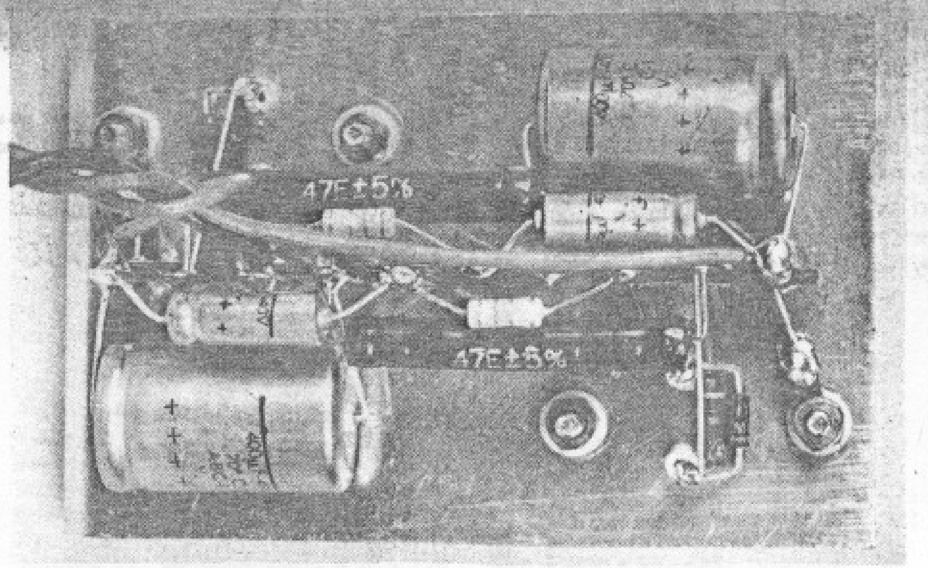
According to the "Radio Communications" article, the base resistors may be calculated on the basis of the required primary current (ie, the transistor collector current), the beta of the transistors and, therefore, the base current required. In general terms the procedure was as follows, in terms of the MR10B requirements.

The primary current may not be known directly but can be calculated with reasonable accuracy from the secondary power. Allowing for the losses in the selenium rectifiers (approx. 15V) the secondary winding will deliver about 165V at 80mA, or 13W. Allowing for a transformer efficiency of, say, 60%, this will call for a primary power of nearly 22W. At a supply of 12V this means a primary current of 1.8A approx.

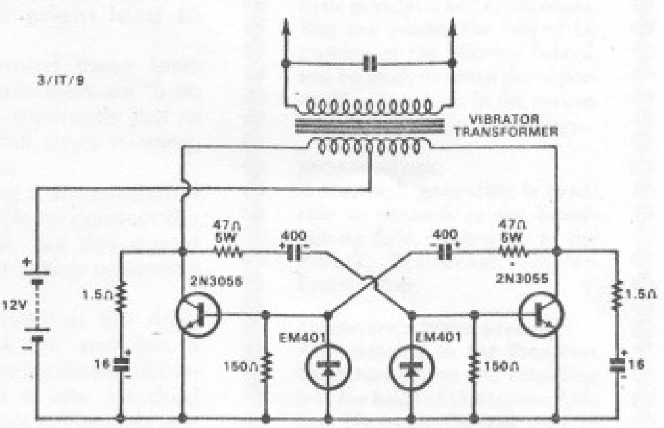
The transistors chosen were 2N3055s, which have a minimum beta of 20. To provide a collector current of 1.8A such a transistor will need a base current of 1.8/20, or 90mA. At a supply voltage of 12 the resistance needed to pass 90mA is 130 ohms.

The value of the isolating capacitors in series with the base resistors should be such that their reactance is low relative to these latter; a ratio of one third is suggested.

On this basis a unit for the MR10B should require base resistors of 130 ohms and isolating capacitors of not less than 40uF. We made up a pair of units according to these figures, using 50uF capacitors, and 120 ohm resistors.



Above: Rear view of the unit, showing the symmetrical layout which is possible, though not essential.



Right; The circuit is simple and uses only a few readily available parts. No changes to the existing equipment should be needed.

Initially, results were very encouraging, and each unit worked exactly as expected first time. Unfortunately, they refused to work together as a pair in the series power supply arrangement. While the receiver unit would work normally while in the receive mode, it would drop out of oscillation immediately the press-to-talk button was operated. The transmitter unit would usually start, meaning that the transmitter would operate after a fashion on 150V and incorrect bias.

To ensure completely reliable operation we had to reduce the base resistors to 47 ohms and increase the capacitors to 400uF. The main disadvantage of this arrangement is the relatively high dissipation in the base resistors and the need to ensure that the heat from them does not cause embarrassment. We used 5W resistors mounted as shown in the photographs and have had no problems even with the supply mounted in its original case.

Inasmuch as the MR10B arrangement is a rather specialised one it would be unfair to criticise the original article. In fact, as we confirmed experimentally, the approach is quite valid for a conventional situation. Where only a single vibrator is involved it would still be a good place from which to start, modifying the values only if unreliable starting is encountered.

Normally, a unit will start the first time, unless there is a faulty component or silly wiring mistake, and the presence of normal voltage at the transformer secondary should be sufficient indication that all is well. If a CRO is available check the waveform between either collector and chassis; it should be a clean square wave with a frequency around 100 to 120Hz, varying slightly with load.

At least one of these units has been made, using 120 ohm resistors, and used to replace a defunct vibrator in an otherwise perfectly good car radio. It worked first time and has given no trouble of any kind.

The construction is as shown in the photographs. The components are mounted on a small 16 gauge aluminium panel, which also serves as a heat sink for the transistors. It measures 115 mm x 65 mm and is folded at one end to form a 13 mm mounting foot. One is mounted in place of each support bracket which previously held the selenium rectifiers.

Each one is plugged into the vibrator socket by means of a six pin plug on a short lead. (Plugs from discarded vibrators may be used.) It should not be necessary to change the circuit of the power supply itself and, in fact, the vibrator and its substitute should be directly interchangeable. On this basis the vibrator, if it is still functioning, can be retained as a spare in the event that the transistor circuit develops a defect.

The unit is constructed around two tag strips, each with five terminals, sitting end to end. The layout is so arranged that the components around each transistor are mounted symmetrically. This is not a critical requirement, but it does make a neat layout.

(The tag strips used were of an older variety and rather larger than those currently available. Some slight rearrangement may be necessary if smaller ones are used.)

One outstanding advantage of the transistor device, compared with the original vibrators, is that it appears to be notably free from hash problems. The author originally purchased two MR10Bs, one for the car and one for the shack. After conversion both performed essentially the same, except that one had a nasty background of vibrator hash.

A considerable time was spent trying to track this down and every likely component was checked and, in some cases, changed. It was all to no avail and, inasmuch as it was planned to operate the shack unit from a mains supply, we finally gave it best at least temporarily.

Nevertheless, we always had it in mind to try to solve the problem, in order to retain battery operation as an alternative mode. When we were eventually forced to replace the vibrators in the mobile unit we took the opportunity to try the transistor unit in the previously noisy set. Lo and behold, the hash problem had vanished. We subsequently made transistor units for this set also, thus fulfilling the original intention.

On the other hand, there are some restrictions with the transistor circuit compared with the vibrator arrangement. Whereas the vibrator (non-synchronous) is not polarised (active may be either positive or negative) the transistor arrangement must be connected with due regard to polarity. Also, the vibrator will handle any current up to its rated maximum with maximum efficiency, whereas it is advisable to design the transistor circuit to suit the current drain of the particular piece of equipment if maximum efficiency and minimum temperature rise is to be achieved.

At one stage an attempt was made to accommodate all the components on a "U" shaped aluminium bracket, about 32mm wide and 115mm high, sitting on top of a six pin plug. The whole assembly occupied little more space than the vibrator and would fit easily into the same position. The idea worked up to a point, but the heat from the 47 ohm resistors, combined with the crowding caused by the 400uF capacitors, made the arrangement impractical. On the other hand, assuming that the alternative values (120 ohms, 50uF) could be used, this configuration might well be practical.

Earlier, we mentioned mains operation of the MR10B. While this can be achieved in a number of ways, one of the most convenient is simply to feed 12V AC into the vibrator transformer primary. The advantage is that only one minor circuit modification is necessary and even this does not inhibit the set's operation from batteries should it be desirable. Changing over from mains to battery operation, or vice versa, requires only a few moments.

When this idea was originally conceived, we had some doubts as to how the transformers would react. In theory, there are two objections. One is that the transformers were designed for 100Hz operation, rather than 50Hz, and so might run hotter at the lower frequency. The other is that only half the primary winding can be used, since it is a 12V centre tapped winding or, in reality, a 24V winding. Again this might lead to overheating.

A practical test proved these fears groundless. These transformers are "built like a battleship" and apparently just as sturdy. Even after a full day's running, they are not unduly hot.

(The primary winding is so terminated that it would be possible to connect the two halves in parallel, but this would commit the supply to mains operation only.)

The modification concerns the relay circuits. These require DC and this is most easily provided by a suitable silicon rectifier (EM401) and a few hundred microfarads of capacitance. The only restriction is that, if it is intended to be operated in a car, the rectifier polarity must be chosen to suit the electrical system concerned, ie, whether negative or positive chassis.

Apart from this all that is required is to remove the vibrator and strap together pins 1 and 6 (or 5 and 6) of the vibrator socket. This is most conveniently done by means of a 6 pin plug with these pins bridged. An old vibrator base will do and the bridge may be made from 16g tinned copper wire, formed into a small loop to provide a convenient finger grip to aid withdrawal.

Conversion from one mode to the other then involves three steps:

(1) Disconnect existing input plug before opening case.

(2) Remove vibrator and substitute shorting plug, or vice versa.

(3) Replace in case and fit alternative input plug.

A convenient source of 12V AC is a discarded TV power transformer, which usually has two 6V windings of substantial rating which may be connected in series. Since the transmitting duty cycle is normally small, some liberties may be taken with the ratings.

While the above remarks are based mainly on the MR10B, most other vibrator power supplies may be operated from 12V AC in a similar way, assuming they use a non-synchronous vibrator.

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MINOR MODS TO ORIGINAL CIRCUIT

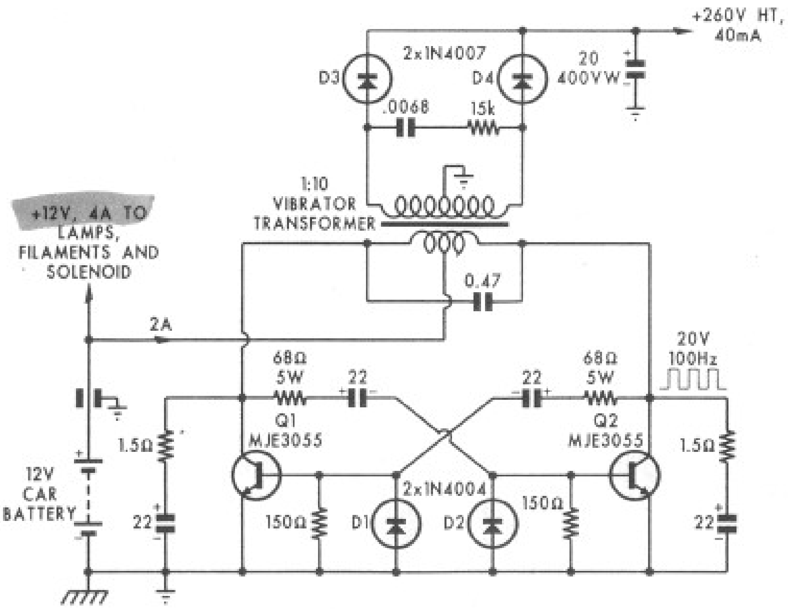
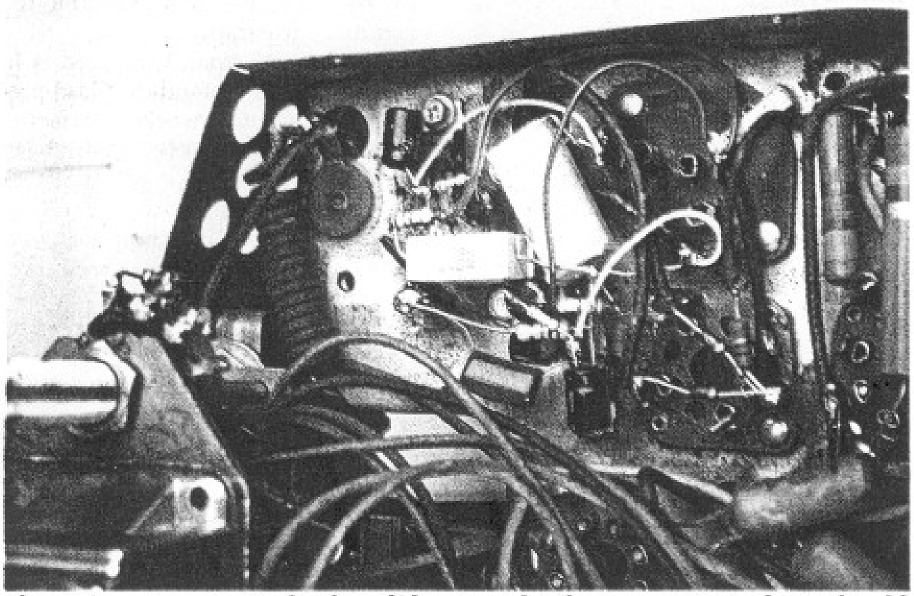


Fig.1: this solid state multivibrator circuit was used to replace the defunct mechanical vibrator in the old Delco car radio.



The various components for the solid state multivibrator were wired into the old radio in point-to-point fashion, to match the style of the other parts.

was now perfectly converted to right-hand drive (in fact, you would never guess that the steering wheel had once been on the left). The radio was working in-situ and it sounded very good indeed.

However, there was still a minor problem. Because of the larger current drain (6A), the battery now has a tougher job. If its voltage drops, the reduced valve gain due to lowered filament voltages causes the radio's self-seeking tuning system to become erratic. It may be necessary to have the car's electrical system modified to cope but that's up to the mechanics.

The other sets

The other two Delco radios were slightly later models (7272505) with five valves and one transistor. I haven't tackled these yet but hope to solve all the problems in these two sets in the next week or so. All going well, I'll tell you about them in next month's column.

The Masuda TV set

The next customer's problem involved a Masuda TV set with one of the most puzzling series of faults I have encountered for a long time. Mr Cleary's set was a late-model S21TXS Chinese-built 51cm Multi System Stereo set with Teletext. His main complaint was that he couldn't tune the set because it kept drifting. However, he did list five other faults: (1) no colour, even when the set was correctly tuned; (2) no Teletext; (3) no stereo; (4) no remote control; and (5) the set would cut off after a few minutes.

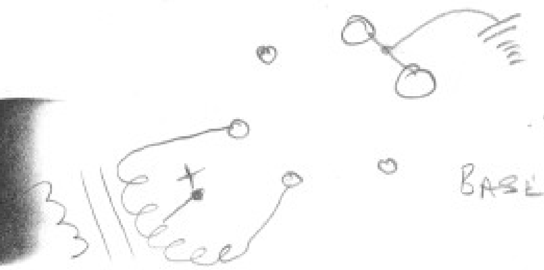
I tackled problem 4 first and on disassembling the remote control, found it to be full of some unspecified liquid. The only thing for it was a complete wash and clean in sugar soap. Fortunately, the liquid had not been there long enough to corrode the PC board tracks and after drying it thoroughly and applying a little CRC 2-26, it worked perfectly.

But I despaired over the five remaining faults, although I suspected that there was a common denominator – if only I could find it. The thought of fixing five separate faults, all difficult, did not bear contemplating.

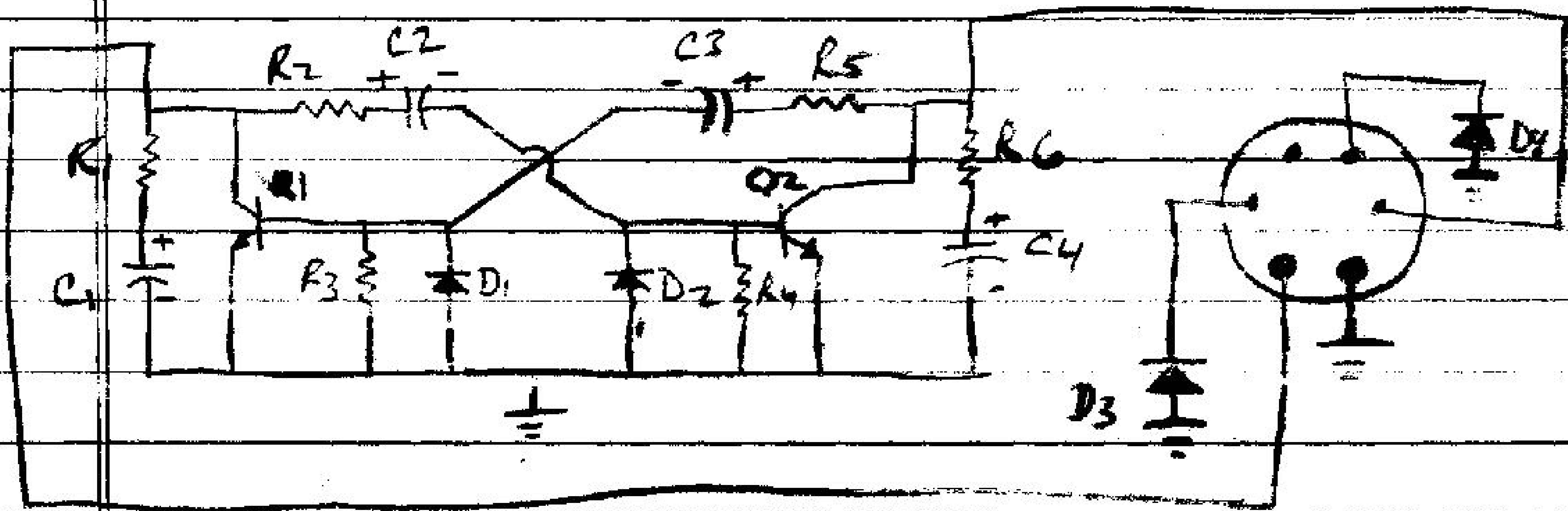
The first thing was to check the main voltage rails. I was lucky enough to have a circuit diagram and even though this didn't give voltages, I could guess at what they should be. The main HT rail was 105V and there was also a secondary rail of 14V, the latter feeding a subsidiary 5V rail.

I also established that there were 18V and 12V rails derived from the secondary of the horizontal output transformer (T302). There was no significant ripple on these rails when checked with the CRO and I concluded that they were correct and that the other rails also looked reasonable.

When the set was switched on, it initially gave a very good monochrome picture on all channels, which gradually slipped off tune. What's more, the self-seeking tuning system never stopped on the stations and couldn't be persuaded to lock in. I checked the 33V tuning voltage source which supplies the tuning voltage (VT) via IC004 and transistor Q001 (2SC1815Y), the latter controlled by pin 1 of the microprocessor (IC001). The whole chain



ASTOR
VIBRATOR SOCKET
BASE VIEW



R1, R6 - 1 Ω

R2, R5 - 47 Ω 2W

C1, C4 - 22mf 35V

C2, C3 - 470mf, 16V

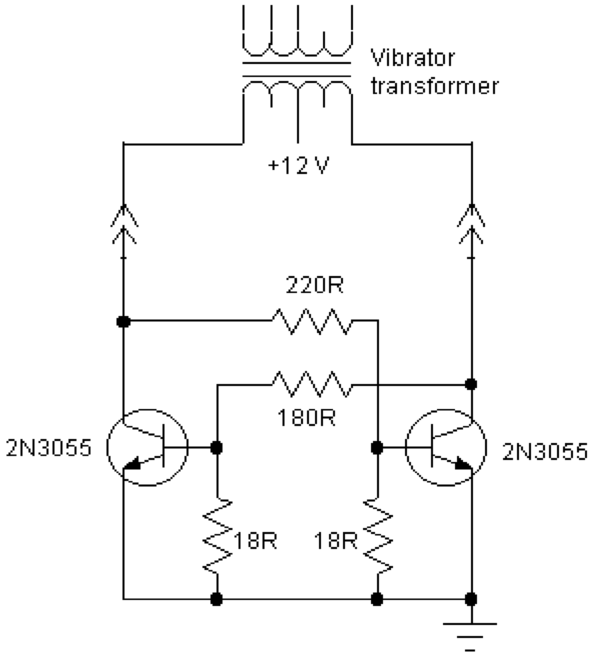
R3, R4 - 75 Ω

D1-D4 - 1N4004

Q1-Q2 - 2N3055

A Solid State Vibrator

Simon Dabbs G4GFN



I thought readers might be interested in this circuit. I discovered it "in the flesh" when I acquired a Canadian W.S. 19 power supply. A previous owner had installed a solid state unit to replace the original mechanical device. I have been using the psu for several years, and I'm surprised by its simplicity and effectiveness. It uses just two 2N3055 transistors and four wire-wound ceramic resistors (3 watts apiece). It forms a multivibrator, which seems to oscillate at just the right frequency. As it has no capacitors, I am at a bit of a loss to understand how it works, but I guess it's the back-emf from the transformer which turns the transistors off after each half-cycle.

Anyway, it seems to work a treat. The previous owner had mounted the transistors (insulated) on a small heat sink, which he lodged in a convenient void under the chassis. It is a straight substitute for the mechanical vibrator, and he had wired it to the underside of the vibrator socket. One thing I like about it is that it is, of course, very easy to re-instate the original vibrator, which in fact I have done recently.