Build this:

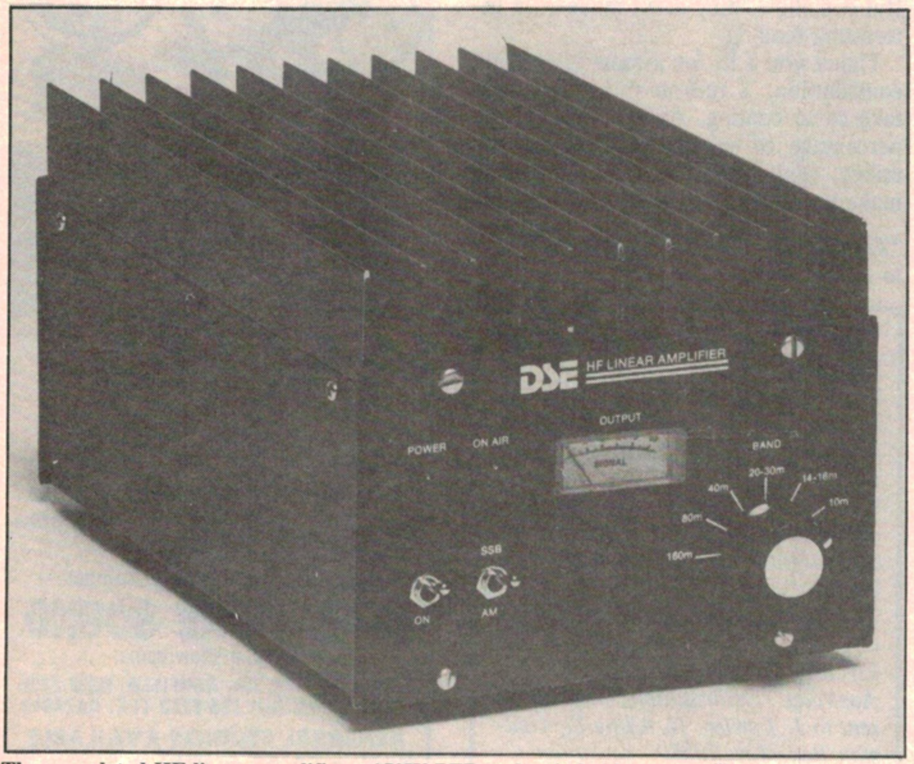
High-power HF Linear Amplifier

Most high-power HF linear amplifiers cost an arm and a leg. This one costs around $300, boasts a power output of up to 150W PEP, and includes switchable output filters.

by GREG SWAIN

If you've having trouble making some of those distant QSOs (contacts) or just want more power for your HF rig, this new HF Linear Amplifier is the answer. Installed between your rig and the antenna, it will boost your power output by 10-14dB — up to a maximum of 150W PEP (peak envelope power) in fact!

This unit can be used on any HF amateur band between 1.8 and 30MHz and will pump out a good clean signal with better than 30dB rejection of unwanted harmonics. That's made possible by the use of switchable low pass filters, a feature often missing from commercial linear amplifiers.



The completed HF linear amplifier —150W PEP and switchable output filters.

In fact, some commercial units deliver a third harmonic content that's almost as strong as the primary frequency. Such units represent a significant potential source of radio frequency interference (RFI).

How much input power can you feed into the new linear amplifier? Answer: you can use any HF transceiver with a power output of up to 15W CW (30W PEP). The only proviso is that a 2:1 attenuator must be included during construction for transceivers in the 10-15W range.

Figs.1 and 2 plot the performance of the unit. As can be seen from Fig.1, the output power is generally better than 110W for an input of 10W from 1.8 to 24MHz. Above that figure, the power output drops due to the ferrite material used in the input and output transformers.

Even so, a power output of about 50W is still available at 28MHz for 10W input.

Let's now take a look at the front panel. There are just three operating controls: an on/off switch; a switch to select between AM and SSB operating modes; and the band filter switch. A power LED, an on-air LED and a power meter complete the front panel line-up.

The rear panel carries the input and output sockets.

Inside the amplifier are two relays which switch the unit in and out of circuit. When power is applied (ie, the on/off switch is in the 'on' position), the amplifier is switched into circuit by the relays whenever the press-to-talk (PTT) button on the transceiver is pressed.

When the PTT button is subsequently released, the amplifier is switched out of circuit and the relay contacts now connect the transceiver output "straight through"

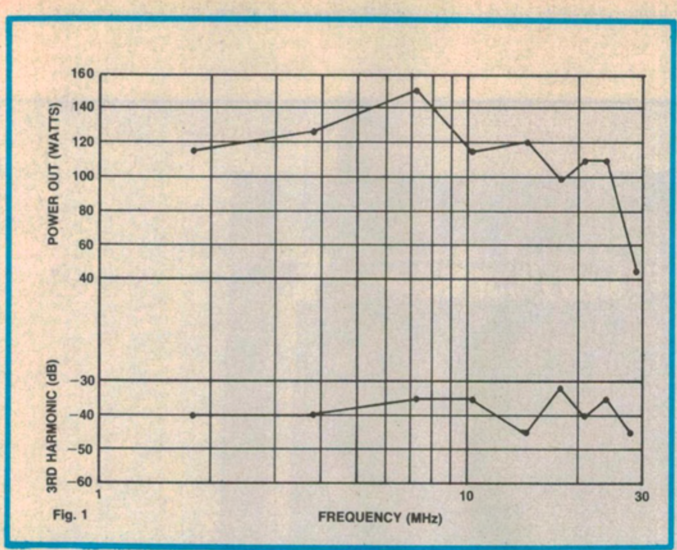


Fig.1: output power vs. frequency (10W drive).

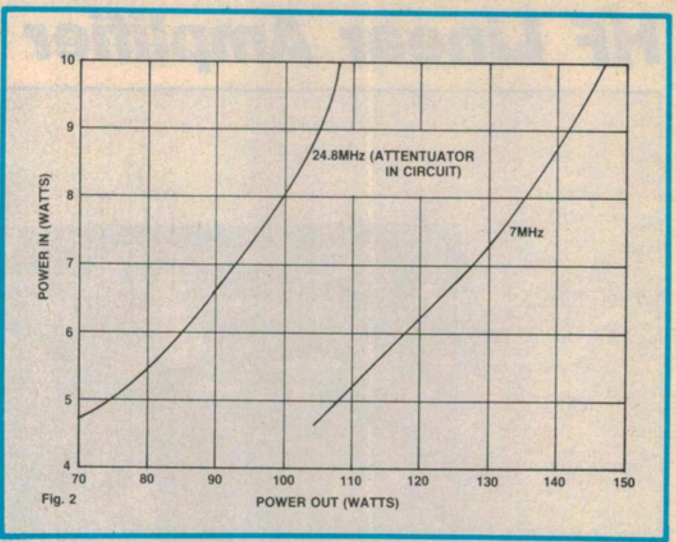


Fig.2: power out vs. power in for 7MHz and 24.8MHz.

to the antenna socket (on the back of the amplifier).

Finally, in addition to all of the above features, the unit is virtually "bullet-proof". It is protected against reverse battery connection and battery overvoltage; it automatically shuts down in the event of RF overdrive; and it shuts down if the antenna SWR becomes excessive (eg, if the antenna lead goes open circuit).

How it works

Fig.3 shows the circuit diagram. It looks complicated but can be broken down into four easily understood sections: a power booster (Q101 and Q102); a low-pass filter circuit; a VSWR-cum-power indicator circuit; and a carrier operated relay circuit.

The booster is based on two 2SC2290 RF power transistors arranged in a standard push-pull design and operating in class B mode.

Starting at the input, the RF signal from the transceiver is fed via relay contacts RL2a to the 2:1 attenuator network and thence to transformer T1. This scales the input impedance down by 16:1, from 50 ohms to around three ohms, to drive the power transistors (Q101 and Q102).

Base bias for the power transistors is provided by Q103 which is configured as a diode. Because it is thermally coupled to the heatsink, this arrangement also prevents thermal runaway of the power devices. The hotter the heatsink becomes due to dissipation in Q101 and Q102, the hotter Q103 becomes.

And the hotter Q103 becomes, the lower the voltage across it and therefore the lower the bias on the power transistors. Q101 and Q102 are thus automatically throttled back as the heatsink temperature rises.

Resistor R7 limits the bias current to about 100mA per device, while capacitors C107-C113 provide supply decoupling. Inductor L101 is designed to filter out RF in the bias supply to Q101 and Q102.

The collector outputs of the power transistors drive output transformer T2. This transformer steps up the output voltage and, in turn, drives the following low-pass filter stage. Trimmer capacitor TC101 and parallel capacitor C106 tune the output transformer primary to give maximum power transfer and to guard against output stage oscillation.

Negative feedback for the booster is derived from a single winding on the output transformer secondary and is applied to the bases of Q101 and Q102 via series RC networks. This helps maintain a low VSWR across the input transformer and also helps compensate for gain variations over the 1.8-30MHz range.

The low-pass filter stage consists of six independent sections arranged in standard Chebyshev configuration (L2-L13 and C14 to C41). The –3dB cutoff frequencies are listed in Table 1. Double-pole switch S3 selects the required filter and couples the RF energy to the following VSWR-cum-power indicator stage.

VSWR/power indicator

The VSWR/power meter is fairly conventional. It employs a current transformer consisting of a centre-tapped secondary wound on a toroid, with the primary being a heavy gauge conductor through the middle. Diodes D10 and D11 rectify the voltage developed across L1 due to the forward power. The resultant DC signal is then applied to the meter movement via calibration trimpot VR1.

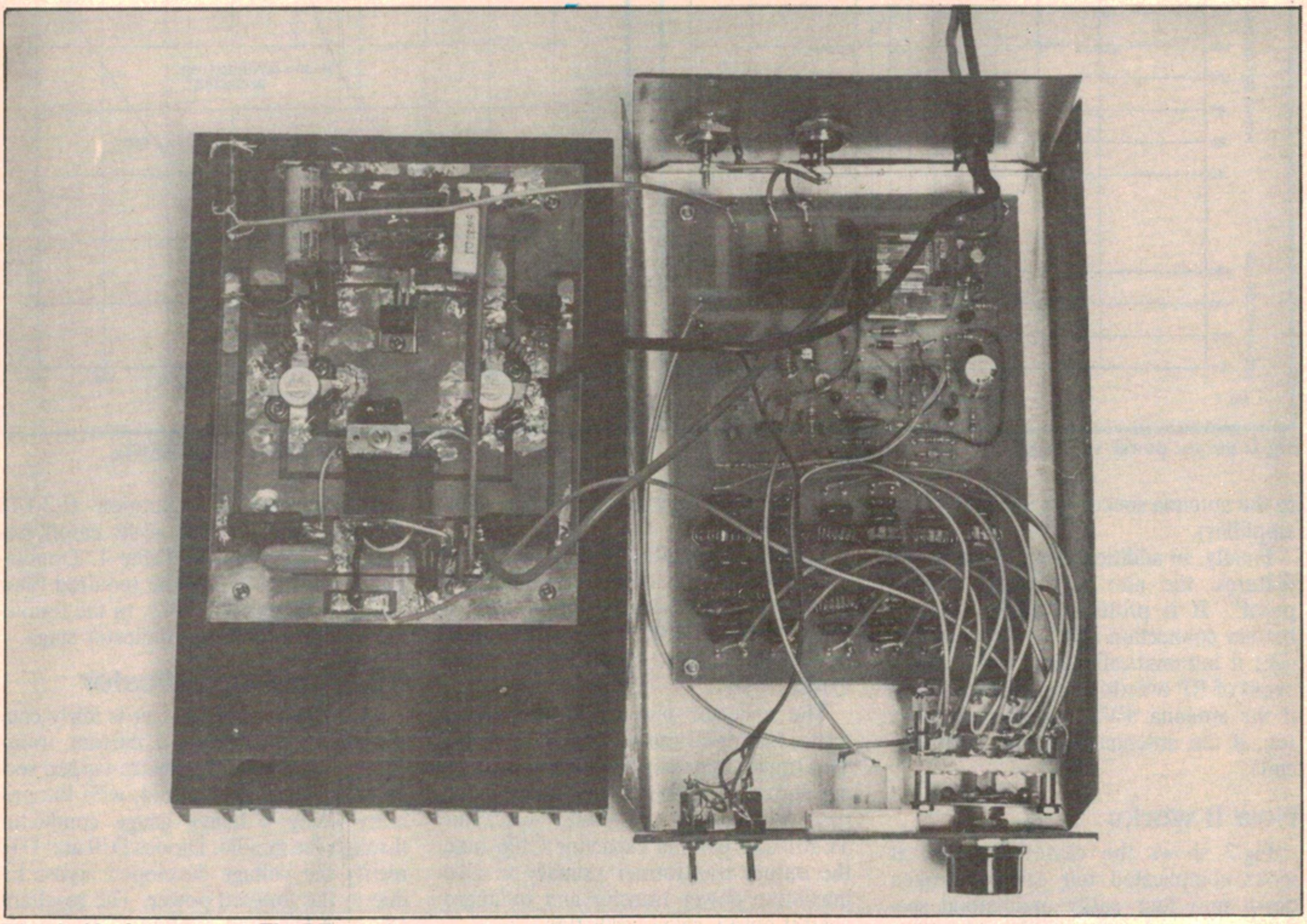
Trimmer capacitor TC1 is used to peak the circuit for a maximum reading on the meter.

Similarly, D12 and D13 rectify the voltage developed across L1 due to the reflected power. This signal is then applied via VR2 and R17 to the gate of SCR1 in the carrier operated relay circuit. More on this later.

TABLE 1

Band	-3dB Fc	Suitable For:
160 metres	2.5MHz	1.8 - 1.86MHz
80 metres	5MHz	3.5 - 3.8MHz
40 metres	10MHz	7 - 7.3MHz
20-30 metres	17MHz	10.1 - 14.35MHz
14-16 metres	26MHz	18 - 21.45MHz
10 metres	31MHz	28 - 29.7MHz

Table 1: 3dB cutoff frequencies for the filter switch settings.



View inside the prototype. The RF transistors are bolted directly to the heatsink.

Carrier operated relay

Q1, Q3 and Q4 form the relay switching circuit. This switches the amplifier into circuit on transmit, and switches the amplifier out of circuit during receive. Ignore Q2 and the two SCRs for the time being — they're in the protection business.

Here's how the circuit works: During receive, Q1 and Q3 are off. Thus, relay driver transistor Q4 is also off and the transceiver is connected directly to the output socket via relay contacts RL2a and RL2b.

When the transmit button is pressed, part of the signal passes via C1 to a diode pump consisting of D1 and D2. This charges C2 and provides base bias for Q1 which turns on. Thus, Q3 and relay driver Q4 also turn on and so power is applied to the amplifier circuit and to the on-air LED (D15) via relay contacts RL1a.

At the same time, power is also applied to RL2 which turns on and switches the amplifier into circuit.

When the transmit button is released, the relays remain on for a short time until C3 charges sufficiently to turn Q3 (and thus Q4) off. Switch S2 considerably extends the relay dropout time for SSB and CW by switching out R3. This is necessary to prevent relay chatter since there is no carrier in SSB mode and only an intermittent carrier in CW mode.

Protection

The remaining components shut the circuit down if there is excessive VSWR, RF overdrive or excessive supply voltage. Let's look at the VSWR protection circuit first. This consists of Q2 and SCR1.

As described previously, the output from the reverse side of the VSWR circuit is connected via R17 to the gate of SCR1. Normally, both Q2 and SCR1 are off but if the VSWR signal becomes excessive, the SCR turns on and provides base current for Q2. This turns Q2 on and Q3, Q4 and the relays off, thereby switching the booster out of circuit.

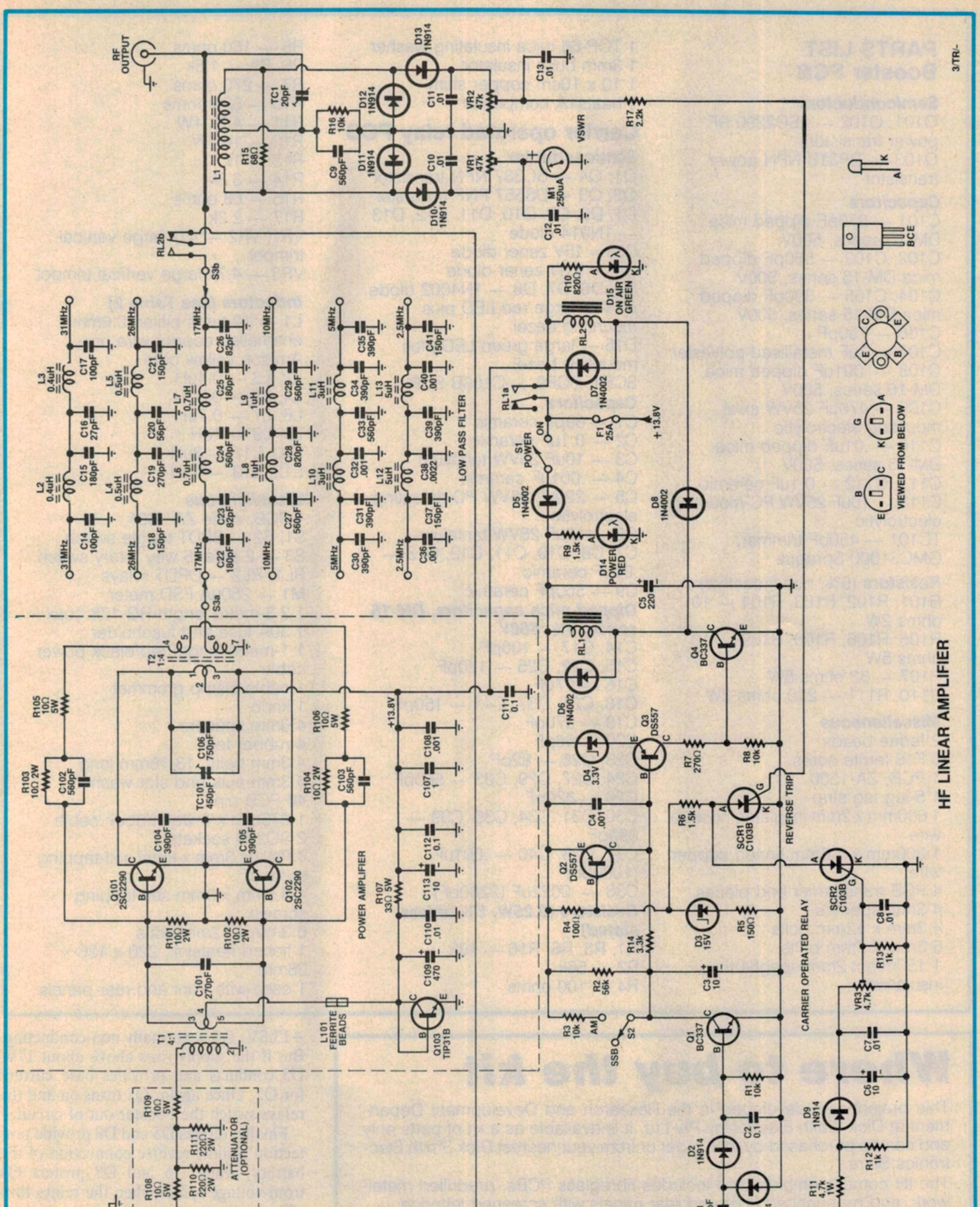
Q2 and SCR2 work in exactly the same way to protect the booster from RF overdrive. In this case, RF energy from the transceiver is first applied to a voltage divider consisting of R11 and R12. D9 then rectifies the divider output and charges C6. The higher the RF drive, the higher the voltage across C6.

This voltage is sampled by VR3 and applied to the gate of SCR2. If the RF drives becomes excessive, the voltage across C6 rises and the SCR is triggered into conduction. As before, this turns Q2 on and the relays off.

Trimpot VR3 sets the drive level at which the circuit trips. It can be set to any desired level up to a maximum of 15W. Note that the SCR1 and SCR2 protection circuits can only be reset by turning the power switch off for several seconds and then on again.

Zener diode D3 provides protection against excessive supply voltage. Because the supply voltage is usually around

Fig.3: the circuit uses two RF transistors, Q101 and Q102, operating a standard class B push-pull mode.


HF LINEAR AMPLIFIER
RF INPUT
RF OUTPUT
ATTENUATOR (OPTIONAL)
POWER AMPLIFIER
LOW PASS FILTER
CARRIER OPERATED RELAY
REVERSE TRIP
VSWR
POWER
ON AIR GREEN
POWER RED
+13.8V
FERRITE BEADS
VIEWED FROM BELOW

PARTS LIST
Booster PCB

Semiconductors
Q101, Q102 — 2SC2290 RF power transistors
Q103 — TIP31B NPN power transistor

Capacitors
C101 — 270pF dipped mica DM-15 series, 500V
C102, C103 — 560pF dipped mica DM-15 series, 500V
C104, C105 — 390pF dipped mica DM-15 series, 500V
C106 — 750pF
C107 — 1uF metallised polyester
C108 — .001uF dipped mica DM-16 series, 500V
C109 — 470uF 25VW axial mounting electrolytic
C110 — .01uF dipped mica DM-15 series, 500V
C111, C112 — 0.1uF ceramic
C113 — 10uF 25VW PC-mounting electrolytic
TC101 — 450pF trimmer, GMC31000 Sprague

Resistors (5%, non-inductive)
R101, R102, R103, R104 — 10 ohms 2W
R105, R106, R108, R109 — 10 ohms 5W
R107 — 33 ohms 5W
R110, R111 — 220 ohms 2W

Miscellaneous
2 ferrite beads
6 F16 ferrite cores
1 PCB, ZA-1500
1 5-lug tag strip
1 600mm x 2mm insulated hookup wire
1 300mm x 1.6mm tinned copper wire
4 PCB transformer end pieces
4 3mm spacers
4 3mm x 12mm bolts
5 3mm x 7mm bolts
1 150mm x 2mm spaghetti insulation
1 TOP-66 mica insulating washer
1 3mm bush insulator
1 10 x 10cm copper shim
1 heatsink compound

Carrier operated relay PCB

Semiconductor
Q1, Q4 — BC337 NPN transistor
Q2, Q3 — DS557 PNP transistor
D1, D2, D9, D10, D11, D12, D13 — 1N914 diode
D3 — 15V zener diode
D4 — 3.3V zener diode
D5, D6, D7, D8 — 1N4002 diode
D14 — large red LED plus mounting bezel
D15 — large green LED plus mounting bezel
SCR1, SCR2 — C103B SCR

Capacitors
C1 — 39pF ceramic
C2 — 0.1uF ceramic
C3 — 10uF 25VW tantalum
C4 — .001uF ceramic
C5 — 220uF 25VW PC-mounting electrolytic
C6 — 10uF 25VW tantalum
C7, C8, C10, C11, C12, C13 — .01uF ceramic
C9 — 560pF ceramic

Dipped mica capacitors, DM-15 series, 5%, 500V
C14, C17 — 100pF
C15, C22, C25 — 180pF
C16 — 27pF
C18, C21, C37, C41 — 150pF
C19 — 270pF
C20 — 56pF
C23, C26 — 82pF
C24, C27, C29, C33 — 560pF
C28 — 820pF
C30, C31, C34, C35, C39 — 390pF
C32, C36, C40 — .001uF (1000pF)
C38 — .0022uF (2200pF)

Resistors (0.25W, 5% unless stated)
R1, R3, R8, R16 — 10k
R2 — 56k
R4 — 100 ohms
R5 — 150 ohms
R6, R9 — 1.5k
R7 — 270 ohms
R10 — 820 ohms
R11 — 4.7k 1W
R12 — 1k 1W
R13 — 1k
R14 — 3.3k
R15 — 68 ohms
R17 — 2.2k
VR1, VR2 — 47k large vertical trimpot
VR3 — 4.7k large vertical trimpot

Inductors (see Table 2)
L1 — 10 turns bifilar, 0.6mm enamelled copper wire on Amidon yellow core
L2, L3 — 0.4uH
L4, L5 — 0.5uH
L6, L7 — 0.7uH
L8, L9 — 1uH
L10, L11 — 3uH
L12, L13 — 5uH

Miscellaneous
1 PCB, code ZA-1501
S1, S2 — SPDT toggle switch
S3 — 2 pole, 6 way rotary switch
RL1, RL2 — DPDT relays
M1 — 250uA FSD meter
1 2.3-metre length RG-178 coax
1 30A fuse and fuseholder
1 1-metre length red/black power cable
1 cable clamp grommet
1 knob
4 6mm spacers
4 rubber feet
4 3mm bolts, 13-16mm long
4 3mm nuts and star washers
46 PCB pins
1 275mm x 6-way ribbon cable
2 SO239 sockets
4 Philips 3mm x 8mm self-tapping screws
4 3.5mm x 9mm self-tapping screws
6 3mm x 12mm bolts
1 finned heatsink, 220 x 136 x 38mm
1 case with front and rear panels

Where to buy the kit

This project was developed in the Research and Development Department at Dick Smith Electronics Pty Ltd. It is available as a kit of parts only and can be purchased by mail order or from your nearest Dick Smith Electronics Store.

The kit comes complete and includes fibreglass PCBs, predrilled metalwork, and prepunched front and rear panels with screened lettering.

Mail orders should be addressed to: Dick Smith Electronics Pty Ltd, PO Box 321, North Ryde 2113. Phone (02) 888 2105.

+13.8V, D3 is normally non-conducting. But if the supply rises above about 17V, D3 conducts and provides base current for Q2. Once again, Q2 turns on and the relays switch the booster out of circuit.

Finally, diodes D5 and D8 provide protection against reverse connection of the battery, while D6 and D7 protect Q4 from voltage spikes when the relays turn off.

Next month, we shall give the full construction and alignment details. In the meantime, you can order your kit from Dick Smith Electronics (see box).