P. W. VIGOR

A NEW M.F DRIVE UNIT

INTRODUCTION

The new m.f drive type B6003 has been designed to meet the need for a general-purpose unit providing an unmodulated r.f output of 5W over the 525kHz to 1605kHz broadcast band. The design makes extensive use of integrated circuits to ensure a simple, reliable unit which is easy to adjust; the entire m.f band is covered by the adjustment of two preset tuning controls and a few links.

A useful feature is the facility for fitting two oscillators, the spare being available for instant use by operation of a front-panel switch. Oscillator aging correction, sufficient to cover the expected life, is also available on the front panel.

The unit is self-contained in a 19in rack-mounted chassis, (Fig.1). All internally derived low-voltage supplies, including that for the crystal ovens, are regulated to ensure well-defined operation of the electronic circuitry and a stable output in both frequency and amplitude.

GENERAL DESIGN

The unit is fully transistorized and uses integrated circuits to perform the major circuit functions. All the signal processing is carried out by digital means, except for the final stage which has a tuned circuit on the output to remove harmonics and provide the pure r.f carrier.

This approach has the following advantages:

(a) **Easy adjustment.** The divider stages, being digital, require no tuning. Only the output stage conduction angle and output tuning require adjustment.

(b) **High reliability.** Simplicity of design ensures a low component count and hence reduced risk of component failure plus lower capital cost.

The unit comprises oscillator(s), dividers, drive and output stages and associated power supplies (Fig.2).

OSCILLATORS

The unit utilizes quartz crystal oscillators as stable frequency sources; two types may be fitted depending on the frequency stability required. The medium stability oscillator yields a long-term stability of ±5 parts in 10^6 over 30 days, and is suitable for the majority of applications where a small amount of frequency variation is acceptable. Where extreme frequency stability is required, i.e, in co-channel working, high-stability oscillators

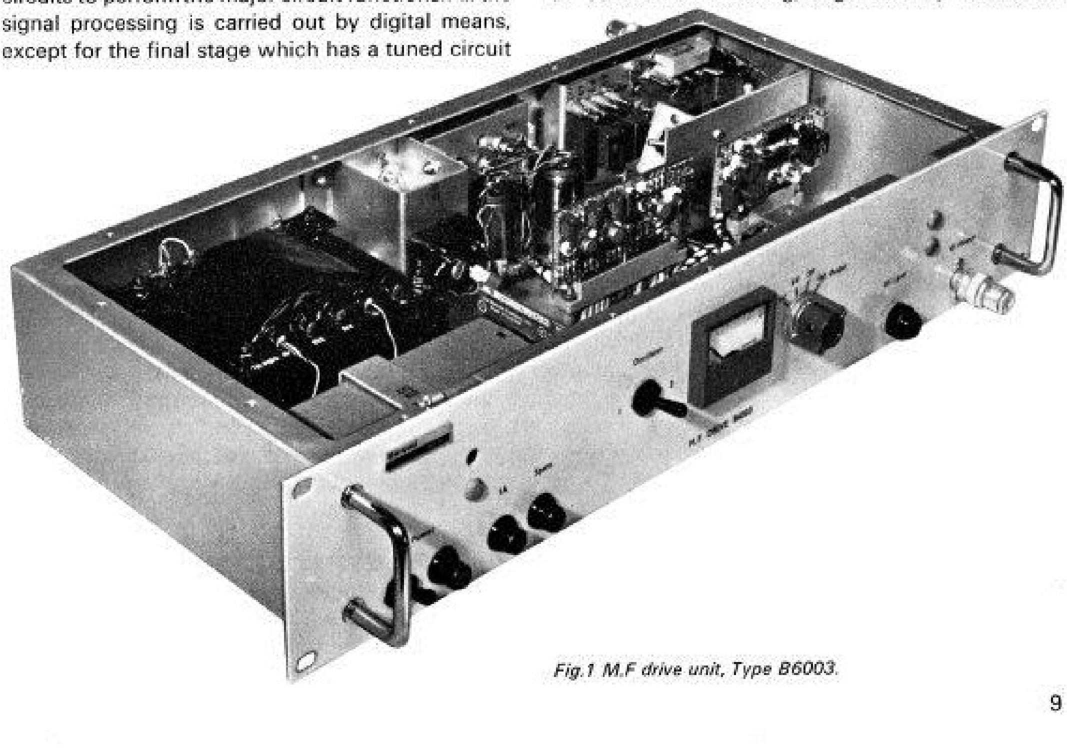

Fig.1 M.F drive unit, Type B6003.

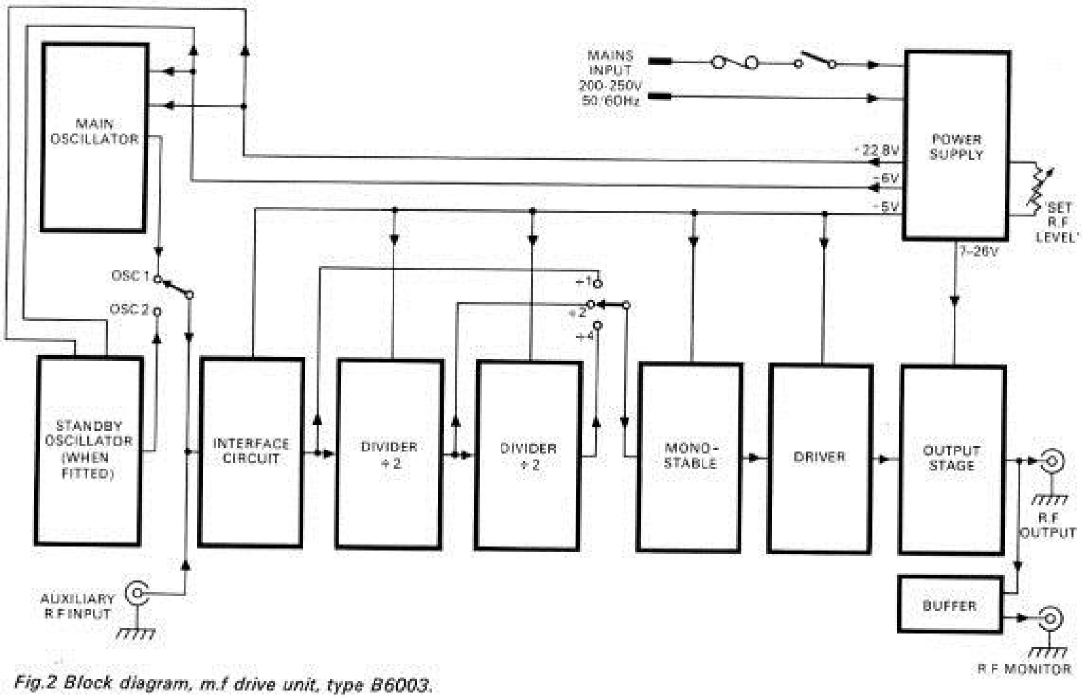

Fig.2 Block diagram, m.f drive unit, type B6003.

are available with a long-term frequency stability of +5, —0 parts in 10^8 over 30 days. Either oscillator may be plugged into the main chassis using the corresponding adaptor board.

Both types of oscillator are operated in a proportionally-controlled oven for increased stability in changing ambient temperatures. In the case of the high-stability version, the oscillator and the oven are integral in one mechanical assembly, whereas the medium-stability oscillator is a discrete unit placed inside a separate oven. Access to the crystal oscillator is via holes in the front panel allowing fine adjustment of their running frequency to offset the slight positive frequency drift of the crystals due to aging.

All medium-stability oscillators are arranged to operate at four times the required carrier frequency as crystals in this frequency ranges are easier to manufacture with good frequency characteristics at an economic cost.

The high stability version has an output at twice carrier frequency for frequencies below 1MHz, and at fundamental for frequencies above 1MHz,. Oscillators are available for any carrier frequency in the m.f band (525kHz-1605kHz). Provision is made for fitting two oscillators, a main plus an optional standby. When two oscillators are fitted the ovens are powered simultaneously. Should one oscillator fail the other is immediately ready for action.

Alternatively, an external signal source may be fed in via the auxiliary r.f input socket at the rear of the unit at a level of 1V r.m.s into 1 kilohm and at a frequency of carrier, 2 × carrier of 4 × carrier.

INTERFACE AND DIVIDERS

A discrete component interface circuit converts the output from the oscillators into square waves which feed the digital divider circuit with the correct logic levels. This is necessary to prevent jitter-free triggering over the complete frequency range which, at this stage, may be up to 6·42MHz depending on the oscillator fitted. The dividers consist of J.K bistables, each connected to divide by two. Two such circuits are contained in one 14-lead, dual-in-line integrated circuit package and are interconnected by links to give the required division ratio.

DRIVER STAGE

The output of the final divider stage is applied to the input of a monostable (one-shot) multivibrator, again an integrated circuit contained in a 14-lead dual-in-line package. This monostable produces a pulse which, when fed to the output stage, will produce a conduction angle of between 120° and 180°. The duration of the pulses is adjustable by a preset potentiometer such that the output pulse may have the same duty angle irrespective of frequency. The actual pulse length is shorter than the conduction time of the output stage due to hole storage effects in the base of the final transistor which effectively increases the conduction time. The output of the monostable is fed into a push-pull driver stage which is coupled into the output stage via a wideband ferrite pulse transformer. The driver stage is short and open-circuit-proof; should the output stage fail, no damage will result to the driver circuits.

OUTPUT STAGE

The output stage employs a silicon power transistor operated in the switching mode, (Fig.3). In this configuration the transistor takes pulses of energy from the supply rail and drives them through a filter to obtain a continuous r.f sinewave output. In this way an efficiency of between 60% and 70% is obtained without critical circuit adjustment. The drive is arranged to saturate the transistor hard during its conduction period and hence keep its dissipation down. During the non-conducting half of the switching cycles the base of the transistor is taken negative with respect to its emitter to remove base hole-storage charge rapidly and so increase switching time. The application of a negative voltage to the transistor base also increases the breakdown voltage of the device when it is most needed, as this is the time at which the collector voltage swings up to about twice the supply voltage. The transistor used is of the high-power, high-frequency, inverter type and is therefore remarkably rugged, hence a load of any impedance or phase angle may safely be driven. In fact, the drive may safely be operated into a short or open-circuit load, or a misadjusted tuned circuit, without any detrimental effect.

Current to the output stage is supplied via an r.f choke which provides a high impedance to the r.f voltage developed at the collector. The filter employed is of the 'pi' type and is tuned to pass the fundamental frequency to the load and reject all harmonics. It also acts as an impedance transformer to convert the relatively low impedance at the collector of the transistor up to 50 Ω at the output. To provide full frequency range coverage, the tuning capacity at either end of the 'pi' filter is made up of three separate smaller capacitors; two of each three may be linked, as required, the third being permanently connected. This enables correct tuning and substantially constant output over the entire m.f band. The tuning inductor has sufficient range without tapping, this being achieved by the use of a high permeability ferrite tuning slug, screwed in or out of the coil as required. To provide an r.f monitor voltage, the output of the drive is detected and use to drive a meter on the front panel.

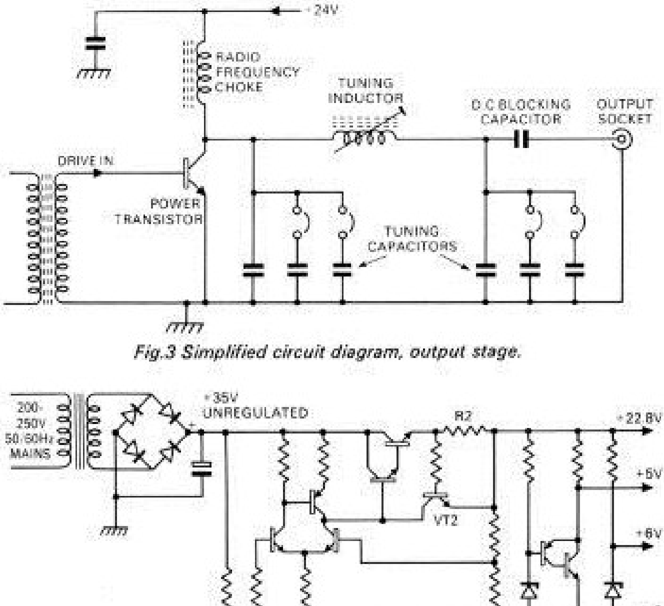

Fig.3 Simplified circuit diagram, output stage.

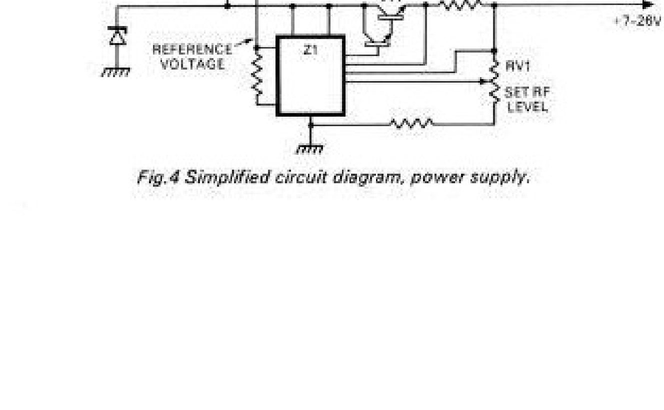

Fig.4 Simplified circuit diagram, power supply.

POWER SUPPLIES

The drive unit contains integral power supplies operated from a single phase 200-250V a.c mains input. All the low voltage rails generated are electrically regulated to ensure proper operation of the electronics and crystal ovens contained in the unit. Four regulated rails are produced, +22·8V for the high-stability crystal oscillator and crystal ovens, +6V for the medium-stability oscillator, +5V for the low-power signal stages and a variable supply of 7V to 26V for the r.f output stage.

The integrated circuit Z1, (Fig.4), contains a highly stable, temperature-compensated voltage source and a high-gain differential amplifier in a TO5 package and forms the heart of the stabilizer. Used in conjunction with additional emitter follower stages to increase its current handling capacity, it produces a highly stable, low-noise voltage source for the r.f output stage. The low hum and noise content is essential to ensure a clean r.f output from the unit with negligible amplitude modulation caused by supply voltage variations.

The regulator uses the feedback principle, a proportion of the output voltage being fed back to the inverting input of the differential amplifier and compared with the reference voltage which is applied to the non-inverting input. Any voltage difference between the two inputs causes the output voltage to be changed by raising or lowering the impedance of VT1 until the error is corrected. Hence, the output voltage remains constant irrespective of normal load current and input voltage variations. In the event of an overload current being drawn, the voltage drop across R1 is used to activate the current-limiting circuitry inside the integrated circuit which then limits the current to a safe value to prevent self-destruction of the regulator. RV1 controls the proportion of the output voltage fed back to the differential amplifier and hence the output voltage. This control is used to vary the r.f output voltage as the output is proportional to the voltage applied to the final stage.

The oven supply regulator works on a similar principle, but uses a discrete component amplifier for error correction, the reference voltage being derived from the integrated circuit. Overload protection is provided by VT2 which switches on when the voltage drop across R2 exceeds about 0·7V and so drains the base current from VT3. This action limits the output to a safe value.

The +5V and +6V stabilizers use Zener diodes as shunt regulator elements, the voltage stability on these rails being less critical. As the 6V rail supplies very little current, a single Zener diode is adequate for stabilization. The +5V rail is of a higher current capacity and a two-transistor circuit is used to reinforce the Zener action. Shunt regulators were chosen for the low-voltage rails as they provide lower power dissipation in the active elements for low output voltages and relatively constant current loads.

MECHANICAL LAYOUT

The whole electronics assembly is contained in a standard 19in rack mounted chassis 3½in high and 11in deep. On the front panel is the main on/off switch, mains and spare fuses, meter and associated four position switch, oscillator changeover switch, r.f level control and r.f monitor point. Holes are also provided through which the oscillator frequency may be adjusted. The meter is used to check the +5V, +6V, +22·8V ovens supply and the r.f output level. The r.f monitor socket is for frequency checking only and is capable of producing 1V of signal into 75 Ω. The rear panel contains the r.f output socket, the auxiliary input socket and the mains input plug. All r.f connectors are of the TNC type; the mains plug is a 4-pin Cannon. The two printed-wiring boards are held vertically in edge-connector sockets and may be removed for easy servicing. The complete r.f output circuitry is mounted on a sub-chassis held into the main chassis by four screws and may be easily removed for maintenance. The r.f output transistor and the two power supply regulator power transistors are in thermal contact with the back of the chassis which forms a more than adequate heat sink.

A split cover fits on the top of the chassis; the left-hand half covers the mains transformer and need not normally be removed while the right-hand half covers all the electronics and may be removed for servicing and tuning. The oscillators are supplied with their corresponding adaptor board and are plugged into edge-connector sockets similar to those used for the printed wiring boards. The fine frequency adjustment capacitors are integrated in the assembly of the high-stability version, the medium stability version has its trimmer capacitor fitted on to the oscillator mounting bracket.