1.3-GHz design is consistency, i.e., ensuring that any copy of the design is built exactly the same, even down to component lead lengths, height above the PCB, etc. Other problems are the frequency stability and power output — both must be adequate to ensure a noise free picture into the repeater.

Dealing with the problem of components first, this design is totally surface mount. That means all the components are soldered directly to the board with pre-set lead lengths and at a pre-determined height above the PCB.

This technique ensures a high degree of repeatability, and, as a bonus, a compact, easily portable unit for 'outside broadcast' use!

Obviously, a free-running oscillator at 1.3 GHz is going to drift, but as the re‑‑iver bandwidth is typically 1‿ .MHz, that is not too much of a problem. This transmitter, though, is a fairly powerful compact design, and the heat dissipated by other parts of the circuit could lead to unacceptable amounts of frequency drift. Therefore, a simple phase locked loop (PLL) is included to maintain frequency stability — more on the design of the loop later. If operators do not mind the occasional re-tune of the transmitter frequency, it is possible to leave out the PLL circuits and install a potentiometer to set the operating frequency. This approach makes for a unit costing approximately £30 less than for the complete device. Of course, the PLL circuit could always be added at a later date.

RF power gain at 1.3 GHz can be difficult to achieve (and expensive) u‑‑ng individual components. F‿ .unately these days it is possible to buy RF power amplifiers which come in the form of modules offering guaranteed performance. Their cost is considerably less than buying the individual parts, and there are no alignment problems.

The inclusion of the sound circuitry is very simple, based upon well proven techniques, and does not merit much description. It, too, uses surface mount parts for the sake of consistency and ease of mounting the PCB. Other designs have been published which use more complex audio circuits and sub-carrier oscillators, but it has been found that this simple circuit is perfectly adequate for working simplex and into the repeater. GB3MV actually uses a more complex arrangement to peak-limit the deviation and maintain the sub-carrier frequency to tighter limits.

As mentioned above, 70-cm ATV has traditionally used amplitude modulation (AM) which means that all the modulation stages and subsequent amplifiers had to be linear if picture distortion was to be avoided.

On 24 cm, frequency modulation (FM) is almost universally used. FM offers several advantages over AM for TV work, and few disadvantages. Perhaps the major advantage is that RF amplifiers can operate in class C, i.e., a non-linear, but high efficiency mode. Also, a properly designed FM TV receiver can exhibit a much better picture quality for a lower RF signal to noise ratio at the receiver input. These two reasons alone explain why FM is used for satellite TV broadcasting, and why amateurs have adopted similar techniques and standards.

Broadly speaking, any FM TV transmitter comprises the same basic stages, as follows:

(1) RF oscillator, either on frequency or multiplied to final frequency;
(2) Pre-emphasized FM modulator, usually associated with (1) above;
(3) Frequency maintaining phase locked loop;
(4) Sound amplifier and sub-carrier oscillator;
(5) RF power amplifiers.

As can be seen from the block diagram in **Fig. 1**, the present design follows the basic principles outlined above.

The circuit is given in detail in Fig. 2. The RF oscillator is formed by $T_2$ running directly at 1.3 GHz. Varicap diode $D_3$ is used to modulate the oscillator's frequency with both baseband video and the 6-MHz sound sub-carrier. In conjunction with the PLL circuits it also maintains the desired mean frequency.

As FM noise rises with frequency, a better overall system signal to noise ratio can be achieved by boosting (pre-emphasising) the high frequency video signal, and then using de-emphasis at the receiver to restore the desired flat frequency response — the same principle as used on terrestrial FM radio.

In this design, the components between $J_3$ and $R_{26}$ perform pre-emphasis to CCIR 405, a widely used broadcast standard. Preset $R_{26}$ sets the total video deviation.

Integrated circuits $U_6$ and $U_5$ amplify the low-level signal from $T_2$ up to about 2 watts output.

The transmitter RF output is turned on by applying bias to $U_5$ via a switch on $J_2$. The PLL is left running all the time power is applied to the unit.

Circuit $U_2$ is a the sound pre-amplifier and pre-emphasis circuit, with $T_1$ being a frequency-modulated 6-MHz oscillator. The exact frequency and level of the sound sub-carrier is set by $C_{20}$ and $R_{12}$ respectively.

The PLL used in this design is very basic and uses only two ICs, $U_3$ and $U_7$. There is no loop filter opamp. Instead, the output of $U_3$ is used directly to drive the loop filter whose output (via $R_{30}$) controls the mean voltage on $D_3$, and thus the oscillator frequency. $R_1$ and $R_6$ are in series purely to make the PCB layout easier!

$U_7$ is used as a fixed divide-by-128 prescaler to bring the output of $T_2$ down to within range of $U_3$. The reference frequency of $U_3$ for use with its internal phase detector is 8 MHz divided by 2048, giving a reference of 3.90625 kHz. This results in a channel step of 500 kHz at 1.3 GHz when it is effectively multiplied by 128 with $U_7$.

For good quality pictures, the overall frequency response of a TV transmitter ideally would be from DC to approximately 5.5 MHz. Usually, the high frequencies are not too much of a problem, provided care is taken with the design. However, when using a PLL which tries to maintain the nominal carrier frequency, if the PLL bandwidth is too great, it can effectively strip off any low frequency components. Therefore, to ensure the PLL cannot attenuate or distort the low frequency frame sync pulses, it must have a loop bandwidth of less than 50 Hz. The design presented here has a loop bandwidth of about 30 Hz, easily low enough to ensure adequate low frequency response.

A side effect of using a low loop bandwidth with a basic design like this is the PLL lock time. Typically, the PLL could take several hundreds of milliseconds to acquire lock from switch on. That is why in this design the PLL is kept 'alive' all the time, and the transmitter turned on by applying bias to the PA. This technique offers the benefit of having a low-level signal present for picture alignment purposes before actually going 'on-air'.

The low loop band bandwidth of 30 Hz also makes it very easy to attenuate any traces of the 3.90625 kHz reference frequency, which may otherwise leak through into the signal path, and modulate the transmission.

By varying the divide ratio in $U_3$, it is possible to program any other frequency in the band to a resolution of 500 kHz. With a jumper (or switch) across $J_5$, the transmitter will operate on 1249 MHz, the most popular repeater input frequency. Due to spreads in $X_1$, $C_{23}$ and $C_{36}$, the reference oscillator may not be exactly on 8 MHz, and may result in a slight frequency offset of up to 100 kHz — not a problem with a 15-MHz receiver bandwidth! If desired, $C_{23}$ could be trimmed to ensure operation on exactly 1249MHz.

Leaving $J_5$ open-circuit results in the transmitter operating on 1265 MHz for simplex operation. All the 'N' programming inputs to $U_3$ have internal pull up resistors, so its quite