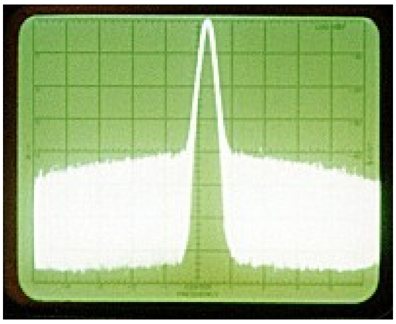
# A Low Phase Noise

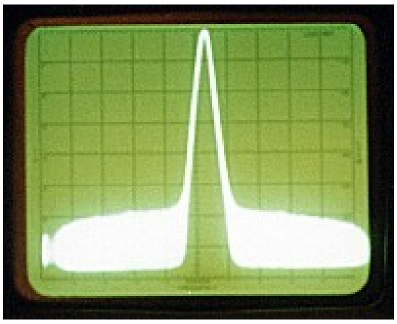
# Temperature Stabilized JFET Crystal Oscillator

# For Microwave Use by G8ACE

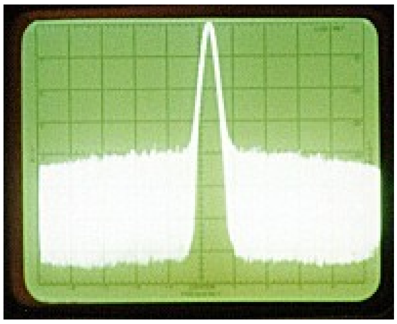
Existing temperature stabilized designs where the whole oscillator circuit is heated to the operating temperature of the crystal have shown a high degree of frequency stability can be achieved. Stability being adequate right up to the highest frequencies currently in use. The use of an attenuator followed by a mmic however at the output of an oscillator module to minimize external frequency pulling does tend to compromise phase noise performance. This is akin to putting a 30db pad into your aerial cable and expecting to retrieve the same signal again by using an amplifier to make up the lost signal. Articles on the phase noise subject emphasize the need for low noise operation particularly in the early stages of multiplication which should also be low order. In tests the G4DDK004 multiplier has been used for the early multiplication stages with its oscillator removed. Direct measurement of phase noise has not been made due to the lack of appropriate test equipment. Instead practical measurement of the receive noise floor variations with different oscillator sources has been made. The spectrum analyser results are shown for three comparisons made at 47Ghz. Vertical scale is 10db/div.



A copy of the DF9LN Oscillator design utilizing an attenuator and output mmic



This Oscillator design with a cascode output stage



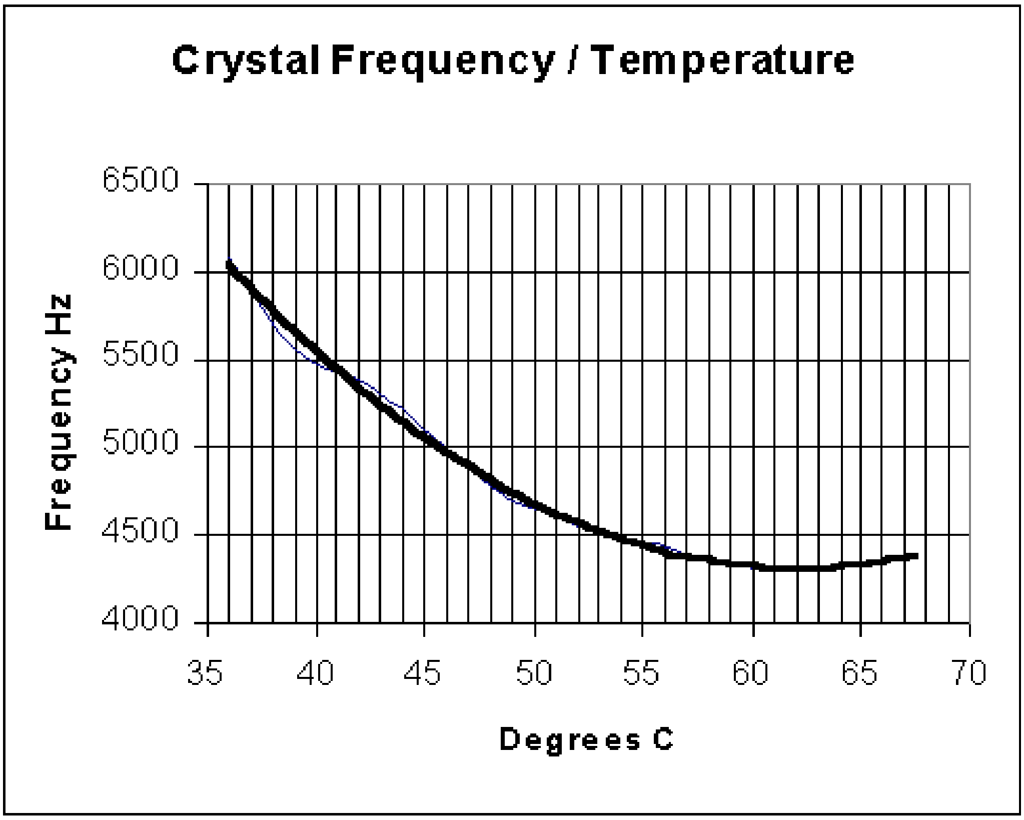
This Oscillator design with a cascode output stage followed by an attenuator and mmic

The centre picture shows a noise floor improvement of 15-16db over the same circuit with the addition of the attenuator and mmic (right hand picture).

The oscillator is the well known Butler arrangement. In this case the first transistor is exchanged for a JFET following the article in QEX, Nov/Dec 1999 by John Stephenson, KD6OZH. In that design however the frequency stability is achieved by phase locking rather than temperature stabilization. The cascode output stage in this design provides adequate isolation against external frequency pulling. The 3db attenuator at the output is to provide improved impedance matching.

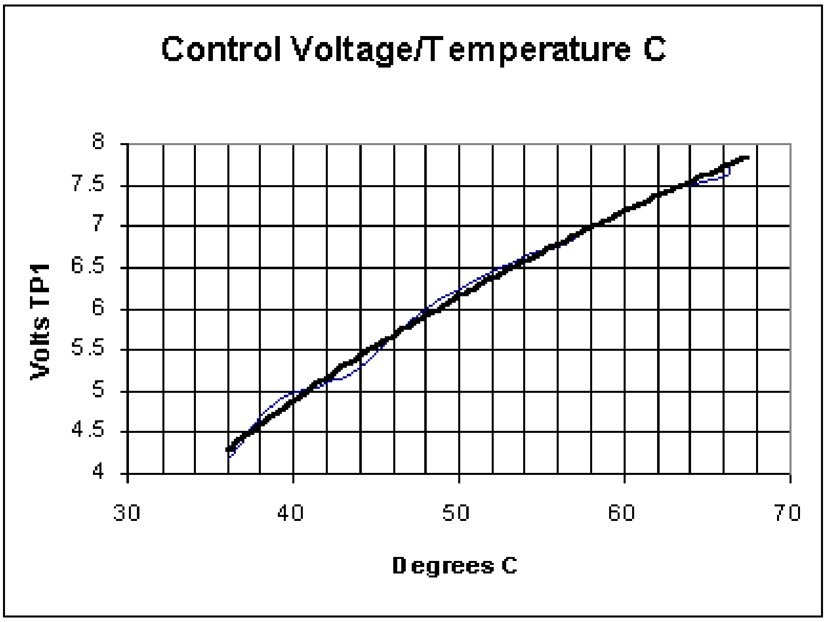
A low noise voltage regulator is used for the power supply. It also features a very small voltage drop essential for portable/battery operation. The standard 78L types require more input headroom and are considered too noisy for this more demanding application.

The operating temperature must be specified for a new crystal. The self heating of the module is such that a running temperature of 40° C is just possible at low ambient temperatures but temperature control may be lost if the ambient rises. This can be observed by monitoring the reduction in total current consumed. Crystals cut for 50 or 60°C operation are to be preferred for optimum trouble free operation. The correct operating temperature can be found by searching for the turnover point as shown in the plotted characteristic below.




This plot shows the change in frequency of the crystal against operating temperature. This crystal was designed to operate at 60° shown by the turnover point in the characteristic.

When crystals are measured and do not show a pronounced temperature turnover point a significant improvement in stability can still be obtained by the use of an ovened oscillator circuit.

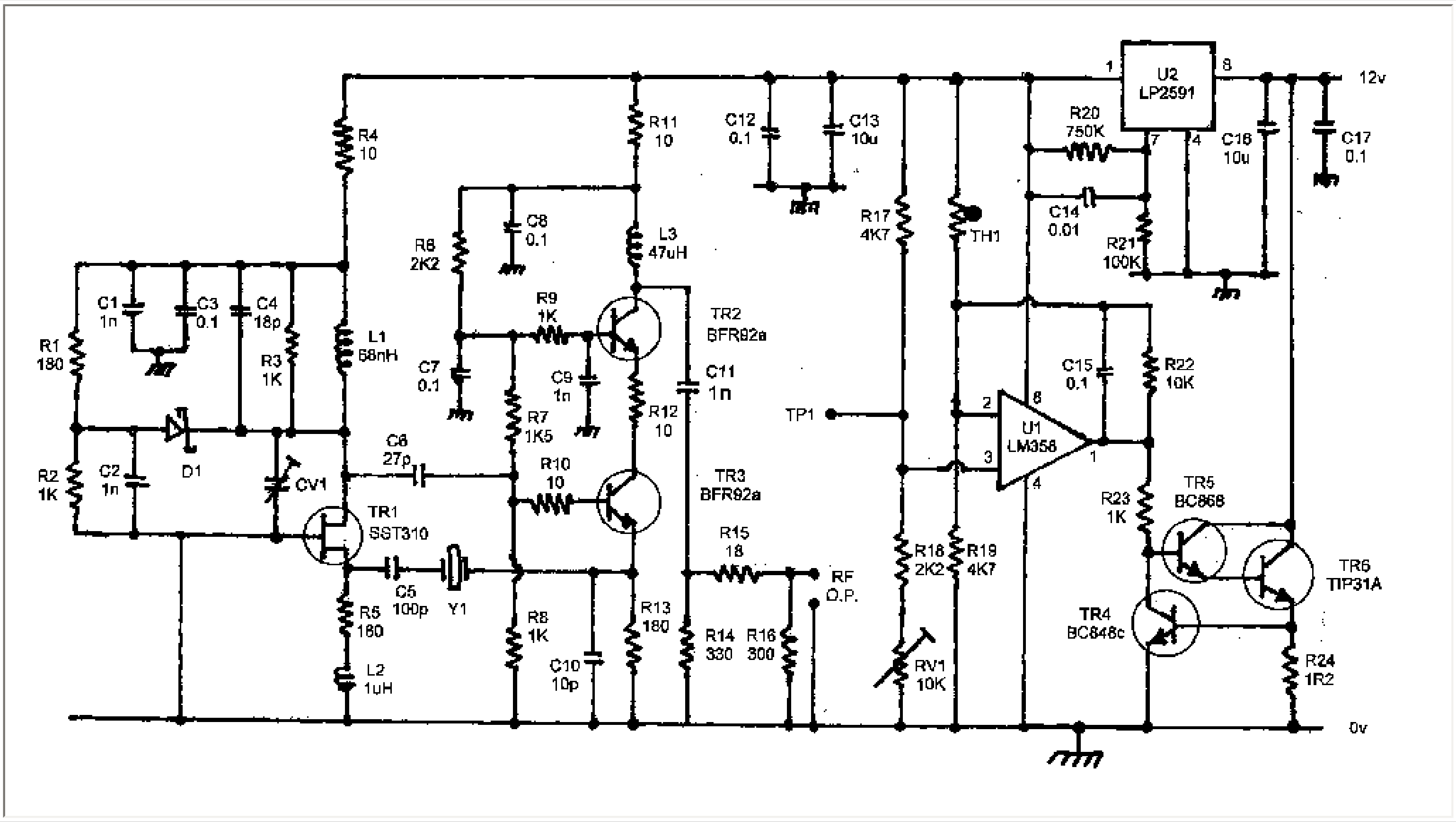



Control voltage values for the crystal oven are plotted against temperature in this graph. This temperature set voltage is derived from RV1 and measured at TP1.

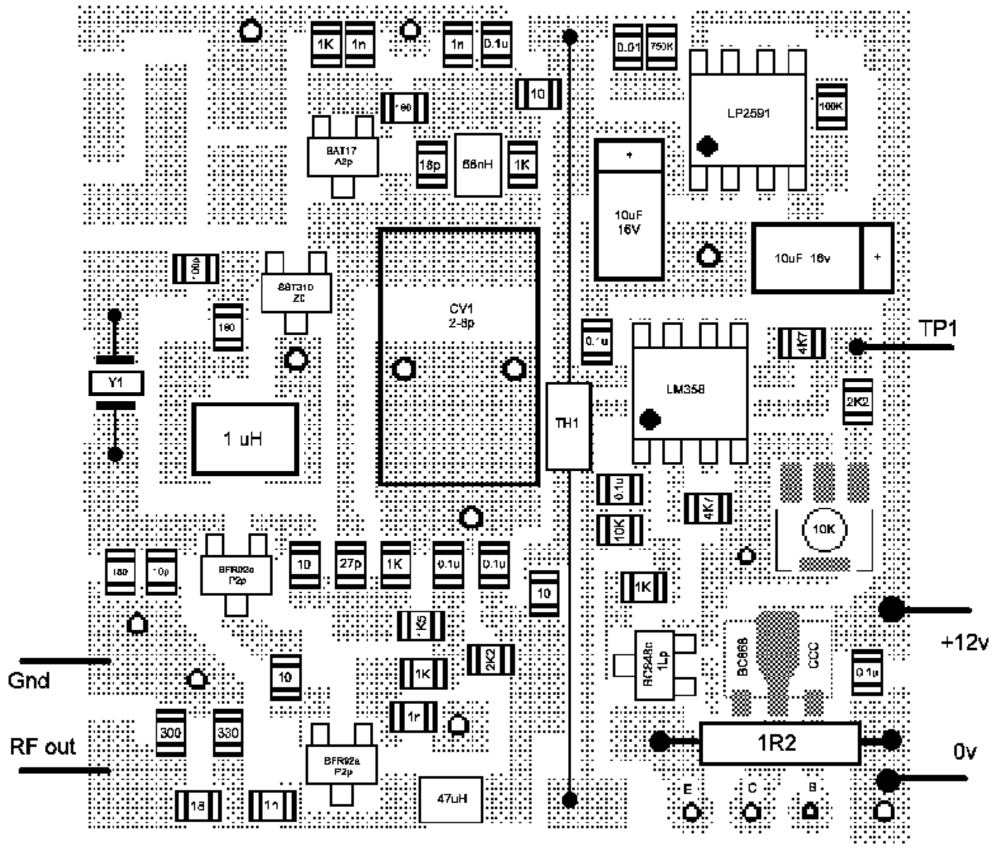
Temperature feedback from the oven plate is provided by a glass bead thermistor. The thermistor can be placed close to the crystal is for accurate control of the crystal temperature.

The circuit board measures 35mm square and contains both the oscillator and oven control circuits on one side. Components are surface mount types except for the thermistor, TO220 heater transistor and its emitter resistor. The trimmer is a high quality ceramic piston type. The limiter diode D1 may be either a HP 2800 type or surface mount. The PCB is glued with araldite to the heat sink plate and this gives adequate thermal conductivity to keep all components at a stable temperature for frequency stability. The module should be housed in a metal box for screening with adequate thermal insulation. Thick insulation will show improved stability and reduced current consumption.

## Circuit Diagram




## PCB Component Locations

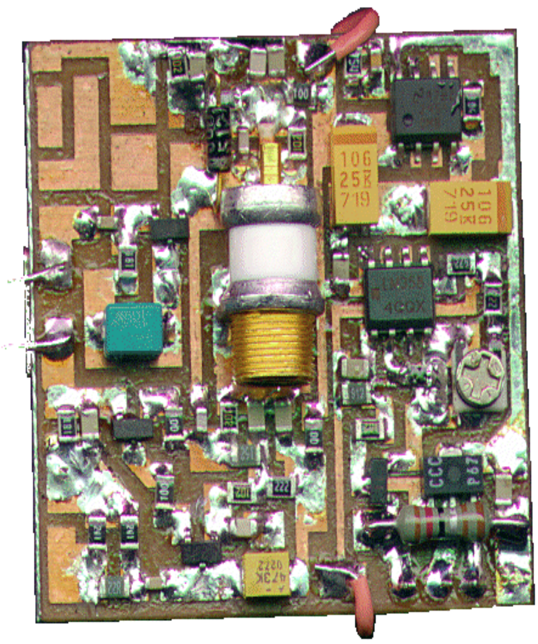



## Component List

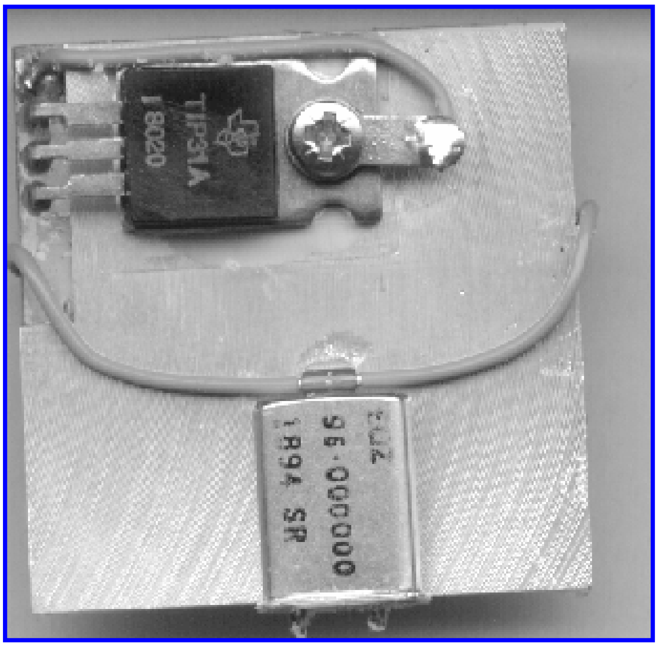
| | | | | | | |
|---|---|---|---|---|---|---|
| R1 | 180 | C1 | 1n NPO | Green | RV1 | 10K |
| R2 | 1K | C2 | 1n NPO | Blue | CV1 | 2-8pf ceramic piston |
| R3 | 1K | C3 | 100n | Black | | type (not supplied) |
| R4 | 10 | C4 | 18p NPO | Brown | L1 | 68nH |
| R5 | 180 | C5 | 100p NPO | Red | L2 | 1µ H |
| R6 | 2K2 | C6 | 27p NPO | | L3 | 47µ H |
| R7 | 1K5 | C7 | 100n | | D1 | HP2800 or BAT17 |
| R8 | 1K | C8 | 100n | Yellow | TH1 | NTC Glass bead type |
| R9 | 1K | C9 | 1n NPO | | | (PTFE sleeving reqd.) |
| R10 | 10 | C10 | 10p NPO | | TR1 | SST310 JFET |
| R11 | 10 | C11 | 1n NPO | Mauve | TR2 | BFR92a |
| R12 | 10 | C12 | 100n | | TR3 | BFR92a |
| R13 | 180 | C13 | 10µ F | | TR4 | BC848c |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R14 | 330 | C14 | 10n | | | TR5 | BC868 |
| R15 | 18 | C15 | 100n | | | TR6 | TIP31A |
| R16 | 300 | C16 | 10µ F | | | U1 | LM358 |
| R17 | 4K7 | C17 | 100n | | | U2 | LP2591 |
| R18 | 2K2 | | | | | Y1 | Crystal 5th Overtone |
| R19 | 4K7 | | | | | | 50° or 60° C type |
| R20 | 750K | | | | | | (not supplied) |
| R21 | 100K | | | | | PCB | |
| R22 | 10K | | | | | Wire | |
| R23 | 1K | | | | | | PTFE insulated |
| R24 | 1R2 | | | | | | connecting wires |

## Finished PCB



## Heater Plate side of the assembly




Contact G8ACE if you would like kit details.

Click here to view the 10Mhz Reference Oscillator version