

An Ovened Reference Oscillator

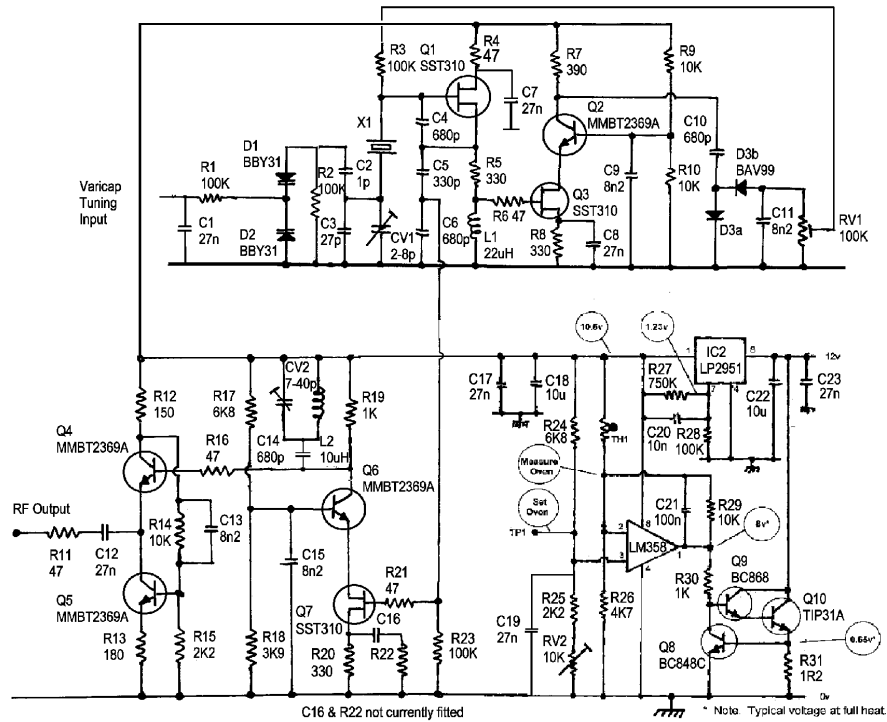
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Applications and Features

The Oscillator module is Surface Mount construction and has a variety of uses for both test equipment and for specific communications purposes. An Applications and Features guide is shown here.

- Suitable for use as a free running reference or as a source locked to DCF, Droitwich, GPS, MSF, etc. This source can then be used to externally lock other equipment such as:
 - Frequency Counters
 - Synthesisers
 - Microwave Oscillator Sources
- The Surface Mount construction with the PCB attached to a common heating plate with the crystal ensures all components operate at a regulated temperature aiding stable operation. The principle circuit features are:
 - Varicap diode fine frequency control adjustment input for accurate manual frequency setting or PLL control input.
 - AGC amplifier with crystal drive control and output signal level set.
 - Output amplifier providing oscillator isolation and 50Ω terminated cable driving capability.
 - Oven temperature control setting for optimum frequency stability.
- Stability is typically better than 1 part in 10⁸ per degree C of ambient temperature for an aged crystal with the module housed for a well insulated enclosure and oven set to within ±1°C of crystal turnover temperature.
- Output level 0dbm into 50Ω with typically 1% total harmonic distortion
- The complete module is a compact 35mm square with a height of 12mm before insulation and boxing.

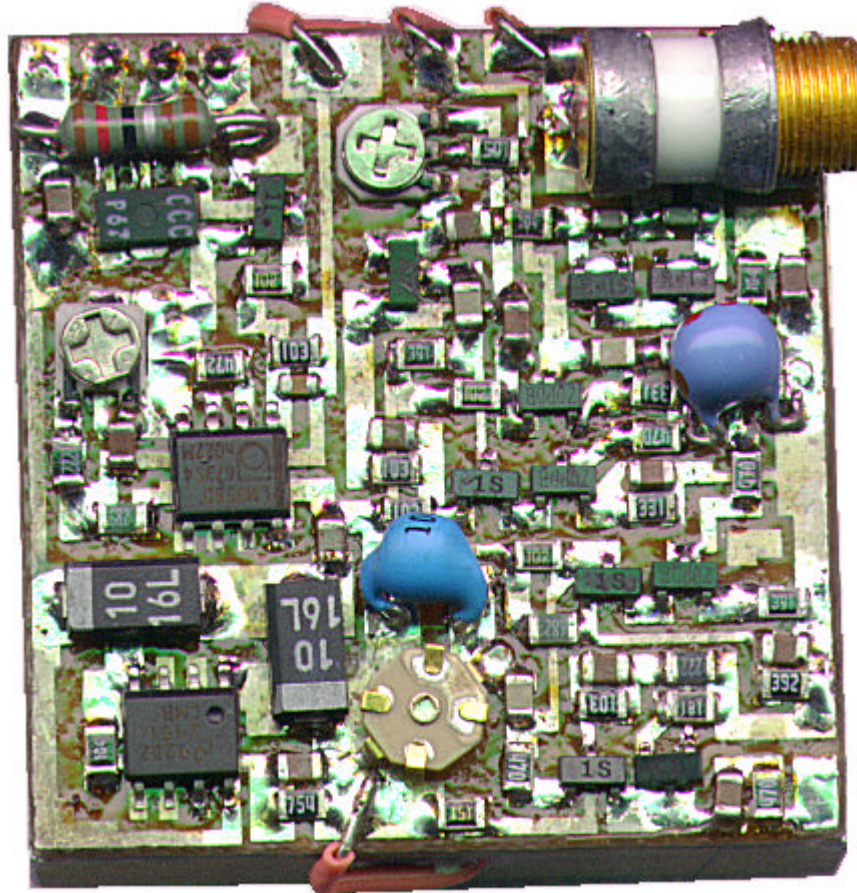
Circuit Description



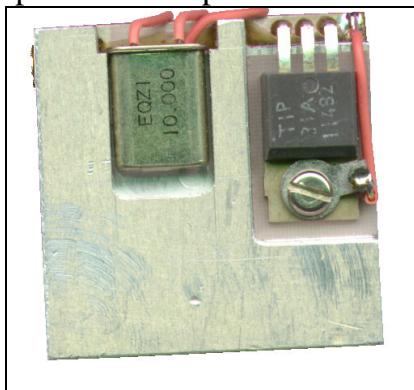
The upper part of the circuit diagram, left to right contains the varicap frequency adjustment control, oscillator and output level control. The varicaps are coupled via C2, 1pf, to the crystal. Their tuning range is small and is typically 7 Hz for a variation of 10 volts at R1. This ensures random noise pickup on the dc input will have minimal effect. The oscillator itself is the common Colpitts arrangement using a JFET semiconductor. The output signal is derived from the capacitive divider, C5,C6. Signal for the drive level is derived from the remote end of R5. In both cases these output signals are fed to further JFET devices to minimise loading of the oscillator. The drive level control voltage is provided by cascode amplifier Q2 and Q3 and the rectifier voltage doubler, D3. RV1 sets the drive level and the output amplitude of the module by adjustment of the gate bias to the oscillator Q1.

In the lower half of the circuit diagram the output amplifier is to the left and the oven temperature control to the right. The JFET, Q7, is the lower half of the cascode amplifier used to achieve isolation between the oscillator and output. The collector of Q6 contains a tuned circuit to minimise distortion and unwanted products. This feeds the output pair Q4 and Q5. A low output impedance enables direct feeding of a 50Ω terminated load at a level of 0dbm. Total harmonic distortion of typically 1% is achievable at 0dbm, terminated. The oven is the familiar bridge arrangement utilising a thermistor as the sensing element and IC1 to drive the heating transistor Q10 via Q9. Q8 provides current limiting. Temperature is set by RV2. Loop gain by R29. The regulated dc supply is provided by IC2 which can also be employed to drive the external varicap frequency tuning and external temperature setting.

Construction



The majority of the resistors and capacitors are 0805 size. The capacitors used in the oscillator are NPO types. The current determining resistor for the oven heating time is a wire ended type at the top left. L1 and L2 (blue) are wire ended types which exhibit good Q. C1 and C2 are ceramic variables. C1 is used as the coarse frequency set and should be of the highest quality. The PCB is attached to the heater plate with an epoxy resin adhesive. Devcon is specified for operation to 90°C and is therefore ideally suited. The plate



shown has milled areas for the crystal and heater. The thermistor is embedded through the plate beneath the crystal. A flat plate is equally suitable provided the thermistor is adequately thermally coupled to the crystal. For it is the crystal temperature stability which is one of the critical variables in achieving frequency stable operation.

Alignment

The PCB may be tested before fitting to the heater plate. Do not fit the thermistor or heater transistor, Q10. Do not connect the crystal temporarily so that signals can be checked. 12v can be applied. The output from the regulator IC2, LP2951 should be $10.5\text{v} \pm 100\text{mv}$. Check for RF signal at the output connections. C1 sets the frequency and RV1 the amplitude which should be set to 650mv pp. with a 50Ω termination. C2 sets the output signal purity. Setting C2 to maximum signal amplitude will minimise other products. The inductors L1, L2 may need revised values for other frequency crystals.

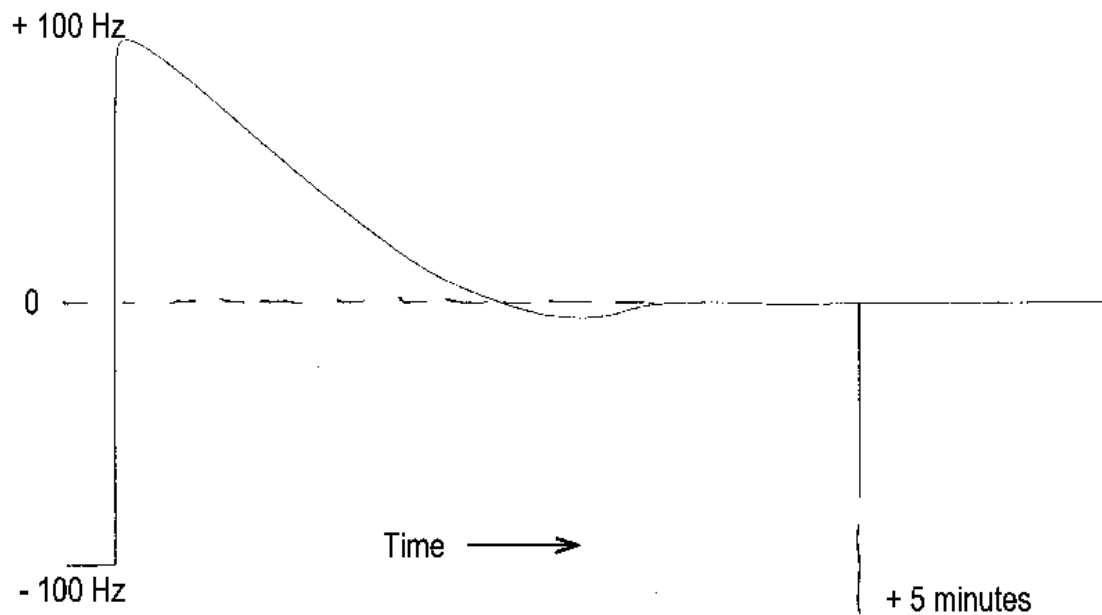
The output from IC1, the LM358, at pin 1 should be of the order 8v at this stage where the transistor Q10 and the thermistor are not fitted.

When it is established that the module is working correctly the heater plate can be attached with Epoxy adhesive and the components fitted to it. Once the epoxy has cured properly then the module can be re-tested. Ageing of a new crystal will be rapid in the first hours of operation. After this phase has passed the module can be accurately aligned. The oven temperature will require setting to the knee temperature of the crystal in use to achieve the optimum stability. The frequency shift due to the ageing process is a continuous one but will slow with time. Crystal specifications suggest 2ppm is a typical maximum shift in the first year. This sounds worse in Hertz, being 20Hz for a 10 Mhz crystal. The small amount of varicap tuning shift available means possible re-setting of the main tuning after a longer operating period may be required.

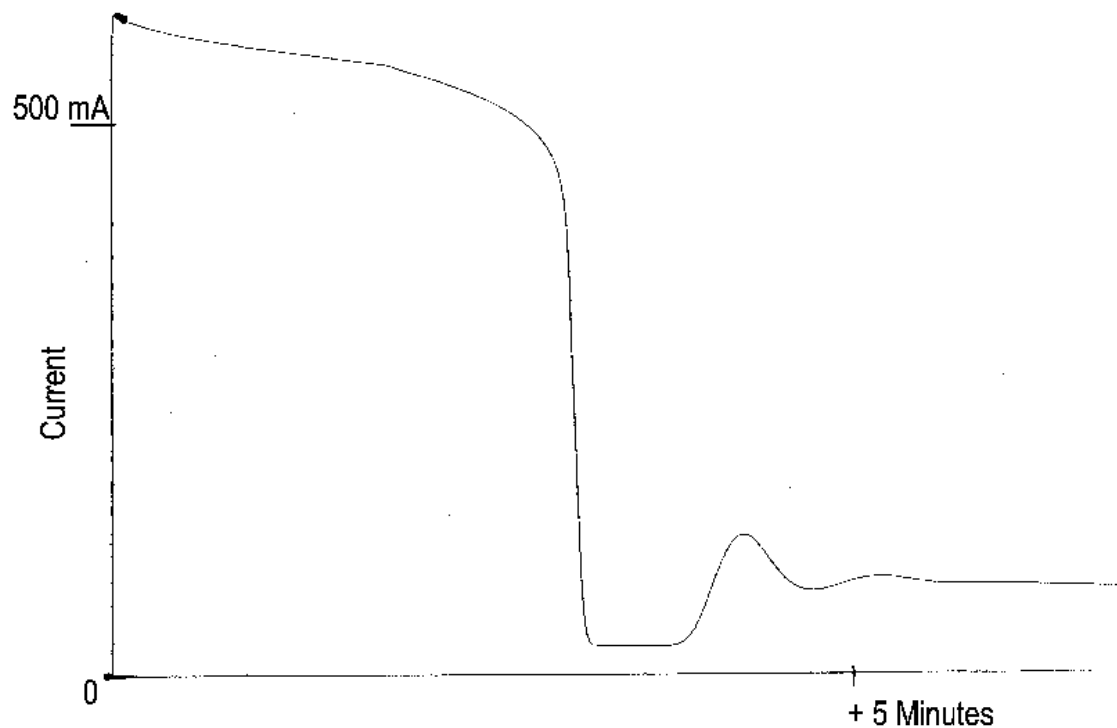
The varicap tuning voltage should be kept in the range $7\text{v} \pm 3.5\text{v}$.

An adequately sized box should be used for housing the module. The foil backed foam used in the building industry to insulate cavity walls is a rigid cellular foam and lends itself well to forming an insulated box into which the module will tightly fit. This is essential to prevent module movement and frequency instability. Lead out wires should come away at right angles from the PCB. High temperature thin insulated wires should be used. Thick wires will sink away the heat from the oven so should be avoided.

Operation during the warm up phase



This plot shows the initial frequency shift as the oscillator oven heats.



Warm up current rapidly reduces as the oven reaches the set temperature. The short period where the heater current is zero is due to the thermal resistance lag between the heating element and the thermistor detector. This illustrates the necessity for good thermal conductivity in the heater plate. The small rebound in the current and subsequent decay are controlled by the feedback around the oven circuit, R29.