Automatic Frequency Control and Suppression of Acoustic Feedback in Conjunction with 10 GHz Transceivers

by Dr. Manfred Wieser, OE 7 WMI

Two disadvantages have been found in practical operation of 10 GHz transceivers (1) and (2):

1. THE INFERIOR SHORT-TERM STABILITY OF THE FREE-RUNNING GUNN OSCILLATORS

The frequency drift can be so high that it runs out of the IF-bandwidth of the receiver, especially during bad weather conditions.

2. THE ACOUSTIC FEEDBACK BETWEEN MICROPHONE AND LOUDSPEAKER DURING DUPLEX OPERATION

Duplex operation is one of the major advantages of microwave communications, which means to do without this, or to only use hedsets would be a great disadvantage.

This article is to describe a module that provides both an automatic frequency control for the Gunn oscillator, and a circuit for suppressing acoustic feedback (basically an attenuator).

The circuit operates as follows:

According to (3), the dependence of the oscillator frequency of a Gunn oscillator on the supply voltage amounts to 0 to 20 MHz/V depending on the operating point and on the Q of the resonator. If the operating point is placed on the rising slope of the characteristic **(Fig. 1)**, one will receive a virtual linear frequency variation of ± 5 MHz on varying the operating voltage by ± 0.5 V when using a conventional construction of the Gunn oscillator (1) and (2). If this possibility is used for modulation, it is possible by inducing the AFC voltage from the receiver to form a frequency control loop with a considerably higher short-term stability.

In the duplex mode, it is not only the signal of the partner station that is converted down to IF-level, but also one's own signal. According to whether the signal is above or below the IF-frequency, the demodulated AF-signal will be of identical or opposite phase to one's own modulation. In both

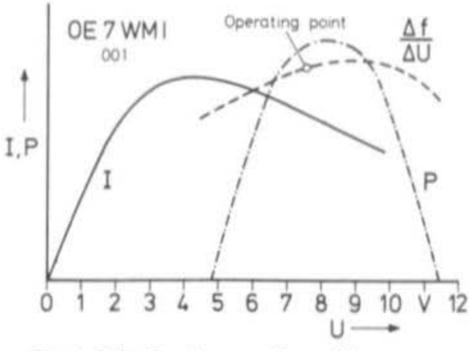

Fig. 1: Selecting the operating point of the Gunn oscillator

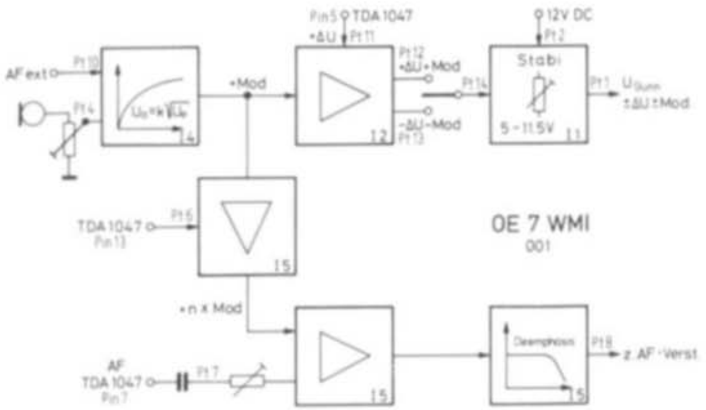

Fig. 2: Block diagram of the overall system

cases, the (variable) phase-shifts in the acoustic path will cause a feedback between loudspeaker and microphone in both cases (even at low-volume levels) and this will be audible as a pumping or whistling tone.

If, on the other hand, the demodulated AF-signal is mixed with the amplified, anti-phase modulation signal, these signals will theoretically cancel each other out, so that no acoustic feedback can occur. In practice, values of between 25 and 30 dB can be obtained using the described method, especially in the range between 1 and 4 kHz. When varying the conversion from one side to the other, it is necessary for the phase position of the added signal to be also reversed, in the same manner as the AFC-signal must be inverted. For this reason, it seems advisable for the modulation and AFC to be passed through the same signal path (inverting) which is shown in **Figure 2**.

CIRCUIT

The design of the circuit given in **Figure 3** is based on the possibilities offered by the integrated IF amplifier/demodulator TDA 1047. The FET T 4 forms the input stage of the modulator amplifier, and has the advantage that both high and low impedance microphones can be used. The amplified microphone signal is fed to the input of the integrated circuit I 4 that is used as compressor. It is possible at this position for signals from other sources to be added via connection Pt 10.

The compressor has – in contrast to the usual dynamic compressors and clippers used in amateur radio technology – a relationship of: $U_{out} = k \times \sqrt{U_{in}}$ between output and input voltage.

The constant k is determined by resistor R 18 in this circuit, and R 19 will determine the behaviour of the IC at low input voltages. The given values have been found to be most favorable in several experiments. The use of the compressor ensures that no overmodulation will occur even at high sound levels.

A well-proved circuit comprising an integrated circuit type NE 555 was used for calling-tone generator.

The operational amplifiers in the integrated circuit I 2 provide the combination of modulation and AFC, as well as their inversion. The AFC-voltage from pin 5 of the TDA 1047 is connected to connection Pt 11. The AFC-output of the TDA 1047 is a push-pull current output and can be connected to any voltage within the operating voltage range; in our case it is connected to + 5 V from the power supply of the Gunn diode.

Resistors R 7 and R 8 determine the AFC-deviation, and thus the hold range. The value of these two resistors depends on the slope of the characteristic, which was discussed previously. Values of between 10 kΩ and 100 kΩ have been found suitable for various elements.

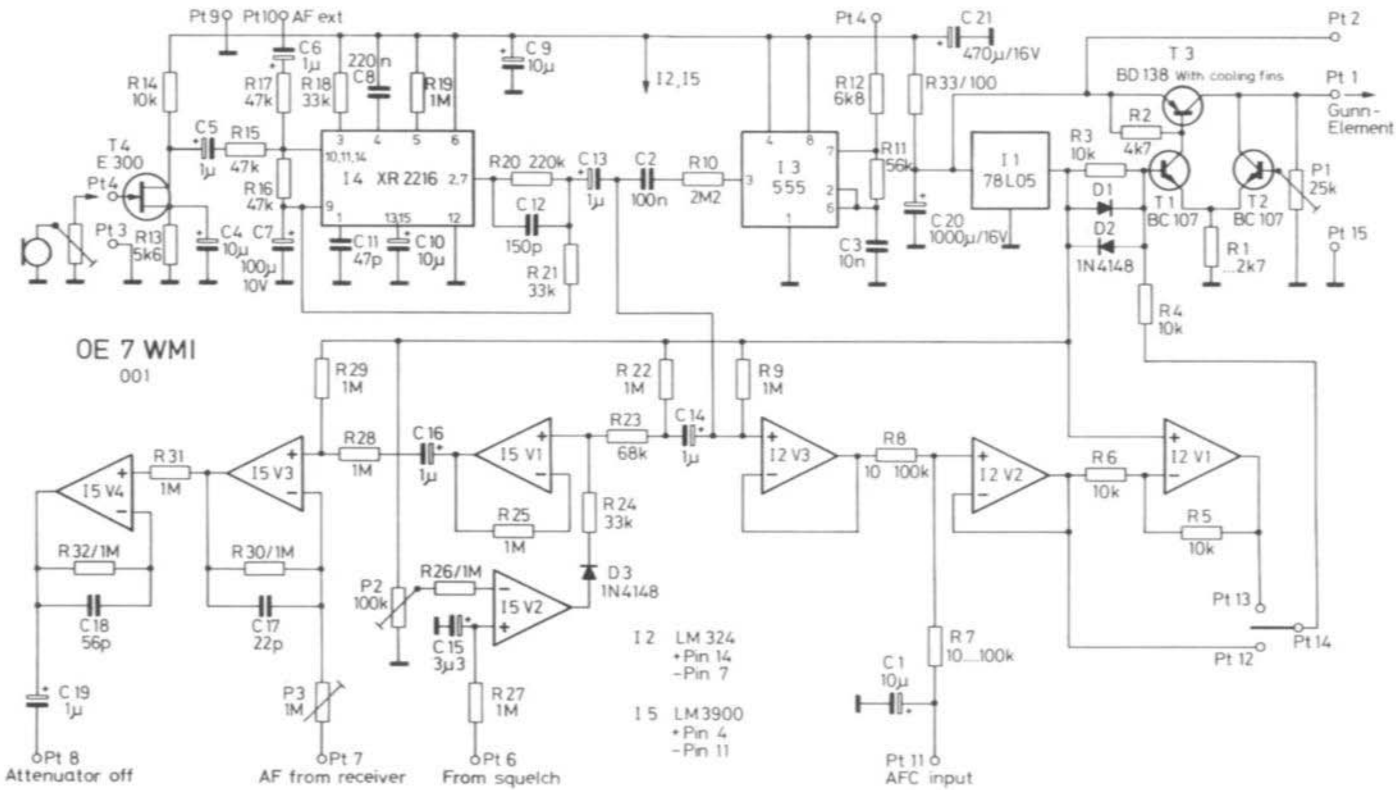

Fig. 3: AFC und suppression of the acoustic feedback in conjunction with Gunn transceivers

The voltage supply of the Gunn diode is a simple circuit equipped with a voltage stabilizer and three transistors. Its advantage is that the lowest possible voltage drop across the pass transistor only amounts to 0.5 V ! The stability of the voltage is less than would be possible with integrated stabilizers (78..), however, the advantage of the AFC is considerable.

A current limiting is provided by resistor R 1. The value is dependent on the current gain of transistors T 1 to T 3.

The four differential current amplifiers of the integrated circuit I 5 form the »attenuator«. The modulation signal is increased in amplifier 1 to approximately the value of the demodulated AF (pin 7 of TDA 1047).

Amplifier 3 forms the subtractor, and potentiometer P 3 can be used to adjust for equal amplitude. Amplifier 4 is used for decoupling and deemphasis.

When not in communication, and thus when one's own modulation signal is not present in the IF-amplifier, feedback would still take place. In order to ensure that this does not happen, amplifier 2 switches off the modulation signal when no signal is present (squelch circuit voltage, pin 13 of the TDA 1047).

A small, single-coated PC-board was designed for accommodation of the circuit given in **Figure 3**. The component locations of the PC-board are given in **Figure 4**. **Figure 5** shows the photograph of the author's prototype.

CONNECTION AND ALIGNMENT

Firstly connect the operating voltage to Pt 2 and Pt 15 (ground). The operating voltage should be adjusted to the correct operating point with the aid of P 1. Resistor R 1 should be adjusted to three to four times the value of the current at the operating point, so that the characteristic is swept quickly.

Check to see whether 5 V is present at Pt 12 and Pt 13, after which the Gunn element can be connected. Connect the microphone to Pt 4 and Pt 5 (galvanic connection is required !); the rest of the alignment is only possible together with a partner station.

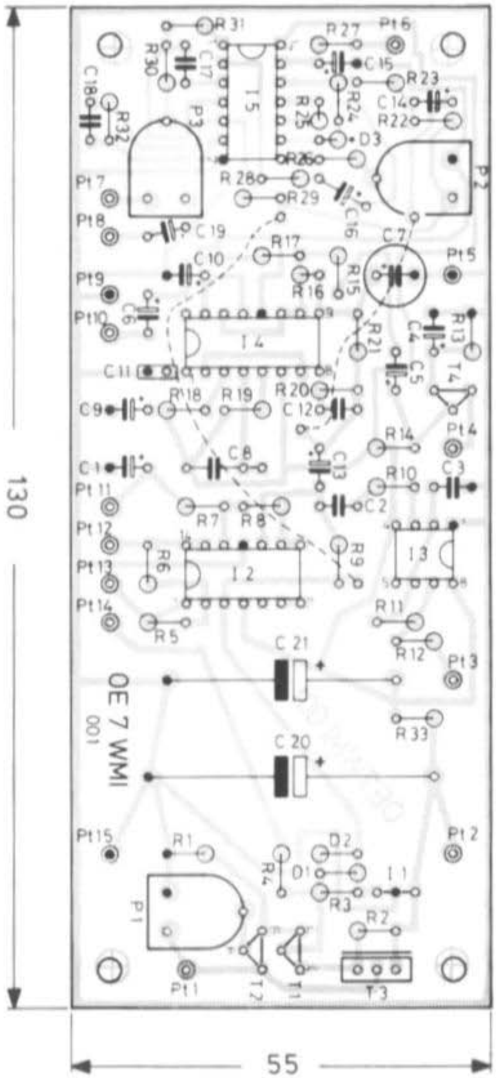

Fig. 4: PC-board OE 7 WMI 001

Connect Pt 3 to the operating voltage after which a calling tone of approximately 1 kHz should be audible. If the frequency deviation of the calling tone is too great, increase the value of R 10. Check to see whether the AFC locks in according to the position of the upper/lower conversion switch with R 7 and R 8 10 kΩ, otherwise increase the values up to a maximum of 100 kΩ. The hold range must always be 10

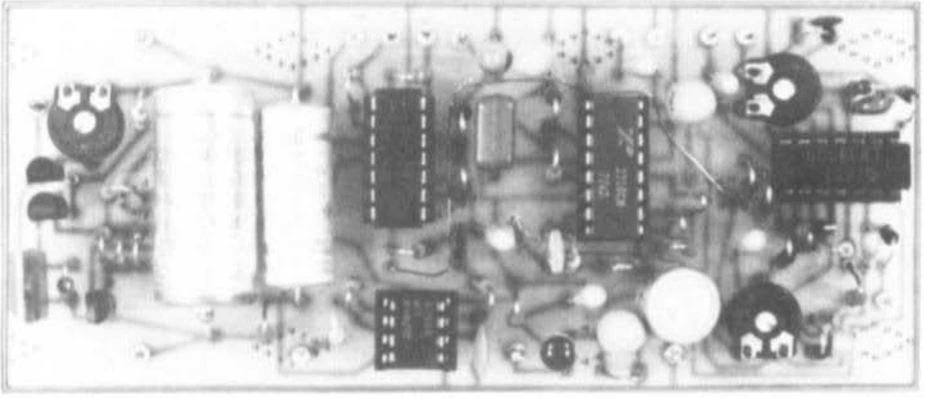

**Fig. 5: Photograph of the author's prototype.
The single-coated board requires two bridges**

to 20 times greater than without AFC! Place P 2 to maximum (5 V) and feed AF from the IF-amplifier to Pt 7, and from Pt 8 back to the loudspeaker amplifier. CAUTION: Both points carry DC-voltages!

When the AFC is locked in correctly, it is possible by varying potentiometer P 3 to hear a minimum of one's own volume. An exact alignment is possible by using an AF-generator set to 2.5 kHz (Pt 10 and Pt 9) and an AF-millivoltmeter or oscilloscope (Pt 8). It is possible to measure the suppression by comparing the measured values with P 2 open (0 V) and P 2 at 5 V; it should be more than 20 dB. Values of 30 dB were measured with several prototypes!

Finally, connection Pt 6 is connected to the squelch output (pin 13) of the TDA 1047, and the threshold for the attenuator is selected with P 2.

MEASURED VALUES

Current drain of the whole module (only operating voltage connected): 19 mA

AF-generator to Pt 9 and Pt 10:
AC-voltages (RMS):
Input voltage: 215 mV, 1 kHz, sinusoidal
Voltage at Pt 14: 12 mV
Voltage at Pt 1: 15 mV

From IF-module, pin 7:
Voltage at Pt 7: 230 mV

Without attenuator,
Voltage at Pt 8: 260 mV

With attenuator,
Voltage at Pt 8: 13 mV
(difference is 26 dB)

DC-voltages:

Pt 12, Pt 13 with open AFC-input:	5 V
Pt 1:	5 V up to $U_B - 0.5$ V
I 4, pin 9:	$U_B/2$
T 4, source:	approx. 2 V
T 4, drain:	approx. 8 V
I 5, V 3 output, V 4 output:	5 V

Calling tone: approx. 1 kHz square wave, 30 mV (peak-to-peak) at Pt 14.

REFERENCES

(1) Heubusch/Dr. Hock/Knauf:
Introduction to Microwave Techniques and a Description of a 10 GHz Transceiver
VHF COMMUNICATIONS 9, Edition 2/1977, pages 66 - 70

(2) J. Reithofer:
A Transceiver for the 10 GHz Band
VHF COMMUNICATIONS 11, Edition 4/1979, pages 208 - 215

(3) VHF/UHF Manual, Third Edition, Section 8: Microwaves
Radio Society of Great Britain