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A 28/432 MHz Transverter in Modular Format

For some time, the author has been engaged on intensive work with transverters for frequencies from 28 MHz up to far above 2.5 GHz. Designs and detailed assembly instructions for transverters for various applications, resulting from his activities, have appeared in various publications and have been presented at the VHF Congress in Weinheim. The following article adds a specific assembly proposal to this occasional series: a 28/432 MHz transmitting-receiving converter.

The transverter described below is intended to fulfill certain basic restrictions. The most important factor here is the two-board technique - i.e., the oscillator and the transmitting/ receiving converter are to be separate assemblies. Moreover, it should be possible for the transverter to control a standard power amplifier directly.

Using wide-band amplifier IC's and a ring mixer makes the circuit universally applicable. By simply dimensioning the filters and the crystal oscillator, the tuning range can be matched to the requirements.

1. CIRCUIT DESCRIPTION

A well-known circuit which includes a U310 and has many applications is used as the oscillator to synthesise the frequency. The crystal frequency is 101 MHz.

The 404 MHz required is already available at the output of the subsequent quadrupler. An etched 2-pole filter provides the filtration.

The downstream integrated MSA0404 (IC1) and MSA1104 (IC2) wide-band amplifiers supply the desired output of 50mW. These MMIC's (Monolithic Microwave Integrated Circuit) are available at various amplifications and outputs. Their input and output impedance over a wide tuning range is 50Ω.

The correct dimensioning of the amplifier stages is important here. Thus only the amplification which is actually necessary should be used. Any excess increases the spurious transmissions present to an extent which is out of proportion.

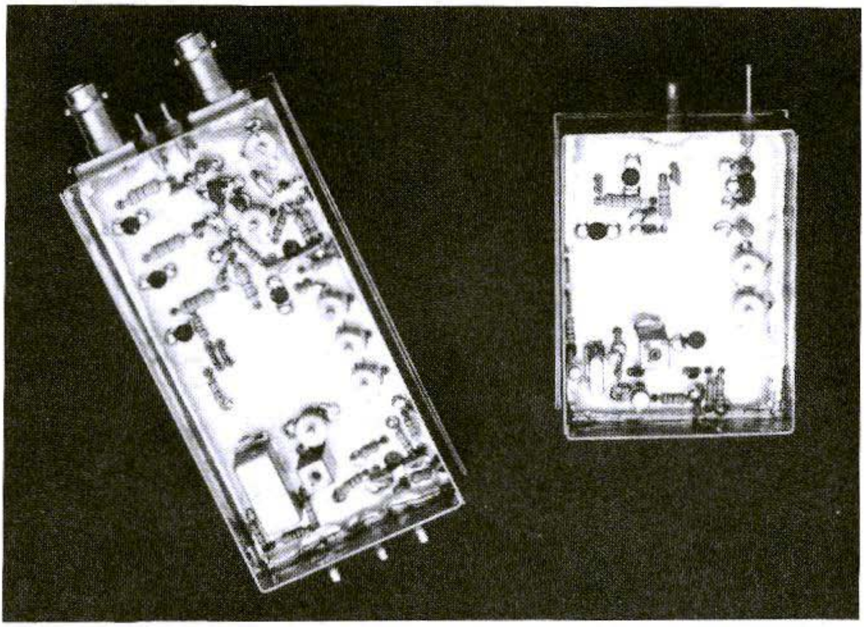

Fig.1: The two Assemblies of the 28/432 MHz Transverter

The SRA1H ring mixer used in the transmitting/receiving converter is suitable for use up to 500 MHz, and requires an oscillator level of 50mW.

The mixer is controlled through an attenuator, which should provide an intermediate-frequency level of no more than 1mW at the ring mixer. The attenuator must be dimensioned on the basis of the output available from the synthesiser.

Table 1 shows the resistance values required for the attenuator in relation to the synthesiser power level. All the values are based on the standard values from the E12 to E24 ranges.

The attenuator simultaneously serves as a wide-band 50Ω termination for the ring mixer (SRA1H). Parallel to this, the received signal is matched at high impedance to the CF300 (T3) using L4 and C3. This low-noise transistor stage provides the necessary intermediate-frequency amplification.

P_{IN}	dB	R_1	R_2	R_3
1mW	0	---	0	51
2mW	3	300	18	300
5mW	7	120	47	120
10mW	10	100	68	100
20mW	13	82	100	82
50mW	17	68	180	68
100mW	20	62	240	62

Table 1: All values are in Ω and are from the E12 or E24 range

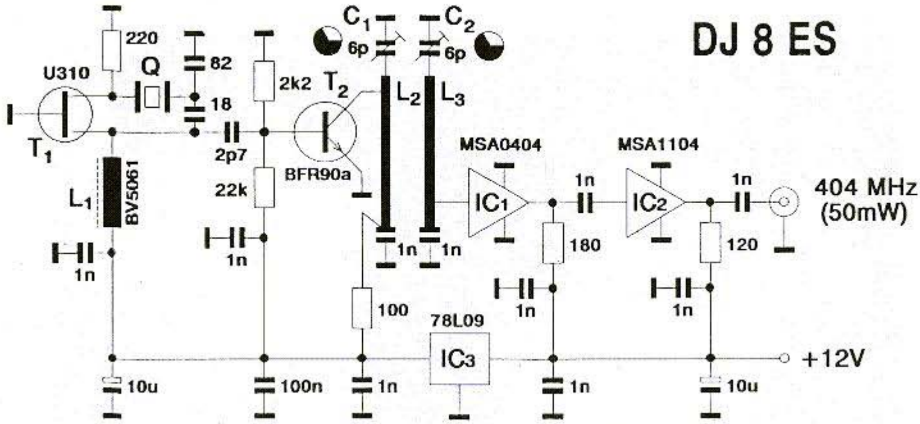

Fig.2: Crystal Oscillator with Quadrupler for 404 MHz

The 70cm received signal is passed to the gate of the CF300 (T4) through a Pi filter (aerial impedance 50Ω). The pre-amplifier is directly followed by an MSA0304 amplifier module (IC5). When the receive +12V power supply is fed in, the PIN diode D1 (BA479) is biased on and the signal passed through.

The 3-pole filter for 70cm is an etched version and is used for both receive and transmit branches. The transmit signal initially passes through the filter and diode D2 is biased on. The subsequent amplifier is again constructed using integrated wide-band amplifiers (IC6, IC7, IC8). The combination of MSA0104, MSA0304 and MSA1104

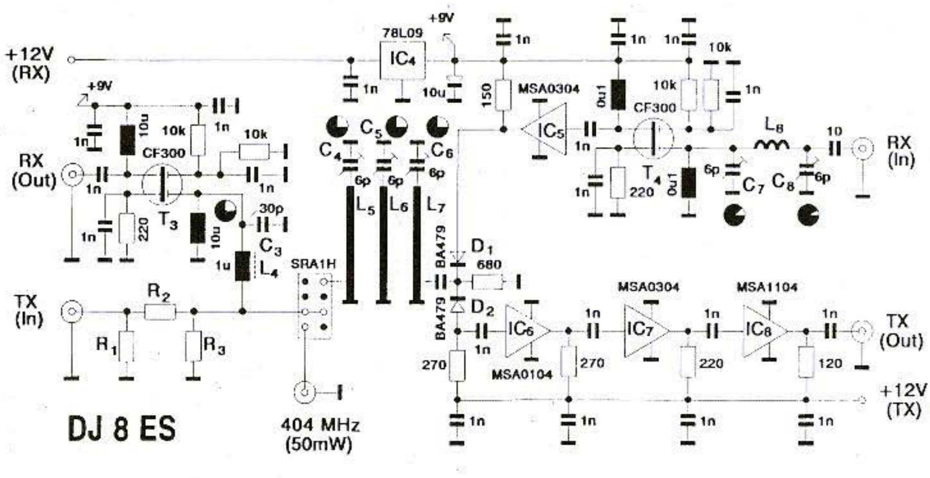

Fig.3: Circuit Diagram of the Transmit/Receive Converter

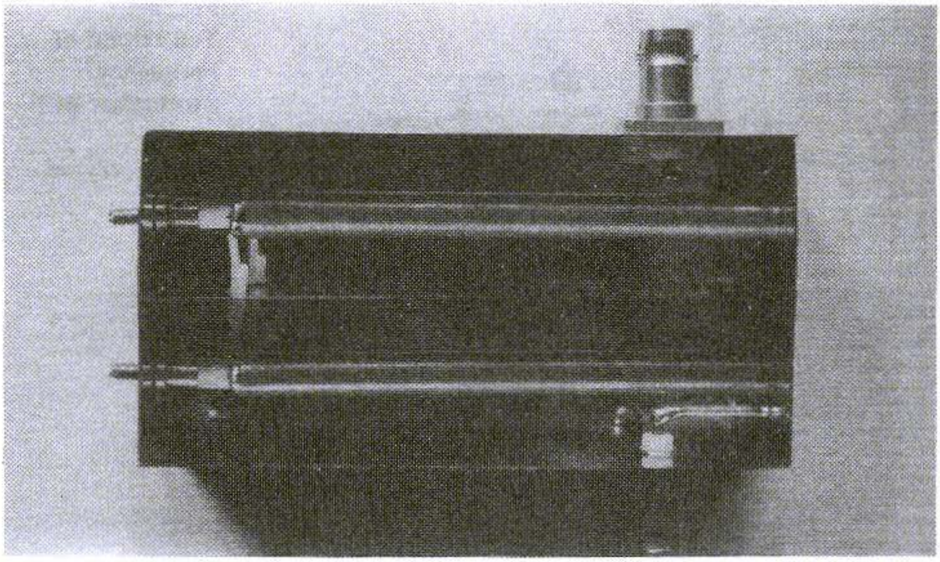

Fig.4: Spurious Transmission/Harmonic Filter for 432 MHz

provides an output of 50mW (+17dBm) with a good 40dB amplification.

In practical operation, such transverters are used with the same driving unit; here an additional filter for harmonics and spurious transmissions is recommended.

Fig.4 shows a possible 2-pole bandpass filter. It can be assembled in air-core construction using a standard tinplate housing measuring 55.5 x 111 x 30 mm. Suitable constructions can also be found in the relevant literature for radio amateurs.

2. ASSEMBLY INSTRUCTIONS

The 28/432 MHz transverter is divided into two independent assemblies: the oscillator frequency synthesiser and the transmitting-receiving converter. The dimensions of the boards (a double-sided coated epoxy board measuring 54mm x 72mm for the oscillator frequency synthesiser and a 54mm x 108mm printed circuit board for the transmission/reception section) allow for incorporation into a standard tinplate housing.

After being cut to size, the boards first undergo silvering and are then drilled. Suitable holes are drilled for the strip-line transistors and the wide-band amplifiers; these components are thus mounted in the boards' surfaces.

The holes for the crystal, the trimmers, the Neosid coils, etc. are drilled on the earth side of the boards (fully-coated side) using a 2.5mm drill.

Suitable slots are to be sawn out in the printed circuit board for the SMC or

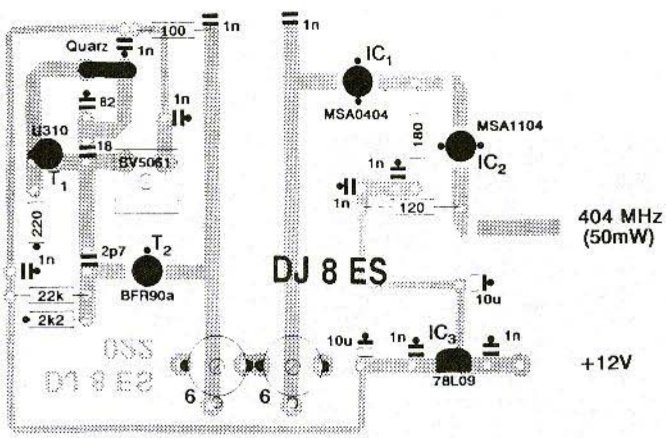

Fig.5a:
Top Layout of Frequency Synthesiser PCB

quarz = **crystal**

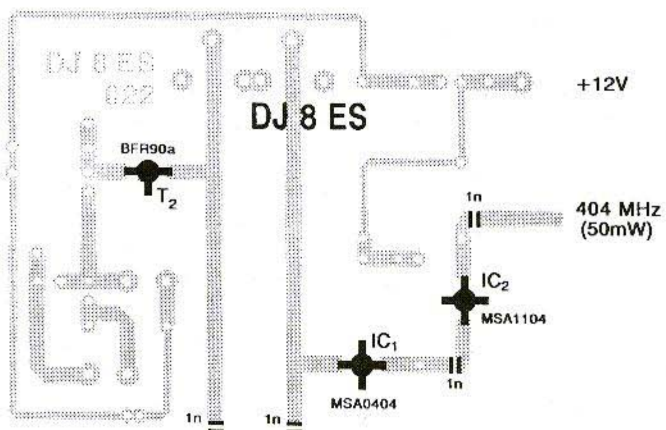

Fig.5b:
Bottom Layout of Frequency Synthesiser PCB

BNC bushes. The same applies to the pick-off capacitors with 1nF at the source connection of the amplifier transistors, T3 and T4.

Once these preliminary steps have been completed, the board can be sprayed with solderable lacquer.

The board is inserted in such a way that the connector pins are surface-mounted (cut off projecting Teflon collars with a knife first). When the "mechanically large" components (filter coils, trimmers, crystal and ring mixer) have been provisionally inserted in their positions, it must still be possible for the housing cover to be placed on top without any obstruction.

When the individual boards have been soldered to the sides of the housing, the actual assembly can be undertaken.

2.1. Oscillator Frequency Synthesiser Component List

IC1	MSA0404 (Avantek)
IC2	MSA1104 (Avantek)
IC3	78L09 voltage regulator
T1	U310 (Siliconix)
T2	BFR90a (Valvo)
L1	Neosid BV5061 0.1µH blue/brown coil
L2, L3	λ/4 stripline, etched
C1, C2	6pF foil trimmer (grey), 7.5mm grid (Valvo)
Q	101 MHz crystal, HC18U or HC25U
1 x	Carbon film: 180Ω, 0.5 W
1 x	Carbon film: 120Ω, 0.5 W
1 x	SMC or BNC flanged socket (UG-290 A/U)
1 x	Teflon bushing
1 x	Tinplate housing: 55.5mm x 74mm x 30mm
2 x	1nF trapezoid capacitor
2 x	10µF/20 V tantalum capacitor

Ceramic Capacitors (2.5mm grid)	Resistors (1/8W/10mm)
1 x 2.7pF	1 x 100Ω
1 x 18nF	1 x 220Ω
1 x 82pF	1 x 2.2kΩ
6 x 1nF	1 x 22kΩ
1 x 100nF	

and in SMD format (model 1206 or 0805) 2 x 1nF

2.2. Transmitting/Receiving Converter Component List

IC4	78L09 voltage regulator
IC6	MSA0104 (Avantek)
IC5, IC7	MSA0304 (Avantek)
IC8	MSA1104 (Avantek)
T3, T4	CF300 (Telefunken)
D1, D2	PIN diode BA479
L4	BV5048 Neosid coil, 1µH, yellow/grey
L5, L6, L7	λ/4 stripline, etched
L8	1.5 turns, 1mm CuAg wire
C3	30pF foil trimmer (red) 7.5mm grid (Valvo)
C4, C5, C6	6pF foil trimmer (grey) 7.5mm grid (Valvo)
C7, C8	6pF foil trimmer (grey) 7.5mm grid (Valvo)
R1, R2, R3	Attenuator, see Table 1
1 x	Carbon film: 120Ω, 0.5W
1 x	Carbon film: 150Ω, 0.5W
1 x	Carbon film: 220Ω, 0.5W
1 x	Carbon film: 270Ω, 5W
5 x	SMC sockets (some of which may be BNC flanged: UG-290 A/U) (see photo of specimen assembly)
2 x	Teflon bushing
1 x	Tinplate housing 55.5 x 111 x 30mm
4 x	1nF trapezoid capacitor
2 x	0.1µH choke, 10mm grid, axial
2 x	10µH choke, 10mm grid, axial
1 x	10µF/20 V tantalum

Ceramic Capacitors (2.5mm grid)	Resistors (1/8W/10mm)
1 x 10pF	2 x 220Ω
12 x 1nF	1 x 270Ω
	1 x 680Ω
	4 x 10kΩ

and in SMD format (model 1206 or 0805) 6 x 1nF

3. COMMISSIONING

When the equipment is used for the first time (and also calibrated), the following test equipment should be available: Multimeter, Frequency counter, Wattmeter and Received signal (e.g. beacon).

The assemblies are put into operation one after another.

Firstly, the oscillator is set to its operating frequency of 101 MHz with by adjusting self-inductive coil, L1. The onset of oscillation results in a slight increase in the collector current of T2 (monitoring voltage drop across 100Ω resistor). A frequency counter is loosely coupled and the oscillator frequency measured.

The 2-pole filter behind the quadrupler T2 (BFR90a) filters the useful frequency, 404 MHz. To this end, the two trimmers (C1, C2) are to be reciprocally set to the maximum level. The wiring diagram shows the approximate trimmer positions.

The oscillator frequency synthesiser assembly supplies an output of at least 50mW. The current consumption for an operating voltage of +12V is about 120mA.

The transmit branch of the transmitting/receiving converter is put into operation first. Only the 3-pole filter (C4, C5, C6) is to be calibrated here.

A current of approximately 130mA should be measured for an operating voltage of +12V. This is already an indication that the amplifier stages are operating satisfactorily. If the input attenuator is dimensioned as described in Table 1, an output greater than 50mW can be expected. Possible spurious transmissions (oscillator, image frequency, etc.) are suppressed better than 50dB here.

The receiver can be calibrated directly, using a strong received signal (e.g. a beacon). Because the same filter is used as in the transmit branch, the beacon signal should be audible immediately.

A further filter is mounted at the intermediate-frequency level (28 MHz) after the mixer. Here the trimmer, C3, should be adjusted to give the maximum signal. The directly connected parallel circuit naturally influences the transmit branch. However, with appropriate reserve capacity this influence is not brought to bear.

Optimising the signal-to-noise ratio (Pi filter with C7, C8 and L8 at the receiver input) completes the calibration.

The current consumption of the receive branch is very low (only 50mA). The noise factor is app. 2dB, with a conversion gain of the order of 30dB.

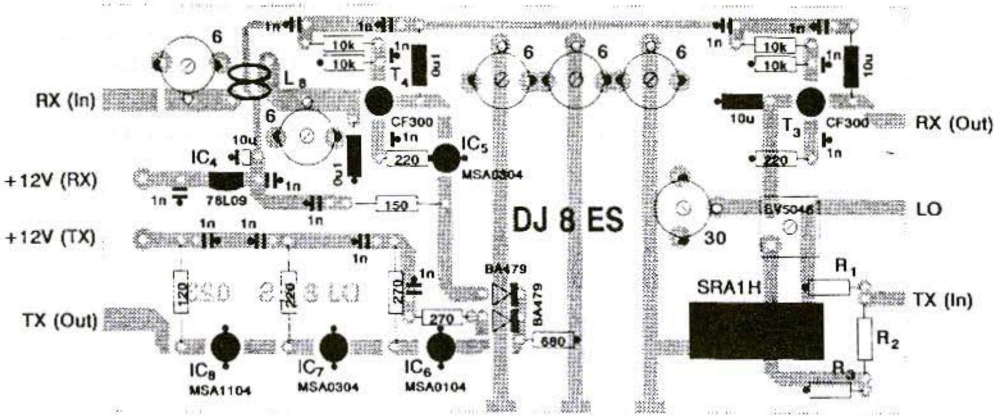

Fig.6a: Component Side of Transmit/Receive Unit

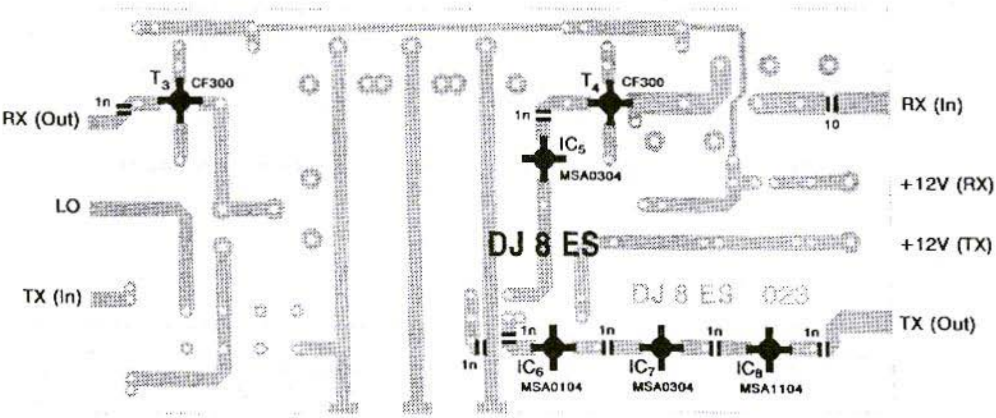

Fig.6b: Semiconductors and Coupling Capacitors on Copper Foil Side

4. CONCLUSION

The author uses the transverter described in association with an external pre-amplifier and a power amplifier. Modern hybrid modules are just the thing for amplifier stages. The output signal can be increased from 50mW to 10 - 20W in one go, using such components.

Fig.7, for example, shows the circuit for such a module (type M55716 from Mitsubishi). A 2C39 type valve high-level PA can be fully driven by means of this 10W output.

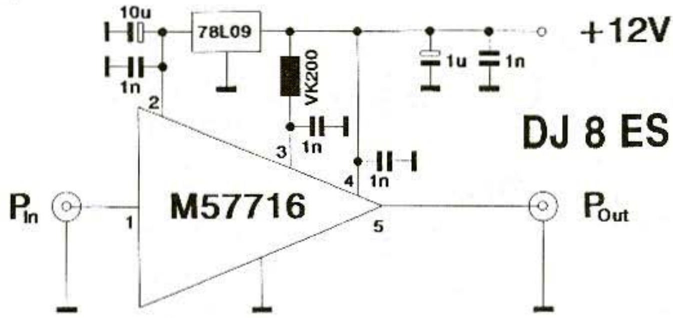

Fig.7: Circuit Diagram of the Hybrid Amplifier Module for 432 MHz

5. LITERATURE

(1) Wolfgang Schneider, DJ8ES: Transverters for the 70, 23 or 13 cm. Tuning Areas. 1992 Weinheim Congress Proceedings

(2) Wolfgang Schneider, DJ8ES: 28/432 MHz Transverter: Instructions, Tips and Improvements: 1993 Weinheim Congress Proceedings