A Low Cost Transceiver for 19,2 kb/s FSK Transmission in the 23 cm Band

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1. Why 23 cm ?

Why not ? Yes, it is well known that many packeteers become quite unsure when they see a circuit diagram full of obvious short circuits (some people call them strip lines) connected to parallel capacitors - what a nonsense ! And why to use even discrete transistor stages instead of the fine HCMOS inverters ? Speaking about microwave transmitters finally cause the complete panic, and everyone assures that he has nor a lathe neither a network analyser at hand.

But, don't panic! 23 cm isn't yet so exotic as you may think perhaps. A lot of good semiconductors and other components are available at low prices, and with a well-designed printed circuit board the assembly is nearly as easy as for a TNC. Yes, there are some special rules to care, but they are few and simple.

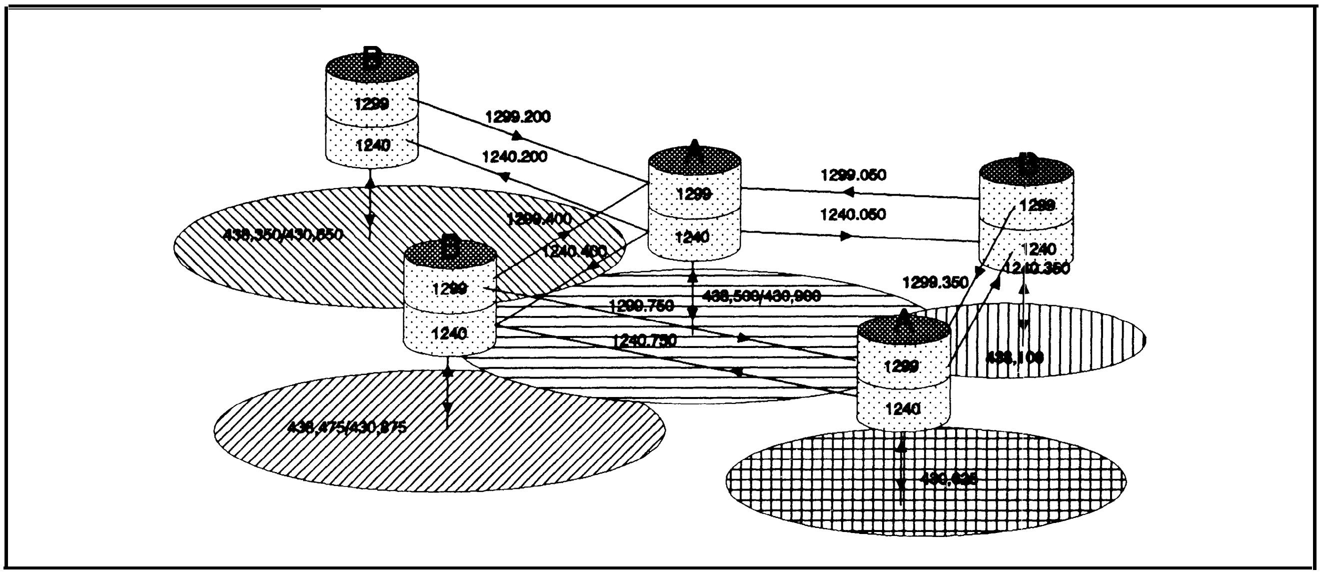

Fig. 1 European network structure: nodes operate with user access in the 70cm band (simplex or repeater like), and several duplex point-to-point links in 23cm

Honestly, this is not the whole truth. The real reason why the author has chosen just 23 cm for his unit is the Central European PR situation where the 23cm band is used for point-to-point-links between the network nodes [1] (see example Fig. 1). A large percentage of these links works with several of the authors former designs (hundreds of units in operation). The latest version of such a simple half-duplex packet radio is presented here, capable to boost your link to 19,2 kb/s with the well known K9NG/G3RUH FSK modem.

2. The concept

To keep the cost low there is only one single microwave frequency generator for both transmitter and receiver. The trick is to use the transmitter frequency as the local oscillator for the receiver, and hence a first IF identical with the Tx/Rx shift. This idea restricts the application to half-duplex radios with enough shift (more than 25 MHz); for the US the subbands 1248-1251 and 1297-1300 with 49 MHz shift are suggested.

The microwave frequency is not generated from an overtone crystal by cascaded multipliers, as usual in transverter circuits. Instead, a simple VCO produces directly the final frequency with very low spurii, without the need for expensive high Q filters and complicated tuning procedures. Its output feeds a frequency divider (a type used in TV sets) with a ratio of 128. The resulting 10 MHz are phase compared to a fundamental crystal oscillator, and the VCO is locked to it. The FM modulation is applied to a varicap in the crystal load circuit - the PLL is so fast that even the 15 kHz FSK modulation is precisely tracked.

The crystal is thermally stabilized by a PTC disk soldered on it - it's a self-regulating system heating up to abt. 110 deg. F when connected to the power supply. Thus the 23cm frequency is stable to 1..2 kHz - good enough for a **30** kHz wide IF filter.

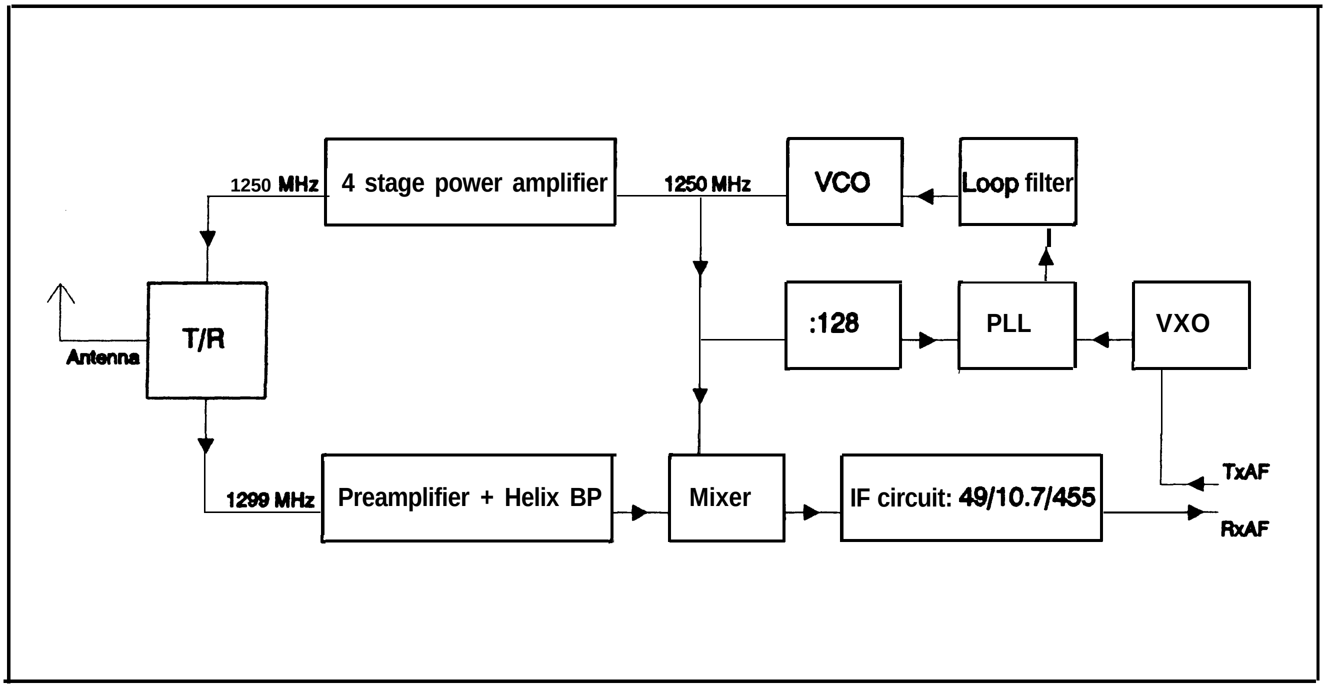

Fig. 2 Block diagram of the transceiver

The **49** MHz IF is downconverted in two steps to 10,7 MHz and 455 kHz, using a crystal and a ceramic filter for adequate channel selection. The 6-pole ceramic filter is a special group-delay-optimized type to achieve the best performance with FSK modulation. A state of the art MC3371 IF amplifier demodulates the signal and provides an additional wide range S meter.

The UHF part consists of a two-stage bipolar preamplifier for an overall noise figure of 3 dB which is a good value as the loss of the T/R switch and the mixer noise is already included. A helix filter feeds the signal to a GaAs dual gate mixer. The transmitter uses low cost Philips bipolar transistors and delivers 0.6 W minimum to the coax. A fast and reliable T/R switch operates with two pin diodes (also TV types).

3. Tuning is simple

What you really need is a 10 Mhz scope and a wattmeter for 23cm (no calibration required, indicator is enough) - careful construction of the unit assumed. The VCO frequency can be tuned by observation of the PLL voltage with the scope - you clearly see when the oscillator locks. The unit produces then a clean signal that can be used to maximize the transmitter gain. and output (Fig. 3).

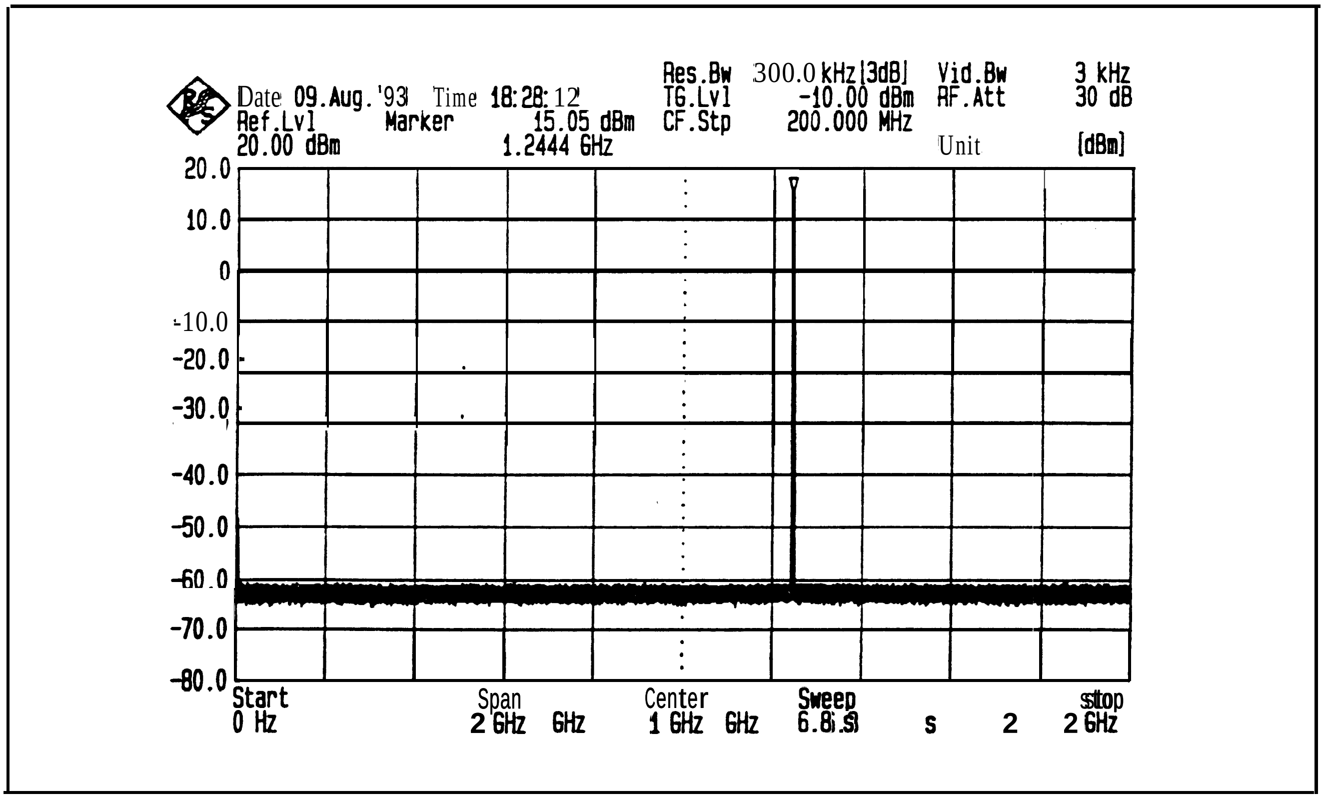

Fig. 3 **Transmitter output spectrum**

For the receiver tuning you need any test signal that is not too strong - e.g. a 70 cm handy transmitting on one third of the frequency. Then tune for maximum S-Meter voltage. The discriminator can be pretuned to maximum audio noise with no signal input, and optimized under operating conditions looking at the eye diagram [2,3].

4. The modem connection

Just 4 wires - transmit and receive AF, PTT, and ground. Use shielded cable for the AF lines to prevent interference from nearby power or digital circuits. The receive level is in the 1 V_{pp} range while the modulator accepts about 2 Vpp. The PTT is switched to ground, with a positive voltage applied, as usual.

The modem itsself has to be modified from the nominal 9k6 design, by doubling the clock frequency, and halfing several capacitor values. Refer to [2] for detailed instructions.

5. How look the signals like ?

Not far from what you know from 9k6 FSK. Both transmitter and receiver are fast enough for a modulation rate of 19.2 kb/s. The sound is as "noisy" as from the 9k6, but the signal cannot be demodulated with common handies or mobile transceivers because its bandwidth is too large for their 15 kHz wide IF filters. During transmission the receiver IF circuits of the unit are not keyed off to minimize the switch-over-time - so audio or noise is present permanently.

6. What about propagation on 23cm ?

Only line of sight ? No, if the distance is not too far some minor obstacles like gentle hills don't matter. But as we use low power we should provide enough antenna gain - look how pretty small even 23cm long yagis are. Or use a dish with 2...6 feet diameter, and an appropriate feed.

Short distances of 20...40 miles non-sight show propagation losses which are usually weather independent within some dBs. In contrast, links over 100 miles between high mountains with line of sight may fail periodically even with a budget of 30 dB above the system margin if inversion layers cross the path.

7. If you want to try such a 23cm link ?

At the time of the manuscript deadline the prototype was just in completion. Kits will be available in Germany at the end of 1993, and also in the US if there is enough interest. Feel free to contact the author for additional information.

8. Bibliography

[1] Rech, W.-H., DF9IC, Kneip, J., DG3RBU: The German (Central European) Packet Radio Network: an Overview. Proceedings 1 lth ARRL Computer Networking Conference 1992.

[2] Miller, J., G3RUH: 9600 baud packet radio modem design. Proceedings of 7th ARRL Computer Networking Conference 1987.

[3] Rech, W.-H., DF9IC: Augen-Diagnostik. ADACOM Magazin 4 (1992), 30-36.