High-Speed VHF/UHF Data Modem R&S®GM 3001S

for the Tactical Radio Family R&S®M3TR

For mobile radiocommunications, military users often employ terminal equipment of narrow bandwidth and with limited channel capacity. Such equipment has limited data transmission capability. The new software-based high-speed modem for the Tactical Radio Family R&S®M3TR allows the transmission of radio data at high rates.

◆ Up to 72 kbit/s
◆ Bandwidth efficiency up to 3 bit/s/Hz
◆ Autobaud capability
◆ Embedded solution for R&S®M3TR transceiver
◆ For complete VHF/UHF range 30 MHz to 512 MHz

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Extendible software for future requirements

Tactical radiocommunications concerns all mobile radiocommunications activities of an army in the forward combat area. Main users are combat troops, combat support troops and logistic supply troops.

The radio equipment used is primarily narrowband and has a limited channel capacity. This is normally no problem with the traditional application of speech transmission in CNR (combat net radio) networks, since modern techniques enable the transmission of digitized and encrypted speech signals even at narrow bandwidths and under unfavourable propagation conditions. However, if data is to be transmitted, the equipment available today is soon at its limits. Present data rates between 2.4 kbit/s and 16 kbit/s are a bottleneck for communications in the digital battlefield.

This, however, does not apply to the universal Software Radios R&S®M3TR: The system philosophy here is consistently oriented towards software solutions and high flexibility. The VHF/UHF modem, too, is a software implementation on one of the signal processors of the R&S®M3TR radio. This allows future extensions or adjustments for specific applications to be made in the form of an upgrade.

Modern radios need to be multitalented

Multirole radios such as the R&S®M3TR on the one hand function as communications equipment for mobile use, and on the other they assume network tasks such as acting as communications nodes RAP (radio access point) on LAS (local area subsystem) level or as a repeater in PR

(packet radio) networks. Since in military networks there is a trend towards using unified standards as in landline networks, for instance TCP/IP or ISDN, radios with flexible applications such as the R&S®M3TR are increasingly called for. Links at the LAS level must be mobile, i.e. using radio channels with constantly changing channel quality.

Data by radio – a must for modern armies

Today, data transmission takes up a substantial part of the radio traffic in tactical networks. Forces need interoperative command and control equipment for the transmission, processing, evaluation and visualization of tactical information. Mobile portable communications equipment plays a key role here.

The wish for seamless data communications covering everything from the backbone at the command level to the "slow/medium speed" data transmission by means of combat radio will stimulate further developments.

Radio data facilitates reconnaissance with sensor and video technology; it allows early warning of BC attacks and ensures unambiguous differentiation between friend and unknown. Data obtained from target reconnaissance and survey can be securely transmitted without delay, and acknowledgements are issued automatically by the command post.

The transmission of encoded messages allows command, reporting and coordination without acoustic signature and exposition. Since the messages are broadcast, all members of a group have the same level of information and there is no room for ambiguities.

Where conventional solutions are left behind

Because of their high immunity to interference, modulation techniques such as FSK or BPSK (binary PSK) are frequently used in tactical radios. However, their bandwidth efficiency is low. Higher-order PSK or QAM (quadrature amplitude modulation) offer considerably better values in this respect, but the reduction of Euclidean distance caused by the growing number of signal statuses leads to higher susceptibility to interference.

Tactical radio networks are also affected by fading, including the important CNR frequency bands 30 MHz to 88 MHz. Multipath fading in particular causes problems for the use of symbol-oriented modulation techniques.

Delay differences larger than the symbol duration Ts are caused by time dispersion and lead to intersymbol interference. To prevent such interference, techniques with sufficient symbol duration combined with high data throughput are required.

Secure radio data transmission needs the best in technology

Conventional solutions in many cases fall short of these stringent requirements (see box on previous page). In contrast, the R&S®M3TR with the new VHF/UHF data modem allows data applications for all branches of the armed forces (see last page). It is fundamentally different from traditional solutions: the use of OFDM (orthogonal frequency diversity modulation) offers significant advantages. With OFDM, the data stream is split up into parallel bit streams and distributed among several carriers in the baseband. In addition to the modulated carriers, pilot tones (sinusoidal tones) are integrated in the spectrum for channel estimation and synchronization.

To be able to transmit the baseband signal with up to 24 kHz bandwidth and with standardized frequency spacing (e.g. 25 kHz), a linear conversion to the channel frequency takes place by means of a modulation similar to SSB. Since the data rate is split up among numerous carriers, the symbol duration can be selected large enough to minimize fading effects and intersymbol interference. The symbol duration with R&S®M3TR is always greater than 1.5 ms.

To obtain a modem waveform that is resistant to interference, the various signal statuses of the QAM (q ≤64) used are trellis-coded. Trellis-coded modulation (TCM) is a combined encoding and modulation technique. The output of the trellis codec directly determines the signal point in the status diagram. This technique increases the Euclidean distance between the symbol sequences, which leads to an improvement (coding gain) of almost 6 dB in comparison with an equivalent QAM without trellis coding.

The VHF/UHF data modem implemented in the R&S®M3TR radio can be operated using various data rates and bandwidths. It can be used in the frequency range from 30 MHz to 512 MHz.

Data rate (user) in kbit/s	IF/RF bandwidth in kHz
72	36
72	24
64	36
64	24
56	24
48	24
36	36
32	24
24	24
16	12
12	12

Depending on the data rate and the selected bandwidth, there may be different signal-code constructs. Their main differences are the following:

◆ Type and distribution of individual carrier modulation
◆ Symbol duration

These parameters ensure optimal matching to the data rate and the required bandwidth. Besides trellis coding, block encoding is implemented in the modem: the useful data is protected by a cyclical block code.

Due to its long symbol duration of >1.5 ms, the OFDM technique is basically immune to fading. However, the data modem contains appropriate measures against fading. To compensate for distortions within the transmission bandwidth, the modem contains an equalizer. The equalizer is adaptive and is primarily set by the pilot tones representing the current channel transmission function.

Tested for toughness

The technique used by the VHF/UHF data modem integrated in the R&S®M3TR was examined in the baseband with the aid of a channel simulator. For this test, a VHF channel with additive white noise was simulated. The simulation results fully met the expectations regarding bit error rate and control quality under the conditions of strong level variation. Thus the R&S®M3TR family provides for mobile and secure radio data for all branches of the forces.

Radio data via software modem makes it possible: flexible DF networks with data rates of 72 kbit/s for DF or control data using R&S®M3TR radios
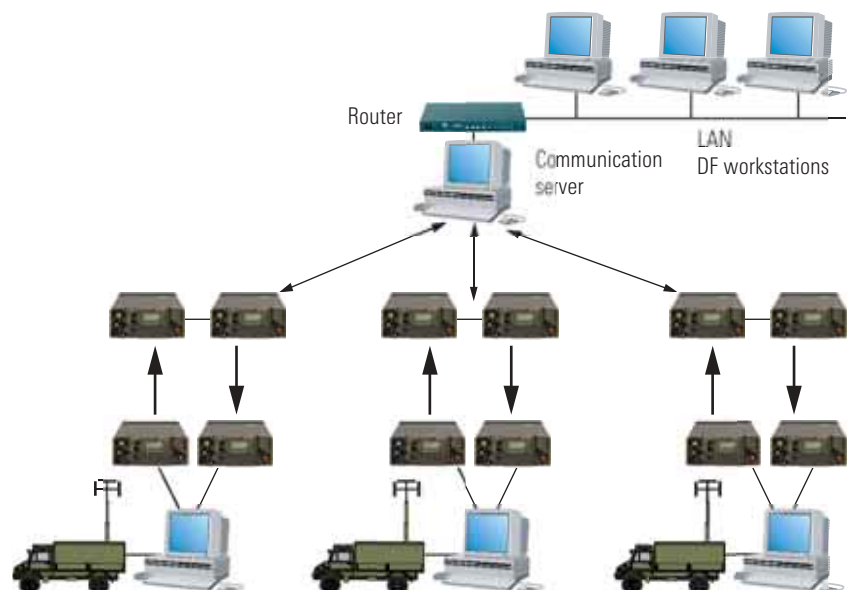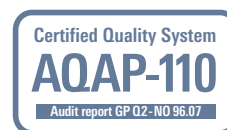
Mobile radio data using R&S®M3TR

◆ The R&S®M3TR tactical messaging system allows applications such as e-mail, transparent Internet access, tactical Internet and wireless Intranet access. Standardized international protocols such as TCP/IP or UDP ensure interoperability with the various platforms – irrespective of manufacturer or operating system

◆ Packet switching protocols enable automatic routing in PR networks for links that are not time-critical

◆ The R&S®M3TR radios can be used for remote-control tasks and the transmission of useful data in monitoring systems. Due to the R&S®M3TR's multiband characteristics, the administration channel can be freely selected, which allows flexible DF operation (see illustration on page 3)

◆ With the R&S®M3TR, radio links can be integrated into command systems enabling automatic data exchange, for instance for online situation charts and distribution

Ordering information

Designation	Type	Order No.
High-Speed VHF/UHF Data Modem	R&S®GM 3001S	6095.5355.02

Certified Quality System
ISO 9001
DQS REG. NO 1954 QM

Certified Environmental System
ISO 14001
DQS REG. NO 1954 UM

Certified Quality System
AS 9100
DQS REG. NO 1954 AS

Certified Quality System
AQAP-110
Audit report GP Q2- NO 96.07

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