E-mail via shortwave into Internet: state of the art in HF communications

FIG 1 LAN/WAN-compatible shortwave communications system with HF Transceiver XK2000 and System Processor MERLIN Photo 42 878/1

The good old shortwave radio set has been perfected in several ways. Information data rates of a few uncertain tens of bits per second were increased to more than 3000 errorfree bit/s by sophisticated modem techniques and error correction. Intelligent algorithms were created to adapt transmission parameters to channel quality or initiate a change to a better channel. System-oriented considerations turned a unit for transmitting Morse into a LAN/WAN-compatible communications system permitting all kinds of data to be exchanged. FIG 1 shows a modern workstation based on Rohde & Schwarz's HF Transceiver XK2000.

Automated radiocommunications

At the end of the 70s, Rohde & Schwarz started to develop processors for automating radiocommunications [1]. These automatically select a frequency for link setup. One method is the use of a radio-link prediction program [2] in conjunction with passive channel analysis (free/busy), possibly supplemented by statistics on previous radio links. Another method is active channel analysis or sounding, ie sending test signals on the assigned pool frequencies. Automatic link setup is normally performed with a flexible address pattern. Automation guarantees a link setup whenever a useful frequency is found in the pool. If feedback is used for subsequent data transmission, the processor adapts radio parameters to transmission quality. Many of the numerous company-specific methods have been ousted by the American ALE standard [3]. The ALIS processor from Rohde & Schwarz is one of the few alternatives to this standard.

Modems

Serial modems with adaptive equalizers were used to solve problems of time-variant channel distortions. FIG 2

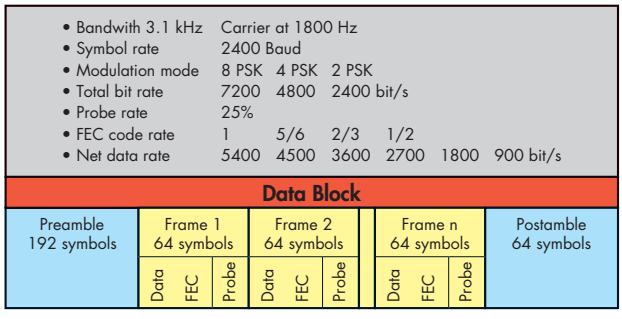

FIG 2 Most powerful waveform (5.4 kbit/s) of HF Modem GM2100

shows the most powerful of the four signal formats used by HF Modem GM2100 [4]. The preamble consisting of a fixed symbol sequence enables the receive station to synchronize with correct timing and phase. The postamble terminates the data block. Its structure is basically the same as that of the frames but it contains a stop code sequence instead of information data. Preambles, postambles and the inserted test data serve as reference signals, allowing channel distortions to be detected and compensated for by appropriate setting of the adaptive digital filters. Multipath signal components with delays of up to 7 ms are coherently combined so that rapidly varying channel conditions can be considered. The modem also includes narrowband notch filters that automatically tune to narrowband interferers. Up to three such interferers can be suppressed with these adaptive FIR (finite impulse response) filters. LSI memory ICs allow implementation of several signal formats, eg Rohde & Schwarz's 2.7 kbit/s waveform for interoperability with older systems, the 5.4 kbit/s waveform already referred to, the MIL-STD-188-110A single tone and a waveform to STANAG 4285/4481 for interoperability with systems of a different make.

The type of modulation and the FEC code rate of the modem can also be varied. This allows it to adapt to channels of different quality. Adaptation can be performed during link setup but also during actual transmission in response to changed channel quality. Coding and forward error correction are integrated in the modem. The Viterbi soft-decision method is used for decoding. Interleaving is also possible, and the code rate can be increased in steps from 1 to $^1/_2$.

Transmission protocols

Channel quality varies with time, so back-signalling methods are preferred for sky-wave transmission. One of these is the **packet radio protocol** (PRP) **RSX.25** with the following features:

- special adaptation to shortwave communication (minimum overhead, high throughput, quasi-duplex operation),
- adaptive matching of frame length and number, redundancy, type of modulation and transmission frequency to channel quality [5],
- residual error rate 10^{-32} (at bit error rate of 10^{-2}).

The RSX.25 protocol organizes the data to be transmitted in packets, which are successively transferred to the data modem. The packets contain a variable number of frames, the number per packet depending on radio-link quality and being adapted at regular intervals. The data transmitted in a packet are distributed among the frames. The length of the frame data is variable and also depends on radio-link quality. In channels of very good quality, a frame contains 250 data bytes, in strongly disturbed channels 4 bytes. The length of the transmitted data is continually adapted to link quality.

Services

FIG 3 shows the services supported by a modern communications system. These include conventional analog voice transmission, Morse and teletype but also hook-up to a private automatic branch exchange for telephone services and to the public switched telephone network. The RSX.25 protocol permits all types of digital data to be transmitted, eg for a printer, digital camera, camcorder or fax unit. Data transmission is supported by a system processor [6] that is able to access a LAN/WAN (eg the Internet).

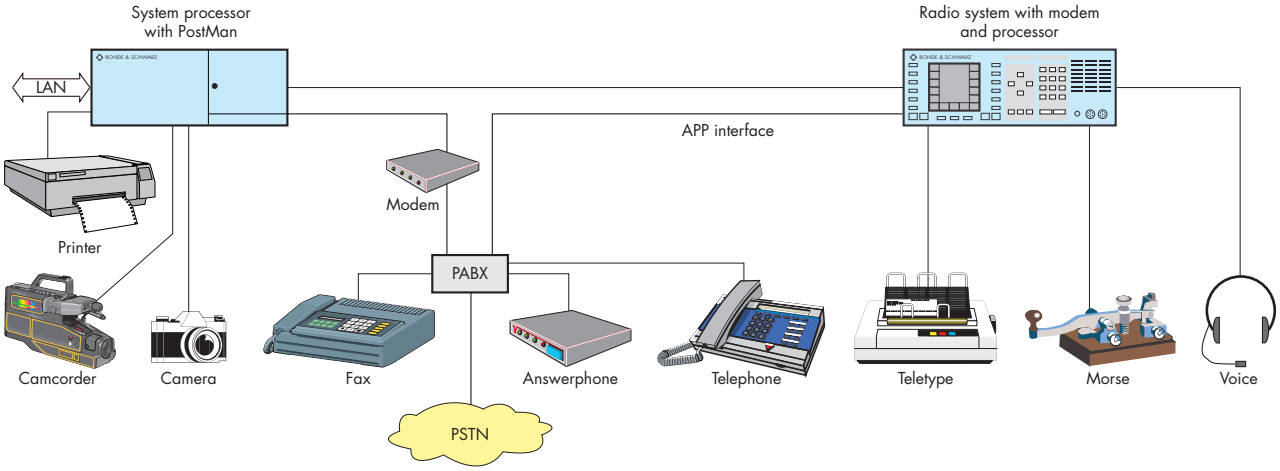

FIG 3 Services in modern communications system

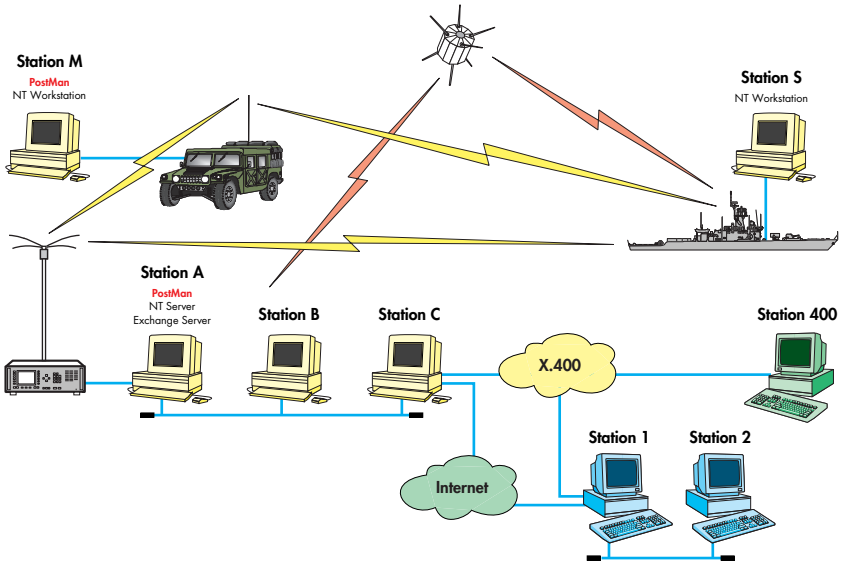

FIG 4 Global communications network

Networking

Computer networks like the Internet or X.400 can be accessed with the aid of software in the system processor, based on TCP/IP (transmission control protocol/Internet protocol) and part of the **Message Handling Software PostMan** [7]. This opens up the following possibilities:

- In contrast to earlier, file-oriented message handling and mail systems, PostMan is the first software for online access to central servers or the Internet via radio link and thus for the use of TCP/IP-based services offered by international communications networks.
- The medium radio (HF/VHF/UHF) is added to the existing transmission media of modern workstations (LAN, SatCom, GSM, telephone line, etc).
- All familiar word and image processing programs for information generation (eg Winword, Designer, Excel) can be integrated.

TCP/IP is the most widely used network protocol and supported by the vast majority of computers and software. This international standard ensures interoperability of very different platforms irrespective of equipment or operating system (FIG 4). In addition to HF/VHF/UHF radio links, PostMan is able to handle the following transmission media as an extension to the LAN: X.400, LAN, X.25 network, ISDN network, GSM network (including short message service), PSTN (leased and dialling lines) and satellite communications network.

Outlook

The next developments are expected in transmission protocols and modem technology for higher transmission speed. Wider bandwidths will be used for modems to achieve higher data rates. Higher rates will also be obtained on time-variant shortwave links, for the same channel bandwidth, by intensifying the modulation/coding association. Furthermore, throughput rates will be increased by coding schemes that are better matched to channel characteristics. Finally, optimizing the adaptation of transmission parameters to time-variant channel quality offers substantial potential for improvements.

Dr Günter Greiner

REFERENCES

[1] Greiner, G.: Reliable shortwave with ALIS. News from Rohde & Schwarz (1986) No. 116, pp 47–50

[2] Waibel, H.; Maurer, P.: PropWiz – Windows program for shortwave link prediction. News from Rohde & Schwarz (1996) No. 152, pp 46–47

[3] Wicker, G.; Schippan, E.: International ALE (automatic link establishment) standard for HF Transceiver XK2000. News from Rohde & Schwarz (1997) No. 155, pp 19–21

[4] Wicker, G.; Greubel, G.: Fast adaptive data transmission on shortwave at up to 5400 bit/s with HF Modem GM2100. News from Rohde & Schwarz (1996) No. 152, pp 42–43

[5] Greiner, G.: Adaptation of frame length, frequency and bandwidth with automatic HF communications. IEE colloquium on frequency selection and management techniques for HF communications, ref. no. 1996/024 (1996)

[6] Maurer, P.; Völker, K.: Multimedia communication with MERLIN system processor. News from Rohde & Schwarz (1993) No. 142, pp 27–28

[7] Kneidel, T.: When the PostMan rings on Internet. News from Rohde & Schwarz (1997) No. 153, pp 28–29