MICROWAVE COMMUNICATIONS ACTIVITY IN EASTERN EUROPE

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ABSTRACT

The paper presents a survey on the microwave activity in Eastern Europe. It concentrates on the achievements in microwave communications, and in their related fields. First, a survey on the microwave communication equipment developed in these countries is presented. Then, the research activity in the field of circuits and their nonlinear simulation is presented. Finally, the trend of future activities is outlined.

GENERAL OVERVIEW

The main activities in microwave communications in the Eastern European countries are shown in Table 1. In the column called "Company" the factories, R & D institutes, and universities are listed (TU means Technical University, and I. means Institute). The area of activity is represented by the highest capacity communication equipment developed and manufactured there. In every country there is a regular conference which gives a good representation of the microwave activity.

Table 1
Main activities

Country	Company	Activity	Conference
Bulgaria	Telecom Electronics I. TU Sofia	Medium capacity digital links Satellite reception	Summer School on microwaves
Czecho-slovakia	Tesla-VUST Radioelect. I. TU Prague TU Bratislava	Low capacity radio links Satellite reception	MITEKO
East-Germany	Robotron TU Dresden TU Ilmenau	Medium capacity analog and digital radio relay	Scientific Colloquium Ilmenau
Hungary	TKI Orion FMV TU Budapest	High capacity analog and digital radio relay Satellite comm.	Microcoll
Poland	Elektrim PIT TU Warsaw TU Gdansk	Medium capacity digital links Satellite reception	MIKON
Romania	TU Bucharest	Low capacity radio links Satellite reception	–
Yugoslavia	Iskra TU Belgrade	Medium capacity digital links	YUTEL

MICROWAVE COMMUNICATION SYSTEMS

A general survey of the microwave communication systems developed and manufactured in the Eastern European countries is presented first. The systems have to meet the specifications based on the regional standards differing from the international ones. There are several deviations from the CCIR and CCITT recommendations in the standards of the Eastern European countries valid for the transmission of television, sound, music, telephone, and data channels. It is an important development goal to meet both international and regional requirements utilizing the same construction and design principle.

The representative radio relay systems are listed in Table 2. The Table includes both analog and digital systems. The frequency bands cover both CCIR and Eastern European standards. In the column of transmission capability TV means color television, S sound, and TP telephone channels. For the TV program channels 4 sound channels are provided because there is a need to transmit the sound in 4 different languages.

Table 2
Radio relay systems

Frequency band, GHz	Transmission capability
0.4 - 0.5	2 Mbit/s or 30 TP
1.3 - 1.7	0.7 Mbit/s or 10 TP
1.9 - 2.1	2-8 Mbit/s or 30-120 TP
3.2 - 4.2	TV + 4 S or 1920 TP
5.6 - 6.4	TV + 4 S or 1920 TP
7.1 - 7.7	TV + 1 S or 960 TP
7.7 - 8.5	TV + 1 S or 960 TP
7.9 - 8.4	8-34 Mbit/s or 120-480 TP
10.7 - 11.7	140 Mbit/s or 1920 TP
12.7 - 13.2	2 x 34 Mbit/s or 960 TP

High and medium capacity links

High and medium capacity microwave radio relay links have been developed to cover the need for long distance telecommunications (1). The frequency ranges are 2, 4, 6, 7, 8, 11, and 13 GHz. Both analog and digital modulation schemes are used (2). All recently developed equipment are of modular design: circuits are housed in horizontal plug-ins of a vertical inset which is functionally self-contained, and placed in a vertical slim-rack column. This vertical construction practice has the advantage of short installation and maintenance time, further a maximum freedom of layout in station planning.

For analog signal transmission, frequency modulation is applied. The transmission capacities extend from 600 to 1920 telephone channels. As an alternative, color television programs can also be transmitted together with 4 sound channels. For digital signal transmission, QPSK (quadrature phase shift keying), and 16 QAM (16-state quadrature amplitude modulation) or 64 QAM schemes are applied. The transmission capacities extend from 480 to 1920 telephone channels (3). Complete systems have been developed containing the antenna and the auxiliary equipment as well.

For the transmission of digital signals, modulators in the microwave and intermediate (IF) frequency ranges and demodulators in the IF range have been developed. Microwave QPSK modulators operate in the 8 and 13 GHz ranges, and IF digital modems operate in the 70 MHz range. For use in digital demodulators, novel type of carrier recovery (4) and clock recovery (5) circuits have been elaborated, tolerating lower frequency stability and smaller carrier-to-noise ratio for achieving a specific bit error rate (BER). Investigations on multipath countermeasures in high capacity digital radio were carried out. A new model for the two-frequency microwave channel has been elaborated leading to the frequency diversity as an effective multipath countermeasure (6).

Small and medium capacity links

Small and medium capacity links have been worked out to cover the need of short haul microwave connections. Their frequency bands are: 0.4, 1.5, 2, 7, 8, and 13 GHz. Both analog and digital modulation schemes are used. For analog signal transmission, frequency modulation is applied. The transmission capacities extend from 120 to 300 telephone channels. For digital signal transmission, ASK (amplitude shift keying), or FSK (frequency shift keying), and BPSK (binary phase shift keying) modulation schemes are applied. The transmission capacities extend from 10 to 120 telephone channels (7).

A special field of small capacity links is the point-to-multipoint subscriber radio system. Several types of this system have been developed in the 1.5 GHz frequency band (8). It applies a TDMA (time division multiple access) techniques. Rural radio systems have also been investigated and developed (9,10). Another special field is the emergency link. It needs the ability of interchanging the transmitter and receiver bands, and selecting any channel by appropriate switching. Thus, highly sophisticated circuits should be employed like broadband diplexers, mixers, synthesizers, and switches in a new arrangement (11).

A new and rather simple frequency-estimation-type acquisition aid, the spectrum discriminator has been developed for suppressed carrier tracking loops making possible the application of coherent transmission even in low rate systems where the carrier uncertainty is in the order of the symbol rate (12). Some research work has been done in QPSK direct phase regenerators. A refined characterization of terrestrial radio links containing direct phase regenerators has been worked out along with a very simple solution of the phase-amplitude converter (13).

Space communications

In the field of space communications, SCPC (single channel per carrier) modems have been worked out for earth stations of satellite systems (14). Adaptive modulation schemes (ADPCM) have also been adopted to increase the transmission capacity in a specific band (15). For the same reason, voice indicators are also applied to control the transmitter. Community and individual receivers have also been constructed in the frequency band of 12 GHz for the reception of direct broadcasting satellites (16,17,18,19). Satellite transmitters for 20 and 30 GHz with an output power of 200 mW have also been worked out (20).

CIRCUITS

Circuit simulation and CAD

Nonlinear active microwave circuits have been studied by frequency and time domain analysis utilizing the spectrum and harmonic balance methods (21). By this way oscillators, amplifiers, mixers, modulators, detectors, frequency multipliers and dividers have been investigated. A simulation program has been developed for the analysis and interactive design of large signal communication circuits such as power amplifiers, frequency multipliers, modulators, mixers, etc. (22). The simulation can be performed with multiple input sources supplying modulated or unmodulated carrier signals.

A spectral domain approach was developed for planar waveguides used in microwave integrated circuits (23,24). Different substrate materials including multi-layered isotropic and anisotropic dielectrics, semiconductors, and magnetized ferrites were considered. The dispersion effects, loss properties, power flow distribution for a variety of waveguiding structures were analyzed. Scattering parameters were determined for microwave networks containing lumped and distributed elements. The transmission lines were treated by modal analysis in the frequency domain, thus involving line losses, while the complete network is analyzed by the modal equations (25). The parameters of high power microstrip lines were determined (26).

Filters

The recently developed microstrip filters have a significantly reduced size because of the application of lumped elements in chip forms. The selectivity is enhanced by creating attenuation poles in the stop band close to the band edges (27). An improvement is achieved by half-wave stepped microwave filters (28). Millimeter wave waveguide band-pass filters utilizing an E-plane metal insert have been developed (29). All of the reactance elements of the filter are created by the strips of a single metallic plate. The advantage of this construction is the good reproducibility and low cost because the metal insert is realized by a printed circuit.

Single mode coupling between cylindrical TE_{011} resonators is an important problem of low loss filters. That has been solved by suitable dimensioning and positioning of the coupling aperture between the resonators (30). The effect of twist on the transfer properties of waveguide filters has been investigated (31). Beside the TE_{10} mode the TE_{01} mode is also generated which is not attenuated by the irises of the filter, resulting in a change in the transfer properties.

Low noise amplifiers

Special analysis and synthesis methods are being developed for the investigation of the role of the feedback circuit in the design procedure of low noise microwave transistor amplifiers (32). The suspended line has been chosen as the most suitable structure due to its low losses and its other features exhibited in millimeter wave transistor design (33,34). A study of the characteristics of cooled FETs was undertaken as well. That resulted in a family of low noise cooled and uncooled amplifiers between 1 and 30 GHz (35).

Mixers

Single sideband down- and up-converters have been developed in microstrip construction (36,37). They cover a wide frequency range which is a very advantageous feature in tunable systems. A series of image rejection mixers with specific configuration has been developed for operation in the Ku band (38). For the millimeter wave region, combined finline-stripline mixers have been constructed (39). Recently, a new type of directional coupler, based on microstrip slotline ring structure has been investigated for new types of mixers (40,41).

Oscillators

High frequency-stability has been achieved by a new arrangement and compensation procedure of dielectric resonator oscillators (42). Another solution for improving the frequency-stability is the digital compensation technique (43). A new method for frequency modulation of dielectric resonator oscillators has been introduced (44). Phase-locked loop synchronization of microwave solid-state oscillators has also been studied (45).

Injection locking with a multitone signal was studied as well (46). Dynamic properties of injection locked oscillators have been determined (47). The stability conditions and the dynamic modulation characteristics of an injection locked oscillators has been studied by applying double sideband voltage and current perturbations and considering the asymptotic stability (48,49).

One of the best synthesizer performances is offered by the sample-and-hold type phase detector. A new model of the sampling phase locked loop (SPLL) has been developed, The circuit parameters belonging to the shortest frequency switching time have been determined (50), the frequency domain and noise analysis of the SPLL have been given (51), and the modulation properties have been scrutinized (52).

Optical control of microwave circuits

The linearity of FET amplifiers is improved by optical illumination (53). Tuning of microwave oscillators is realized by optical illumination of the tuning device (54). Recently optical control of phase detectors and phase-locked oscillators has been investigated.

Antennas

Dual circularly polarized antennas serve for the reception of direct broadcasting satellites. The cross-polarization discrimination has been improved by a novel arrangement (16). A new class of printed antenna array structures have been developed offering several advantages like broader bandwidth, increased tapering possibilities, higher efficiency, and much higher attenuation of cross-polarization (55,56). The properties of microwave spiral antennas have been studied in detail (57).

Ferrite and YIG circuits

Microstrip and lumped element ferrite circulators, isolators, and phase shifters have been developed in a large variety (58). Studies on YIG granat materials have been conducted. A high temperature stability has been achieved for MIC circulators by applying two different ferrites as substrates (59). YIG filters provide highly linear tuning characteristics and an octave bandwidth.

FUTURE TRENDS

The trend in microwave communications is the utilization of higher carrier frequencies up to the millimeter waves. With this goal in mind several problems are being investigated. At enhanced frequencies the attenuation of the microstrip lines is high. Therefore the properties of new structures like fin-lines and suspended strip-lines are studied for application as elements in circuits. Several passive and active circuits like filters, couplers, amplifiers, oscillators, mixers, detectors, etc. are under development utilizing the new structures.

With increasing frequency the stability of the oscillators is reduced. The dielectric resonator offers a simple and appropriate solution to this problem. However, the frequency stability of the dielectric resonator oscillators does not meet the requirements in every case. There is a need for a higher frequency stability which can be achieved by a phase locked loop (PLL). For this purpose, a low level reference signal has to be generated e.g. by multiplying the quartz crystal oscillator frequency .

Power amplification is another crucial task at millimeter waves. Again the principle of phase locked loop is utilized. At these frequencies, the high power active devices are mostly negative conductance diodes or feed-back transistors that can be preferably used in oscillators rather than in amplifiers. In the oscillator mode of operation they provide higher output power; and with the application of the phase locking techniques a higher gain is also attained.

Optical-microwave interaction is another perspective field of future development. Some teams focus their activity on that phenomena. They are dealing with the optical control of microwave circuits like oscillators, amplifiers, mixers, switches, optical injection locking and phase locking, analog and digital optical modulation of microwave signals, etc.

The nonlinear circuit analysis and optimization techniques are of great importance at millimeter waves. A significant effort is devoted to these studies which concern monolithic microwave integrated circuits as well. In the area of communication systems the interest is concentrated on the digital microwave radio links for data transmission, rural radio networks with integrated services, mobile communications, and on code division multiple access (CDMA) techniques.

CONCLUSION

A survey of microwave communications activity in Eastern Europe has been given. The results in the field of systems, circuits, and components have been discussed. Then the trend of future activities has been outlined.

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