SOME ASPECTS OF MICROWAVE DEVELOPMENT IN A DEVELOPING COUNTRY

J.T. SENISE

Escola de Engenharia Mauá
09500 São Caetano do Sul, São Paulo, Brazil

Abstract

The development of modern telecommunications systems is a major factor of progress in countries experiencing a fast economic growth. General information is given on the recent development of microwave systems and of microwave activities in general in Brazil.

Introduction

Brazil is a large country, occupying 8,500,000 sq km or about half of South America (by comparison, excluding Alaska, the U.S. cover 7,800,000 sq km). Brazilian population is over 100 million and increases at the annual rate of 3 per cent.

Contrasts are present in all Brazilian statistics. Vast regions in the country have a very low population density. On regions covering over 64 per cent of the country, population density is about 3 per square kilometer, down to 1 over 42 per cent of the total area. At the same time Brazil has some of the largest cities in the American continent. The metropolitan area of the city of São Paulo concentrates 8 million people. In and around Rio de Janeiro live 6 million. Recife, Salvador (Bahia), Belo Horizonte, Curitiba, Porto Alegre are all cities with more than one million people.

Communications of all kind have always been difficult in the country. The Portuguese discoverers and colonizers met the obstacle of coastal ranges of mountains making difficult the acess to the interior. The country as a whole is mostly hilly and where the country is flat, other obstacles are present: thick tropical forest, very wide rivers, marshland and so on.

Natural obstacles and widely scattered population asked for the development of two of the 20th century means of communications: air travel and radio communications.

Amateur radio and commercial broadcasting had an early development in Brazil. The country has nowadays approximately 25,000 registered radio amateurs, 1,000 commercial broadcasting stations and 50 commercial TV stations.

The development of large-scale telecommunications in a country like Brazil requires huge investments. From early development until about 15 years ago, practically all telecommunications were handled by a large number (over 800) of small private companies and a couple of major ones, these mostly of foreign capital.

The first microwave system in commercial operation in Brazil was built in the late fifties. This was a low-capacity, 4 GHz system linking Rio de Janeiro, Belo Horizonte and São Paulo to the new capital, Brasilia. It operated for about ten years before complete substitution by modern equipment.

EMBRATEL's National System

In 1962 the Federal Government decided that all interstate and international communications would progressively be transferred to the control of a company to be formed under Government sponsorship.

Action was delayed by economical and political difficulties. Only in 1965 EMBRATEL (Empresa Brasileira de Telecomunicações) was formed and in 1967 it embarked in a crash program, which eventually resulted in progressively putting in operation, in a 4-year period (1969-1972), a total of 17,000 km of major microwave links, including about 12,000 km line-of-sight and 5,000 km troposcatter.

Table I gives the timetable for the scheduled operation of EMBRATEL's basic system, spreading over the Brazilian territory as shown by Figure 1.

This system is now in full commercial operation and it has already been expanded, both in channel capacity and in new routes.

Implementation of a network in such a vast and varying territory is a story all by itself. Meteorological data were practically inexistent, and no previous propagation studies were available.

Site location had to rely strictly on surveying and on accepted international practice.

It must be considered as a major engineering accomplishment that with a very few exceptions, all links are presently operating in accordance to CCIR Standards.

Major exceptions worth mentioning are four of the 35 hops in the 1858 km line-of-sight Belem-Brasília (BLM-BSA) route, where large daily variations in humidity cause serious fading. Improved space diversity is now being implemented, based on statistical data collected over one year of operation.

Also in the 1500 km, 6 hop troposcatter Belem-Manaus (BLM-MNS) link, parallel to the Amazon river, problems with intermodulation noise did occur and were already reported at the 1973 Seattle International Conference on Communications[1].

EMBRATEL's line-of-sight links operate according to CCIR, in the 6 GHz (5.9 to 6.4) and in the 4 GHz (3.6 to 4.2) bands. Hops average 50 km, reaching 80 km exceptionally. Space diversity is used where necessary. Antenna towers with heights varying from 30 to 135 meters and 10-ft standard or high-performance parabolic antennas are used. All links operate with Solid-state equipment, except for 1800-channel links, which utilize traveling-wave tubes, for transmitting powers of 7 to 10 watts.

EMBRATEL's troposcatter links operate in the 900 MHz and 2 GHz bands, with all solid-state equipment except for power tetrodes for the lower and power klystrons for the higher frequencies. Transmitting power is 1 kw. 18- or 27 meter billboard and 10 or 12 meter parabolic antennas are utilized.

The effects of the progressive implementation of the national microwave system on toll (interstate) calls were dramatic, as shown in Figure 2.

Until November 1969 no DDD service was available. Operator-assisted toll calls averaged about half a million per month. By December 1970, operator-assisted calls had reached the level of about 1.5 million per month. This figure did not change from then on. At the same time, DDD calls, beginning in 1970, reached the same 1.5 million figure by June 1971. By December 1973, an average of 4 million calls per month were completed by DDD users.

State Systems

EMBRATEL's national network reaches all State capitals and other important cities in the country. In each state a local company takes care of the state system and of its connections with EMBRATEL's system.

The São Paulo State microwave system of the TELESP (Telecomunicações de São Paulo) company can be taken as an example.

As late as January 1973, TELESP operated only 100 km of microwave links in the State. On January 1975, 1130 km were in operation. Table II gives typical System parameters. It should be mentioned that TELESP also has 120-channel 2GHz links and 960 or 1800-channel 11GHz links.

270 thousand long-distance calls originate daily from TELESP system (microwave or not). Urban telephone services also had a considerable growth. In the city of São Paulo, from one million calls in 1967, a total of 14.5 million was reached in 1972.

Other state systems also had a remarkable expansion. In the southern state of Parana, the local company, TELEPAR, has over 2500 km of line-of-sight microwave links in operation. Toll calls through TELEPAR's system increased from about 200 thousand per month in 1973 to 1.5 million in 1974.

This explosive growth of services available to the public could lead to the wrong conclusion that Brazilian telecommunication systems will very soon satisfy all demand. This is not so, first of all because only in 1967 significant action was taken to depart from 20 years or more of no substantial growth. Moreover, Brazilian economy, which has been growing 9 or 10 per cent a year since 1968, demands a parallel growth in communications. It is then very difficult to close the gap.

Expansion plans

System Expansion

EMBRATEL's basic system has been already expanded, both in channel capacity and in extension. A new, considerable expansion is expected in the near future. Table III compares EMBRATEL's system in operation in 1975 with the system planned for 1980.

A similar growth is expected in state systems. TELESP has already contracted or will contract in 1975 3580 km of new links for the state of São Paulo.

The present five-year expansion plan of Brazilian national telecommunication system calls for a total investment of about US$ 8 billion. Capacity of the national basic system should increase 200%. Telex service, 88%. International satellite service, 130%. Submarine cables capacity should expand six times. And the most expensive, most urgently needed growth, that of telephone terminals, should reach 190%. And yet, despite all this effort, by 1980 a density of less than 10 telephone terminals per 100 inhabitants will still keep Brazil in a low position in world statistics.

Local production of microwave equipment

Microwave equipment in operation in Brasil is practically all manufactured abroad. EMBRATEL's basic system utilizes equipment built by NEC, Philips, Standard Electric, GTE, CSF and other well known manufacturers. Some of these companies already had factories in Brazil, but there was no local production of microwave equipment, although these factories were already producing communications equipment in the HF, VHF and UHF bands. It is worth noticing that telephone exchanges and other conventional telephone equipment, manufactured by local branches of Ericsson, Plessey, GTE and other internationally known names already supply about 90 per cent of the market and production is expanding at the rate of 30 per cent per year.

Major difficulties for the expansion of microwave equipment manufacturing in Brazil are the shortage of specialized manpower and the absence of significant production of components for the microwave bands.

The Federal Government is taking steps to change this situation, through several incentives to industries and sponsored R&D projects in universities.

Plans are already in effect for the local production by Philips, AEG-Telefunken and NEC, of 7GHz, 900-channel systems, except for central supervisory units. By 1977, NEC, Philips and Italtel should also furnish 6GHz, 1800-channel equipment manufactured in Brazil. Cables, waveguides and antennas are already in production in the country.

Research projects

Regarding research projects, some of the major ones in the area of telecommunications are sponsored by TELEBRAS, the Federal Government holding company for telecommunications. TELEBRAS sponsors research on antennas and related components at the Catholic University, Rio de Janeiro; propagation studies, particularly regarding troposcatter propagation in the equatorial zone, at the Catholic University, Rio de Janeiro and at the Aeronautics Institute of Technology, São José dos Campos, S.P.; optical transmission and PCM transmission studies, at Campinas State University, Campinas, S.P.; and electronic switching and rural telephony development at São Paulo State University, São Paulo, S.P..

Brazil's National Research Council (CNPq), the National Development Bank (BNDE), the State of São Paulo Research Foundation (FAPESP), among other federal and state organizations, are also sponsoring projects or financing new developments in the telecommunications area in general and in microwave in particular.

Special mention should be made to the educational satellite program being developed by the Institute for Space Research (INPE). Experiments recently performed utilizing NASA's ATS-F satellite should lead to a final decision on the viability of the program and prepare it for the future utilization of a synchronous satellite over Brazil[2].

Microwave education

Microwave people are presently trained in Brazil in some of the major universities and colleges (both undergraduate and graduate levels) and in a few technical schools.

Apart from a few pioneering isolated courses given at different places, regular academic courses on microwave theory and applications were first offered by the Aeronautics Institute of Technology (ITA), S. José dos Campos, São Paulo, at a time (1952) when no microwave system was in operation in the country. The late Prof. Karl Spangenberg, of Stanford University, then a visiting professor at ITA, had a major role in this farsighted initiative.

Microwave industrial applications studies have recently made their debut in Brazilian universities. To our knowledge, two academic groups are engaged in research activities in this field, one at the Campina Grande campus of the Federal University of Paraiba (UFPb) and the other at the Escola de Engenharia Mauá (EEM), São Caetano , São Paulo. The UFPb group is engaged in a project for food processing and preservation, utilizing microwaves and conventional methods. This project should open new possibilities for the large scale utilization of local agricultural and dairy products by the low-income population of the northeastern region of Brazil. The EEM group is engaged in similar activities in food technology and is also developing microwave industrial measurement techniques, under the sponsorship of the State of São Paulo

Research Foundation.

Conclusion

This is a general and necessarily incomplete picture of microwave development in Brazil. What has been done in the last few years leads us to believe that, except for a major economic disaster, microwave activities will continue to increase at a fast pace, playing an important role in the development of modern communications all over the country and helping industries, research laboratories and universities in their efforts to bring modern technology and better living standards to the Brazilian people.

References

1 - N.G. Cordeiro et al., "Tropo-Scatter Link Between Belem-Manaus of EMBRATEL in Brazil" - International Conference on Communications, Seattle, Wash. June 1973. IEEE Publication ICC73 pp 52-31 to 52-36.

2 - Plans for a domestic synchronous satellite system have been recently (Feb. 75) confirmed.

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LINE-OF-SIGHT Systems	Link	Capacity		Dist. km	Stations Rep.	Stations Term.	Sched. Oper.
SOUTH	SPO-PAE	900	1+1	959	19	3	1st/69
	CTA-FNS	900	3+1	281	4	7	2nd/69
	TCU-EIT	900	3+1	13	-	2	1st/69
RJO-SPO	DIRECT	1800	3+1	416	3	8	1st/69
	W/DEMOD	1800	1+1	416			2nd/69
RJO-BSA	RJO-BSA	900	2+1	1407	21	12	2nd/69
	BSA-GNA	900	1+1	192			2nd/69
NORTHEAST	BHE-SDR	900	1+1	1146	22	4	2nd/69
	SDR-RCE	900	1+1	780	18	4	1st/70
	RCE-FLA	900	1+1	839	15	6	1st/70
FLA-SLZ	FLA-SLZ	900	1+1	992	20	5	2nd/71
SPO-URA	SPO-URA	900	1+1	469	7	3	1st/70
WEST	SPO-CPE	900	1+1	1005	17	13	2nd/70
RJO-VTA	RJO-VTA	900	1+1	461	9	4	2nd/70
BLM-BSA	BLM-ANS	900	1+1	1858	38	4	1st/71
SLZ-BLM	STM-ABN	900	1+1	145	4	-	2nd/71
SATELLITE	VOICE	900	1+1	55	-	2	1st/69
TERMINAL	TV	900	1+1	55			1st/69
				11489	194*	63*	
TROPOSCATTER SYSTEMS							
MNS-BLM	MNS-BLM	120	1+1	1471	7	3	1st/71
CGE-RBO	CGE-CBA	120	1+1	2607	9	5	2nd/71
	CBA-RBO	60	1+1				
MNS-PVO	MNS-PVO	60	1+1	777	4	2	2nd/71
SLZ-BLM	SLZ-ABN	120	1+1	250	2	1	2nd/71
				5105	20*	6*	

* Stations common to more than one system accounted for

TABLE I - EMBRATEL's Basic System Implementation

FIGURE 1 - Map of Brazil (on Vue-graph only)

Please follow EMBRATEL's links on a standard geographical map. Main cities abbreviated on Table I as follows:

SPO- São Paulo, PAE- Porto Alegre,
CTA- Curitiba, FNS- Florianópolis,
RJO- Rio de Janeiro, BSA- Brasília,
GNA- Goiânia, BHE- Belo Horizonte,
SDR- Salvador, RCE- Recife,
FLA- Fortaleza, SLZ- São Luiz,
URA- Uberlândia, CPE- Campo Grande,
VTA- Vitória, BLM- Belém, ANS- Anápolis,
MNS- Manaus, CBA- Cuiabá, RBO- Rio Branco,
PVO- Porto Velho

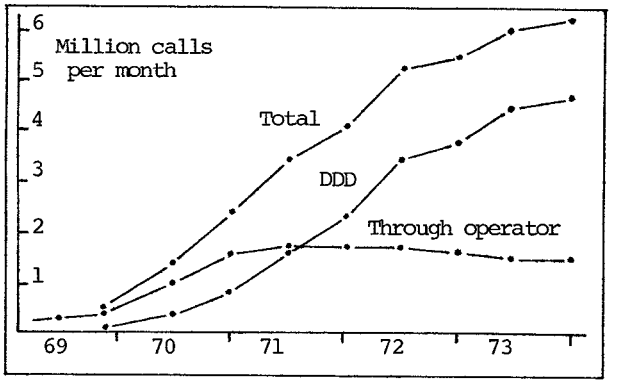

FIGURE 2 - Toll calls per month through EMBRATEL's National System.

Channel capacity	:	300/900
Frequency	:	7125 to 7425 MHz (300 ch.) 7425 to 7725 MHz (900 ch.)
Diversity	:	frequency
Noise figure	:	10 dB
Threshold level	:	-76 dBm
IF	:	70 MHz
IF bandwidth	:	20 MHz (.2 dB points)
Transmitter power	:	.5 w
Baseband width	:	60 to 1364 kHz (300 ch.) 60 to 4287 kHz (900 ch.)
Sub-b.b. width	:	.3 to 36 kHz
Frequency deviation	:	200 kHz rms per channel

TABLE II - TELESP's System Parameters

	1975 in operation	1980 planned
Total distance (km)		
Line-of-sight	11,908	18,688
Troposcatter	4,848	4,580
Channel capacity - Voice (million ch.km)		
Line-of-sight 900 ch.	17.4	24.6
Line-of sight 1800 ch.	4.9	44.3
Troposcatter	.53	.50
Total	22.8	69.4
Channel capacity - T.V. (thousand ch.km)		
Line-of-sight	20.8	47.0

TABLE III - EMBRATEL's National System Expansion