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# A Study of Telecommunications Equipment Standards

for  
National Telecommunications Branch,  
Department of Communications,  
Government of Canada

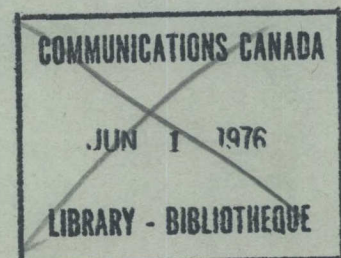
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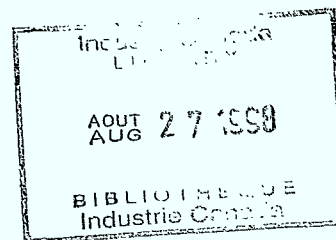
BNR Project TD6106  
May 1975

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Bell-Northern Research

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5103  
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1975  
c.1





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Prepared by  
Bell-Northern Research Systems Consulting

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This report reviews the differences between North American and International standards in specific areas of telecommunications equipment and examines the significance of these differences on the Canadian manufacturers' position in the export market

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## SECTION A

## EXECUTIVE SUMMARY

This report reviews the significant differences between North American telecommunication standards and the standards of other countries. It also examines the significance of these differences on the Canadian manufacturer's position in the export market.

The report concentrates on the major differences between North American and ITU standards in the areas of both analog and digital multiplex cable and radio systems; television and sound program transmission systems; and hardware standards. A more in-depth review of the major differences of all aspects of national and international standards would require a much more extensive study and is outside the scope of this report.

A general overview in the areas of switching and VF (voice frequency) transmission systems has also been included.

It is currently estimated that the present known world telephone installations are in the region of 357 million. The United States, Canada and Japan (which may be classified as conforming largely to North American standards) account for more than 50 percent of the known installations. The telephone administrations, making up the remaining 45 to 50 percent in general conform or at least subscribe to the standards recommended by the ITU.

There are exceptions to this latter statement, particularly in the area of switching systems, where standards can and, in fact, do vary from country to country, particularly in Europe.

Based on recent market surveys [1,2] the switching market would appear to present, from the standpoint of total dollar value, by far the largest potential to manufacturers.

In reviewing the technical differences between standards in the various sections of this report it can be seen that fairly expensive redevelopment effort is required to modify existing North American designs to conform with ITU standards, particularly in the areas of analog and digital multiplex and digital cable systems.

Most Canadian manufacturers questioned on the subject of standards differences have indicated that this has not been a major problem area in the past.

One possible reason for this apparent anomaly is that where major redesigning has been necessary, government financial assistance under such programs as PAIT has been requested and obtained. Also, where export jobs have been funded under programs such as CIDA and EDC, standards tend to be of secondary consideration.

Most manufacturers have indicated that, in the area of potential sales to Western European countries, the 'buy domestic policy' of most telephone administrations presents a formidable barrier to the sale of Canadian communications equipment. It is generally agreed that even if Canadian designs conformed to European standards, the sale of communications products would require considerable marketing effort.

In 1970 only approximately 10 percent of all telephone equipment procurement of individual Western European countries was purchased outside national boundaries, the majority of this 10 percent being purchased from other European countries [2].

In order to overcome the 'buy domestic policy', most manufacturers would agree that establishing a physical presence in a particular country is almost a prerequisite for major sales volume. If this is not considered practical, some form of agreement with an already locally established supplier to market or manufacture Canadian products under license could be a solution to the entry problem.

Third world countries with their present association with ITU will in all probability tend towards adopting ITU recommendations. However, due to the large investments involved in establishing an efficient telephone network, the country supplying the financing can have a considerable influence on the standards adopted.

It is only in recent years that Canada has had the research and development facilities to develop truly Canadian designs and, where communications products have been developed for and sold on the export market, the customer comments on equipment quality and performance have certainly been favorable.

Canadian manufacturers have the technology to design and manufacture equipment to meet ITU standards but naturally are reluctant to invest money in equipment modification programs without being reasonably certain of a market to justify the expenditures.

In this report, a section of Canadian manufacturers' comments on the significance of standards in their export business to date, and a discussion on trends in international standards has also been included.

The advent of systems having a capability to carry up to 50,000 voice channels, has brought abrupt change in the possibilities of implementing a worldwide telephone network.

In spite of the fact that, due to satellite systems, international telephone services have been established between an increasing number of countries and compatibility achieved in this respect, the sheer magnitude of telephone plant investment in the various countries indicates that standards differences will exist for some time to come.

European and other manufacturers, whose equipment presently conforms to ITU standards, planning to export to the North American market would of course be required to modify their equipment to meet North American standards. They do not, however, face the multiplicity of standards differences from country to country which faces Canadian manufacturers wishing to export to ITU countries and are, in fact, in the envious position of being able to design equipment that conforms to the standards of 50 percent of the world telephones. Whether or not they could be successful in obtaining a large portion of the North American market is another question.

#### A.1 REFERENCES

1. 'Project ESS', a study recently completed by Dittberner Associates Inc., Bethesda, Md., U.S.A.
2. 'Improving Telecommunications Exports to Western Europe', edited version of U.S. National Export Expansion Council Report, published in Business Communication Review, Nov.-Dec., 1974.

## SECTION B

### ANALOG SYSTEMS

#### B.1 ANALOG MULTIPLEX

This section compares the differences in standards between North American and CCITT\* analog multiplex equipment, and examines the effects of these differences on the position of Canadian Manufacturers in the export market.

Only major standards for 'toll quality' (4 kHz voice channels) multiplex equipment have been considered. These standards have been identified as a result of a search of established guidelines and procedures. Internal practices in countries may deviate from these established guidelines, and where deviations from the normal are known we have included them in this document. Due to time limitations however, not all countries could be surveyed with respect to internal practices.

##### B.1.1 Basic Description of Analog Multiplex Operations

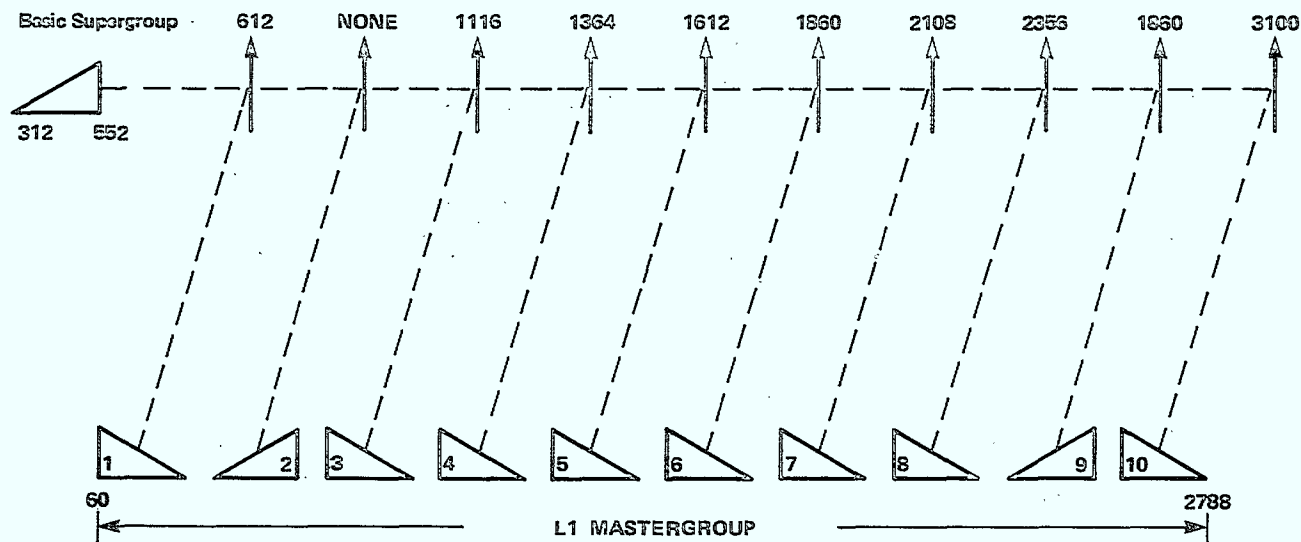
Multiplexing is used to combine a large number of voice conversations prior to transmission over a single broadband facility (radio, etc.). This is accomplished by shifting each voice conversation or channel from its present spectral position (0 - 4 kHz) to some other higher location in the frequency spectrum (for example, 5768 - 5772 kHz). Other voice channels are shifted to different locations in the frequency spectrum until an orderly stacked arrangement of channels similar to that shown in Figure B-1 is built up. This stacked arrangement is then transmitted via broadband transmission facility (radio, cable, etc.) to its intended destination. At the receiver end of the system each voice channel is shifted from its location in the stacked arrangement back to the original 0-4 kHz. The equipment which performs this frequency stacking and unstacking function is known as frequency division multiplex equipment.

The process of shifting each voice channel to its location in the stacked arrangement is accomplished by a series of modulations involving the voice channels and a number of carrier frequencies. The information is recovered at the receive end by de-modulating the stacked arrangement with these same carrier frequencies to recover the original transmitted information.

In order that no distortion be introduced into the information, the carrier frequencies at the transmit and receive ends must be exactly the same frequency. The required frequency accuracy is maintained by transmitting a pilot tone to all multiplex locations and synchronizing the carrier supplies at each location to this tone. This tone is known as the synchronization pilot.

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\* International Telegraph & Telephone Consultative Committee.



NOTE: All frequencies in kHz.

For comparison of the basic supergroup,  
see Figure B-2.

FIGURE B-1

North American Frequency Multiplex Plan  
(L1 Plan)



### B.1.2 Comparison of Standards

There presently exist two standards for 'toll' quality frequency division multiplex: North American Standards and the CCITT standards. The North American standards are used principally by Canada and the United States of America. CCITT standards are followed by most other countries.

#### a) Frequency Plans

The frequency plans advocated by the North American and CCITT standards are given in Figures B-1, B-2 and B-3 respectively.

In the North American standards two frequency plans exist. They are called the L1 plan and the L4 plan respectively. The L1 plan allows expansion up to a maximum of 600 voice channels. L1 systems are no longer manufactured, having been superseded by equipment conforming to the L4 plan. The L4 plan allows expansion up to a capacity of 3600 channels, and is the plan presently in most common usage. Future manufactured equipment must conform to this plan.

The CCITT standards specify two frequency plans: CCITT Plan I and CCITT Plan II respectively. These plans are illustrated in Figure B-3. Both these plans are in common usage throughout countries that conform to the CCITT standards.

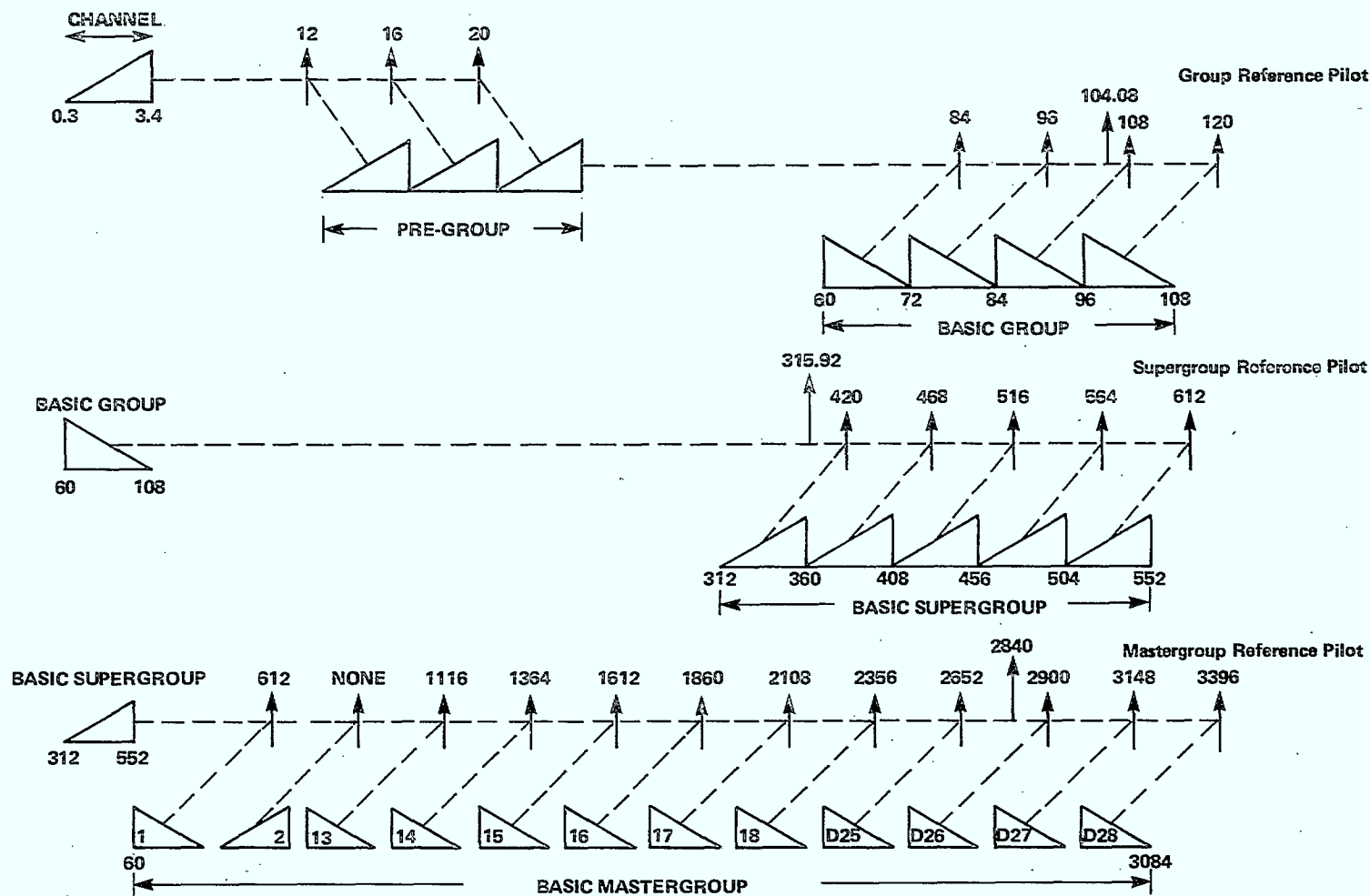
From examining the two frequency plans it can be seen that the L4 plan and CCITT Plans I and II are compatible in frequency allocations up to the basic supergroup level. Above the basic supergroup level the L4 plan basic mastergroup and the CCITT Plan II basic 15 supergroup block are compatible up to 2044 kHz. The L4 basic mastergroup and the CCITT Plan I basic mastergroup are compatible from 812 kHz up to 2044 kHz. Outside of these frequencies the CCITT and North American frequency plans cease to be compatible.

#### b) Interface Levels and Impedances

The standard interface levels and impedances established by the North American and CCITT standards are given in Figure B-4.

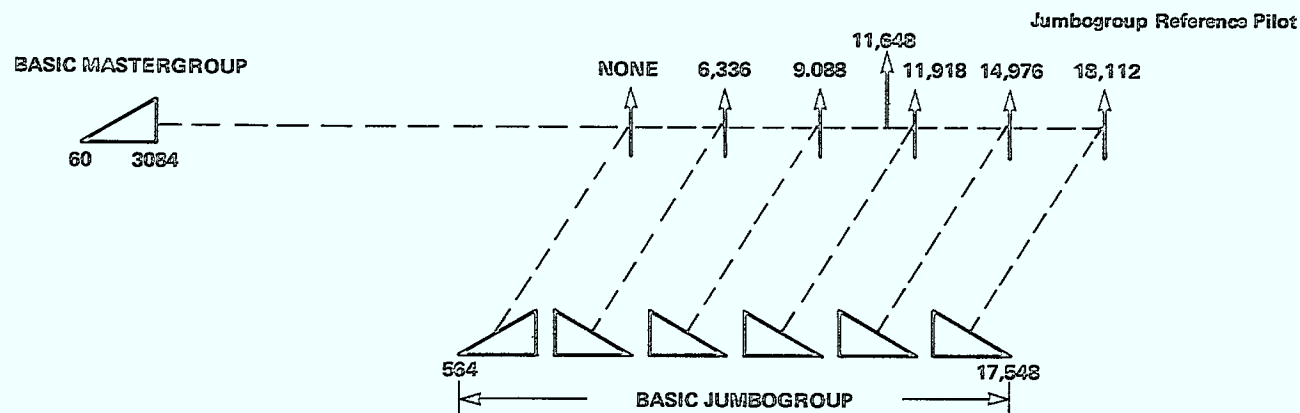
It should be noted that although CCITT has established interface levels for distribution at -36 dBr transmit and -23 dBr receive, very few telephone administrations presently conform to the recommended levels. Table B-1 provides a list of the interface levels that are actually used in various countries.

The North American and the CCITT interface levels are incompatible at all interface points. The interface impedances are incompatible at the group distribution point only.



NOTE: All frequencies in kHz.

FIGURE B-2  
North American Frequency Multiplex Plan  
(L4 Plan)



NOTE: All frequencies in kHz.

FIGURE B-2 Cont'd  
North American Frequency Multiplex Plan  
(L4 Plan)

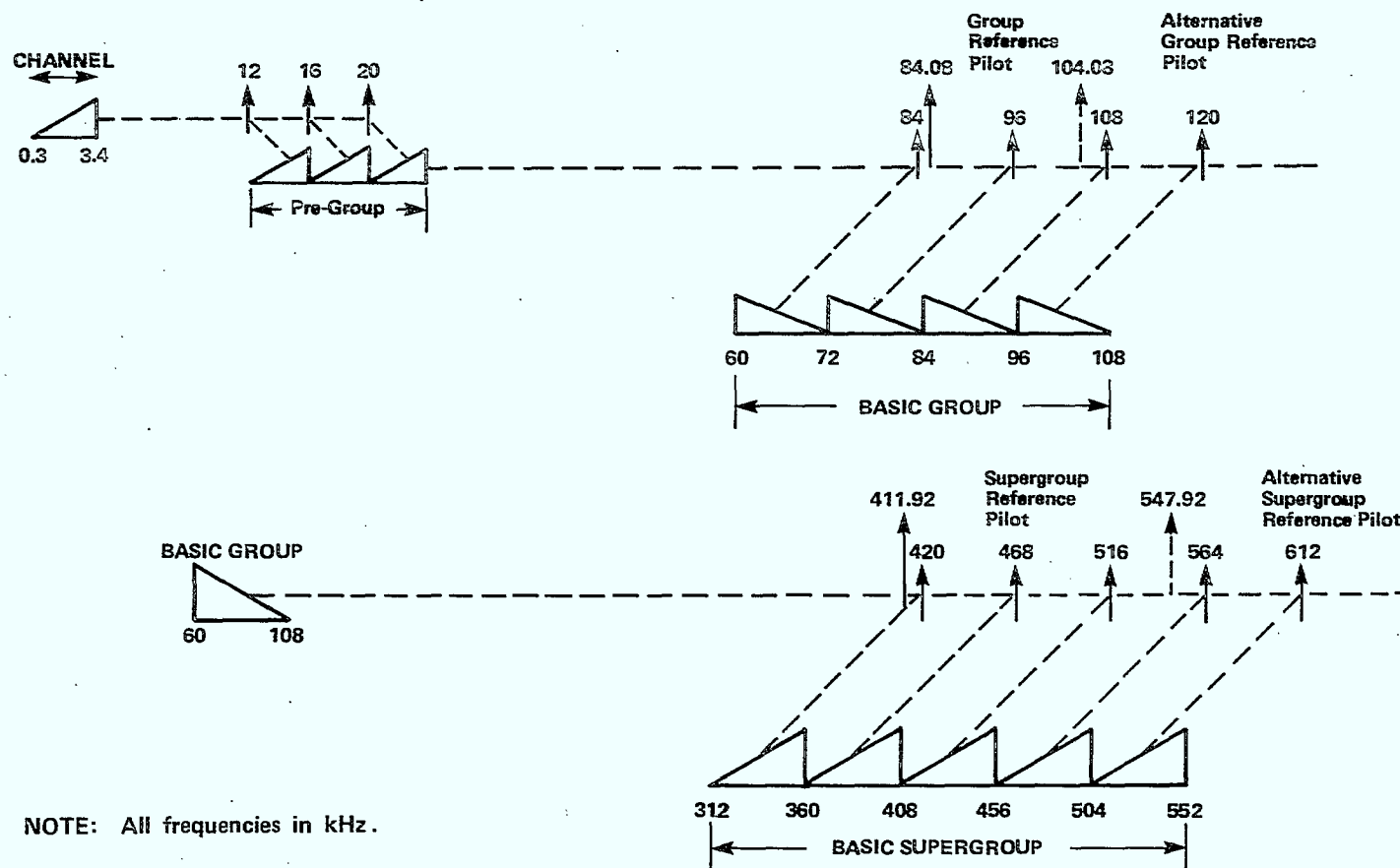


FIGURE B-3  
CCITT Frequency Multiplex Plan

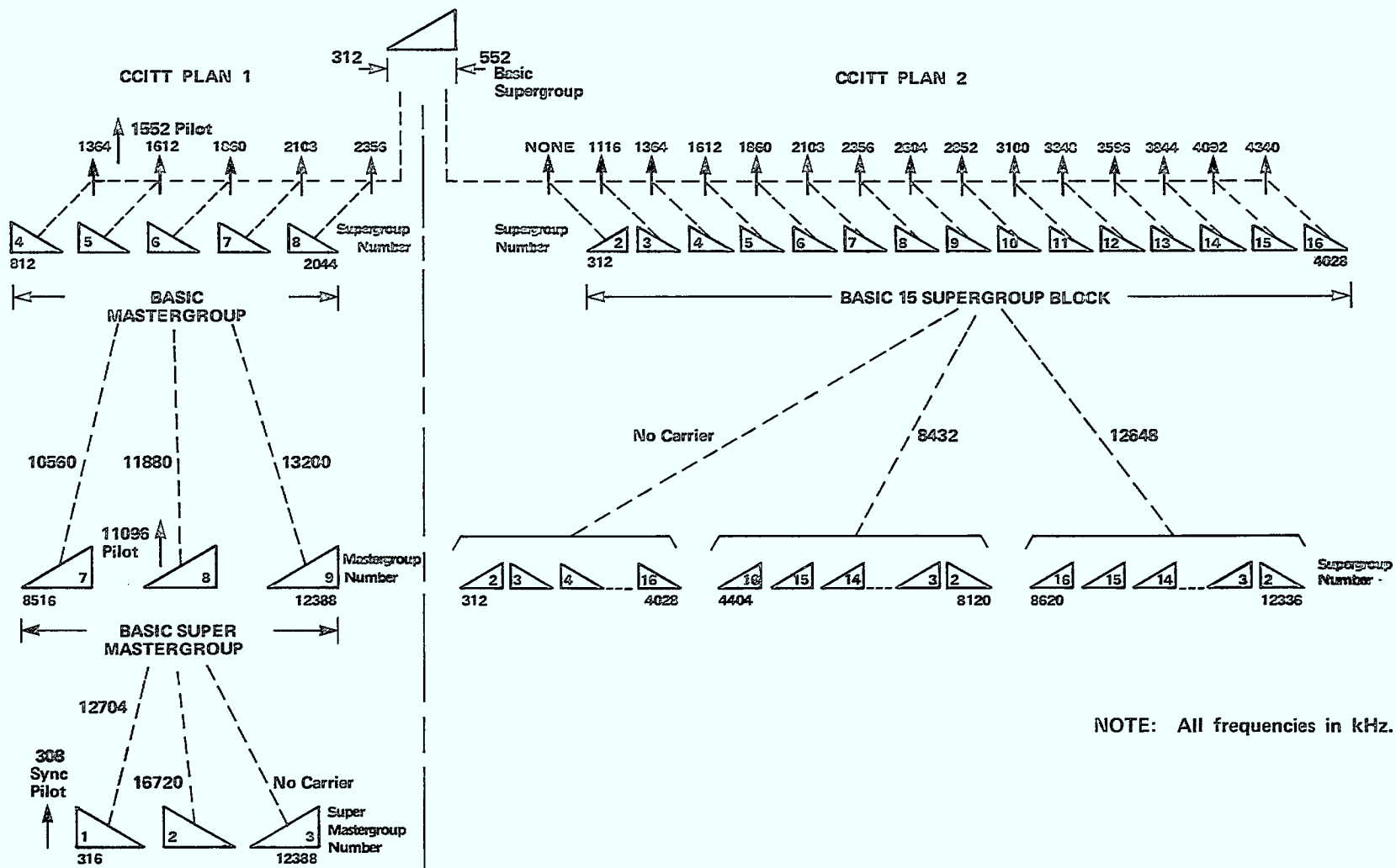
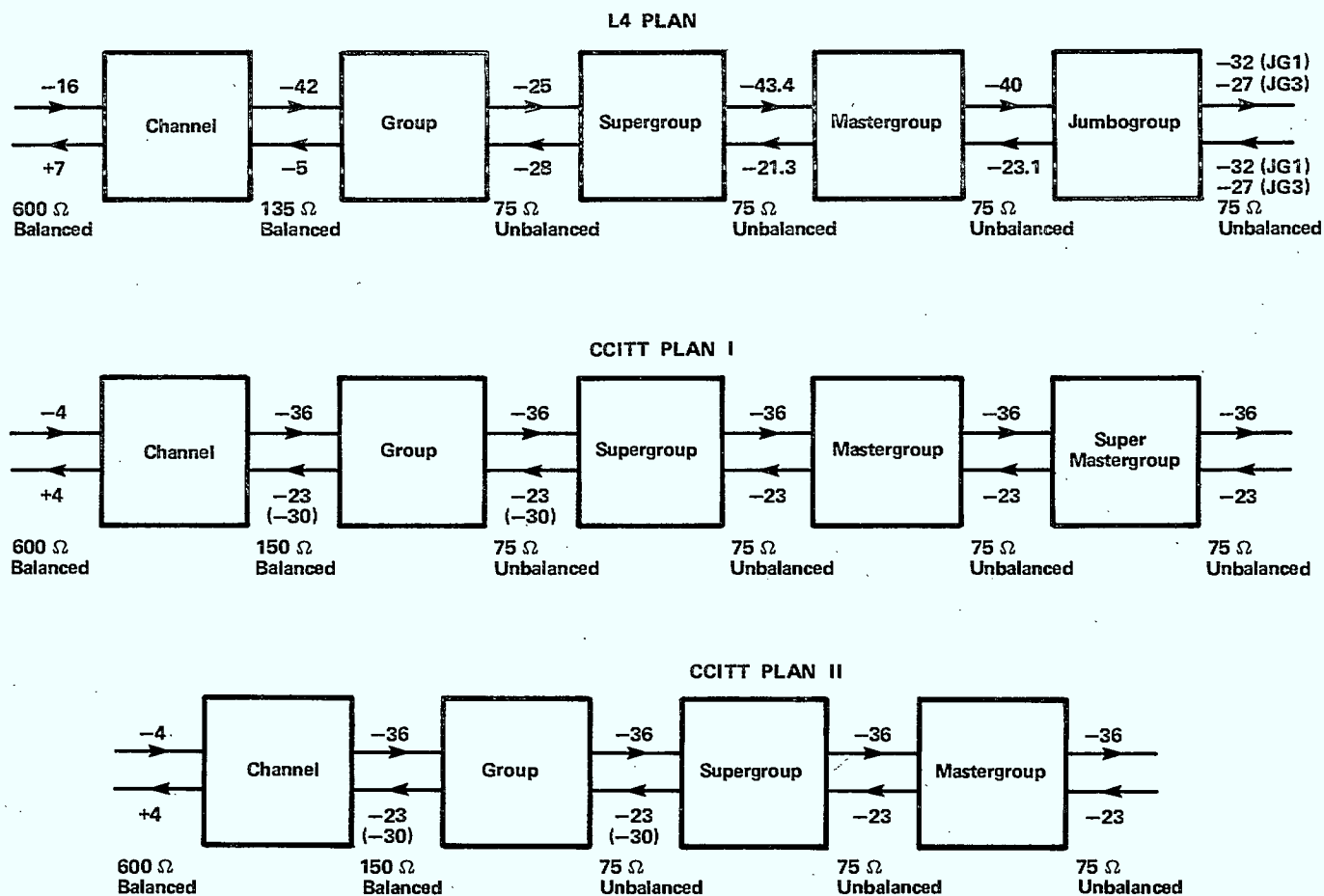


FIGURE B-3 Cont'd  
CCITT Frequency Multiplex Plan



NOTE: All levels are in dBm.

**FIGURE B-4**  
Standard Levels and Impedances (L4 Plan)



TABLE B-1

Relative Power Levels at the Group and Supergroup Distribution Frames  
in the Carrier Systems of Various Countries

COUNTRY	RELATIVE POWER LEVEL AT GROUP DISTRIBUTION FRAME		IMPEDANCE AT GROUP DISTRIBUTION FRAME	RELATIVE POWER LEVEL AT SUPERGROUP DISTRIBUTION FRAME		IMPEDANCE AT SUPERGROUP DISTRIBUTION FRAME
	TRANSMIT (dBr)	RECEIVE (dBr)		TRANSMIT (dBr)	RECEIVE (dBr)	
Federal Republic of Germany	-36	-30	150 $\Omega$ , balanced	-35	-30	75 $\Omega$ , unbalanced
Australia    System 1 System 2	-36.5	-30.5	150 $\Omega$ , balanced	-35	-30.5	id.
	-42	- 5	135 $\Omega$ , balanced	-35	-30	id.
Austria	-37	- 8	75 $\Omega$ , unbalanced	-35	-30	id.
	-36*	-30*	150 $\Omega$ , balanced			
Belgium	-37	- 8	150 $\Omega$ , balanced	-35	-30	id.
People's Republic of Bulgaria	-36*	-23*	150 $\Omega$ , balanced*	-36*	-23*	id.
Denmark, Spain, Ireland, New Zealand, Norway, United Kingdom	-37	- 8	75 $\Omega$ , unbalanced	-35	-30	id.
U.S.A. (American Telephone and Telegraph Company)	-42	- 5	135 $\Omega$ , balanced	-25	-28	id.
France	-52	-17	150 $\Omega$ , balanced	-45	-35	id.
	-33*	-15*				
Hungary, Italy, Netherlands	-37	-30	150 $\Omega$ , balanced	-35	-30	id.
India	-36.5	-30.4	150 $\Omega$ , balanced	-34.8	-30.4	id.
Japan (Nippon Telegraph and Telephone Public Corporation)	-36	-18	75 $\Omega$ , balanced	-29	-29	id.
Mexico (Telefonos de Mexico)	-47	-10	150 $\Omega$ , balanced	-47	-24	id.
People's Republic of Poland		-23*				
	-36	-30	150 $\Omega$ , balanced	-36	-23	id.
Democratic German Republic	-36	-30	150 $\Omega$ , balanced	-35	-30	id.
	-36	-23*		-36*	-23*	
Sweden	—	—	—	-35	-30	id.
Switzerland	-41	- 7.8	75 $\Omega$ , unbalanced	-35	-26	id.
	-36.5*	-30.5*				
U.S.S.R.	-36	-23	150 $\Omega$ , balanced	-36	-23	id.

\* Values proposed for new equipments.

## c) Synchronization Pilot Frequencies and Levels

The levels and frequencies commonly used for synchronization purposes are listed below:

STANDARD	PILOT FREQUENCY (kHz)	RELATIVE LEVEL IN BASEBAND (dBm0)
North American	64	-14
North American	308	-14
North American	512	-14
North American	564	-14
CCITT	60	-20

## d) Level Pilots

Both CCITT and North American standards specify a series of pilot frequencies to be used for level regulation purposes. The frequency and relative level of these pilots specified as standard are listed in the table below.

SYSTEM OF STANDARDS	PILOT FOR	FREQUENCY (kHz)	LEVEL (dBm0)
North American (L4)	Basic Group	104.08	-20
	Basic Supergroup	315.52	-20
	Basic Mastergroup	2840	-20
	Basic Jumbogroup	11,648	-20
CCITT (Plans I & II)	Basic Group	84.08	-20
		84.14	-25
		104.08	-20
	Basic Supergroup	411.86	-25
		411.92	-20
		547.92	-20
	Basic Mastergroup	1552	-20
	Basic Super Mastergroup (Plan I)	11,096	-20
	Basic 15 Supergroup Assembly (Plan II)	1552	-20

It can be seen from the above that the pilot frequencies for the two recommended standards are not compatible.

## e) Level Pilot Frequency Stability

The recommended frequency stability of the pilots discussed in Section B.1.2d above are listed below.

STANDARD	FREQUENCY (kHz)	STABILITY (Hz)
North American	104.08	$\pm 1$
	315.52	$\pm 1$
	2840	$\pm 7$
	11,648	$\pm 10$
	42,880	$\pm 20$
CCITT	84.08	$\pm 1$
	84.14	$\pm 3$
	104.08	$\pm 1$
	411.86	$\pm 3$
	411.92	$\pm 1$
	547.92	$\pm 1$
	1552	$\pm 2$
	11,096	$\pm 10$

## f) Noise

The maximum allowable noise power from all sources (thermal, intermodulation crosstalk, etc.) specified by the various standards are as follows.

EQUIPMENT	MAX NOISE POWER (PWP)	
	NA	CCITT
Pair of channel modulators	78	400
Pair of group modulators	25	100
Pair of supergroup modulators	30	100
Pair of mastergroup modulators	45	60
Pair of super mastergroup modulators (Plan I)	45	60
Pair of 15 supergroup assembly modulators (Plan II)	45	60
Pair of jumbogroup modulators	45	60

From examination of the above table it can be seen that the North American noise standards are considerably tighter than those specified by CCITT.

## g) Accuracy of Carrier Frequencies

The carrier frequencies used to generate the various frequency plans are shown in Figures B-1, B-2, and B-3 respectively. The frequency of these carriers must be maintained within certain specified limits. The limits specified by the various standards are summarized in the table below.

ACCURACY		
CARRIER	NA	CCITT
Channel	$\pm 1 \times 10^{-7}$	$\pm 1 \times 10^{-6}$
Basic Group	$\pm 1 \times 10^{-7}$	$\pm 1 \times 10^{-7}$
Basic Supergroup	$\pm 1 \times 10^{-7}$	$\pm 1 \times 10^{-7}$
Basic Mastergroup	$\pm 1 \times 10^{-7}$	$\pm 1 \times 10^{-8}$
Basic Super Mastergroup (Plan I)	-	$\pm 1 \times 10^{-8}$
Basic 15 Supergroup Assembly (Plan II)	-	$\pm 1 \times 10^{-8}$
Basic Jumbogroup	$3 \times 10^{-8}$	-

#### B.1.3 Significance of the above Differences in Standards on the Canadian Manufacturer Who Desires to Export Analog Multiplex to Countries Conforming to CCITT Recommendations.

The differences in multiplex standards between N.A. and CCITT Recommendations necessitate equipment redesign in the following areas:

- The VF channel banks require redesign due to different signaling arrangements (these are discussed in Section F),
- Group and supergroup amplifiers require redesign due to differences in interface levels,
- Carrier supplies require redesign together with their corresponding filters,
- Mastergroup equipment requires new modulators and filters.

In addition to the above, a complete physical rearrangement of the equipment rack layout is required due to different operating requirements and corresponding equipment arrangements.

Technically the above differences do not present any major problem. We have the technology and can carry out the redesign. The cost of such a redesign is not insignificant however and has been estimated at between 50 to 60 percent of the design cost of the original multiplex designed to meet Canadian requirements; a large portion of this expense being related to drawings and documentation requirements.

Equipment designed to meet CCITT recommendations has been designed and manufactured by Northern Electric, and sales have been made to both Greece and Turkey.

Sales to other European telecommunication companies have not however been realised to date. Competition from local European domestic supplies and from Japan has been extremely keen in this area, and the profitability of Canadian manufactured multiplex equipment in such a competitive market is somewhat questionable.

The 'buy domestic policy' of most Western European administrations is a formidable hurdle to overcome, and in the absence of a physical presence in the form of manufacturing facilities in a particular country (as Northern Electric presently has in Turkey and Ireland) marketing of multiplex to these countries requires major effort.

Customers have been impressed by the quality of the Canadian product, particularly from the standpoint of reliability and maintainability, but unfortunately quality alone does not sell a product.

#### B.1.4 References

CCIR - CCITT Recommendations Nos.\*

G.211, G.231, G.232, G.233, G.234, G.235

Trans Canada Telephone System Analogue Technical Guidelines Nos.

TG 3.000, E.002.

#### B.2 ANALOG CABLE SYSTEMS

Analog cable systems can basically be subdivided into two different categories: (a) VF pair cable systems and (b) Coaxial cable systems.

The VF pair cable systems were the first generation of cable carrier systems which made use of ordinary 19-21 gauge VF pairs and a repeater spacing of approximately 3.5-5 miles dependent on the environmental conditions (the capacity of a single such system being 12 VF channels).

Development of similar systems in both North America and Europe took place about the same time although the capacity and cable characteristics of most European systems are quite different from North American systems (see Table B-2).

---

\* CCIR - International Radio Consultative Committee

TABLE B-2  
Coaxial Cable Systems

a) North American Coaxial Cable Systems

SYSTEM	REPEATER SPACING	CAPACITY/SYSTEM
L1	8 miles	600 channels
L3	4 miles	1860 channels
L4	2 miles	3600 channels
L5	1 mile	10,800 channels

b) CCITT Recommendations for Coaxial Cable Systems

SYSTEM	REPEATER SPACING	CAPACITY/SYSTEM
1.3 MHz	3.7 miles	300 channels
2.6 MHz	6 miles	600 channels
4 MHz	6 miles	960 channels
6 MHz	6 miles	1200 channels
12 MHz	3 miles	2700 channels
60 MHz	1 mile	10,800 channels



A large number of these systems are in use today but equipment manufacture in this area tends to be limited to plug-in modules to expand existing common equipment bays. Digital Systems are rapidly taking over from analog systems in this area.

#### B.2.1 Coaxial Cable Systems

Due to the geography and population density distribution within Canada, microwave systems are more economical for long-haul applications. As a result, the requirements for analog cable systems are extremely limited. The major application for cable systems is interconnection between the central telephone office located downtown and the microwave radio site normally located on the outskirts of the downtown built-up area.

Due to the rather limited domestic requirement, it was not economical for Canadian manufacturers to develop analog cable systems.

Initially our requirements for coaxial systems were fulfilled by United States' designs, and as described in the section on analog multiplex we presently have systems operating in a radio entrance link capacity on the L1 and L4 frequency plans. The maximum capacity of Canadian systems on the L4 plan is 1320 channels.

The capacity and the repeater spacing of the various North American and CCITT recommended systems are shown in Table B-1.

The L5 cable system developed in the U.S. has been designed essentially to supercede the existing L4 system and could have an application in the area of entrance links should Bell Labs be successful in developing single-sideband analog radio.

Canadian manufacturers are at present offering European High Quality Systems for domestic applications. Typical examples are Northern Electric offering Phillips Equipment and Lenkurt Electric offering Siemens Equipment.

#### B.2.2 Export Market

With regard to the export market for cable systems it would certainly appear that Canadian manufacturers are in a much better position to offer digital rather than analog cable systems, and the future market for cable facilities will in all probability tend towards the cheaper digital systems.

### B.2.3 References

CCIR-CCITT Recommendations G235, G232, G313, G324, G321, G322, G326, G331, G342, G531, G532, G541, G542, G551.

Trans-Canada Telephone System Analog Technical Guidelines Nos. TG5000.

## B.3 ANALOG RADIO

### B.3.1 Performance

There are no significant technical differences between Canadian and off-shore radio relay equipments that would preclude the Canadian product from off-shore markets. Radio equipment performance is measured against a standard known as a Hypothetical Reference Circuit (HRC). The North American HRC is 4000 miles (6400 km) while the CCIR reference, used off-shore, is a shorter 2500 km, making for some small difference in the noise requirement. Generally, equipment designed in Canada to the longer standard tends to have better noise performance than the European equipment. Naturally, the better performance makes the Canadian equipment more expensive. Off-shore customers may not be willing to pay for performance that exceeds their needs. A reduction in costs could perhaps be realized by a relaxation in filter specifications, amplifier and local oscillator noise, and bay equalization. However, from a production standpoint a sizeable off-shore order would be required to justify these changes.

Radio is not a high-profit item. A relaxation of the equipment specifications could result in additional expenses on equipment installation on jobs bid on an EF&I (Engineering, Furnish and Installation) basis.

### B.3.2 Equipment Options

The major telephony carriers in North America use multichannel radio systems employing IF switching. In the interest of performance, baseband sections are as long as possible. Often, then, features that European users look for, such as baseband switching, drop and insert and built-in order wire facilities, are not generally available in Canadian designs.

Recently, however, in a sale to a U.S. customer geared to CCIR standards, baseband switching and built-in order wire facilities were developed and provided by a major Canadian manufacturer, with no undue distortion of price. This would indicate that equipment options present no barrier to off-shore sales.

### B.3.3 Frequency Plans

In the 4 GHz band, the most commonly used frequency plan in North America interleaves receivers and transmitters at frequencies spaced 20 MHz apart. In Canada this 4 GHz band extends from 3540 MHz to 4200 MHz. The CCIR frequency plan used in Europe groups all the receivers at one end of the band and all the transmitters at the other.

The upper 6 GHz band in Canada is divided into two bands; channels 1 to 8 being 6440 MHz to 6580 MHz, while channels 1' to 8' use 6780 MHz to 6920 MHz. A quote for radio equipment in this frequency band leads the recipient to believe that no equipment is available for the band of frequencies from 6590 MHz to 6770 MHz.

Neither of these differences are of sufficient magnitude as to preclude the Canadian product from off-shore markets, since the small change in frequency requires only a retuning of RF filters and local oscillators. The RF bandwidth and performance of the Canadian product is quite capable of carrying an equivalent load of CCITT designed MUX circuits. The attached tables depict the differences between the North American and CCIR frequency plans (Tables B-3, B-4, B-5).

The competition in the field of microwave radio in the international marketplace is very keen, and radio cannot be classified as a high-profit item particularly if a job is supplied on an EF&I basis. As the result of some sad experiences in the past, Canadian suppliers are tending to favor 'equipment furnish only' type contracts.

TABLE B-3  
Channel Assignments in 4 GHz Band

CCIR Frequency Plan (3803.5 - 4203.5 MHz)

1 2 3 4 5 6    1' 2' 3' 4' 5' 6'

GO		RETURN	
CHANNELS	FREQUENCY (MHz)	CHANNELS	FREQUENCY (MHz)
1	3824.5	1'	4037.5
2	3853.5	2'	4066.5
3	3882.5	3'	4095.5
4	3911.5	4'	4124.5
5	3940.5	5'	4153.5
6	3969.5	6'	4182.5

North American Frequency Plan (3540 - 4200 MHz)

001    001'   01   01'   1   1'   2   2'   3   3'   4   5   5'   6   6'

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007   007'   07   07'   7   7'   8   8'   9   9'   10   11   11'   12   12'   13

GROUP 1		GROUP 2		DOWN BAND (CDN only)	
CHANNEL	FREQUENCY (MHz)	CHANNEL	FREQUENCY (MHz)	CHANNEL	FREQUENCY (MHz)
1	3730	7	3710	007	3550
1'	3770	7'	3750	007'	3590
2	3810	8	3790	001	3570
2'	3850	8'	3830	001'	3610
3	3890	9	3870	07	3630
3'	3930	9'	3910	07'	3670
4	3970	10	3950	01	3650
4'	4010	10'	3990	01'	3690
5	4050	11	4030		
5'	4090	11'	4070		
6	4130	12	4110		
6'	4170	12'	4150		
		13	4190		
		(additional 1-way channel)			

TABLE B-4  
Channel Assignments in 6 GHz Band

CHANNEL DESIGNATION	FREQUENCY (MHz)	
	CCIR (6 GHz)	CANADA (U6 GHz)
1	6440	6440
2	6480	6460
3	6520	6480
4	6560	6500
5	6600	6520
6	6640	6540
7	6680	6560
8	6720	6580
1'	6780	6780
2'	6820	6800
3'	6860	6820
4'	6900	6840
5'	6940	6860
6'	6980	6880
7'	7020	6900
8'	7060	6920

TABLE B-5  
Existing Canadian Allocations for the Fixed Services in the Microwave Bands  
(These allocations do not include changes under consideration for digital radio).

DESIGNATION	LOWER 2 GHz	UPPER 2 GHz	ITV*	4 GHz	5 GHz	LOWER 6 GHz
Frequency Limits (GHz)	1.710 - 1.900	1.900 - 2.290	2.548 - 2.690	3.500 - 4.200	4.4 - 4.990	5.925 - 6.425
SRSP Number	303	304	300	302	None	301
Number of RF Chan.	24	12	23	32	?	16
Type of Plan	4 Frequency	2/4 Frequency	Broadcast	2 Frequency	-	2 Frequency
Development	4 Channels	6 Channels	3 Channels	16 Channels	-	8 Channels
Protection	(2+2)	(5+1)	None	(14+2)	-	(6+2)
Number of VF Chan.	60 - 300	1800/960	N.A.	1260	-	1800
Alternate Use	6-60 VF FDM FM	None	None	2700 (7+1)	-	None
Channel BW	7 MHz	29 MHz	6 MHz	20 MHz	-	29.65 MHz
CCIR Rec.	No	279-1	No	382-2 Annex	No	383-1
DESIGNATION	UPPER 6 GHz	STL & PU*	7 GHz	8 GHz	UPPER 8 GHz	11 GHz
Frequency Limits (GHz)	6.425 - 6.590 & 6.770 - 6.930	6.590 - 6.770 6.930 - 7.125	7.125 - 7.725	7.725 - 7.975 8.025 - 8.275	8.275 - 8.500	10.7 - 11.7
SRSP Number	307	308	305	306	None	None
Number of RF Chan.	16	19	24 (20)	16	4	24
Type of Plan	2 Frequency	One-Way	4 Frequency	2 Frequency	-	4 Frequency
Development	8 Channels	-	4 Channels	8 Channels	**	4 Channels
Protection	(6+2)	-	(3+1)	(6+2)	-	(3+1)
Number of VF Chan.	1260	-	300 - 960	1800	N.A.	960
Alternate Use	2700 (3+1)	N.A.	12-120 FDM - FM 24 PCM	None	None	None
Channel BW	20 MHz	20 MHz	19.5 MHz	29.65 MHz	29.65 MHz	40 MHz
CCIR Rec.	384-1	No	No	386-1 Annex	No	387-1

\* ITV = Instructional Television  
STL = Studio Transmitter Link  
PU = Television Pickup

\*\* Single Hop = 8 Channels  
Multihop = 4 Channels



## SECTION C

## DIGITAL SYSTEMS

The phenomenal growth of digital systems in national networks during the past decade has been due mainly to reasons of flexibility, cost and performance. Digital cable and radio systems provide maximum flexibility for new services such as data and video, and are readily applicable to new media where digital transmission is inescapable e.g., long-haul wave guides and fiber optics. Digital transmission is highly compatible with modern technology such as medium and large scale integrated circuits where large R&D effort has resulted in small high-reliability low-cost devices.

The Bell System in the United States introduced the first 24-channel T1 digital system into service in 1962. Canada's first T1 system, manufactured by Northern Electric to Bell Laboratories' design, was installed in 1965. The T1 was a PCM (Pulse Code Modulation) cable system with 24 voice channels per digroup (primary block), transmitted over standard voice frequency cable pairs whose multiplexer operated at 1.544 Mbit/s, and has become the primary multiplex equipment of the North American digital hierarchy. Japan introduced their T1 system around the same time as Canada, and a few European countries (U.K., Italy) came up with a T1 system a few years later. General Electric (U.K.) performed their first T1 system field trial in Canada in 1968 (Halifax - Dartmouth) and sold a couple of systems to New Brunswick Telephone. However, both U.K. and Italy have since standardized on an alternative system agreed to by CEPT (Conférence Européenne Des Administrations Des Postes et Télécommunications). This alternative standard is based on 32 channels (30 voice channels and 2 signaling channels) per digroup whose multiplexer operates at 2.048 Mbit/s, and forms the primary multiplex equipment of the European digital hierarchy.

Due to the evolution of these different standards, incompatibility of North American hardware with European exists. Presently Canada is actively participating in recommendations for international standardization of digital transmission systems which is now emerging as the CCITT G700 series. This Section C reviews the principal parameters of a digital system; how these parameters differ among the world users; and thus, their effects on international trade.

## C.1 DIGITAL MULTIPLEX

## C.1.1 Basic Principles of PCM and Differences among Users

Today, the most widely used method of coding analog signal is by Pulse Code Modulation (PCM). This is a process in which a signal is sampled, and the samples are quantized and converted by coding into a digital signal. Delta Modulation is another form of coding analog signals. Although this form is still limited in usage compared to PCM, Delta Modulation with syllabic companding can provide telecommunication links of lower quality at lower cost than that needed for PCM transmission.

## SAMPLING

This is a process where the input analog signal is measured with a very narrow pulse, at a regular repetition frequency and short time duration. As long as the sampling rate is sufficiently frequent, the discrete measurements will contain enough information such that by suitable processing, the original analog signal can be recovered. The sampling rate of 8000 samples per second  $\pm$  50 parts per million is universally accepted (per VF channel).

## QUANTIZING AND COMPANDING

The sampling process of an analog signal produces a series of Pulse Amplitude Modulated signals (PAM). Each amplitude is given a discrete level, 'quantizing', according to an approximation of the analog to numerical transfer function. More discrete levels are provided in the region of small amplitude where the probability of a sample is higher, and fewer discrete levels are provided in the region of amplitudes that are large and the probability is less. This companding process which differs among various countries has created the greatest differences in digital transmission standards. Countries belonging to CEPT have chosen an 'A-law' segmented companding process, which is linear at very low levels and logarithmic at high levels approximated by 13 linear segments, using 256 quantized values. Canada, U.S.A. and Japan have chosen a ' $\mu$ -255 Law' segmented companding which is a logarithmic law approximated by 15 linear segments using 255 quantized values. Both companding laws are presently recommended by CCITT. It also recommends the following:

"Digital paths between countries which have adopted different companding laws should carry signals encoded in accordance with the A-law. Where both countries have adopted the same law, that law should be used on digital paths between them. Any necessary conversion will be done by the countries using  $\mu$ -law".

This means that, internationally, the A-law is favored. Therefore  $\mu$ -law countries like Canada, U.S.A. and Japan, have the responsibility of conversion for compatibility.

## MULTIPLEXING

Both ' $\mu$ -law' and 'A-law' companding digital systems use eight binary digits (bits) per word to encode each sample. An encoder sequentially encodes a number of voice frequency channels. The set of consecutive 8-bit encoded samples of each channel with a synchronizing signal forms the basic frame structure. In  $\mu$ -law countries the primary multiplex rate is 1.544 Mbit/s providing 24-channel time slots per frame, with 193 bits/frame assigned to 24 telephone channels. In A-law countries the primary multiplex rate is 2.048 Mbit/s providing 32 channel time slots per frame, with 256 bits/frame assigned to 30 telephone channels. Although the sampling rate of 8 kHz and 8 bit per word encoding are agreed upon by major administration, other fundamental parameters such as companding and multiplexing differ so markedly

between North America and Europe that international trade is affected. Presently available North American equipment is not compatible with the European system, and to export to this market requires the development of a new family of digital equipment different from those used domestically.

### C.1.2 Digital Hierarchy of Various Countries

The developed countries have a digital hierarchy for their national network. They differ in bit-rate at each order of multiplex level (primary DS-1, second order DS-2, etc.) but can be broadly identified as two hierarchal structures: hierarchies based on A-law companding with DS-1 rate of 2.048 Mbit/s, and those based on  $\mu$ -law companding with DS-1 rate of 1.544 Mbit/s. Due to these differences, higher order multiplex equipment, line equipment and other hardware for services apart from voice channels which are planned for the future will also be different. Some of the less developed countries are at a stage of choosing a digital hierarchy, and the one chosen will more than likely be the A-law companding favored by CCITT or will perhaps conform to the first large system that is installed in the country. An export market in the future for higher order digital equipment will only be available as long as the equipment is compatible with the digital hierarchy of the national network.

#### $\mu$ -LAW COUNTRIES

##### a) U.S.A. and Canada

BIT-RATE (Mbit/s)		
DS-1	1.544	24 Voice Channels, Data
DS-2	6.312	Conference Video
DS-3	44.736	Digital Radio, 600 CH FDM Mastergroup, Broadcast Video
DS-4	274.176	
DS-5	564	

(So far, only the DS-1 and DS-2 parameters have been mutually agreed upon.)

## b) Japan

BIT-RATE (Mbit/s)		
DS-1	1.544	24 Voice CH, Data, 1 MHz Visual Telephone, FDM 1.5 SG, 4 MHz Visual Telephone, FDM MG, NTSC* Color TV,
DS-2	6.312	
DS-3	32.064	
DS-4	97.728	
DS-5	397.200	20 GHz Radio, W-40G Waveguide
DS-6	806	

## A-LAW COUNTRIES

## a) BPO (U.K.)\*\*

BIT-RATE (Mbit/s)		
DS-1	2.048	Voice (30 Channels)
DS-2	8.448	
DS-3	119.700	Color TV
DS-4	360	

## b) French PT Admin.

BIT-RATE (Mbit/s)		
DS-1	2.048	30 Voice Channels
DS-2	8.448, 25.873 and 51.747	
DS-3	139.264	

The 25.873 Mbit/s on 1.2/4.4 mm coaxial pr. provides 720 channels and is compatible with the 12 MHz FDM system. The 7 GHz radio system is based on two 26 Mbit/s streams and can be replaced by the 140 Mbit/s system.

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\* National Television Systems Committee

\*\* British Post Office

## c) Swiss PTT Admin.

BIT-RATE (Mbit/s)		
DS-1	2.048	
DS-2	8.448	
DS-3	34.368	
DS-4	139.264	

0.65/2.80 mm minicoaxial cable will be used extensively for the 8.448 and 34.368 Mbit/s systems.

## d) Italy

BIT-RATE (Mbit/s)		
DS-1	2.048	Voice (30 Channels), data, sound
DS-2	8.448	FDM Basic Supergroup, Visual Telephone
DS-3	34.304	TV Program (Long-Term Goal)
DS-4	139.264	TV Program, FDM Supergroup
DS-5	565.148	

## e) Indications are that the emerging CCITT digital hierarchy will be the following:

BIT-RATE (Mbit/s)		
DS-1	2.048	30 voice channels
DS-2	8.488	
DS-3	34.304	
DS-4	143	
DS-5	589	

### C.1.3 Future Trends in Standardization

Although international standardization bodies such as CCITT strive to achieve a commonality in standards, the large investment already made in  $\mu$ -law companding equipment in North America\* and Japan and A-law companding systems in Europe will prevent any drastic change. Incompatibility of the two systems will exist, and conversions at interface points will have to be made. The required  $\mu$ -law-to-A-law conversion and vice versa, and bit inversion from one system to another, can be provided by necessary hardware. Technology is at a stage where conversion circuits can be built without too great a difficulty - perhaps a sequential circuit or read-only memory containing a conversion table with 128 seven-bit words that can be fully memorized in one chip of ROM. Conversion equipment and international standards for its application will become increasingly important in the near future when intercontinental digital links will be considered.

### C.1.4 Effects of Standards on the Digital Multiplex Market

The technical incompatibility of European digital systems and North American systems will continue to exist in the future. The national hierarchy of European countries and North America is based on different primary multiplex characteristics. Hence, higher order multiplex and line equipment will differ accordingly. These technical standards differences restrict the sale of Canadian domestic digital multiplex equipment in off-shore markets today, and in all probability, this will continue in the future. Likewise the unique North American equipment standards have closed the door to European-type equipment on entering the Canadian market.

The domestic market for DS-1 multiplex equipment is enjoying rapid growth in T1 and LD-1 cable systems. Digital services are growing, and with the availability of higher order multiplex equipment for services other than telephone - such as television (NTSC, 525 lines by AT&T,\*\* COMSAT and Japan), visual telephone, data service, facsimile, telex, high quality loudspeaker telephones and wideband broadcast program will result in greater digital equipment requirement.

At present, most digital systems in service in Canada are made in Canada (Northern Electric and Lenkurt). However the recent penetration of U.S. companies into the Canadian digital transmission market has created tougher competition for Canadian manufacturers. In order to ensure a large production volume of digital systems, Northern Electric, Canada's largest manufacturer of

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\* The growth of digital facilities within the Bell system has been impressive (about two million channels) as compared with only approximately two hundred thousand channels in Europe.

\*\*American Telephone and Telegraph.



digital equipment, is aiming to capture some of the digital transmission market in the U.S. Consistent with this present plan, new cost reduced channel banks are being developed that will be adequate for the Canadian market as well as being competitive in the U.S. market.

It is estimated that to justify the development of a channel bank conforming to the CCITT plan for A-law countries operating with 30 VF time slots and two signaling slots, an export market potential of between \$30 and \$40 million would be required.

## C.2 DIGITAL CABLE SYSTEMS

Digital transmission over cable is used for a wide range of applications: short-haul (up to 50 miles), medium-haul (up to 250 miles), and long-haul systems (4000 miles). Applications of various distances employ different types of cables, different transmission bit-rates and capacities, different regenerative type repeaters, and varying types of maintenance and surveillance equipment. Cable routes can be aerial or buried depending on the environment and cable system used.

### C.2.1 Types of Cable

Different types of cables are required for different transmission rates. However, most of these varying types of cables used are standard types. DS-1 transmission rates, 1.544 and 2.048 Mbit/s, can be carried over existing Voice Frequency paired cable. Second-order transmission rates, DS-2, require a high quality, low-capacitance, balanced pair cable and are used in North America by AT&T and in Europe by France. Higher order transmission rates are carried over coaxial cables. Most coaxial cables used by various countries are standard types. The minicoaxial pair 0.65/2.8 mm is used extensively in Switzerland and, to a certain extent, in France and Italy. The 1.2/4.4 mm coaxial cable is widely used in France, U.K., Italy and Japan; and the 2.6/9.5 mm for high-speed digital lines in Canada (Northern Electric's LD-4) and Japan. The CCITT recommendation on coaxial pairs covers only the strictly essential checks so as to avoid any undue increases in the cost of the cable. Any digital system should be adapted to the manufacturing characteristics of the pair (except minor alterations) and not the contrary.

### C.2.2 Line Codes for Transmission

The different digital hierarchies of various countries use different types of line codes for each order of multiplex. The line code only at the DS-1 transmission rate, 1.544 and 2.048 Mbit/s, over Voice frequency pairs, is the same: AMI (alternate mark inversion - bipolar). Some European countries are using the 3-level HDB3 (high density bipolar with a maximum of 3 consecutive spaces) code for 8.448 Mbit/s which is provisionally recommended by CCITT. Japan is using 3-level AMI with scrambler; the U.K. 3-level 4B3T (4 binary digits translated into

3 ternary digits) with scrambler; the U.S.S.R. ADQ (almost differential quasiternary); and Canada (Northern Electric's LD-4) 3-level B3ZS (bipolar, 3 zero substitution). This non-standardization of line codes presently prevailing for higher order transmission rates would make regenerative repeaters of different systems incompatible, and thus make it impossible to market the cable system alone without the terminal equipment.

#### C.2.3 Regeneration Spacing

At the DS-1 rate of transmission over Voice Frequency paired cable, the regenerator (digital repeater) spacing is 1.8 - 2 km. However, a barrier to standardization of regenerator spacing exists due to different transmission bit-rates, line codes and cable types used by various countries.

#### C.2.4 System Surveillance and Maintenance

Generally, maintenance and surveillance philosophy of digital transmission equipment is universal. Facilities for sectionalized line fault conditions, spare stand-by lines, alarms, etc., on Canadian equipment are adequately provided to meet the needs of the export market. However, all maintenance test gear and surveillance equipment are designed around this digital system so that any technical standards barrier experienced by the digital system will also apply to the maintenance and surveillance equipment.

#### C.2.5 Intercontinental Digital Links

Terrestrial intercontinental digital links are not foreseeable in the immediate future due to technical difficulties with submarine cables and regenerator spacing. However, intercontinental digital paths via Satellite TDMA (Time Division Multiple Access) systems between two countries using different primary PCM standards will become a reality in the near future. Indications are that digital satellite links will use A-law companding with a gross bit-rate that is an integral multiple of 64 kbit/s. Therefore, a definite need will arise in the future to provide code conversion from A-law companding to  $\mu$ -law on terrestrial links with satellite.

#### C.2.6 Effects of Standards on the Digital Cable System Market

The different types of cables used for different digital transmission roles are standard cable types. These vary from cable pairs for Voice Frequency to different sizes of coaxial cable. Canada's well established cable and wire manufactures are not limited by differences in technical standards to supply the required cables for digital transmission.

The usage of coaxial cable in the European national network is quite different from that in Canada. To date, virtually all long-haul, back-



bone toll routes in Bell Canada have been developed with 4 GHz FM radio and frequency division multiplex equipment. Due to the terrain and distances involved, coaxial FDM routes were considered too expensive in comparison to radio links. In Europe, however, a considerable network of FDM systems over coaxial cables exists today. And, much of their digital routes in the future will grow on these existing coaxial cables, preferably in joint use with FDM systems and similar repeater spacing. Due to these different growth patterns of coaxial cable routes, Canada's coaxial systems might be limited to large capacity, high-speed digital systems.

Northern Electric's unique LD-4 coaxial cable system, line-rate of 274.176 Mbit/s, has aroused interest around the world. Presently, France is particularly interested in this system, although their digital hierarchy is different from Canada's, since there is a possibility of feeding two LD-4 bit streams to form France's 565.148 Mbit/s millimeter waveguide system. The outcome of their interest might result in a technological consulting service due to Canada's experience, rather than in hardware sales with an off-shore, or perhaps increased sales in the component part area.

Regenerative type repeaters and related apparatus are designed for a particular type of line code, bit-rate, and repeater spacing so that a market for this type of equipment will exist providing there is technical compatibility.

To produce equipment compatible with the CEPT countries would mean the development of a new family of digital equipment. We have the technology, but, large development and manufacturing expenses would be involved in redesigning digital equipment to comply with the European requirements. Certainly if the potential market was large enough and it was felt that Canadian digital equipment could be manufactured in Canada at a competitive price, Canadian manufacturers would be only too willing to enter the market.

In this area, as well as in others related to the telecommunications industry, the 'buy domestic policy' of the PTTs\* of developed countries still looms as a big hurdle to be overcome.

Perhaps in countries where Canadian companies have no existing manufacturing facilities - which almost appears to be a prerequisite to sell in developed countries (unless of course the product is of a nature that is not presently manufactured in a particular country) - cross licensing of equipment with an already established company could possibly be the best approach.

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\* Public Telephone and Telegraph.

### C.3 DIGITAL RADIO

With the rapid growth in data and digitized voice cable facilities, most telephone administrations have turned their attention to the development of digital microwave systems, for the extension of cable facilities over rugged terrain where cable installations are excessively expensive or impractical. The use of analog facilities in such applications would require the use of digital-to-analog converters.

Interest in digital radio facilities has also been generated as a result of the fact that the existing FDM/FM analog frequency bands below 10 GHz are becoming increasingly congested, and administrations are being forced to consider the higher frequency bands in order to fulfill their future circuit growth requirements.

At these higher frequency bands, rainfall attenuation becomes a major factor necessitating closer repeater spacing. In a FDM/FM analog radio system the noise contribution of each individual repeater is additive. Therefore, as the number of repeaters increases due to reduced repeater spacing, one rapidly reaches a point where the total noise contribution makes it impossible to meet the overall circuit noise performance requirements. (These requirements are specified by both CCIR and N.A. telephone administrations for Hypothetical Reference Circuits per Trans Canada Guidelines and CCIR Recommendations 393-1.)

Digital radio systems, on the other hand, do not exhibit such a noise build-up due to the fact that a new digital signal can be regenerated if required at every repeater location.

Economic factors also support the use of digital radio systems over analog. The large amount of development effort that has been expended in the area of PCM solid state circuits has resulted in digital multiplex costs almost half those of equivalent analog.

#### C.3.1 Standards

The development of digital radio systems is in its infancy, and standards as such do not exist either in N.A. or in CCIR.

Standards similar to those existing for analog radio systems will no doubt eventually be established. A hypothetical reference circuit will probably be established, and system performance requirements based on such things as: percentage of time a certain error rate may be exceeded; maximum event size, and, perhaps, average time between error events - will be specified.

With the present voice encoding and radio modulation techniques, digital radio systems tend to be less efficient in spectrum usage than analog systems, and it is therefore highly probable that a requirement on the allowable minimum number of bits transmitted per cycle of bandwidth will be set.

In the United States the Federal Communication Commission (FCC) has in fact already taken steps in the direction of minimum bit-rate per cycle of bandwidth. In Docket No. 19311 a requirement that digital radio equipment should be "capable of operation with a bit-rate numerically equal to or greater than the authorized bandwidth and where employed to carry encoded speech channels, have a capability to carry a minimum of 1200 such speech channels for operation in the 4, 6 and 11 GHz common carrier bands and 96 such speech channels for operation in the 2 GHz common carrier bands".

Docket No. 19311, as can be seen from the above, also permits the use of digital radio systems in frequency bands below 11 GHz. Digital radio equipment designed for operation in those lower frequency bands should not however restrict the orderly growth of existing analog facilities.

To comply with the 1200-channel capacity in the 11 GHz band, U.S. manufacturers are taking advantage of the fact that in digital systems the same carrier frequency can be used on the same path in both horizontal and vertical polarizations to carry different information and are modulating each of these polarizations with 600 channels to make 1200 channels per RF frequency. AvanteK of California is complying with the 96-channel requirement in the 2 GHz band by use of 4 phase PCM with partial response filtering. Canadian Marconi also complies with the minimum FCC requirement in their MCS 6900 type equipment using 8 level FSK.

In general, in the area of digital radio most administrations are developing equipment to fulfill their immediate needs - in frequency bands from 2 to 80 GHz. Systems being developed for use in existing analog bands are generally designed to conform to established frequency plans and normally have the additional requirement that their installation in an analog environment must not interfere with the normal growth of the analog network. Each administration naturally wants equipment operating at a bit-rate which is a multiple of their digital hierarchy.

The various hierarchical structure presently used by the various countries has been covered in detail in Section C.1 on digital multiplex.

### C.3.2 Review of Digital Radio Equipment Presently Available and Under Development

#### JAPAN

Nippon Electric has been very active since the early sixties in the area of digital radio.

They have designed equipment in 2, 6, 11, and 20 GHz frequency bands operating at bit-rates from 1.544 Mbit/s up 400 Mbit/s. The 400 Mbit/s system is now operating in Japan. Nippon have also developed multiplexers compatible with the North American and CCITT digital hierarchy and have systems operating in both the U.S. and Europe.

OKI has developed systems operating in the 18, 22 and 38 GHz frequency bands. These systems operate at 92.6 Mbit/s (2xT3) and 274 Mbit/s (T4).

#### UNITED STATES

Avantek is presently marketing a 96-channel system in the 2 GHz frequency band operating at 6.312 Mbit/s (T2). They also have available or shortly will have a 192-channel system occupying twice the bandwidth.

Raytheon has developed a 600-channel system operating in the 11 GHz band at a bit-rate of 40 Mbit/s. This system occupies the standard 40 MHz analog frequency spacing.

Microwave Associates. This company is presently field trialing a 11 GHz digital radio system operating at approximately 80 Mbit/s and 1152 VF channels.

Norden (A Division of United Aircraft). This company has developed a digital radio system operating in 38 - 40 GHz band with a capacity of 96 VF channels 6.3 Mbit/s.

Western Electric has developed an 18 GHz digital radio operation at 274.176 Mbit/s (T4) (4032 VF circuits).

Other companies in the U.S. are planning to enter the digital radio field. It is understood that the U.S. military are considering installing an 8 GHz digital radio network.

#### EUROPE

It is known that the British Post Office is presently field trialing a 6 GHz radio system operating at bit rates of 2.048 Mbit/s and 6.336 Mbit/s. This has been installed as an overbuild of an existing network. They are also field trialing an 11 GHz system operating at 120 - 132 Mb/s and have a development contract let to industry for 18 GHz system operating at 240 - 280 Mbit/s.

Standard Telephone and Radio in Munich has developed a system in the 12 GHz band.

The French PTT is believed to have a system operating in the 6 or 7 GHz frequency band.

In Norway Nera of Bergen has developed a 13 GHz system operating at 2.048 Mbit/s.

#### CANADA

Here in Canada, Canadian Marconi is the only company who are presently marketing a digital radio system. Their MCS 6900 equipment is available in the 2, 6, 7 and 12 GHz bands operating at a list rate of 7.720 Mbit/s.

The CTCA has presented a proposal to the DOC for rechannelization of the 8 GHz frequency band for optimum use of digital radio based on 40 MHz channel spacing and are planning the world's first long-haul digital radio system operating at approximately 90 Mbit/s (2×T3) equivalent to 1344 telephone channels. The 8 GHz band has been chosen as it is presently sparingly used in Canada, and equipment can be installed on an overbuild basis on our existing 4 GHz long-haul network. The use of existing buildings, towers and power plants has large economic advantages.

Higher frequency bands are subject to prolonged system outages due to rainfall and could not be used in the overbuild mode due to the requirement of much shorter path lengths to meet system availability requirements.

### C.3.3 Export Market

From the above review of digital radio systems it can be seen that systems have been designed in frequency bands from 2 - 20 GHz. Developments are in fact being carried out to frequencies up to 80 GHz.

There are, in fact, four basic markets that can be identified for digital radio systems:

- (1) Extension of digital cable facilities over rugged terrain.
- (2) Relatively low bit-rates for data only applications.
- (3) High capacity digital systems as feeders and entrance links for waveguide and fiber optics high capacity systems.
- (4) Long-haul voice and data network. This requirement certainly applies to the Canadian environment.

To enter the export market in any of the above applications Canadian manufacturers will no doubt have to interface with the digital hierarchy of the country under consideration and therefore will have to develop an interface unit compatible with the existing multiplex.

Much marketing effort is required to identify future markets for digital radio equipment as to which frequency bands and at which bit-rates.

Development effort should concentrate on carrier modulation techniques to maximize bit-rate per cycle of RF bandwidth and hence to maximize use of the spectrum available. It goes without saying that the system should be reliable, easy to maintain, and priced to sell.

## C.4 REFERENCES

CCIR Documents affecting Digital Systems (maintained, revised or newly-adopted at the CCIR Plenary Assembly, Geneva, 1974).

## C.4.1 Study Group 9 (Fixed Service using Radio-Relay Systems).

"Green Book" Number	Plenary Assembly "Pink" Number	Subject or Title
<u>Questions</u>		
Q 12-1/9*	9/1008	Asks about: propagation characteristics, performance objectives, channel arrangements, and how to minimize interference between different kinds of systems.
Q 21/9	9/1011	Asks about: Interconnection of baseband frequencies for digital radio-relay systems
Q 16/9	-	Asks about: use of frequencies above 12 GHz modulation, propagation effects, channel arrangements.
<u>Decisions</u>		
Decision 16	9/1028	Establishes IWP for digital quality criteria and question of reliability.
<u>Study Programs</u>		
SP 12C/9	9/1009	HRC and performance objectives for digital radio-relay system.
SP 12B/9	9/1010	Preferred characteristics for digital radio-relay.

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\* The letter "Q" indicates that it is a question; the first number "12" indicates that it is the twelfth question asked by Study Group 9; -1 indicates that it is the first revision of that question (subsequent revisions would be designated: 12-2, 12-3, etc.); /9 indicates the Study Group originating the Question.



"Green Book" Number	Plenary Assembly "Pink" Number	Subject or Title
SP 21A/9	9/1015	Interconnection at baseband frequencies.
SP 12E/9	9/1016	RF channel arrangements for high-capacity (greater than 34 Mb/s digital systems (10.7 - 11.7 GHz band)).
SP 12D/9	9/1017	RF channel arrangements 17.7 - 19.7 GHz band.
SP 12A-1/9	9/1018	Effects of propagation and interference.
SP 12F/9	9/1027	Digital RF channel spacing and arrangements.
<u>Reports</u>		
REP. 378-2	9/1041	Basic report on digital radio-relay systems: characteristics and performance requirements.
Rep. 609	AA/9 9/1039	RF channel arrangements 17.7 - 19.7 GHz
Rep. 608	AB/9 9/1035	RF channel arrangements: general principles.
Rep. 605	AD/9 9/1040	Interference allocation.
Rep. 607	AE/9 9/1045	RF channel arrangements for 11.7 - 15.35 GHz band.
Rep. 611	AF/9 9/1052	Calculation and measurement of the effects of propagation.
Rep. 606	AG/9 9/1049	Interference considerations.
Rep. 613	9/296, 9/1047	Measurement of bit error rate.
Rep. 610	9/1050	Digital and FDM/FM compatibility.
Rep. 379-2	9/1006	Low cost analog and digital R-R for new and developing countries.

"Green Book" Number	Plenary Assembly "Pink" Number	Subject or Title
<u>Recommendations</u>		
Rec. 497	9/1032	RF channel arrangements (for 960 ckts) 12.75 - 13.25 GHz bands.
Rec. 387-2	9/1026	RF channel arrangements (600 - 1800 ckts) 10.7 - 11.7 GHz band.

#### C.4.2 US Federal Communications Commission (FCC) Rules and Regulations

Docket No. 19311  
Docket No. 18920  
Docket No. 19869  
Docket No. 19658

Canadian Telecommunications Carriers Association - Report on "Use  
of the Frequency Spectrum for Digital Modulation" submitted  
Communications Canada in January 1973.



## SECTION D

### VIDEO EQUIPMENT

This portion of the study deals with video transmission over coaxial links, microwave radio systems, and miscellaneous equipment and systems employed by communications carriers in their terminals. Although some of the topics dealt with may also be applicable to equipment used by broadcasters (including operators of CATV systems), these areas are not intentionally considered, and the information may be incomplete.

#### D.1 TELEVISION SIGNAL STANDARDS

Many of the standards which must be considered during the design of video transmission equipment or systems are the result of the differing television signal standards used throughout the world. These standards can be defined according to two basic characteristics:

- line/field scan rate;
- color systems.

Each of these has a bearing on the equipment or system design requirements. The basic effects are discussed in the following subsections.

##### D.1.1 Line/field Scan Rate:

Two basic scan rates are used:

- 625 line/50 or 60 Hz field rate;
- 525 line/60 Hz field rate.

NOTE: Other line scan rates have been used in the past (405 line and 829 line systems). These are now being phased out in deference to the above systems.

The fundamental requirement which affects equipment design is the bandwidth required for each of these television systems. The nominal minimum bandwidth designated is:

- 625 line system: 5.0 to 6.0 MHz,
- 525 line system: 4.2 MHz.

The bandwidth of transmission systems is not normally truncated at the nominal bandwidth specified for the television system in Canada - both for technical reasons and as a result of what can be called broadcasters philosophy which calls for a slow degradation in performance above 4.2 MHz. In other countries this philosophy is regarded as desirable but is not always adhered to. Notwithstanding this, the bandwidth of transmission systems used in Canada is generally not adequate for the 625 line signal. Some typical systems used in Canada are as follows:

- Coaxial cable with VSB modulated sub-carrier: These systems are not manufactured in Canada. They are built to CCITT specifications and provide adequate bandwidth for 525 line and 625 line signals (e.g., Philips 8TR 317 coaxial system).
- Baseband cable amplifier systems: These systems are extensively used in Canada (manufactured in the U.S.A.) and provide a nominal bandwidth which would not be adequate for 625 line systems except under hardship conditions (e.g., General Electric).
- Baseband amplifiers: Used extensively at terminal locations these amplifiers are manufactured in Canada and provide a bandwidth which would be adequate for both 525 line and 625 line signals (e.g., Central Dynamics VTR 2045).
- Microwave radio systems: The RF bandwidth typically used in Canada is 20 MHz. This would provide only marginal performance with 625 line signals when long distances are involved. A wider RF bandwidth (near 30 MHz) is typical in the CCIR frequency plans used in countries with the 625 line television system.

#### D.1.2 Color Systems

Three color systems are currently in use:

- National Television Systems Committee, NTSC,
- Phase Alternation Line, PAL,
- Sequential Couleurs à Mémoires, SECAM.

The NTSC color system is generally associated (to date) with the 525 line scanning system, whereas the PAL and SECAM systems are in most cases used with the 625 line scanning systems (Brazil is an exception - 525 line PAL). The problems which may arise from these differing standards are:

- The difference in bandwidth over which stringent transmission tolerances must be specified as a result of differing color sub-carrier frequencies (3.58 MHz for 525 line/NTSC, and 4.43 MHz for the 625 line/PAL and SECAM systems). With the exception of Brazil (525 line PAL) the color system bandwidth requirements are aligned with the line scan rate.
- Each color system exhibits a differing sensitivity to certain color transmission parameters, thus affecting the system design requirements. As an example: The NTSC system is very sensitive to differential phase and gain distortion. The PAL system is very sensitive to differential gain but relatively insensitive to differential phase. The SECAM system is sensitive to some differential gain characteristics.

These differing characteristics will have some bearing on the design of a system and must be considered when a manufacturer approaches a foreign market.

### D.1.3 References:

The international standards on television systems are given in great detail in CCIR reports published in the CCIR Green Book Volume V. Some of the important references are:

- 1) CCIR Study Group XI: Report 308-2, characteristics of Monochrome Television Systems.

This report defines the characteristics of the various line/field scanning systems and, in an Annex, lists the systems used in each country.

- 2) CCIR Study Group XI: Report 406, Color Television.

This report provides some background on various aspects of the different color television systems.

- 3) CCIR Study Group XI: Report 407-1, Characteristics of Color Television Systems.

This report gives the technical characteristics of the various color television systems.

Details of national systems which may have minor variations within the tolerances indicated in Reports 308-2 and 407-1 may be found in publications issued by national organizations under the auspices of the national government or the industry.

## D.2 TELEVISION SIGNAL TRANSMISSION (QUALITY)

To be able to properly specify the system performance and, perhaps more important, to properly design the system, the manufacturer must be aware of the parameters and the methods used to define transmission performance.

A great deal of progress has been achieved in recent years towards the definition of common parameters and measurement procedures. Most of this progress has been on an international level in CCIR, and to this end Canada has played a significant role. The standards are well documented and are described at the end of this section under references.

There remain, however, a number of optional procedures in use by various organizations which may have some bearing on system design. Some of the more important aspects are covered in the following subsections:

### D.2.1 Test Signal Overload

Some organizations require the equipment or system performance to be specified at a signal amplitude which is 3 dB higher than the nominal

amplitude. The parameters measured in this manner are those which indicate some form of amplitude nonlinearity such as differential phase and gain. Separate performance requirements are stipulated for such measurements.

This requirement should normally be considered during the design stage and is only of some consequence when systems with limited headroom (amplitude overload) are involved.

#### D.2.2 Time Domain vs Frequency Domain

While most linear distortions are measured on a time domain basis with appropriate test waveforms, it is still the practice in some cases to file parallel frequency domain specifications for insertion gain and delay vs frequency. Because of the very complex relationships between time and frequency domain characteristics, and the added effect of nonlinear distortion, it is not practical to equate the two forms of specification on a one-for-one basis. When such a procedure is used, the time domain characteristics are usually used as the final criteria with the frequency domain specifications considered only as a guideline.

An example of this procedure was the specification issued by Bell Canada for the performance of the Philips 8TR 317 coaxial cable system using a video modulated subcarrier. Similar specifications are used for other components such as video amplifiers.

Without the qualification that one method of specifying the performance will predominate, this procedure may place the system designer in a very awkward position if the specifications do not correlate.

#### D.2.3 Test Waveform Spectra

Some organizations measure linear distortions with test signals that have their spectra terminated by appropriate filters at the top frequency defined for the television standard involved. Other organizations prefer to use signals which have spectral components terminated at twice the top frequency. These signals indicate the severity of system cut-off effects and are used primarily in North America and countries affiliated with the OIRT.

Examples are the 2T pulse and the T Step waveforms.

#### D.2.4 Use of Signal Clamping Devices

In North America signal clamping devices are used extensively in transmission systems. This allows the use of video amplifiers with marginal response at very low frequencies. In many countries the use of clampers is frowned upon, and the design of video amplifiers must be such that the low frequency response is very good.

In some cases the use of clamping devices is mandatory, e.g., on systems which use amplitude modulated subcarriers - coaxial cable systems.

An example of clamping device application in Canada is: Baseband cable systems where clampers are necessary to improve the low frequency waveform response and to remove low frequency oscillations which occur after large transitions in picture level, i.e., black to white changes. These may overload subsequent systems in the transmission chain, or, if microwave systems are involved, cause excessive deviation of the carrier.

NOTE: The introduction of digitally coded sound signals in the line sync time interval requires a clamper which operates during the back porch interval of the video line signal. This procedure is now being introduced in Canada, and clampers which operated on the tip of the line sync pulse are being replaced by back porch clampers specially designed in Canada for this purpose (CDL VTA2045 - Central Dynamics).

The problems caused by poor low frequency response are quite serious and can be eliminated by clamping devices. The alternative is a more stringent design requirement for low frequency response. When this alternative is chosen, the use of many systems in tandem without clampers will ultimately introduce low frequency distortions and overload problems. This subject is currently under study by CCIR/CMTT and is described in a report which is identified under References at the end of this section.

#### D.2.5 Test Signal Options

The test signals used to define transmission performance have been standardized to a very great extent and are described in several CCIR/CMTT reports discussed at the end of this section. For a given parameter, however, options which involve the amplitude or form of the test signal are possible. Since these differences in amplitude or form of the signals involved may cause differences in the measured result, the system specification should be determined in terms of the signal option to be used by the organization involved.

An example of different signal options is signal G2, used to measure chrominance gain and phase nonlinearity on 625 line systems, and signal G which is used to measure these distortions on 525 line systems. In this case the chrominance signal amplitude used in signal G2 is 25 percent greater than that on signal G.

Other signals which differ in amplitude and/or form are:

- Signal G1 (625 line), signal F (525 line) which have a different form and are used to measure chrominance-luminance gain inequalities.
- Signal D2 (625 line), signal D2 (525 line) which differ in amplitude and are used to measure differential phase and gain.



- Signal F (625 line), signal F (525 line) which differ in duration and are used to measure chrominance-luminance gain and delay inequalities.

NOTE: There is also a basic difference in the amplitude of the test signal components for all signals which is caused by the differing picture/sync ratio used by the 525 line and 625 line TV standards. These are respectively 2:5 and 2:33.

While these differences should not cause a distinct requirement for changes in system design (assuming the requirements for wider bandwidth and higher chrominance subcarrier frequency on 625 line systems are considered), the ability of a system, to meet the specification specified for one form of test signal and measured with another, may be compromised in marginal cases.

#### D.2.6 Average Picture Level

North American (525 line) systems specifications quote Average Picture Levels (APL) from 10 to 90 percent whereas 12.5 percent to 87.5 percent is used elsewhere. This difference in APL is based on the number of active vertical lines available in each system and slightly different techniques used to simulate the various APLs. Except in very marginal cases this difference should not cause a significant variation in the results obtained.

#### D.2.7 Signal/Noise Ratio

The definition of video signal/noise used in the U.S. differs from that used in all other countries. The U.S. definition relates noise to the picture plus sync components whereas the CCIR definition used elsewhere relates noise only to the picture component of the signal. The CCIR definition for the 525 line TV standard is therefore 2.9 dB more stringent than that used in the U.S.

Noise weighting factors defined for the various TV standards also vary significantly. Attempts to agree on a unified weighting standard are now underway in CCIR/CMTT. A report on this subject is discussed in the references at the end of this section. These differences in standards do not affect the system design requirements to a great degree but may cause the performance specification to be incorrect if they are not considered.

NOTE: A revision of the U.S. EIA Standard RS 250-A will bring the signal/noise ratio definition used in the U.S. into line with that of CCIR. This revision is currently in circulation for comment by the industry.

### D.2.8 References

Standards on television system performance and methods for the determination of performance are given in detail in the CCIR Green Book, Volume V. The important references are as follows:

- CCIR/CMTT Report 486 (Rev. 74): This report deals with the definition of transmission parameters, the test signal elements used to measure the various parameters, performance of hypothetical circuits and the laws of addition to be used to determine overall performance for a given parameter.
- CCIR/CMTT Recommendation 421-2: This recommendation covers the same aspects as Report 486. It is to a great degree obsolete and will ultimately be replaced by the information contained in Report 486.
- CCIR/CMTT Recommendation 451-1: This recommendation covers the same aspects as Report 486 but specifically for System I (U.K.). This recommendation will be replaced by the information contained in Report 486.
- CCIR/CMTT Recommendation 473-1: This recommendation defines the signals and signal dimensions to be used for international circuit performance measurement with vertical interval test signals. Since many countries will adopt these signals for national use this information is of some interest.
- CCIR/CMTT Report 410-2: This report deals with the study of a unified weighting network for signal/noise ratio on all systems.
- CCIR/CMTT Study Program 1-1D/CMTT and associated report (not numbered at time of writing): This report describes the problems found as a result of poor low frequency response on transmission systems. The solutions, including the use of clamping devices, are discussed.
- CCITT Recommendation N62: This recommendation, published in the CCITT Green Book, Vol. IV-1, Geneva 1972, provides information on operational performance requirements for terrestrial and satellite circuits.
- EIA Standard RS-250A (under revision): This draft standard contains information which is drawn from Report 486 and other sources and covers the definition of parameters, measurement methods and performance requirements.

### D.3 GENERAL EQUIPMENT CHARACTERISTICS

A number of equipment characteristics have some influence on the acceptability of a system in a foreign environment. These are discussed in the following subsections.

### D.3.1 Impedance of Baseband Interfaces

The impedance most often used on video systems throughout the world is 75 ohms unbalanced to ground. In Canada, however, many of the systems and components are designed for 124 ohms balanced to ground. This presents a problem for manufacturers in Canada where both standards are used, and has made design changes necessary on systems purchased offshore. Two examples of such changes are:

- BBC/PYE\* sound in sync equipment recently purchased for Canadian television networks. Auxiliary impedance conversion unit was designed to allow insertion in balanced cable circuits.
- Philips 12 MHz TV Modulating System 8TR 331/11 used with the 8TR 317/11 coaxial cable system. In this case the equipment was designed to Canadian specifications and included both impedance options.

Obviously, in this case, equipment designed for the dual Canadian standards would be technically acceptable offshore. Modification of offshore systems which usually use only 75 ohms is necessary for some applications in Canada.

### D.3.2 Clamping Devices

The need for more stringent design criteria on some types of system when clampers are not used is covered in Section D.3. The systems which are used in Canada with clampers would not be acceptable for some offshore organizations where philosophy dictates that clampers will not be used.

### D.3.3 Microwave Systems - Sense of Modulation

The sense of modulation (i.e., the carrier deviation polarity relative to peak white) is not standardized. As a result, both positive and negative senses of modulation are used by the Canadian carriers. When the baseband impedances of the FM terminals are 75 ohms, the interface of microwave systems at RF is not possible when both senses of modulation are used (the signal polarity would be inverted). Where such a possibility exists the FM terminals should be provided with a signal inversion capability.

### D.3.4 Signal Pre-Emphasis on Microwave Systems

Video signal pre-emphasis characteristics are defined by CCIR in Study Group IX, Recommendation 405. In addition to these, carriers in Canada use a pre-emphasis which is based on a Western Electric design (Bell System) which is not fully compatible with the CCIR network.

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\* British Broadcasting Corporation



#### D.4 SUMMARY

The topics discussed in the preceding sections cover the various differences in standards. In general, equipment manufactured strictly for the Canadian 525 line television standard would require some modification or change in specification for 625 line use. The following summarizes the changes which would be required:

##### D.4.1 Microwave Radio Systems

**Frequency Plans:** Some Canadian frequency plans are different from those stipulated in other countries and would need to be changed. In particular, the long-haul 4 GHz plan used in Canada does not conform. Long-haul plans standardized by CCIR employ a wider channel bandwidth, hence, the compliance with these plans will automatically improve the capability of the system for transmission of the 625 line television systems.

**Transmission Parameters:** The 625 line television system requires a wider baseband (up to 6.0 MHz) and as a result of the higher color subcarrier frequency (4.43 MHz), filters used in radio system must be designed to consistently high tolerances over a bandwidth which is wider than that required for the 525 line system. This is required to maintain the same levels of performance for the nonlinear distortions and baseband width enjoyed by the 525 line system with a lower color subcarrier frequency. Of course, the wider RF bandwidths used will more than offset the difficulty involved.

**Low Frequency Response:** Since clamping devices are not used in many countries the very low frequency response of video amplifiers in the FM terminals must be designed to stringent specifications to prevent excessive buildup of low frequency oscillation when systems are used in tandem. Since this topic is currently under discussion in CCIR and no numerical standards which are universally accepted are in existence, it is difficult to determine whether or not Canadian practices are equivalent to those used elsewhere. However, the latest FM terminal built and designed in Canada, the NECo RM-3 terminal, is as near perfection in this respect as is possible. (It is realized that this statement could be construed as being biased but the figures obtained will back it up.)

##### D.4.2 Video Amplifiers

In general, video amplifiers designed for the Canadian market exceed by far the basic requirement for bandwidth and should in all respects be capable of handling 625 line signals.

#### D.4.3 Baseband Cable Systems

Systems of the type used in Canada (solid state variants of the Western Electric A2A system) are not manufactured in this country. If they were made here to the same criteria as those made by GE and Telemet (both U.S. manufacturers) they would not be acceptable for 625 line transmission without some modification.

The changes required would involve:

- providing a wider bandwidth,
- improving the very low frequency response to eliminate the need for clamping devices,
- the use of 124 ohm cable balanced to ground might also not be acceptable to offshore organizations.

#### D.4.4 Coaxial Cable with Modulated Carrier

The systems used in Canada are built by Philips of Holland and equivalent systems are not available in Canada (the nearest equivalent is the old Bell System L3 cable system used in the U.S.A.). Should such a system be manufactured in Canada the sharp cut-off characteristics inherent in a modulated subcarrier system would make adherence to the CCITT standards for bandwidth a necessity. Such a system would therefore meet the requirements of the 625 line standards.

#### D.5 CANADIAN ACTIVITY

Apart from microwave systems manufacturers and manufacturers of video amplifiers (such as Central Dynamics and Richmond Hill Laboratories) there is little activity in the high-quality video transmission field. Complex cable systems, both baseband and sub-carrier systems used by carriers are manufactured offshore. With the exception of intracity links, video transmission was until recently totally confined to microwave systems and a market for heavy coaxial systems has not existed. Even for the Philips systems which have been purchased, the market is not large enough to warrant development in this country.

It can be concluded therefore that a major reason for the low level of activity in the long-haul high quality television carrier market is the lack of a consistent and high quantity demand for such equipment.

## SECTION E

## SOUND PROGRAM EQUIPMENT

This section covers the transmission of sound program signals over telecommunication carrier networks and excludes distribution of program signals by means of broadcasting and cable distribution systems such as CATV.

Sound program signals may be distributed by baseband cable systems, cable carrier systems, insertion into the complex high density message systems by frequency division multiplex, frequency modulated subcarriers on microwave radio systems, or by discrete or time shared digital systems. There are two basic differences in standards. The first is bandwidth which does not present a design problem to the would be exporter but requires the production for some systems of dual lines of products. The second difference is program level references which must be understood if the equipment is to be properly defined and specified. These areas are discussed further in the following sections.

## E.1 OUTSTANDING DIFFERENCES IN STANDARDS

## E.1.1 Bandwidth

Program circuit bandwidths are in some cases different in Canada when compared with those recommended by CCIR/CMTT. The bandwidths are:

- Canada: 5 kHz, 8 kHz and 15 kHz;
- CCIR: 5 kHz, 6.4 kHz, 10 kHz and 15 kHz.

Variation in bandwidth probably does not affect the design of program amplifiers, but it will cause design changes to be necessary when cable equalizers and FDM Group Band insertion equipments are considered. In the latter case the number of voice channels replaced by the program channel will vary with bandwidth as will the bandwidth of the modulated signal.

## E.1.2 Program Level Reference

The measurement of program levels is far from being standardized. Measuring instrument characteristics used in various countries have significant differences, a very large one being the type of filtering employed in the instrument, which result in measurements which vary from quasi peak to quasi

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\* The 5 kHz circuit is recommended primarily as a commentary circuit.

rms. This obviously has a bearing on amplitude head room relative to a given reference level which must be considered at the design stage. One further point of confusion exists in regard to the units used in Canada which are 'Volume Units' (VU) and those used by organizations which prefer CCIR nomenclature where milliwatts are standard with psophometric weighting.

These differences in measuring standards have little effect on system design but must definitely be considered in system specification.

### E.1.3 References

CMTT Study Programs (listed below) have resulted in a large number of reports and recommendations which are available at the time of writing only as Pink documents from the 1974 CCIR Plenary session. The content of these results from the last session of CCIR will in some cases alter the content of CCITT J Recommendations listed below.

- CMTT Study Programme 5-1A-1/CMTT
- CMTT Study Programme 5-1B-1/CMTT
- CMTT Study Programme 5-1C-1/CMTT
- CMTT Study Programme 5-19/CMTT
- CMTT Opinion 41
- CCITT Recommendation J11
- CCITT Recommendation J12
- CCITT Recommendation J21
- CCITT Recommendation J22
- CCITT Recommendation J23.

The following recommendations and the reports and recommendations resulting from the CCIR/CMTT Study Programmes provide information on program circuit requirements.

- CCITT Recommendation J14
- CCITT Recommendation J15
- CCITT Recommendation J21
- CCITT Recommendation J22
- CCITT Recommendation J23;

- National Association of Broadcasters Handbook.

These references provide information on signal levels, and methods of measurement, including data on the measurement instruments.

### E.2 EQUIPMENT STANDARDS

These standards involve topics such as compandor characteristics, FDM group access frequencies etc., details of which are discussed in the following subsections.

### E.2.1 Compandor Characteristics

Information on compandor characteristics working at group band frequencies is given in CCITT Recommendation J31. In addition, Canadian systems have for years used compandors which operate at baseband frequencies. A great deal of experience on these systems has led to considerable input to CCIR/CMTT Report 493 (Rev 72), and recent advances in this field will undoubtedly cause further inputs to be originated.

There is considerable disagreement between various organizations regarding the relative merit of HF and baseband compandors. Given the standardization of both types, which are incompatible, the companding law must also be standardized. Dual band compandors have recently been shown in Canada to provide the answer to some of the problems caused by single band compandors - introducing yet another variant in system characteristics.

### E.2.2 Group Band Access

Apart from differences in bandwidth there are also differences in the carrier frequency used in Canada and those recommended by CCITT for monophonic transmission. These are 88 kHz in Canada (Bell System) and 96 kHz or 95.5 kHz recommended by CCITT.

These differences involve different carrier frequency supplies and HF filters in the modulating equipment. This requires dual lines to be manufactured by would-be exporters.

NOTE: Group band transmission of stereo signals has recently been introduced in Canada using a Siemens system purchased offshore and designed to CCITT standards.

### E.2.3 References

- CCITT Recommendation J31: Provides information on group band access options and HF compandor characteristics.
- CCIR/CMTT Report 493 (Rev 72): Provides information on the results of using compandors on programme circuits.

## E.3 GENERAL ITEMS

### E.3.1 Noise Weighting

At present system noise performance is considerably confused by the existence of a number of noise weighting curves. A study is underway to determine a single weighting network, the results of which were contained in CCIR/CMTT Draft Recommendation AM/CMTT (1972) (Rev. 1974).

Noise weighting will have a direct effect on system specifications and may affect the design.

### E.3.2 Access Jacks

There are many types of plugs and jacks throughout the world the use of which must generally be tailored to the practice of the system user.

Many manufacturers now allow for a number of different access jacks during initial design. An example of such a change being negotiated with its manufacturer is the Siemen's stereo modulating system recently introduced into Canada where a number of physical changes were required to adapt the equipment to the Canadian environment.

### E.4 SUMMARY

Standards have quite a large effect on the design of program transmission equipment resulting in some cases in dual lines of equipment to meet CCIR/CCITT standards and Canadian standards. These differences involve primarily bandwidth and group access frequencies on FDM systems. Some important differences in standards also affect the system specification - level references and noise weighting characteristics.

## SECTION F

## OVERVIEW OF SWITCHING SYSTEMS AND CUSTOMER EQUIPMENT

The following section gives an overview of differences existing between countries in the field of Telephone Switching, PBX and Station Systems. It will identify areas for future study in order to evaluate the significance of differences in standards.

## F.1 SWITCHING SYSTEM TYPES

## F.1.1 Manual Switching Systems

Although not many manual switchers still exist in North America, switching toll and local calls by an operator is still done in many locations in other countries. Other switching machines will obviously have to interface with this manual operation, and be able to recognize the signaling type used (see Section F.2).

## F.1.2 Automatic Switching Machines

By far the majority of switching machines in use today are automatic, and they can be classified into three major types: electro-mechanical selector, common control and stored program control.

## a) Electromechanical Selector Type

These are typically electromechanical rotary selectors (Step-by-step in North America or two-motion selector (Strowger) in Europe) and have limited flexibility in accommodating new features and, because of this, there is a conscious effort in North America to replace them with modern equipment. Unfortunately, in most countries (especially Britain and France) this equipment is predominant in their switching network, and so their ability to changing customer needs is severely hampered (e.g. the addition of pushbutton dialing or Centrex<sup>®</sup> operation is difficult and expensive to apply).

## b) Common Control - Wired Logic

This is a more flexible type of switcher with the ability to carry out translations (the ability to determine routes and class of service). The talk paths are switched through a matrix of electromechanical crosspoints, under the management of a wired logic controller. The North American version is termed Cross-bar<sup>®</sup> and European types include ESC-1 and LME<sup>®</sup>.



### c) Stored Program Control

This is the current line of switching machines using electronic processors (similar to that of a computer) to control the switching matrix which may be electromechanical, reed relays, or even a time/space division digital switch. Such machines are now being produced, field-trialed and introduced into the switching network of many countries, and probably constitute the major revenue producers of potential inter-country trade in switching machines. Their flexibility is high, as they have the ability to accommodate new features by simply reprogramming the software (a much easier task than hardware modifications or additions). These machines also have a much higher degree of self-maintenance and self diagnosis than any other machines and need less manpower to operate them. Examples of this type of machines are SP-1<sup>®</sup> in Canada, ESS<sup>®</sup> in U.S., D10<sup>®</sup> in Japan and Metaconta<sup>®</sup> in Europe.

## F.2 SIGNALING SYSTEMS

### F.2.1 CCITT Signaling Systems

Standardized signaling systems have been proposed by CCITT, providing guidelines for telephone administrations to follow. This was deemed necessary due to the advent of international dialing between countries. Although signaling systems in some countries do not conform with these standards, it is presumed that, in the future, attempts will be made to conform, especially with the installation of new switching systems.

In the systems described below, register, line, in-band and compelled signaling are referred to.

Registers are types of equipment which store and forward the information about a call during a call setup. Inter-register signaling transmits dialed information, class-of-service and state-or-connection of the call.

Line signaling involves seizure, release, answer and clear signals, and may be transmitted at any time (usually when registers are not associated with the connections).

In-band signaling is that which is done over the talk path connection.

A compelled signaling system is one in which one signal in the forward direction and one signal in the backward direction are always used in combination, so that the length of each of these signals is determined by the other.

Fully (or continuously) compelled signaling exists where the operation continues unbroken until signaling has been completed.



Partial or pulsed compelled signaling exists where it is permissible for some signals to be of fixed duration only (i.e. timed) rather than being dependent upon a signal in the reverse direction.

Terminal traffic is calls which terminate at locations served by the switching center. Transit traffic is calls which pass through switching centers en route for another location.

a) System #3

One-way operation (preventing a simultaneous double seizure from both ends), this system uses an in-band 2280 Hz frequency for transmitting both line and register signals. It is suitable for terminal traffic in Europe only.

b) System #4

One-way operation, this system uses frequencies 2040 and 2400 Hz for end-to-end transmission of line and register signals. It is used internationally in Europe and is suitable for terminal and transit traffic, submarine or land cable circuits and microwave radio circuits. Two or three System #4 switchers may be connected in tandem. However, it is not compatible with TASI<sup>1</sup> - equipped systems, and its use on satellite circuits may not be practicable as the call setup speed is slow due to the compelled digit-by-digit method of inter-register signaling.<sup>3</sup>

c) System #5

This two-way system uses frequencies 2400 and 2600 Hz for link by link transmission of line signals, and a 2-out-of-6 code<sup>2</sup> transmitted en bloc for link-by-link transmission of register signals. This is used for intercontinental traffic via TASI-equipped submarine calls land cable, microwave radio circuits (TASI or not) and satellite. Two or more #5 systems can be connected in tandem and it is compatible with Systems #4, #5 bis and #6.

d) System #5 bis

This system is similar to System #5 but has more facilities, using the same 2-out-of-6 code but with a guard and TASI locking frequency (1850 Hz) for link-by-link transmission of register signals, as a forward and backward exchange of information during call setup. Its suitabilities and compatibilities are otherwise the same as in System #5.

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<sup>1</sup> Time Assignment Speech Interpolation - a concentrator technique used mainly on undersea cables which 'packs' bursts of speech into available time.

<sup>2</sup> Two frequencies out of 700, 900, 1100, 1300, 1500, and 1700 Hz.

<sup>3</sup> Ref: Post Office Electrical Engineering Journal, Vol 63, Part 4, Jan 71

## e) System #6

This system is designed to provide separate - channel signaling for high-usage routes. The signaling (both line and inter-register) for all channels between two points is concentrated on a 2400 bps link using 4-phase modulation. When such a system is used between stored program switching machines (Section F.1.2c the high-speed data link provides faster call setup and reduced holding time on the talk paths.

## f) System R1

This two-way system uses an in-band 2600 Hz frequency, continuous-type for line signaling, and a 2-out-of-6 code for forward transmission of register signals. It can be utilized for both terminal and transit traffic, but does not have compatibility with TASI-equipped systems.

## g) System R2

This two-way system uses a 3825 Hz continuous-type low-level frequency for line signaling and a 2-out-of-6 code<sup>4</sup> for end-to-end, continuous compelled transmission of register signals. It can be used for both terminal and transit traffic, but does not have compatibility with TASI-equipped systems of 3KHz spaced channels, and is not recommended for use with satellites. It was designed for 2-wire compatibility but is usually used in a 4-wire mode.

## F.2.2 North American Signaling Systems

Signaling in both the United States and Canada are almost identical and are therefore termed North American signaling.

## a) Line Signaling (dc)

Some of the more well-known dc signaling systems are dc loop, Reverse Battery, High-Low/Low-High (variable impedance resistive shunt - not used in Direct Distance Dialing), Wet/Dry (battery/shunt - a disadvantage in DDD). Battery and Ground (voltage at both ends doubles the current available), and E & M.

## b) AC Signaling

Inband signaling includes single frequency 2600 Hz in the 4-wire mode and 2600 and 2400 Hz in the 2-wire mode. Out-of-band signaling uses frequency 3700 Hz on N, 0 and ON carrier, multifrequency (MF) signaling uses 2-out-of-6 frequencies as in CCITT System #5.

<sup>4</sup> Forward Signaling - 1380, 1500, 1620, 1740, 1860, 1980 Hz  
Backward Signaling - 1140, 1020, 900, 780, 660, 540 Hz

### c) Separate Channel Signaling

AT&T have proposed a separate channel signaling system namely Common Channel Interoffice Signaling (CCIS). This software option has been included in all electronic switching machines currently being installed in North America, but has yet to be used extensively in the network. Its purpose is similar to CCITT System #6 but its mode of operation and format are slightly different.

### F.2.3 Comparison of Signaling Systems

Due to the unique frequencies used, CCITT Systems #3 and #4 are incompatible with North American signaling. Conversions are possible between the systems, but would be probably unwieldly and expensive.

However, CCITT System #5 is compatible with North American signaling and both are used for intercontinental traffic with or without TASI-equipped systems.

CCIS and CCITT System #6, although basically designed for the same purpose, have different formats and are therefore basically incompatible. Conversions could be made using microprocessors but this approach could be unwieldly compared to redesigning the software.

CCITT System R1, is in fact, the same as North American SF signaling with MF pulsing although some minor modifications would be necessary. System R2 is incompatible with North American signaling.

Generally, the question as to whether a non-domestic switching machine could be installed to interface with an existing network (on a signaling basis) should be approached on an individual basis as to what signaling systems it must interface with. Other incompatibility considerations may preclude its use, however, and these are covered in the sections to follow.

### F.3 TONE STANDARDS

Various audible tones are applied to the switching network at various points in time to indicate to the caller (or operator) what the status of the call is. Such commonly recognizable tones are, for example dial tone, ringing tone and busy tone. Unfortunately, each country has implemented their own combination of tones, not only having different frequencies (or multiples thereof) but also different make/break ratios. This makes international dialing somewhat confusing, as a caller may reach a tone and not be able to interpret its meaning. It may therefore, be advantageous to provide the intervention of an operator at the incoming international exchange in the event of the receipt of these tones. A special information tone is provided in some European countries (not in North America) which indicates that the caller should get in touch with his operator - this tone is

provided between recorded messages (in a potentially foreign language), by foreign operators and, if not, interception facilities are available for abnormally terminating calls (line out of service, changed number, telephone answering service, no such number, inland congestion). CCITT System R2, on receipt of this tone, drops the international link and provides a tone from the local country.

The installation of a new switching machine, therefore, must accommodate all the tone frequencies and repetition rates peculiar to that country. New hardware may have to be designed and installed on a per-country basis. This is not as major a modification as that with signaling incompatibilities, but will still require some effort on the part of the manufacturer.

#### F.4 ACCOUNTING

Various methods are employed to charge customers for the calls they make. Normally in North America a customer pays a flat monthly rate for equipment rental, and this also entitles him to unlimited free calling to other phones served by his local exchange, and also a number of other specified exchanges which comprise his 'local free calling area'. The monthly rate is also a function of the number of phones to which he has unlimited free access. Should he wish to call outside this area, then each call is charged at a rate dependant on its distance and duration using one of the methods described below.

Other charging philosophies, in use primarily in Europe, charge the customer for every call he makes, whether it be a local call or long distance. The charge is again dependant on distance and duration, but obviously every call must be processed through the accounting system.

Current Stored Program machines are easily adaptable between the different charging systems.

##### F.4.1 Usage Sensitive Pricing

One of the earlier methods used to automatically keep track of the telephone usage of each customer was to assign each a meter or register (similar to electric or gas meters in concept). These would generally be electromechanical, and be incremented by switching machines initially or as the call progressed and by amount dependant on distance. There are three major types of registers.

###### a) Coulomb - meters

These meters measure the quantity of electricity (ampere-hours) used over the duration of the call. As the rate of consumption is independent of the distance of the call, some modifications (e.g., adjusting shunts) must be made to discriminate between rate groups. Their accuracy is dependant on many factors, which tend to cause undue variations in charging rates.

## b) Pulse Counters

These registers are incremented by pulses which are periodically sent to them from the switching equipment. Each pulse can then be translated into its equivalent current worth and the customer billed accordingly. The pulses can be sent every 3 minutes, 1 minute, or 6 seconds, as necessary and the number of pulses sent will obviously be a function of the distance of the call. Individual calls are not identified on the bill.

## c) Scanners

These can be electromechanical or electronic equipment which scan the status of the lines periodically to detect whether a call is in progress or not. Changes of state are recorded, when applicable, on magnetic or paper tape, together with enough information to assemble the billing details of the call by downstream data processing. This method has the advantage over (a) and (b) in that individual call records are produced for the customer to see rather than an accumulated total.

The different philosophies in message charging will undoubtedly impose an opportunity cost on the manufacturer of switching machines. Most modern day stored program electronic machines use method (c) and store the records on magnetic tape. If a per-customer register is required as in (b) such a facility may be provided within the program software (rather than by hardware). Some machines already have this feature but it may tend to reduce machine call attempt capacity.

Other factors that must be taken into account under the accounting category are (i) Division of Revenue (between participating telephone administrations) and associated traffic measurements, (ii) discrimination between automatic and operator assisted calls, (iii) omission of international transit traffic and (iv) discrimination according to destination, when a country has many charging zones or special frontier arrangements.

## F.5 STATION SETS

The telephone situated at the customer's premises is referred to as a station set, and differences exist between those in use in North America and in Europe.

The transmit level of European sets is 3 to 5 dB higher than those of North America, and the sidetone level is 3-4 dB higher, although they have equal receive levels. The dialing speed of each are nominally the same (10 pps) although the interdigital timing is different. The characteristics of the ringer (bell) of the sets are also radically different,



being operated by a different frequency in each country and having vastly differing internal impedance, being 900 ohms for the former and 600 for the latter, but some countries use both standards. North American sets contain components which by-pass heavy loop currents when a short loop is utilized between set and exchange, while most European sets do not (exceptions are BPO and Ericsson).

Another difference is that most countries have their own standards for payphones or coin-collecting boxes. They require their own coins to be accepted and some have unique systems which return unused coins to the caller after the call is complete (e.g., Switzerland). They often require special trunking arrangements and operating voltages.

It is evident, then, that because of these hardware differences (some of them major), North American and European telephone sets are not directly interchangeable. It should, however, be mentioned that some administrations' acceptance criteria are more lenient than others, so substitution may be possible in some cases.

#### F.6 PBX<sup>5</sup> Systems

A PBX is normally located at the customer's premises (office, factory, etc.) and has one or more operators, employed by the customer, whose job it is to receive incoming calls and relay them to the appropriate stations (or extensions).<sup>6</sup> PBXs have seen some of the heaviest commercial competition of all telephone systems, probably because of their profitability when obviously the manufacturer has a free reign in his design of the station sets, internal features, etc. His only constraint is that he must interface with the outside world and be compatible with the switching machine of the telephone administration which is providing telephone service. The system, however, will need to be maintained by the telephone administration.

It is at this point that the problems start. The PBX manufacturer must provide trunk circuits (that which connects the PBX to the outside telephone lines) which can correctly function with any telephone exchange encountered. He may have to redesign a separate trunk circuit for each interconnection envisaged, and therefore foreign interfaces may involve him in even further hardware development.

Other incompatibilities include differences in the requirements of foreign purchasers - differing ringing and tone standards (see 4.0) and other unique features that the customer insists on being available.

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<sup>5</sup> Private Branch Exchange

<sup>6</sup> Direct In-Dialing is not normally included in the historical definition of PBX.

## F.7 MISCELLANEOUS SWITCHING INCOMPATIBILITIES

Various minor points arise which must be resolved somehow for switching machines to be compatible with their ambient.

Various associations of dial pulses with the position of the number on the dial (three world standards) could cause some confusion. The association of letters of the alphabet with numbers on a rotary or pushbutton dial is also different on either side of the Atlantic Ocean. North American practice is to associate letters M, N and O with the number 6 and Q with number 0 (zero), whereas Europe tends to associate M and N with 6, and Q & O with number 0. This problem could eventually be eliminated if all alphabetic use in telephone numbers were phased out. However, this would be a massive task.

Party line methods of operation differ widely between countries (varying from 2 to 10 or more parties in some rural areas), and switching machines may be called upon to provide such unique systems to customers or administrations unwilling to upgrade their service for economic reasons.

Numbering plans of different countries also differ widely. Some countries have a set number of digits to be dialed for any connection within its boundaries, and this can be different for local or long distance calling (e.g., North America). Other European countries require a variable number of digits to be dialed, independent of local or long-distance but more a function of routing. In fact, in some cases, access codes to the same city or zone will depend on where you are calling from within that country. It will be evident, then, that switching machines that are designed to accept a fixed number of digits before processing a call will have to be modified to detect the end of dialing in another manner. In some cases the machine's digit receiving capacity may have to be expanded to cover the additional digits used, and modifications must be developed to prevent fraudulent calling. This may result in extensive development.

## F.8 SUMMARY

As has been established in the preceding sections, the inclusion of a foreign switching machine in a domestic telephone environment is likely to incur myriads of incompatibilities.

Major modifications are likely to be required to interface with signaling systems not supported in the original design.

Tone differences do not pose such drastic problems, as tone sources (and repetition rates) can be substituted for existing ones fairly easily.

The message charging philosophy (accounting) will need to be thoroughly investigated to determine what (if any) modifications are required - some machines already have the software for usage sensitive pricing with the associated hardware under development.



Whether or not station sets can be substituted for one another depends to a large degree on the tolerances of the test criteria of the accepting telephone administration - normally modifications would be needed and may therefore affect their economic feasibility.

Problems with PBXs reside in the interface with the outside world - trunk circuits, and special features not normally provided by the PBX. Miscellaneous switching incompatibilities include the use of alphabetic letters in a phone number, party lines and numbering plans.

#### F.9 CONCLUSION

As was stated in Part 1 of this section, this is only an overview of Telephone Switching PBX and Station Systems. In order to deal with this subject in greater depth, so that specific questions and examples may be covered, it would be necessary to commission a study with more time available than was currently allocated for this work. This could also address itself to the concept of digital switching, whose era is on the horizon.

## SECTION G

## OVERVIEW OF VOICE-FREQUENCY (VF) TRANSMISSION

To a large extent, the line facilities and apparatus that are applied in practice to the local telephone plant operate at Voice Frequency. The loop plant employs a two-wire mode of operation almost exclusively, and the local network trunk plant is operated in both the two-wire and the four-wire modes. In either mode, the transmission medium introduces signal loss which must be controlled within established limits in order to provide satisfactory service. When the losses exceed the established limits, compensation must be made by means of voice-frequency repeaters (amplifiers and associated circuit features) whose gains are designed to restore signal amplitudes. For economical circuit design, then, proper choice must be made of the minimum wire size compatible with circuit length, as well as the appropriate repeater type relative to mode of operation, wire size, and circuit length.

The telephone station set is basically a four-wire instrument, one that requires two wires for the transmitter and two wires for the receiver. If the four-wire nature of the set were extended into the entire local plant including both loops and trunks, four wires would have to be provided for every connection including the transmission paths through the switching machines. Such an arrangement would offer some transmission advantages, but it would be inordinately expensive since it would nearly double the amount of copper required for cables and other types of conductors needed to provide transmission paths and would impose a burden on local switching machines, nearly all of which provide two-wire transmission paths only. To avoid this expense, the station set is provided with circuitry that combines the transmitter and receiver conductors so that only one pair of wires is needed for transmission in both directions. This arrangement is called two-wire transmission.

Two-wire transmission is used almost exclusively in loops and commonly in short trunks between local central offices. However, when trunks are long or when the bandwidth is significantly greater than the 4 kHz used for speech transmission, the technical problems are such that four-wire transmission is necessary. Net losses can be held at lower values, and there are fewer echo and singing paths. Therefore, there are applications for four-wire voice-frequency circuits even before carrier applications become economical.

The following sections give an overview of system definition and the necessary components required in VF transmission systems in order to ensure satisfactory system performance.

## G.1 DEFINITION OF TECHNICAL TERMS

This section defines the technical terms used throughout this study. These definitions are required to compare standards used by various administrations to provide Voice Frequency telecommunication services.

To provide the communication required, a transmission system must supply the means and facilities for connecting a customer's stations at the beginning of the call and disconnecting them when the call is completed. This involves switching, signaling and transmission functions. The switching functions include identifying and connecting the customers to a suitable transmission path. The signaling function involves supplying and interpreting the control and supervisory signals needed to perform this operation. The transmission aspect deals with the transmission of the customer's message and the control signals.

For this reason, this section provides a brief outlook of switching plans used and defines the technical terms in relation to these plans. It also provides the same information for the transmission plans.

### G.1.1 CCITT Definitions

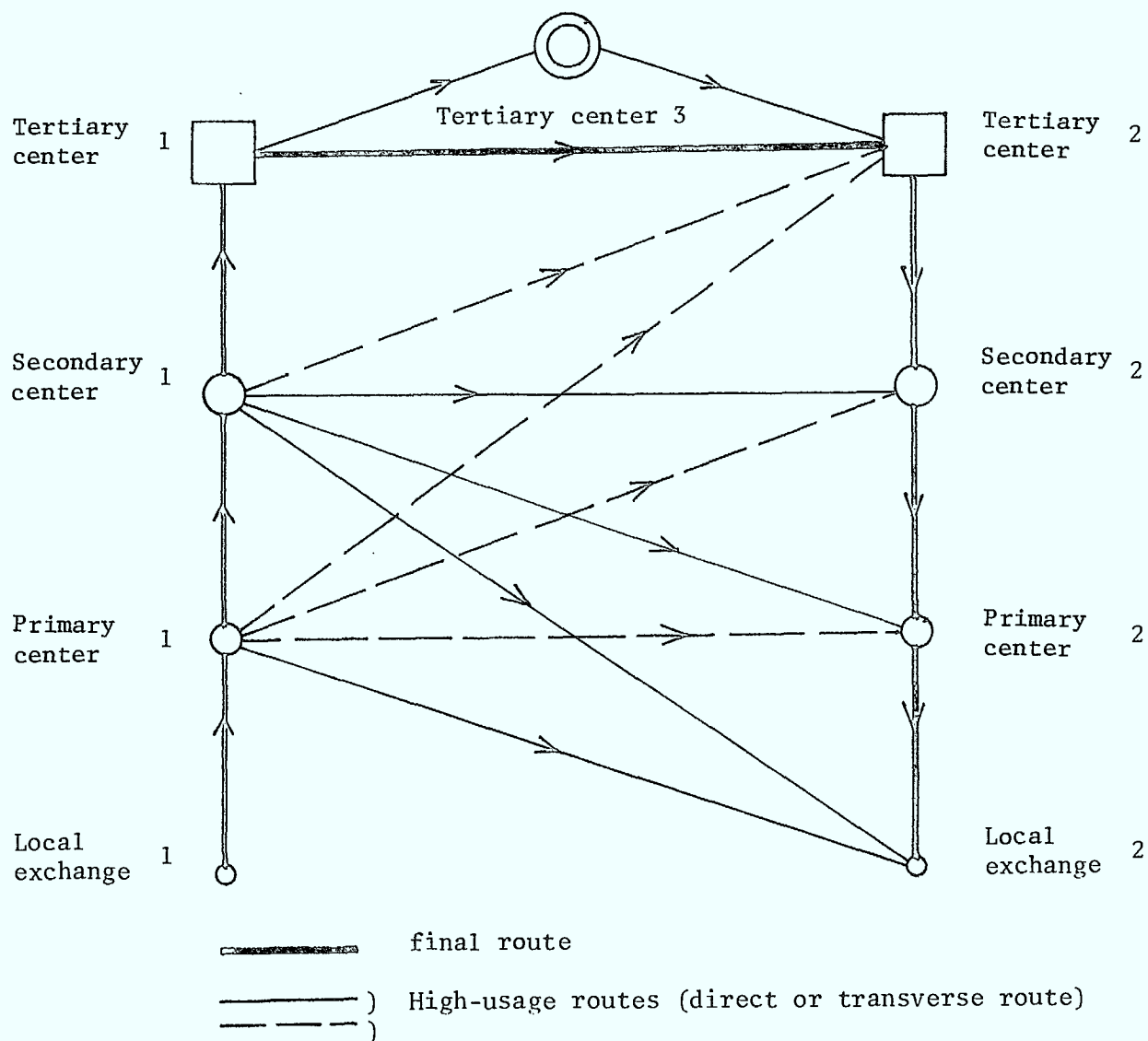
#### SWITCHING PLAN

The switching hierarchy in a national network depends on the size of the network and on the number of four-wire circuits in the national chain.

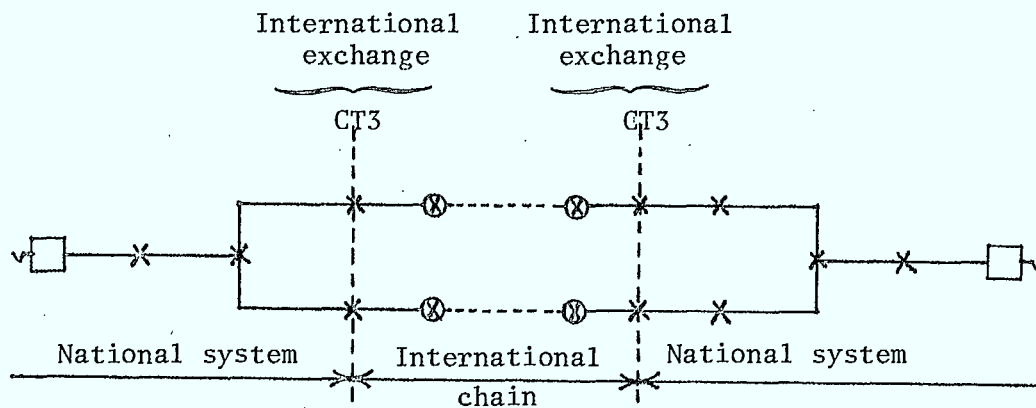
For the purpose of this study, Figure G-1 shows the hierarchy of the National network of the Federal Republic of Germany. Apart from the actual final route, this figure also shows high usage routes.

National Systems: these may comprise one or more four-wire national trunk circuits with four-wire interconnection as well as circuits with two-wire connection up to the terminal exchanges and to the subscribers.

International Chain: made up of one or more four-wire circuits interconnected on a four-wire basis in the international transmit centers and on a four-wire basis to national systems in the international centres. Figure G-2 shows the constituent parts for an international connection.



**FIGURE G-1**  
Switching Hierarchy in the National Network  
of the Federal Republic of Germany



X Switching exchange

⊗ International transit center (CT1 and CT2)

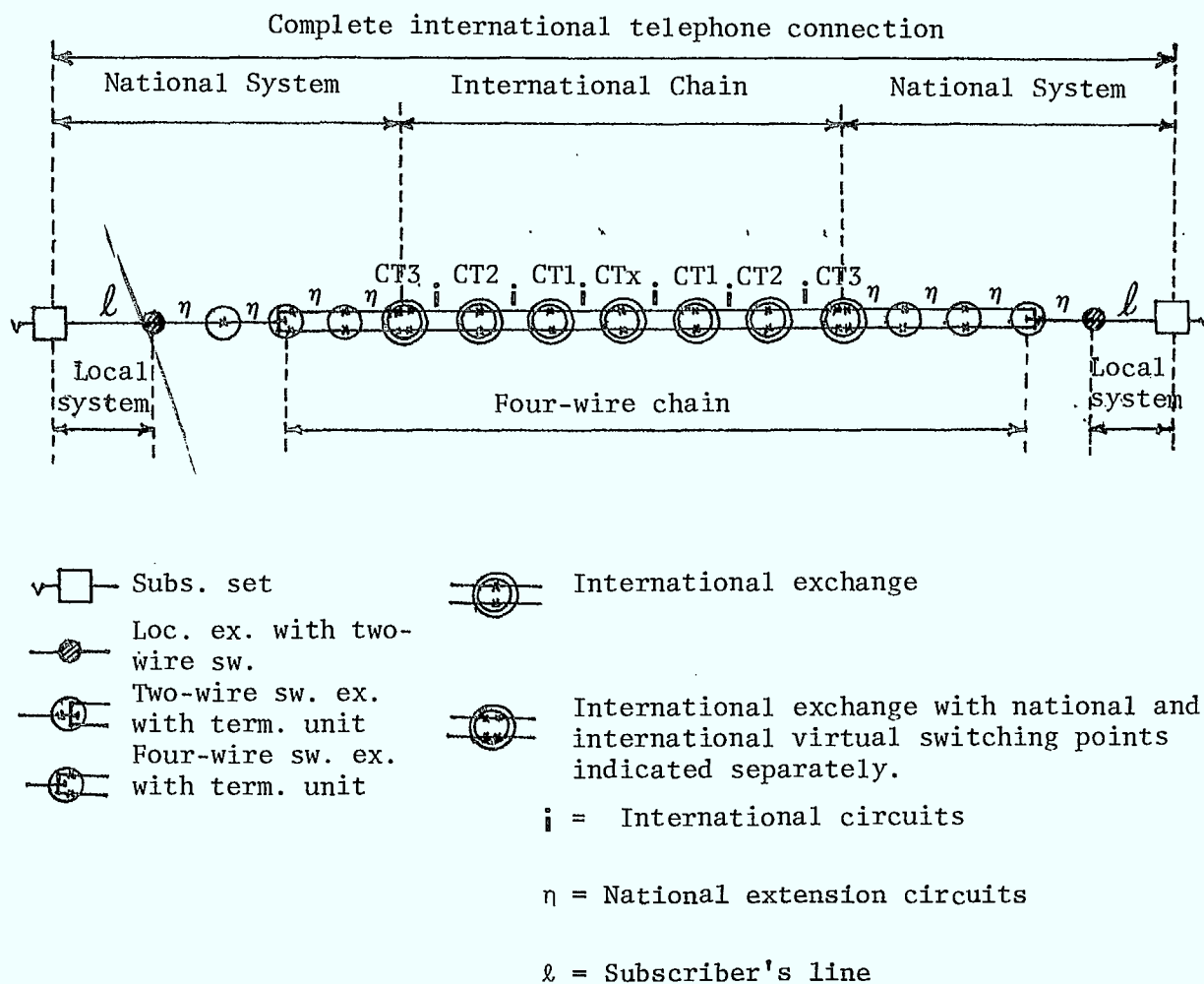
**FIGURE G-2**  
Constituent Parts of an International Connection

#### TRANSMISSION PLAN

The transmission plan of the CCITT was drawn up in 1964 with the object of making use, in the international service, of the advantages offered by four-wire switching.

Figure G-3 shows a complete international telephone connection including two national systems and the international chain. It also illustrates the nomenclature adopted by CCITT.

Four-wire chain: chain composed of the international chain and the national extension circuits connected to it by four-wire switching.



NOTE - The arrangement shown for the national systems are examples only.

**FIGURE G-3**  
**An International Connection**

Virtual switching point: the division between the international chain and the national system. Figure G-4 shows the virtual switching points and their relative levels in dBr.

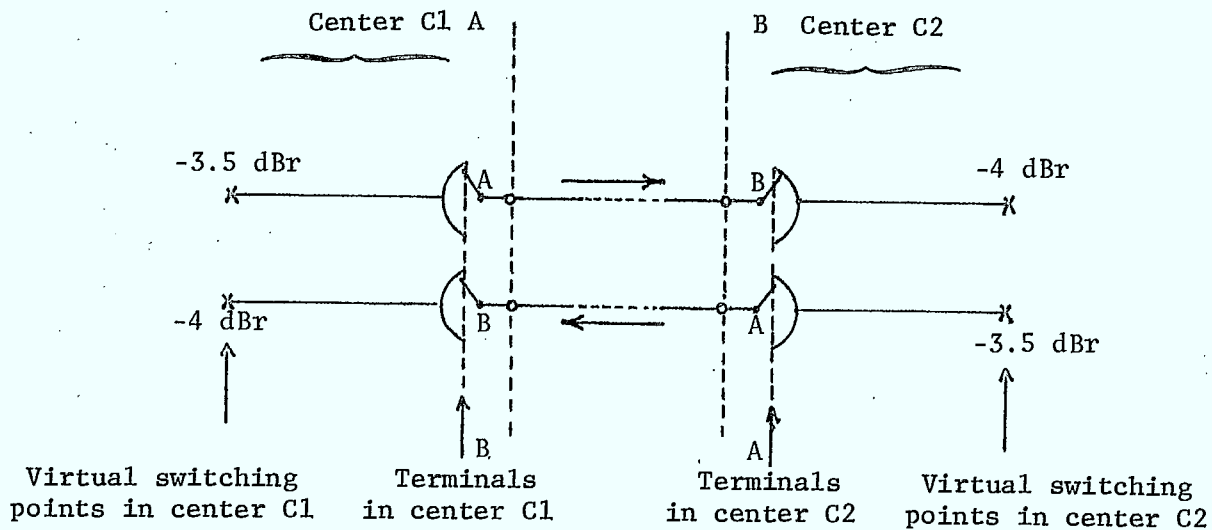


FIGURE G-4  
Virtual Switching Points

Nominal reference equivalent: national sending and receiving reference equivalents are those calculated at the virtual switching points of the international circuit.

Nominal transmission loss: the difference in a four-wire circuit between virtual switching points of the sending and receiving nominal relative levels at the reference frequency.

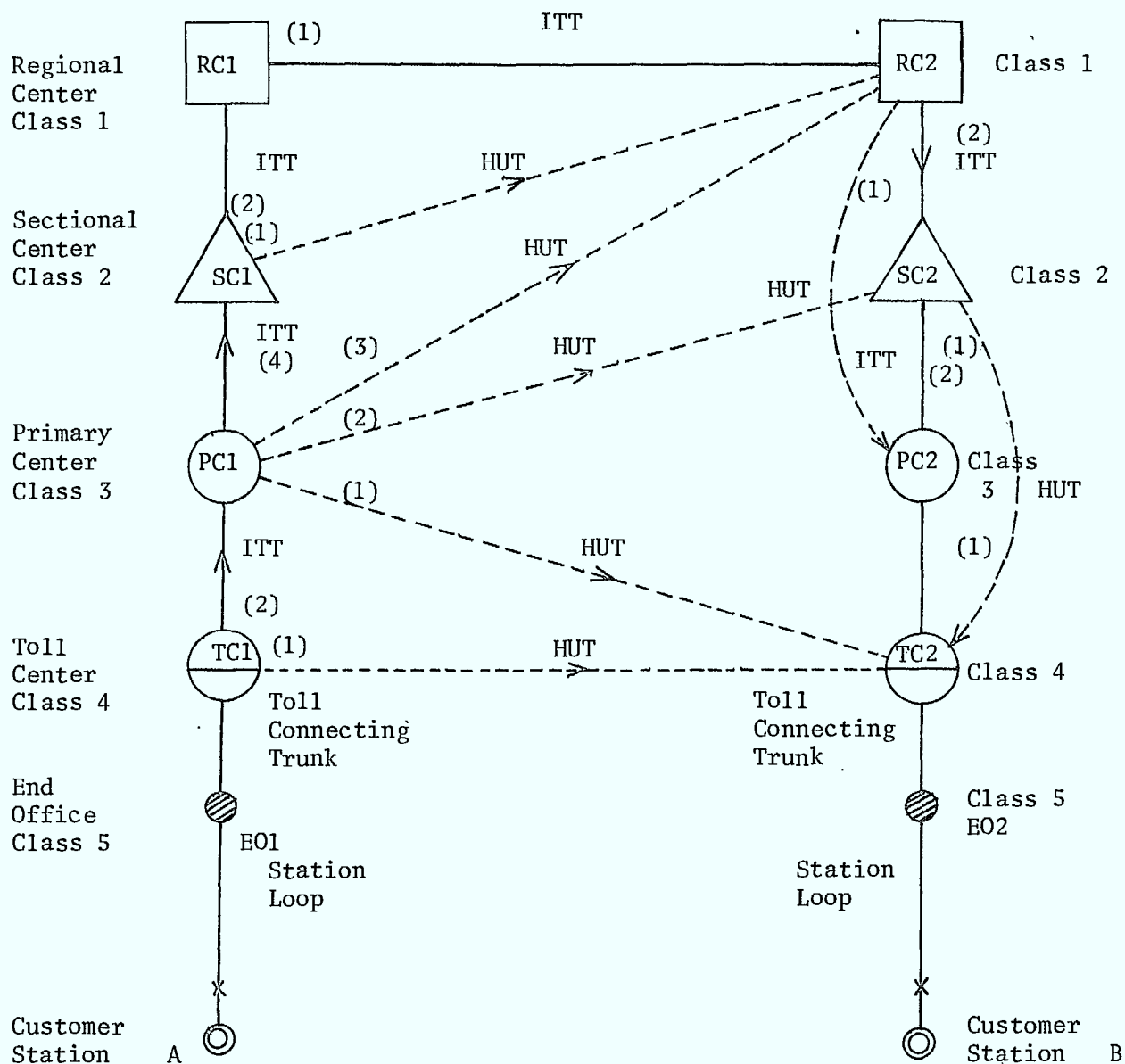
#### G.1.2 Canadian Definitions

##### SWITCHING PLAN

The present switching plan for the switched network involves a five level hierarchy of switching offices. These are identified as the end office (Class 5) which serves the subscriber lines, the toll center (Class 4), the primary center (Class 3), the sectional center (Class 2) and regional center (Class 1). A maximum of nine interoffice circuits may be encountered in this switching plan to complete a call between two end offices.

Figure G-5 shows this switching plan and the choice of alternate routes.





**FIGURE G-5**  
Choice of Routes on Assumed Call

Class of office: is the ranking assigned to switching offices in the switched network, determined by their switching functions and interrelationships with other offices (see table below).

CLASS NO.	NAME	ABBREVIATION	HOME OFFICE
1	Regional Center	RC	
2	Sectional Center	SC	Class 1
3	Primary Center	PC	Class 2, Class 1
4 { 4C 4P	Toll Center Toll Point	TC* TP**	Class 3, Class 2, or Class 1
5	End Office	EO	Class 4, Class 3 Class 2, or Class 1

\*TC: a center where operator assistance can be provided on incoming calls.

\*\*TP: provides operator assistance only on outgoing calls, and may have no operators at all.

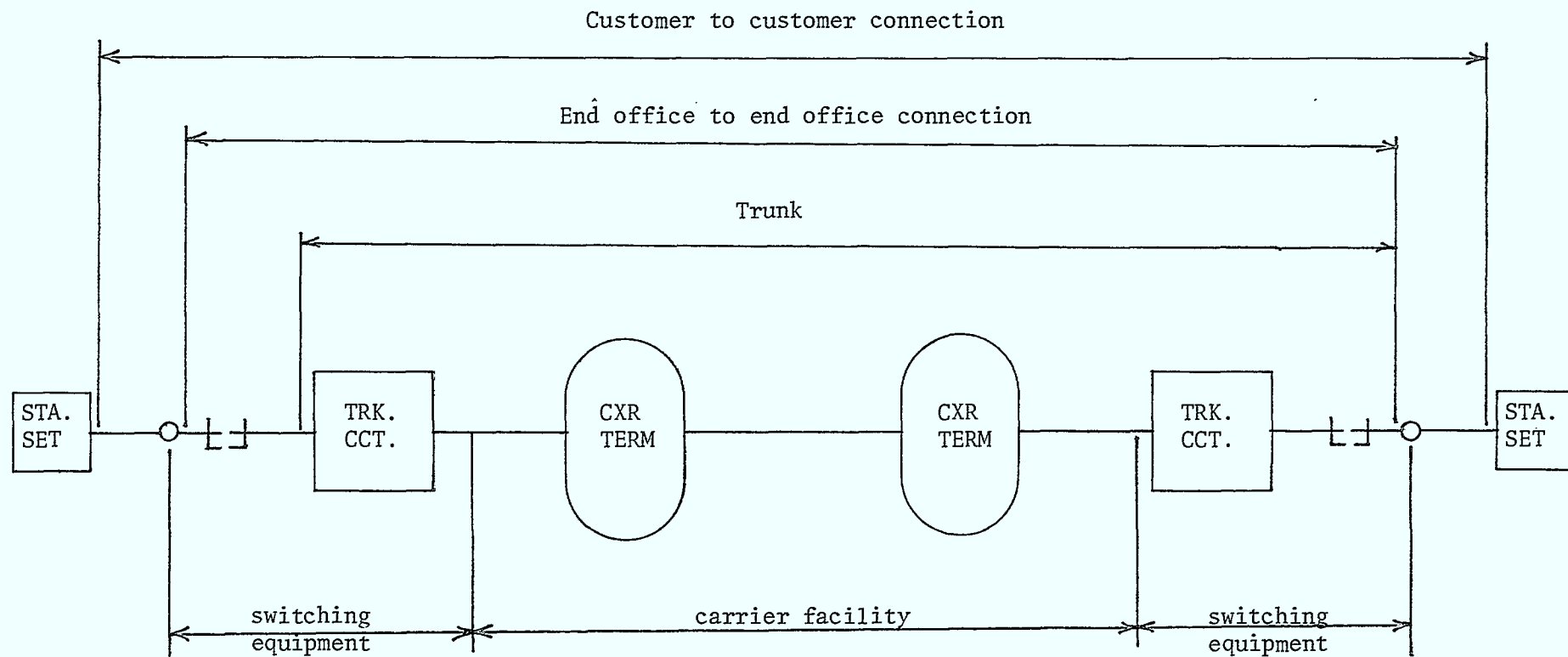
Trunk: a communication channel between two switching centers. It is defined as extending from the outgoing side of the switch in the originating office to the outgoing side of the switch in the terminating switching office to which the trunk is connected. It therefore includes the switching path at the terminating end, the office equipment at each end and the transmission media between the two offices.

Station Loop: the transmission path between the station apparatus and the originating switching office. It extends from the line terminal of the station apparatus to the main distributing frame.

#### TRANSMISSION PLAN

Figure G-6 shows a customer-to-customer connection through an intermediate office using carrier facilities.

Customer-to-Customer Connection: such a connection includes two loops and one or more trunks in tandem. It is therefore the transmission path encountered by a customer.



**FIGURE G-6**  
Relationships between Definitions

End Office to End Office Connection: the same as a customer-to-customer connection except that the normal loop facilities are replaced by zero length loop facilities.

Station Apparatus: refers to any type of customer telephone or other terminal apparatus.

Originating Switching Office: the end office at which the calling customer's line is connected.

Intermediate Switching Office: any tandem or Class 1 through 4 office at which trunks are switched together.

Intermediate Office: any office where facilities are interconnected at voice frequency.

Terminating Switching Office: the end-office at which the called customer's line is connected.

## G.2 COMPARISON OF STANDARDS

This section summarizes the CCITT recommendations for transmission characteristics of VF circuits, terminal equipment and transmission facilities. The study of these characteristics is required to compare standards used in Canada to design and manufacture VF equipment to the standards used outside of North America.

### G.2.1 Transmission Characteristics of Voice Circuits (National System)

Frequency band: 300 Hz to 3400 Hz

Sending system: nominal reference equivalent between a subscriber and the first international circuit not to exceed 21 dB

Receiving system: nominal reference equivalent not to exceed 12 dB

Nominal transmission loss	Freq. (Hz)	Loss relative to 800 Hz
	Below 100	not less than 4 dB
	100-200	not less than 1 dB
	200-300	not less than 0 dB
	above 3400	not less than 0 dB

Variation of transmission loss with time should not exceed 1 dB.

Linear crosstalk:

a) between circuits: near-end and far-end crosstalk ratio should not be less than 58 dB.

b) between transmit and receive of a four-wire circuit:

- ordinary telephone circuits: near-end crosstalk ratio should be at least 43 dB.
- circuits used with a speech concentrator: near-end crosstalk ratio should not be less than 58 dB.
- circuits used with echo suppressors: near-end crosstalk ratio should not be less than 55 dB.

Return loss: mean value of 27 dB with standard deviation of 3 dB.

Mean one-way propagation time:  $12 + (0.004 \times \text{dist. in km})$  ms.

0-150 ms - acceptable using echo suppressor (50 ms).

150-400 ms - acceptable using echo suppressors designed for long delay circuits.

above 400 ms - unacceptable.

Mean psophometric noise power during any hour should be of the order of 4L picowatts where  $L \leq 2500$  km.

## G.2.2 General Characteristics of VF Equipment

a) Repeaters for two-wire circuits

Type: reversible (2-way)

Frequency band: 300 Hz to 3400 Hz

Amplification steps: not exceeding 1 dB

Gain frequency response curves: parallel for all values of gain

Monitoring loss: should not exceed 0.26 dB

Crosstalk:

- between repeaters at output terminals: signal to crosstalk ratio should not be less than 70 dB at maximum gain
- in a station including cabling: signal-to-crosstalk ratio of not less than 65 dB at maximum gain

Nonlinear distortion: total harmonic ratio should not exceed 5 percent at 800 Hz for a maximum power of 20 mW.

Impedance: including line transformers should be approximately equal to the impedance of the circuit so the return current coefficient should not be greater than 0.2 for medium loading and 0.1 for light loading.

b) Repeaters for four-wire circuits

Type: should amplify in one direction only without noticeably affecting the quality of transmission at any frequency with maximum input power allowed.

Frequency band: 300 Hz to 3400 Hz.

Amplification steps: not exceeding 1 dB.

Gain frequency response curves: parallel for all values of gain.

Monitoring loss: should not exceed 0.26 dB in either or both directions.

Crosstalk:

- between repeaters at output terminals: signal-to-crosstalk ratio should not be less than 74 dB at maximum gain,
- in a station including cabling: including line transformers should have a signal-to-crosstalk ratio of not less than 70 dB at maximum working gain.

Nonlinear distortion: total harmonic ratio should not exceed 5 percent at a frequency of 800 Hz for a maximum power of 50 mW.

Impedance: excluding line transformers should be approximately equal to the impedance of the circuit so the return current coefficient should not be greater than 0.4 for the input impedance of the repeater and 0.6 for the output impedance of the repeater.

c) Line Transformers

These characteristics are for line transformers used on voice frequency repeater circuits.

Composite attenuation: should not exceed 0.7 dB for any frequency in the band transmitted.

Crosstalk attenuation:

- between windings of side and phantom circuits should be greater than 78 dB.
- between transformers of the different side and phantom combinations should be greater than 104 dB.

Insulation resistance: between two windings or between one winding and the case should not be less than 500 megohms when measured with 100 volts dc.

Power ratio: should not be less than 55 percent measured with the line side terminated and applying  $45 \pm 3$  volts on the office side.

## d) Terminating Units

Composite attenuation:

- between input and output terminals of the four-wire circuit:  
at least 61 dB.
- between four-wire to two-wire and vice versa;  
Including a filter: should not exceed 4.8 dB  
Excluding a filter: should not exceed 4.3 dB

Impedance: to match the impedance of international circuits and repeaters.

## e) Echo-suppressors

Insertion loss:  $0 \pm 0.3$  dB at 800 Hz or 1000 Hz

Loss frequency characteristics:  $+0.3$  dB to  $-0.2$  dB relative to loss at 800 Hz or 1000 Hz within the band 300 Hz to 3400 Hz  
At 200 Hz:  $+1.0$  dB to  $-0.2$  dB.

Delay distortion: shall not exceed 30  $\mu$ s between any two frequencies in the band 1000 to 2400 Hz and 60  $\mu$ s in the band 500 to 3000 Hz.

Impedance: 600 ohms - inputs and outputs.

Return loss: shall not be less than 20 dB from 300 to 600 Hz nor less than 25 dB from 600 to 3400 Hz.

Impedance unbalance to earth: shall not be less than 50 dB over the frequency range 300 to 3400 Hz.

Overload: the insertion loss at 800 Hz (or 1000 Hz) shall not increase by more than 0.2 dB for test tone levels from 0 to  $+5$  dBm0.

Harmonic distortion: the total harmonic power shall not exceed  $-34$  dBm0 for a pure 800 Hz or 1000 Hz at 0 dBm0.

Intermodulation: should be at least 45 dB when using 900 Hz and 1020 Hz applied simultaneously at a level of  $-5$  dBm0. When speech compressors are used, this requirement is reduced during the double talking mode to 26 dB.

Transient response: the attack time should not exceed 5 ms and the recovery time should not exceed 22.5 ms.

Noise: the mean weighted psophometric power shall not exceed  $-70$  dBm0  
Unweighted noise power in the band 300 to 3400 Hz shall not exceed  $-50$  dBm0.



Crosstalk: the crosstalk attenuation between the send and receive paths shall not exceed -50 dBm0 for a signal of +5 dBm0 or less and within the band 300 to 3400 Hz.

External enabling: this feature provides for enabling or disabling of the echo suppressor by an externally derived ground from the trunk circuit.

Tone-disablers: echo suppressors should be equipped with tone disablers to prevent suppression when data or other specified tone signals are transmitted through the suppressor.

Disabling frequency:  $2100 \text{ Hz} \pm 15 \text{ Hz}$ .

Disabling level:  $-12 \pm 6 \text{ dBm0}$ .

Guard band characteristics: speech shall not falsely operate the tone disabler.

Holding characteristics: tone disabler should hold in the disabled mode for any single frequency tone in the band 390 to 700 Hz having a level of -27 dBm0 or greater and from 700 Hz to 3000 Hz having a level of -31 dBm0 or greater. The tone disabler should release for any signal from 200 to 3400 Hz having a level of -36 dBm0 or less.

Operate time:  $300 \pm 100 \text{ ms}$  at a level ranging between a value of 3 dB above the midband disabler threshold level and a value of 0 dBm0.

False operation due to speech currents: should not false operate more than 10 times during 100 hours of speech.

Release time:  $250 \pm 150 \text{ ms}$  after a signal in the holding band falls at least 3 dB below the maximum holding sensitivity.

### G.2.3 General Characteristics of Transmission Facilities

Facilities used by the various administrations include open wires, cables and carrier systems. Since the purpose of this study is to compare voice frequency equipment and not transmission facilities, only a brief outlook of loaded cable facilities is considered in this section.

Loading, which consists in adding inductance to the cable pairs, increases the characteristic impedance in order to reduce attenuation. However it decreases the velocity of propagation and provides infinite loss above the point of the cut-off frequency. The type of loading, its spacing and the type of cables used must therefore be very carefully considered in order to maintain standard transmission characteristics for two and four-wire cable circuits.

Due to the fact that each administration already has an extensive cable network, it would not be practical for CCITT to specify characteristics such as type of cable, loading coils, loading coil spacing, conductor diameter, etc., for cable circuits. Instead general characteristics relating to national circuits liable to be used for international service, are provided. These characteristics are summarized in Section G.2.1 and are applicable to two-wire and four-wire circuits.

To meet these characteristics, different methods of loading cable pairs are used for circuits in national systems: each administration having their own loading scheme. For example: Japan used 50 mH coils spaced at 1 km on 0.9 mm cables for subscriber loops; Germany uses 80 mH loading at 1.7 km on 0.4 mm cables between their primary centers and local exchanges and Denmark uses  $20 \text{ mH} \pm 10 \text{ percent}$  coils for loading of subscriber lines.

## G.2.4 Comparisons

### a) Two-Wire Repeater Units

Canadian made two-wire repeaters are designed to provide amplification and proper matching of the characteristic impedance of transmission lines used in Canada. This matching is required to allow maximum power transfer and therefore prevent impedance mismatch causing reflections.

Two models of two-wire repeaters are currently available: the negative impedance repeater and the hybrid type repeater. The gain module of these units will provide the required amount of gain to meet the reference equivalent level specified by CCITT but fail to properly match the transmission lines.

The Line-Building-Out (LBO) networks of the negative impedance repeater and the precision balancing networks of the hybrid type repeaters are designed to match either nonloaded or loaded facilities. The most commonly used types of loading include the D66 (66 MHz at 4500 feet spacing) and H88 (88 MHz at 6000 feet spacing). The gauge of cables used are 19 ga (.912 mm), 22 ga (.643 mm), 24 ga (.511 mm) and 26 ga (.404 mm).

The difference in line characteristics, would prevent using these repeaters outside of North America without a major redesign of LBOs and precision balancing networks.

### b) Four-Wire Repeater Units

Four-wire repeaters designed for the Canadian network incorporates line transformers to match line impedance for either 150, 600 or 1200 ohms. These units are equipped with built-in equalizers used to compensate for the amplitude distortion of both nonloaded and loaded facilities. The gain units (one in each direction of transmission) provide from 0 to 36 dB of gain.

To make these units compatible with line characteristics other than 19 ga, 22 ga, 24 ga and 26 ga nonloaded or H88 loaded would require the replacement of the line transformers and the redesign of the equalizers.

c) Line Transformers

Line transformers specified in Section G.2.2c are used to derive phantom circuits from two separate two-wire circuits. This type of circuit (phantom) are very seldom used in Canada as voice circuits but used mainly for transmitting dc power or signaling information and are referred to as simplex circuits.

Again, our line transformer units are designed to match the line characteristics of the cables used in Canada and provide equalization of H88 loading. To make these units compatible with other line characteristics would require a major redesign.

d) Terminating Units

The terminating units specified in Section G.2.2 are known in Canada as four-wire terminating sets used to provide interconnection between two-wire (either 600 ohms or 900 ohms) office equipment and 600 ohms four-wire VF cable facilities or carrier channels. Precision balancing networks are provided on the balancing port of the hybrid to balance the facility connected to the two-wire side of the hybrid. These networks provide balancing of 19, 22, 24 and 26 gauge H88 loaded and nonloaded facilities including various combination of terminations of these facilities in either a 500 type or touch tone telephone set.

Even though the characteristics specified are met, the difference in line characteristics would prevent proper matching and thus incompatibility without redesigning the unit.

e) Echo-Suppressors

The echo suppressor specified by CCITT very closely resembles the modern type echo suppressors now used in Canada. The disabler functions are identical and the input and output impedance specified (600 ohms) is the same.

Canadian manufacturers have in fact been very successful in sales in this area.

## G.3 CONCLUSION

Sections G.2.4 (Comparisons) revealed that only the echo suppressor unit matches the CCITT specifications for circuits having either a short or long propagation time. Of all the other units studied including two and four-wire repeater units, line transformer units and terminating units, none seem to be able to cope with the characteristics of the transmission lines used by various administrations.

To properly evaluate the effect of standards on the trade of voice frequency equipment, this type of study should be aimed at a particular country since the transmission plan for a national system is the responsibility of the country concerned. The transmission characteristics of the cables (primary and secondary constants), the carrier systems and the signaling systems used would have to be studied to determine the difference in standards.

## G.4 REFERENCES

1. CCITT - International Seminar on National Telephone Transmission Planning - Melbourne, Vol. 1, (27 February to 2 March 1970).
2. CCITT - Fifth Plenary Assembly - Geneva, "Line Transmission", Vol. III-1, Green Book, Part 1, Section 1, (December 1972).
3. CCITT - Fifth Plenary Assembly - Geneva, "Line Transmission", Vol. III-2, Green Book, Part 1, Section 5 (December 1972).
4. Cyr., J.J., "Transmission Objectives Handbook", Issue 1, Bell-Northern Research (April 1974).
5. Bell Telephone Laboratories, "Transmission Systems for Communication," Fourth Edition (December 1971).

## SECTION H

## HARDWARE STANDARDS

In this section a comparison of the following hardware standards are considered to be representative of this subject: EIA, IEC, ANSI, (International); DIN (German), BSI (British), ISI (Indian) (foreign national), and national domestic standards.

The comparison has been limited to the following areas: equipment racks, waveguide hardware, connectors and color coding of wires and cables. Areas like ac supply voltage, power plug type, screw thread types, etc., have not been covered since it is considered that manufacturers planning to sell in the export market would make themselves aware of these differences and that such differences would not result in major redevelopment of their equipment.

Table H-6 shows the full complement of standards which were used in this study.

## H.1 EQUIPMENT RACK STANDARDS

Electronic equipment racks for general use (Table H-1) as covered by international standards, IEC, EIA, and in one national case, DIN, are quite compatible. However, in the specific case of telecommunication equipment, these requirements are usually covered by either a national body external to the national standards organization (e.g., BPO) or within the national standards organization itself - such as BSI.

There is a difference between the rack sizes of the North American manufacturers and those of Britain and Germany.

No standards have been found to exist for telecommunications equipment racks in India. These may be covered separately by another organization; however, this avenue was not pursued.

Using those standards for telecommunications equipment which were obtainable, or information from other sources reliably known to be the same as the standard, the comparison shown in Table H-2 was made.

The inclusion of ITT multiplex equipment data was made because it was generated by ITT companies\* from Germany, Belgium, Sweden and Spain, and this 'group' design 'covers the majority of the customer requirements'.

Countries listed as intending or considering to use this equipment were: Argentina, Australia, Bahamas, Belgium, Brazil, Greece, Hong Kong, India, Kuwait, Luxembourg, Mexico, Morocco, Peru, Philippines, Portugal, Scandinavia, S. Africa, Spain, Taiwan and Thailand.

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\* L.C. Deschuytere, et al., "International Multiplex Equipments," Electrical Communication, Volume 46, November 1971.

TABLE H-1  
General Use Electronics Racks and Panels

	WIDTH	RACK (OVERALL)			PANEL				
		DEPTH	HEIGHT	EQUIP. OPENING	WIDTH m.m.	IN	HORIZ HOLE MTG	'U' MIN MODULE HEIGHT	VERT HOLE MTG
EIA RS 310-B  SAME AS ANSI C 83.9	NOT DEFINED	OPEN NOT DEFINED	OPEN NOT DEFINED	450.8	482.6	19	465.1	44.4	12.7 + 15.9 + 15.9
		CLOSED 387.4	CLOSED VARIOUS MULTIPLES	577.8	645.2	24	592.1	44.4	OR
		457.2 609.6 762.0	OF 44.4(U) MAX 45 U	730.2	762.0	30	744.1	44.4	12.7 + 31.75
IEC PUBLICATION 297	NOT DEFINED	NOT DEFINED	NOT DEFINED	450.0	482.6	19	465.1	44.4	12.7 + 31.75
DIN 41494 BLATT 1	NOT DEFINED	NOT DEFINED	NOT DEFINED	450.0	482.6	19	465.1	44.4	12.7 + 31.75
DIN 41488	600 800 900 1200	400 450 600 800	1600 1800 2000 2200	?	?	?	?	?	?

Unless otherwise specified, all dimensions  
are in millimeters.



There is no way at this time to confirm whether all these countries have standards and, if so, how close their standards are to the data listed, except for Germany (DIN).

It can readily be seen from Table H-2 that very few international standards exist which are applicable to telecommunications equipment racks. The controlling standards are either from national or special interest bodies, whether government or private.

It can also be seen that apart from basic overall dimensions, very little other data (such as panel and shelf sizes) is shown. In the case of the national standard (DIN) this 'other' information was also not given. For other sources the information probably exists but requires more time to research.

Regarding the non-Northern Electric designs or standards, although there are some similarities in the equipment dimensions, generally they are different and varied. It should be noted that the majority of these appear to be metric base designs.

The Northern Electric designs, while also showing some common dimensions, appear to be even more varied, not only between switching and transmission, but within each group. The designs represented for N.E. in Table H-2 are all basically inch systems.

## H.2 WAVEGUIDE STANDARDS

Comparisons of rectangular and circular waveguides were possible between EIA, IEC, DIN and B.S.I. ANSI requirements are identical to EIA, but no standards were available for India.

The comparison figures shown in Table H-3, H-4 and H-5 are for the TE<sub>01</sub> mode.

For rectangular waveguides the differences occur only in some of the tolerances. Nominal dimensions were compatible.

Circular waveguides did show a difference in the outside diameter for EIA to all the others, but when assembled with a flange, may not present any difficulty. Unfortunately, standards for circular W/G flanges were not available to check this.

Pressurized flanges for rectangular W/G also showed differences in the grooves for the 'O' ring seal and in the size of screws and screw holes. This would only be a significant problem if the designer (suppliers) failed to provide the proper matching flange.

Generally this particular area of design should not provide any significant design problems.



TABLE H-2  
Telecommunications Equipment Racks and Shelves

		RACK (OVERALL)			CEILING SUPP.	SHELF SPACE		PANEL OR SHELF MTG		
		WIDTH	DEPTH	HEIGHT		WIDTH	MIN HEIGHT	BRKT	HOLE	
								VERT MODULE	VERT	HORIZ.
B P O	62 TYPE (CURRENT FOR TRANS. & RAD.)	520	450	3230 2740	YES	488	50.8	50.8	-	-
	NEW EQUIPT PRACTICE	520	350	1825 2285	?	?	?	?	?	?
	(PROPOSED FOR ALL TELECOM.)	910	500	2495 2600						
	ANY COMBINATION OF WIDTH, HEIGHT & DEPTH		610	3200						
	T.10.000 (ELECTRONIC SWITCHING)	910	610	3200	?	?	?	?	?	?
I T T	CARRIER MUX									
	CHANNEL TRANSLATION	520	225	2740	?	445	107	15.24	-	-
	GROUP TRANSLATION	600 670								
		670	225	2740	?	445	107	15.24	-	-
D I N	GENERAL TELECOMMUNICATIONS EXCEPT SWITCHING DIN 41493	600	225	738 1044 1554 2064 2600	YES	540	MULTIPLE OF 17.0	?	?	?
	SEIMENS SWITCHING EQUIPT. PROBABLY BASED ON DIN. STANDARDS	850	480	900 1100 1320 1530 2130	?	?	?	?	?	?
		1700	480	1530						
C C I T T	RECOMMENDATION G 231 CARRIER EQUIPMENT		450	3200						

Unless otherwise specified, all dimensions  
are in millimeters.

TABLE H-2 (Cont'd)  
Telecommunications Equipment Racks and Shelves

		RACK (OVERALL)			CEILING SUPP.	SHELF SPACE		PANEL OR SHELF MTG		
		WIDTH	DEPTH	HEIGHT		WIDTH	MIN HEIGHT	BRKT	HOLE	
								VERT MODULE	VERT	HORIZ
N O R T H E R N	TRANSMISSION- MUX & CABLE SYSTEMS	670	381	2134 2743 3505	NO YES YES	?	?	?	?	?
	TRANSMISSION- RADIO (RA3)	614	254	3505	YES	482.6 PANEL WIDTH			12.7 + 31.75	465.1
	SWITCHING- (DMS)	660	457	2134 MAX	NO	559	357		12.7	
E L E C T R I C		572	457	2134	NO	432	357		12.7	
	SWITCHING (RELAY RACKS)	619		3505	BOTH CEILING OR FLOOR SUPPORT	451			TAPPED HOLES FOR 44.5 & 50.8 MTG	465.1
		518				552	?			566.7
	SWITCHING- SP-1	711	305	2134	NO	660 USABLE	?		12.7	643.0
C						(660 PANEL)				

Unless otherwise specified, all dimensions  
are in millimeters.

TABLE H-3  
Rectangular W/G (TE<sub>01</sub>)

	DIN 47302	EIA-RS261A ANSI C83.10	IEC 153-2	BS 9220 N 001
DESIGNATION	R 22	WR 430	R 22	R 22
INSIDE a <sub>1</sub>	109.22 ±.11	109.22 ±.13 †4.300 ±.005	* ±.22	* ±.14
INSIDE b <sub>1</sub>	54.61 ±.11	54.61 ±.13 †2.150 ±.005	* ±.22	* ±.14
OUTSIDE a <sub>2</sub>	113.28 ±.11	113.28 ±.13 †4.460 ±.005	* ±.20	* ±.15
OUTSIDE b <sub>2</sub>	58.67 ±.11	58.67 ±.13 †2.310 ±.005	* ±.20	* ±.15
FREQ. RANGE	1720 - 2610	1700 - 2600	*	*
DESIGNATION	R 40	WR 229	R 40	R 40
INSIDE a <sub>1</sub>	58.17 ±.06	58.17 ±.13 †2.290 ±.005	* ±.12	* ±.076
INSIDE b <sub>1</sub>	29.083 ±.06	29.083 ±.13 †1.145 ±.005	* ±.12	* ±.076
OUTSIDE a <sub>2</sub>	61.42 ±.06	61.42 ±.13 †2.418 ±.005	* ±.12	* ±.076
OUTSIDE b <sub>2</sub>	32.33 ±.06	32.33 ±.13 †1.273 ±.005	* ±.12	* ±.076
FREQ. RANGE	3220 - 4900	3300 - 4900	*	*
DESIGNATION	R 70	WR 137	R 70	R 70
INSIDE a <sub>1</sub>	34.85 ±.035	34.85 ±.10 †1.372 ±.004	* ±.07	* ±.046
INSIDE b <sub>1</sub>	15.8 ±.035	15.8 ±.10 †0.622 ±.004	* ±.07	* ±.046
OUTSIDE a <sub>2</sub>	38.10 ±.05	38.10 ±.10 †1.500 ±.004	* ±.07	* ±.051
OUTSIDE b <sub>2</sub>	19.05 ±.05	19.05 ±.10 †0.750 ±.004	* ±.07	* ±.051
FREQ. RANGE	5380 - 8180	5850 - 8200	5380-8170	*

\* Denotes same as corresponding DIN dimension

† Dimensions are in inches.

Unless otherwise specified, all dimensions  
are in millimeters.

TABLE H-4  
Circular W/G (TE<sub>01</sub>)

	DIN 47302 BLATT 2	EIA RS 200-A	IEC 153-4	B.S.I. BS 9220 - N004
DESIGNATION	C 40	WC 205	C 40	C 40
I. DIA	51.99 ±.05	51.99 ±.051 †2.047 ±.002	*	*
O. DIA	57.07 ±.094	58.60 ±.10 †2.307 ±.004	*	*
FREQ. RANGE	8510 - 13890	8510 - 11700	*	*
DESIGNATION	C 30	WC 281	C 30	C 30
I. DIA	71.42 ±.07	71.42 ±.075 †2.812 ±.003	*	*
O. DIA	78.02 ±.095	79.04 ±.13 †3.112 ±.005	*	*
FREQ. RANGE	6194 - 9727	6190 - 8530	*	*

\* Denotes same as corresponding DIN dimension

† Dimensions are in inches.

TABLE H-5  
Rectangular W/G Flange Dimensions

	DIN 47303 BLATT 1	EIA RS271-A	DIN 47303	EIA RS271-A
	PDR 40	WR 229	PDR 70	WR 137
SEAL GROOVE $\phi$ (MAJOR AXIS)	69.30	69.29 2.728 (IN)	44.8	44.78 1.763 (IN)
SEAL GROOVE $\phi$ (MINOR AXIS)	40.2	40.2 1.583 (IN)	25.80	25.73 1.013 (IN)
SEAL GROOVE WIDTH	4.78	4.78 .188 (IN)	3.58	3.58 .141 (IN)
SEAL GROOVE DEPTH	3.90	1.35 .053 (IN)	3.90	1.02 .040 (IN)
OUTER SCREW HOLE $\phi$ (MAJOR AXIS)	41.15	41.15 1.620 (IN)	27.79	27.79 1.094 (IN)
OUTER SCREW HOLE $\phi$ (MINOR AXIS)	26.67	26.67 1.050 (IN)	18.26	18.26 .719 (IN)
INNER SCREW HOLE $\phi$ (MAJOR AXIS)	27.18	27.18 1.070 (IN)	11.11	11.13 .438 (IN)
INNER SCREW HOLE $\phi$ (MINOR AXIS)	12.70	12.70 .500 (IN)	7.94	7.94 .313 (IN)
HOLE DIA.	6.35 B9 .250 (IN)	6.53 .257 (IN)	5.0 B9	4.98 .196 (IN)

Unless otherwise specified, all dimensions are in millimeters.

## H.3 CONNECTOR STANDARDS

This group of hardware items, although originally selected for detailed investigation, was relegated to an overview based on interviews or comments from knowledgeable people such as designers.

The following points appeared dominant in the discussions:

- a) The great majority of electrical connections for switching systems are hard wired and achieved by a quick clip or similar device which is quite flexible in application and apparently used by the majority of the telephone equipment suppliers.
- b) RF type connections (coax) are generally dimensionally compatible, mainly as a result of the large American influence, particularly with those developed originally for military use and which are also used commercially.

The American influence is also apparent in the non-coax, type of connectors and, in most cases, are accepted as the standard although unofficially.

- c) If a connection method is required which utilizes a different standard or set of requirements to our own, it is generally not difficult to comply provided the appropriate hardware can be obtained.
- d) Connectors used within the equipment do not normally present difficulties, for example, edge board connectors.
- e) One area which can present problems is in the use of coax cables and the connectors for these cables. In North America about four basic sizes of cable are used; however, in Europe many different cables are used for which special connectors often have to be designed and at the very least matching up is difficult.

## H.4 COLOR CODES FOR WIRES AND CABLES

### H.4.1 International Standards

There is not yet an IEC standard on color code markings for thermoplastic insulated wire such as is used for wiring telecommunication equipment units. Based on discussions with a Canadian representative on the relevant IEC committee, this is under review, but there is no indication as to when such a standard will be prepared.

The only IEC standard to be found was one on colors to be used for low frequency cables and wires.

### H.4.2 National Standards

No national standards were identified which related to color coding of wire for telecommunication equipment. The standards which were identified, EIA, DIN and ANSI related to chassis wiring for consumer electronics products and are therefore not directly applicable to this study.

### H.4.3 Standards Used by Telecommunications Manufacturers

The color code marking system used by Northern Electric for example is based on a Bell Labs coding system.

Presumably the British Post Office has standards which their suppliers follow. This information was not readily available from local sources.

In the event that a potential customer requests adherence to a wire color coding standard which differs from that normally used by the Canadian manufacturer, this could be a potential problem area. It is however difficult to draw a general conclusion since each situation will be different, and the extent of variation or difference in coding cannot be determined without the pertinent standard.

The color identification for ac power wiring line, neutral, etc., differs between North America and Europe. This, however, is not considered a major problem but one which the manufacturer must be aware of and be prepared to provide the appropriate colors of wire insulation required for each application.

## H.5 EVALUATION OF DATA

Based strictly on the information that was obtained for this very limited investigation, the main conclusion is that standards do not represent a significant barrier, except possibly in the area of a metric redesign of equipment racks and the equipment mounted thereon.

The circumstances of the project will have a bearing on whether standards are significant or not. For example, shelves or individual units of equipment would have to conform to the rack or cabinet of the customer, whereas complete systems of a number of bays installed in a new building devoid of other equipment should not present any problems at all unless the customer chooses to enforce the pertinent standards regardless of whether or not there are practical incompatibility problems.

The inclusion of India in the study which was partly based on expected availability of their applicable standards (which did not materialize), was also partly based on its status being regarded as a developing nation outside of Europe and North America, whose position would be one of the following:

- a) having its own national standards,
- b) having no standards at all,
- c) standards established by the first installation(s) of foreign equipment,
- d) adoption of IEC Standards or CCITT recommendations for electronic equipment in general or communications equipment (carrier) respectively.

In general, standards information for other developing nations (which are presumably potential sales areas) was not locally available and, as in the case for India, these critical questions could not be answered.

In the area of color coding for wires and cables there is not enough evidence to draw any conclusions except to say that provided proper documentation is given to the customer circuit tracing should not be a problem regardless of the color coding system used.

A large portion of potential standards differences of a minor nature can usually be resolved by good design housekeeping. For example, making provisions for the correct type of ac outlets and the pertinent ac electrical code requirements for each customer (country) as it becomes necessary.



TABLE H-6  
Total List of Standards Used in Study

RACKS AND PANELS	
ANSI C 83.9-1972	-Racks, Panels and Associated Equipment
EIA RS-310-B-1972	-Racks, Panels and Associated Equipment
DIN 41488 BLATT 1-1971	-Electrical Engineering switch band dimension
DIN 41493 -1962	-Electrical Communications engineering, cabinet type rack, design dimensions
DIN 41494 BLATT 1-1974	-Panel Mounting racks for electronic equipments; racks and panels, dimensions
IEC Pub. 297 (DRAFT 1973)	-Dimensions of panels and racks for electronic equipment
BPO-Spec RC 2000G	-General requirements for electronic transmission equipment standard construction practice (62-type)
WAVEGUIDE	
ANSI C 83.10-1969	-Rectangular waveguides (WR3 to WR 2300)
ANSI C 83.19-1969	-Circular waveguides
EIA-RS 200-A 1965	-Circular waveguides
EIA-RS-261-A 1965	-Rectangular waveguides (WR3 to WR 2300)
EIA-RS-271-A 1963	-Waveguide flanges-Pressurizable Contact types types for waveguide sizes WR 90 to WR 2300
DIN 47302-1964	-Hollow metallic waveguide dimensions
DIN 47302 BLATT 2 1967	-Hollow metallic waveguide, circular waveguides dimensions
DIN 47303 BLATT 1 1964	-R.F. waveguides; dimensions for flanges, pressurized, rectangular tubes type R, size 14 to 100
DIN 47305 BLATT 1,2,3,4. 1972	-R.F. waveguides, circular flanges
IEC Pub. 153-2 1964	-Hollow metallic waveguides-Part 2, relevant specifications for ordinary rectangular waveguides
IEC Pub 153-4 1973	-Hollow metallic waveguides-Part 4, relevant specifications for circular waveguides
IEC Pub 154-1 1964	-Flanges for waveguides-Part 1, general requirements and measuring methods
B.S.I. - BS 9220 1971	-Specifications for rigid waveguide tubing of assessed quality: generic data and test methods
B.S.I. - BS 9220-N001 1971	-Rigid waveguide tubing ordinary rectangular
B.S.I. - BS 9220-N004 1971	-Circular rigid waveguide tubing
COLOUR MARKING FOR CABLES AND WIRES	
IEC-304 1969	-Standard colors for PVC insulation for low frequency cables and wires
EIA-RS-230 1959	-Color Marking of thermoplastic covered wire

## SECTION I

## SOME TRENDS IN INTERNATIONAL STANDARDS DEVELOPMENT

Other sections of this report have identified specific differences between telecommunications standards as used in North America and those recommended for international networks by the CCITT and CCIR. This section will summarize in general terms the background to the emergence of the different standards and will discuss some trends towards achieving universal compatibility. Discussion will be confined to telephone networks and related standards.

## I.1 BACKGROUND

## I.1.1 Early Stages

The first telephone systems were created about one hundred years ago. At first, local networks were devised to connect subscribers within communities. Later, links were constructed to connect communities, and eventually extended to create national networks. Networks grew in different places according to local demand for telephone communications.

Standardization in this early period was achieved mainly through common ownership or reliance on a single supplier of equipment. The benefits derived by standardization contributed largely to the rapid growth of networks. Economies of scale, ease of manufacture and simplicity of operation were all realized by adopting common practices for internal use. But little attempt was made to coordinate standards between independent networks. Many different choices were made by operating entities in different countries with resultant proliferation of standards.

## I.1.2 Mid-Term Development

Not until regional networks were formed did standards move towards consolidation.

In Europe, as national networks expanded, the need to cross international boundaries arose, which posed new problems of interconnection. National networks were no longer isolated. Collaboration between national administrations in Europe became a necessity and to achieve this aim the Comité Consultatif International (CCI) was formed in 1924 and became CCIF in 1925 when CCIT was created to deal with telegraph matters.\* Subsequent work of the CCIF made possible the establishment of a European regional telephone network, and CCIF recommendations became the standards for international connections within the region.

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\* In 1956 CCIF combined with CCITT to form CCITT dealing with both telephone and telegraph, and later, data matters.

At the same time in North America, a regional network had grown more readily, and consolidation of standards occurred in a different way. Telephone operations were mostly uninhibited by national boundaries since a single company could operate in both the United States and Canada, and problems of interconnection did not arise. Telephone networks spread rapidly across the continent, experiencing considerable growth compared with some other parts of the world. For example, in 1925 there were 17 million telephones in North America compared with about 7 million in Europe, and a world total of 26 million. As the pioneering Bell System became dominant, its standards were widely accepted in the region and eventually emerged as North American standards.

Hence, although consolidation took place, two separate bodies of technical standards were developed. North American (Bell System) and European (CCITT). Each served a regional network essentially isolated from the other. Each region enjoyed a captive market for its equipment.

### I.1.3 Later Developments

The first major conflict between the practices of the two major regional systems came in the early 1950s when the first trans-Atlantic telephone cable was laid. To ensure satisfactory operation many technical difficulties had first to be overcome. Technical ingenuity and compromise provided solutions to compatibility problems. In 1956 the AT&T, UKPO and COTC combined to lay twin cables under the Atlantic. These cables, the latest of their kind, were capable of carrying 36 simultaneous telephone conversations between networks containing 60 million telephones in North America and 29 million in Europe.\* At that time perhaps a choice could have been made between the standards of either region for international use, and it might have been rational to adopt those of the majority. Such was not the case and the solution to the problem of transatlantic interconnections was resolved by adjusting the parameters of the 'small pipe' in between. In 1965 the capacity of submarine cables was increased to 128 voice channels, a sizable increase but still not large enough to support television. Early satellite systems provided a capacity of 300 telephone channels and the promise of sufficient bandwidth to carry television over intercontinental distances.

These and subsequent developments put pressure on international discussions within CCITT, and participation increased from outside Europe, notably from United States, Canada, and Japan. The net result was to direct CCITT more towards world issues and to plan for the emerging world network. A world numbering plan to assign a discrete number to each telephone in the world had to be agreed upon. This was done. Subsequently, a world routing plan and a world transmission plan were also agreed upon to enable worldwide telephone communication to take place. These were first steps towards the long range goal of the

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\* Strictly speaking, a fraction of this number in Europe since connection was made mainly to the United Kingdom.

CCITT to establish fully automatic calling on a global basis. The intent of this ambitious objective is to automate operations in order to keep pace with demand and at the same time overcome language as a barrier in establishing international calls. To reach agreement, these plans have required a high degree of international collaboration in which Canada has played an increasingly active role.

The advent of satellite systems, having a capability to carry up to 50,000 voice channels, brought abrupt change in the possibilities for a worldwide telephone network. Three synchronous satellites properly spaced could connect most points in the world. This great leap forward put increasing pressure on both national and international organizations to agree to compatible standards.

To date, international telephone service has been established between an increasing number of countries, and hence compatibility achieved in this respect. What do remain are the many variances in equipment standardization as detailed elsewhere in this report. As has been seen the over-all network was not created at one stroke, and hence much work has yet to be done to overcome obstacles inherited from the past.

## I.2 SOME CURRENT ISSUES AND TRENDS

Developments of the past 25 years have brought about profound changes in global communications. The next quarter century will likely see equally dynamic change if current plans materialize. In considering briefly some of the main current issues, an attempt is also made to associate them with possible outcomes.

### I.2.1 Primary Digital Systems

Recent years have seen the wide-scale introduction of PCM systems in national networks for reasons of economy, flexibility and ruggedness. In North America, demand exceeded most expectations and by 1973 the AT&T had 28 million channel kilometers of their pioneering short-haul digital system T1 in service. This phenomenal growth was hardly matched elsewhere except in Japan, which by then had rapidly emerged as a world leader in telecommunications.\* In Europe, the introduction of digital systems lagged appreciably behind North America causing once again a time lag fatal to the development of common standards. The first systems installed in Britain and Italy were also made to T1 standards but regrettably their future systems will be in accordance with an alternative standard adopted for European regional use by the CEPT.\*\* This belated standard fitted in more suitably with other CCITT recommendations (e.g., FDM multiplex hierarchy) and so again a fundamental misfit occurred based to a degree on historical reasons.

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\* At the end of 1971 there were close to 30 million telephones in Japan, compared to 125 million in the USA, and about 61 million in Western Europe and 10 million in Canada.

\*\* CEPT: Conference of European Postal and Telecommunication Administrations.

An underlying reason for failure to reach agreement in such cases is once more the time span between similar demands occurring in the two major regional networks. Technological developments frequently outrun the institutional arrangements required to agree on necessary standards. By the time the gap has closed a more attractive alternative has invariably appeared.

All is not lost however, since many basic characteristics for PCM systems have been agreed upon. The voiceband sampling rate of 8000 samples per second, 8 bits per word to encode each sample, +3 dBm0 as the maximum signal power to be encoded without clipping, and most important of all a 64 kbit/s time slot are fundamental parameters which have been agreed upon.

Long experience suggests that when most of the significant technical factors can be agreed upon, then remaining differences can be suitably matched. For example, before international connection of FDM carrier systems could take place in an earlier era, basic characteristics such as a standard channel spacing and a primary 12-channel group of telephone channels had to be agreed upon. The adoption of 4 kHz spacing for voice channels and agreement of basic groups in the 12 to 60 kHz and 60 to 180 kHz bands, proved enough to permit interconnection of carrier signals from one country with terminal equipment provided by another. This set of agreements was vital to that particular stage of development.

Similarly, the common factors now agreed upon for primary PCM systems are expected to provide sufficient commonality to allow international digital networks to grow and provide a basis for future systems.

It is anticipated that continuing efforts will be made to reconcile technical differences which have arisen so far between the two primary PCM standards. It is quite clear, however, that the weight of large investments already committed to existing systems will preclude radical change. Again conversion between one standard and another will be required, and interface arrangements will need to be agreed upon.

### I.2.2 Integrated Digital Networks

Growth of networks has continued at a rapid pace in recent years, primarily because of growth of telephone traffic.

In the Bell System, for example, long distance messages were reported in 1973 to be 9.5 billion, more than twice as many as 10 years before. In the next decade the calling rate was expected to triple. With this huge demand has come the need to streamline operations and reduce cost. there has also been a revolutionary trend towards digital transmission. More than two million T1 carrier channels in service in 1974, increasing at 30 to 40 percent per year.



With this rapidly increasing traffic has come the need to provide powerful digital switching machines and improved signaling systems with faster call setup times. In essence, the United States' approach is to respond to demand and develop integrated digital networks for telephony service. Only in this way is it expected to keep pace with demand. The term integrated in this instance refers to the use of digital techniques for switching, transmission and signaling. This subject has become a topic for active consideration within CCITT in the current study period (1972-1976).

Another type of integrated digital network is that providing a single digital network for several services, such as telephony, telex data, facsimile, etc. Such a network is referred to as an integrated services digital network (ISDN). In CCITT in the current period there has been an increasing number of administrations indicating their intention to integrate various services in a digital network at an early stage. This is largely due to the fact that networks (and demand) in these countries have evolved in different ways in keeping with special conditions such as size, topography, distribution and density of population, standard of living, etc. Switzerland is a case in point where conditions exist which are radically different from those in the United States. The Swiss telephone network in 1971 comprised three million telephones serving a population of 6.5 million in a very small territory. The Swiss PTT believe firmly in the provision of a fully integrated services digital network. Growth is less dramatic in Switzerland and it would not be economically viable to provide separate networks.

Hence, there is once again need to understand the different needs and conditions of different networks. No single solution is necessarily optimum for all. Again continuing effort will be required to achieve a fair measure of agreement to permit international connections between networks of different type.

### I.2.3 Common Channel Signaling

A previous section of this report has detailed the various international signaling systems which have been standardized over the years as semi-automatic and automatic systems were expanded. This section will now review briefly some aspects of a new common-channel signaling system which has been agreed upon to fill the needs for international direct distance dialing.

Telephone signaling is concerned with the exchange of electrical information (other than by speech) specifically concerned with the establishment and control of connections and management in a communication network. Since different designs of switching machines have their own internal languages, an international signaling system is required to provide a common language between them.

The CCITT Signaling System No. 5 which is widely used at present, although providing good service today, was judged as early as 1964 to be inadequate for a greatly expanded international network in the future. Major reservations included: post-dialing delay, answer signal delay, limited number of signals, inter-register signaling in forward direction only, and slow signaling. To overcome these deficiencies a new system (No. 6) has been developed.

CCITT Signaling System No. 6 uses a separate common channel for all signals (line, register and administrative) for circuits between switching machines. System No. 6 is designed primarily for use between modern stored program controlled machines, and especially to fill the needs for international subscriber dialing. New signaling facilities are provided and a vast potential is available for additional features which will permit the introduction of new services as required.

The specification for System No. 6 was agreed upon at the 1972 Plenary Assembly after a period of some eight years of study and field evaluation. Currently, the specification is in process of amendment to take account of PCM links in international connections. New studies have been launched to specify a new system of common-channel signaling for digital networks, taking into account the possibilities of integration. Further developments will depend on the introduction of similar common-channel signaling systems in national networks. A system called CCIS is soon to be introduced into the North American network, and in Europe the CEPT is studying a similar system. Japan and Australia have also indicated that they expect to introduce common-channel signaling in their national networks.

Hence, again a single universal system could not serve all, due to the different features and requirements of national networks. But prolonged studies within CCITT have ensured that regional and national common-channel systems will be developed in a compatible fashion. As these modern coordinated signaling systems come into use in both international and national networks, it will become possible to establish connections more rapidly and reliably and keep pace with future demand.

### I.3 CONCLUDING COMMENTS

#### I.3.1 Scope

The scope of this section of the report has been confined to a general overview of some of the reasons for technical differences outlined in detail in other parts of this report.

In view of the comparatively short time available for preparation of this section and for reasons of simplicity, the discussion deals only with the case of telephony and related recommendations of the CCITT. Complete reference to other telecommunications media and to the work



of the CCIR would require much further study. The impact of differences in technical standards as a barrier to trade is discussed more fully in the individual sections of this report.

### I.3.2 Comments

Some examples of differences in standards and practices adopted within the framework of the international telephone network have been given. The reasons for the basic differences in many cases are seen to be due to divergence at earlier stages in historical development. In certain other cases, although similar systems have been developed within the same period, rapid technological advances over a relatively short interval have resulted in different standards being adopted in different regions, or countries.

In most cases problems which have arisen due to incompatible standards have not proved insoluble. Methods of interworking have been agreed upon to facilitate continuing growth of the international telephone network. Some manufacturers, notably from Japan, have marketed their products worldwide irrespective of impediments due to standards.

Gradually, more universal agreements are being reached to achieve universal compatibility. The differences between the needs of individual countries and regions remain. The utopian view of a single standard for all lacks reality, unless needs and economies are equally uniform.

What will be required in the future is intensive collaborative effort at the international level. There is a need to involve the most interested parties at an early stage and for them to agree on a single solution. This may seem highly optimistic, but it is no more so than hoping to reverse dual-standards after they have become firmly entrenched.

## SECTION J

## MANUFACTURERS COMMENTS

## J.1 QUESTIONS AND ANSWERS

The attached letter (Figure J-1) was mailed to a large number of Canadian manufacturers soliciting their comments on the subject matter of this report. No formal replies have been received to date.

Personal contacts were however made with representatives of the various companies by visits to their facilities and by telephone. A number of basic questions were asked related to the subject of this report.

FROM YOUR EXPERIENCE ON PAST EXPORT JOBS, HOW SIGNIFICANT HAVE DIFFERENCES IN STANDARDS BEEN ON YOUR COMPETITIVE POSITION?

The large majority of suppliers indicated that standards had been of little significance if any. One supplier did feel however that in the area of microwave radio, the modification of equipment designed to meet Canadian requirements by merely a change of filters and microwave generators still resulted in his words a Cadillac being offered where the customer would be happy with a Ford.

This particular manufacturer felt that this put his equipment at a price disadvantage.

HAVE YOU FOUND YOURSELF IN A SITUATION WHERE NECESSARY DESIGN CHANGES HAVE RESULTED IN YOUR BEING IN AN NONCOMPETITIVE POSITION IN AN OTHERWISE COMPETITIVE SITUATION?

The answer to this question was almost universally NO.

Considering the major design changes necessary in some of the equipments reviewed in the body of this report, it can only be assumed that in answering the question in such a manner the supplier had prescreened the export jobs and only considered those where it was felt that they would be reasonably competitive in the first place.

ON ACTUAL EXPORT JOBS HAVE YOU FOUND THAT ADDITIONAL COSTS HAVE BEEN INCURRED DURING INSTALLATION AS A RESULT OF UNFORESEEN STANDARDS DIFFERENCES?

While a number of suppliers indicated that extra unforeseen costs had been incurred during installation, none of them felt that these were as a result of standards differences.

28 February 1975

The Systems Consulting Group of Bell-Northern Research have been awarded a contract by the Department of Communications to examine the major differences between N.A. Standards for Communications Equipment and those of other nations. Particular attention being paid to those technical differences which have a major effect on the export sales of Canadian Communications Products.

Standards Comparisons will be carried out in the following areas:

- Analog and Digital Multiplex Systems
- Analog and Digital Cable Systems
- Analog and Digital Radio Systems
- Television and Program Transmission Systems

A general overview will also be presented on the subjects of Switching Systems, Signalling Systems, Billing Systems, PBX, Key and Station Apparatus.

The study itself is of a limited nature, being of only 2 months duration with a target completion date of mid April and as such will only highlight the significant differences in standards and the effects of same on equipment design.

We would like, therefore, to enlist the help of your staff to discuss and assess the problems of international standards as a barrier to trade at present, and through your experience to date, identify factors which are likely to increase or decrease the future impact of said standards in exporting Canadian manufactured telecommunications equipment abroad.

Thank you in advance.

Yours very truly,

J.D. Frame  
Manager, Transmission Systems Consulting  
Dept. 3K10

BMM/ap

FIGURE J-1  
Letter of Request

WHAT ARE YOUR VIEWS ON FOREIGN MANUFACTURERS SELLING INTO THE CANADIAN MARKET?

In general most manufacturers felt that some competition from foreign suppliers was not a bad thing. However, they were all quick to point out that this was an area that should be monitored to ensure that foreign equipment volume did not jeopardize the position of Canadian manufacturers in the Domestic market.

HOW DO YOU FEEL REGARDING CANADIAN PARTICIPATION IN INTERNATIONAL STANDARDS?

In general manufacturers were satisfied with present representation in this area.

J.2 COMMENTS ON THE ABOVE ANSWERS

The majority of telecommunications manufacturers in Canada are foreign owned and are essentially branch plants of corporations with their head offices outside Canada. These corporations also have branch plants throughout the world to supply local demands where the market justifies them.

In the area of analog microwave radio some of the Canadian operations are responsible for the supply of radio equipment for the whole corporation. In other areas the Canadian operation essentially manufactures equipment to US designs for the Canadian market.

It is questionable whether the Canadian operation could successfully compete against the parent company for a nonfunded export job (In the absence of any firm Corporate Policy on the subject). Even Northern Electric, the major Canadian owned manufacturer of telecommunications equipment up to the passing of the 'Consent Decree' by the US in 1956 was entirely dependent on Western Electric for its equipment designs and manufacturing drawings. Up until that time Northern had no design capability of its own, employed no scientists engaged in product and process development and had been content with selling products to domestic telephone administrations.

Northern is a relative newcomer to the international market when compared with other major corporations with branch plants in Canada. Northern Electric's recent efforts to establish itself as a major exporter can perhaps be described by the following extract from its 1974 annual report.

*"Northern Electric, through Northern Telecom in Boston, is continuing to increase its share of the United States' market where standards do not present a problem. The company now operates five manufacturing plants in the US.*

*In the Far East, Northern Electric has established a subsidiary Northern Electric (Asia) Limited. A trading company with offices in Singapore and Hong Kong, it was formed to sell telecommunication products manufactured in the company's plants in other parts of the world. It also acts as a purchasing agency for various materials and components required by the company for its international and domestic manufacturing operations.*

*Northern Electric has been in Europe for many years as an exporter but only in recent years has it been establishing a position as a multinational manufacturer. Despite the complexities of the European market, its potential more than justifies the effort. As one step in consolidation of its multinational presence in Europe, a new subsidiary Northern Electric (Europe NV) was incorporated to direct the company's sales marketing and manufacturing functions in Europe.*

*Under the jurisdiction of the company are two manufacturing subsidiaries Northern Electric Company (Ireland) Limited and Istanbul-based Northern Electric Telekomunikasyon A.S. a joint venture with the Turkish Post Telephone and Telegraph Administration. Northern Electric has also explored the possibilities of joint ventures, licensing and distribution agreements, as a means of getting its products accepted in the European market.*

*In 1974, a five-year contract for the reciprocal distribution and manufacture of telecommunications equipment was signed with Gustav A. Ring of Norway. Under the agreement the Ring group will act as distributor to the Scandinavian countries Finland and Ireland for such Northern Electric Products as speaker phone, the Pulse EPABX, a key telephone system and the Venture 1 headset."*

### J.3 OTHER COMMENTS FROM MANUFACTURERS

Some manufacturers indicated that, for the present at least, they were only interested in export jobs that are tied to favorable financing offered under the CIDA and EDC programs.

Some manufacturers complained that the administrative cycle of such government organisations as CIDA were unduly long: that the Department of Industry Trade and Commerce can be of greatest assistance to industry in the export marketing area; 'That D of IT and C's influence, entries to proper foreign government officials, indication of general support of industry and specific suppliers, and assistance in CIDA and EDC financing is most beneficial to the Canadian telecommunication industry.'

In line with their philosophy - mainly, being interested in Government financed export jobs - some companies even suggest that the Canadian Government carry out the product marketing. It should be stressed that others reacted strongly to the latter suggestion, they agreed that the Government should certainly provide assistance in exports but the companies should be responsible for their own marketing.

## SECTION K

## REVIEW AND CONCLUSIONS

The various sections of this report reviewed the differences in N.A. and ITU Standards in order to determine how significant these differences are to a manufacturer who wishes to sell his telecommunications products on the export market.

In the areas of switching and analog and digital multiplex systems, extensive modifications are required to achieve compatibility with ITU standards. These can result in development costs in excess of 50 percent of that incurred to develop the equipment initially for the Canadian market. (Only an overview of switching systems is contained in this report; due to the complexities of switching systems, a detailed analysis would, in fact, require a separate study.)

## K.1 ANALOG MULTIPLEX

In the area of analog multiplex Northern Electric has in fact carried out the necessary development to comply with the ITU market.

Sales were made in both Turkey and Greece. (Countries that presently do not have domestic manufacturers of similar equipment.)

Sales to other Western European countries, however, have not materialized. Competition from local European Domestic suppliers is stiff and the buy domestic policy of the PTTs of most developed nations is a formidable barrier to overcome. It has been indicated that perhaps the quality of the Canadian equipment is too high and as a result we tend to be higher in price. In general where sales have been made customers have been favorably impressed with the quality of Canadian Equipment.

## K.2 ANALOG CABLE

In the area of analog cable systems, the domestic demand for such systems has not been large enough to justify development by Canadian manufacturers. Microwave radio is much more economical for long-haul applications and the use of analog cable systems has been limited mainly to the role as entrance links to carry traffic from Central Office to radio site. Canadian manufacturers are presently offering European systems for domestic requirements. Northern Electric offer a Philips system and Lenkurt Electric offer Siemens equipment.

## K.3 MICROWAVE RADIO

This area does not present any major problems from a technical standpoint. Necessary changes to equipment involve not much more than filter and microwave generator retuning.



The required performance standards for the domestic market are higher than those required for the CCIR market. One manufacturer has estimated that the higher standards in reliability and system noise require more expensive components resulting in Canadian equipment being approximately 10 percent more expensive to manufacturer, compared to that supplied by other foreign suppliers.

Cheaper components could certainly be used, however, development expense would be involved in the changeover to ensure satisfactory equipment operation. New manufacturing and equipment drawings would also be required.

Microwave radio is not a high-profit item and a reduction in equipment performance could result in additional expenses in meeting system requirements line-up and test on jobs where the manufacturer has the responsibility to engineer, furnish and install the complete system, more than offsetting the savings in equipment price.

Manufacturers have expressed a preference for export jobs that require equipment furnish only, no doubt as a result of some rather sad experiences in past installation jobs.

#### K.4 DIGITAL MULTIPLEX

In this area the only common bit rate between North American and European systems in the 64 kbit/s sampling rate of speech channels.

In spite of the extensive development of digital facilities in North America (the Bell System has about two million channels as compared to about two hundred thousand in Europe) the Europeans have decided to adopt a digital hierarchy which differs from that of North American.

Due to the rather large plant investment both sides of the Atlantic, it would appear that manufacturers will have to accept that the two hierarchical structures will exist for some time to come. Both systems will therefore have to be developed by a manufacturer who desires to export to countries adopting the European system.

We certainly have the technology, but major development expenses are involved in the conversion of N.A. equipment to conform with the European hierarchy. Redevelopment is required starting from the VF channel banks and continuing all the way up the digital multiplex hierarchy. The expense involved in the area of additional drawings and documentation alone is substantial.

#### K.5 DIGITAL CABLE SYSTEMS

In the area of High Capacity Digital Cable systems Canadian Industry has been a leader. (Northern Electric's LD-4 system).



The technology is well developed and Canadian Industry certainly has the know how to redevelop digital cable systems to conform to the European Digital hierarchy.

The redevelopment expenses involved are again substantial and certainly could not be justified in the absence of any guaranteed market for the product.

#### K.6 DIGITAL RADIO

Apart from the problems due to the different hierarchal structures already described in the preceding sections, manufacturers have the additional problem in the area of digital radio of deciding what market to attack,

Digital radio is in its infancy and the difficulty facing manufacturers is that of deciding in what frequency bands should they develop equipment for export and at what bit rates?

Canadian Marconi, the only Canadian manufacturer presently manufacturing a digital radio system, has expressed confidence in its ability to market its product in Europe. It should be pointed out however that their equipment can interface VF-to-VF and as such does not experience problems with hierarchal structural differences.

Standards for Digital Radio systems do not presently exist either in North America or in countries subscribing to ITU standards. However, it appears certain that to sell digital radio systems on the export market, equipment will have to interface with the digital hierarchy adopted by that country.

#### K.7 VIDEO TRANSMISSION

Apart from microwave systems manufacturers and manufacturers of video amplifiers (such as Central Dynamics and Richmond Hill Laboratories) there is little activity in the high quality video transmission field.

Complex cable systems both baseband and sub-carrier types used by carriers are manufactured off-shore.

With the exception of intracity links, video transmission was until recently totally confined to microwave systems and the market for heavy coaxial systems has not existed. Even for the Philips systems which have been purchased, the market is not large enough to warrant manufacture in this country.

It can be concluded therefore that a major reason for the low level activity in the long-haul high-quality television carrier market is the lack of a consistent and high quantity demand for such equipment.

## K.8 SOUND PROGRAM

The market for sound program equipment is not considered to be a major one. It tends to be unpredictable and the firm forecasts of future requirements are extremely difficult to obtain. Standards again differ between N.A. and CCITT countries. This is possibly a market area that a smaller manufacturer could find attractive.

## K.9 SWITCHING

Standards differences in the area of switching systems present something of a nightmare to would-be exporters. In Canada and the U.S. we have had the advantage of being able to plan an integrated telephone system that is consistent from Province to Province, State to State and between countries. The European Countries on the other hand have developed their own national systems and little thought initially was given to system compatibility between countries.

Modification therefore of switching equipment to meet the requirements of say the French PTT would not result in compatibility with the British or that of German Domestic Systems, which are also incompatible with one another.

The incompatibilities arise due to differences in signaling systems, supervisory and billing systems. These differences require major system modifications, even in the area of Stored Program type machines, modifications in the program software can run into tens of millions of dollars.

The switching market is potentially large being estimated [1] in excess of \$50 billion for the period 1975-1990 in countries not presently committed to existing internal manufacturers.

The estimated annual compound growth rate in this area for Western Europe is 9.7 percent with a dollar value in 1980 of approximately 3.5 billion [2].

Reference [1] gives a comprehensive review of each of 70 electronic and semi-electronic switching system developments in the world which have or will provide systems for world market competition.

The majority of switching requirements for Western Europe will no doubt be manufactured within national boundaries. The large volume requirements, however, could perhaps permit Canadians to obtain part of this market. The differences in switching standards require major redevelopment; however, the potential market could possibly make these insignificant.

Only an overview of switching systems has been presented in this report. An in-depth study would have required a much longer period. The significance of standards in this area as in others, is really relative to the potential market.

## K.10 VF TRANSMISSION

In this area only echo suppressors match the CCITT specifications. Of all the other units studies including two and four wire repeater units, line transformers and terminating units some redesign would be required for compatibility with the various transmission line characteristics.

## K.11 HARDWARE STANDARDS

Hardware Standards do not appear to be a major problem in the telecommunications market, except possibly in the area of a metric redesign of equipment racks and equipment mounting panels. This problem should be alleviated by the plans to convert to metrication of Canadian industry.

The majority of potential standards differences of a minor nature can usually be resolved by good design housekeeping. For example making provisions for the correct type of ac outlets and the pertinent ac electric code requirements for each customer (country) as it becomes necessary.

## K.12 CONCLUSIONS

Differences in technical standards between those of NA and countries subscribing to ITU recommendations require major redevelopment of domestic designs in the areas of digital and analog multiplex and switching systems for export markets.

The majority of manufacturers indicated that they did not consider standards differences to be of major significance in their experiences to date in the export market.

The major barrier to trade would appear to be the strong 'buy domestic policy' of most foreign PTTs.

In order to overcome the 'buy domestic policy', most manufacturers agree that manufacturing facilities in a particular country are almost a prerequisite in order to establish a major sales volume. Barring physical presence, some form of agreement with an established local national supplier to market or manufacture under license could be solution to the entry problem. It would also be important once sales have been established in a particular country that attention is paid to after-sales services.

Developing nations presently participate in the ITU and the tendency in these countries is to adopt ITU standards for their national telephone networks. However due to the large investment require to develop an efficient telephone network in these countries, the country providing the funding can obviously have a major influence on the equipment standards to be adopted.

Off-shore manufacturers who wish to import to Canada their telecommunication products from countries subscribing to ITU standards face similar problems in the standards area, in modifying their equipment to meet North American requirements.

In considering export of communications equipment we should not forget the potentially large market in the U.S.A. where standards present no problem whatsoever.

In order to sustain markets, once they have been established, it is essential that Canadian industry maintain a high level of research and development to ensure that Canadian products maintain their high standards and keep up with the State of the Art.

#### K.13 REFERENCES

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- (2) Improving "TELECOMMUNICATIONS EXPORTS TO WESTERN EUROPE", edited version of U.S. National Export Expansion Council Report published in Business Communications Review, Nov - Dec, 1974.



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