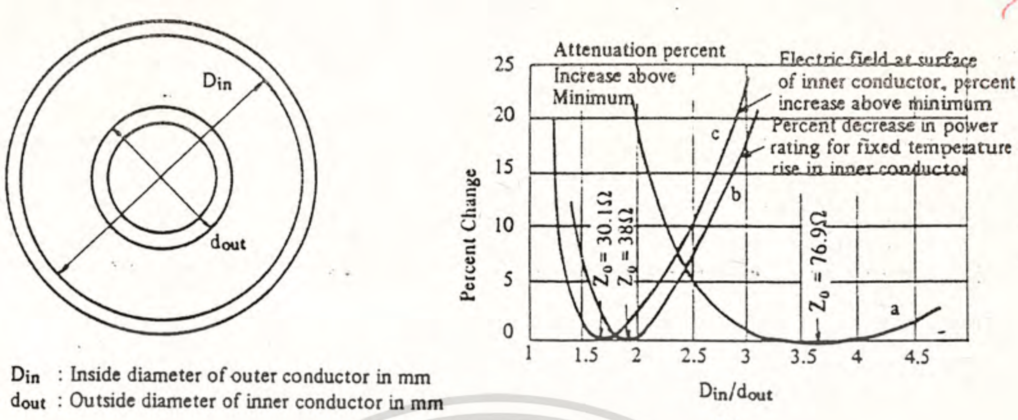


Fig. 4.2 Effect of Diameter Ratio Din/dout on Attenuation and on Power-handling Capacity as Limited by Flashover and by Temperature Rise

Curve b in Fig. 4.2 (b) shows the ratio of decline of power-handling capacity at each diameter ratio, with this maximum power-handling capacity taken as reference. Next, note that flashover which is caused when voltage is applied between the inner conductor and outer varies with dielectric constant of the insulating material, the diameter ratio between the inner conductor and outer and surface roughness of the conductors.

Power-handling capacity as limited by flashover becomes maximum at a diameter ratio of $\frac{Din}{dout}$ = 1.652 between the inner conductor and outer.

Curve c in Fig. 4.2 (b) shows the ratio of decline of power-handling capacity at each diameter ratio, with this maximum power-handling capacity taken as reference.

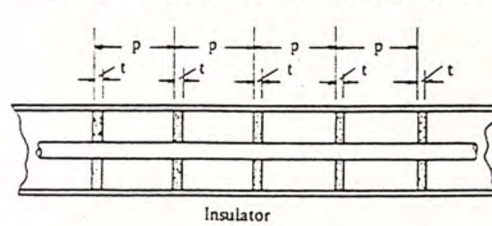
The transmission line of 50Ω in characteristic impedance has been selected in consideration of these characteristics.

Note that the characteristic impedance of a transmission line can be calculated by the following equation:

$$Z_0 = \frac{138.052}{\sqrt{\epsilon e}} \log \frac{Din}{dout} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(4.1)}$$

Where ϵe the effective dielectric constant of insulating materials between the inner conductor and outer.

Also note that the effective dielectric constant and the effective dielectric loss of insulating materials when inserted at equal spacing to the transmission line shown in Fig. 4.3 can be calculated by the following equations. However, this is possible only at $P < 0.02\lambda$.



t: Effective width of insulating material
p: Spacing between insulators

Fig. 4.3 Schematic Diagram of a Transmission Line with Dielectric Beads Supports

$$\left.\begin{aligned} \epsilon_e &= \frac{(\epsilon_0 - 1)\,t}{P} + 1 \\ \epsilon_e \cdot \tan\delta e &= \epsilon_0 \frac{t}{p} \tan\delta_0 \end{aligned}\right\} \quad \ldots\ldots\ (4.2)$$

where t, ϵ_0 and tan δ_0 are the thickness, the dielectric constant and the dielectric power factor of each insulating material and P is spacing between insulating materials.

(b) Attenuation

Attenuation is a transmission line loss created by imperfect conductivity of the conductors and the imperfect insulating medium or dielectric.

Attenuation for RF cable is generally expressed in dB per 100 m.

Attenuation of a transmission line is the summation of the conductor losses of the inner conductor and outer which constitute the transmission line and the dielectric losses associated with material used as the inner-conductor support.

The conductor loss can be calculated from the resistivities of the inner conductor and outer and their diameters by the following equations:

$$\text{Conductor loss} = 0.00629\sqrt{\epsilon_e}\cdot\sqrt{f(\text{MHz})}\ \frac{\left[\dfrac{\sqrt{\rho_1}}{d_{out}} + \dfrac{\sqrt{\rho_2}}{D_{in}}\right]}{\log_{10}\dfrac{D_{in}}{d_{out}}}\ [\text{dB}/100\ \text{m}] \quad \ldots\ldots\ (4.3)$$

where ρ_1 : Resistivity of Inner Conductor
ρ_2 : Resistivity of Outer Conductor
d_{out}: Outside Diameter of Inner Conductor (mm)
D_{in} : Inside Diameter of Outer Conductor (mm)

$$\text{Dielectric loss} = 9.09\ f\ (\text{MHz})\sqrt{\epsilon_e}\cdot\tan\delta e \quad [\text{dB}/100\ \text{m}] \quad \ldots\ldots\ (4.4)$$

where ϵ_e : Effective Dielectric Constant
$\epsilon_e\cdot\tan\delta e$: Effective Dielectric Loss

Note that resistivity in copper at 20°C is 1.69$\mu\Omega$ cm and that in aluminum is 2.62$\mu\Omega$ cm. In teflon now used as an insulating material for transmission lines $\epsilon_0 = 2.1$ and tan $\delta_0 < 2 \times 10^{-4}$ (100 MHz), in polyethylene $\epsilon_0 = 2.55$ and tan $\delta_0 \leq 1 \times 10^{-4}$ (100 MHz).

Attenuation due to conductor losses thus increases with frequency and in proportion to the square root of frequency.

Attenuation due to dielectric losses is directly proportional to frequency.

Attenuation can be calculated, however, actual measured values are not always equal with theoretical values.

The actual attenuation is generally quite close to calculated values but may vary owing to surface condition, connector alloy, and its actual conductivity.

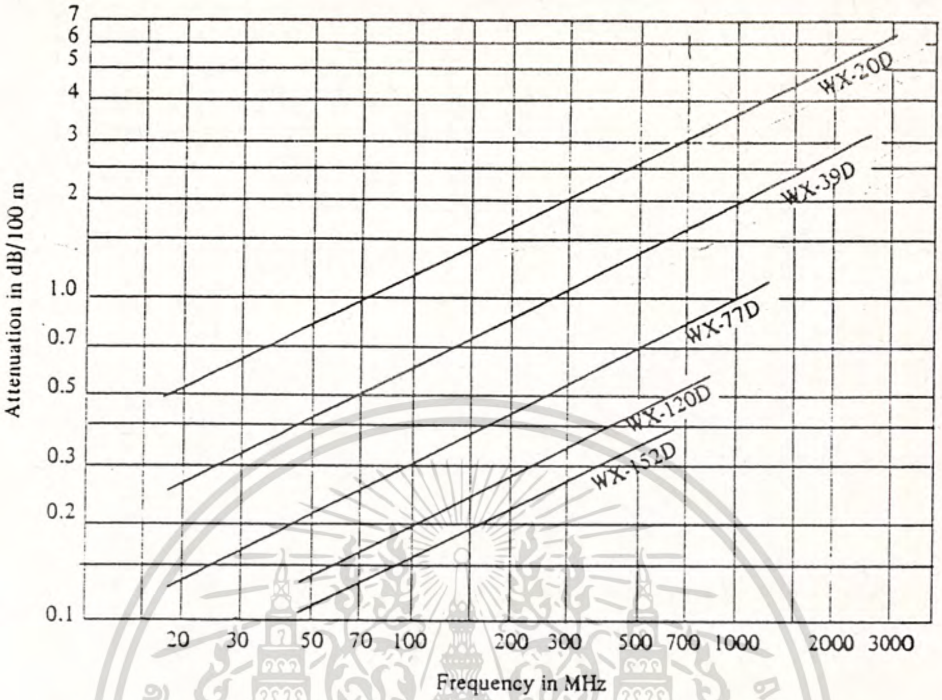


Fig. 4.4 Attenuation for Several Sizes of Rigid Transmission Lines

Measured attenuation curves for several line sizes are shown in Fig. 4.4.

Actually, attenuation increases with VSWR on transmission line and the ratio of such increase is proportional to $\frac{1 + (VSWR)^2}{2 \times (VSWR)}$.

(c) Power Ratings

There are two types of power ratings for transmission lines. One is based on the maximum heating which the cable construction might safely withstand. It is generally referred to as the "average power rating".

The other is based on voltage-breakdown considerations and is generally described as the "peak-power rating".

Consideration of both ratings is necessary for most services.

Average power is the power in the signal capable of creating heat.

Nowadays, power ratings for coaxial transmission lines used for TV transmission in the VHF and UHF bands are specified by average power, whereas values themselves are specified by power-handling capacity which is necessary for outer conductor

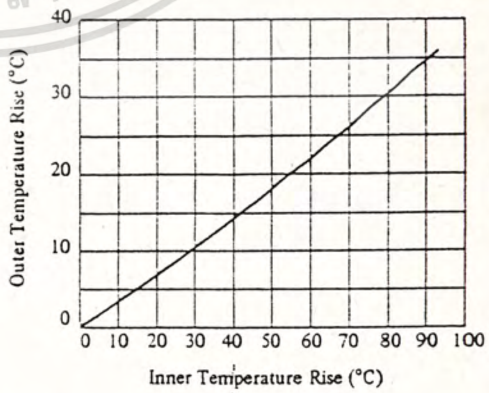


Fig. 4.5 Inner and Outer-Conductor Temperature Rise for a Coaxial Transmission Line with $Z_0 = 50\Omega$

temperature rise to reach 23°C, when the transmission line is in operation at an ambient temperature of 40°C.

Temperature rise of inner conductor in this case is about 62°C, so the temperature of inner conductor including the ambient temperature becomes about 102°C.

Fig. 4.5 shows the relation of the values in temperature rise between the inner conductor and outer one.

Average power rating can be calculated from the following:

$$Pave = \frac{2.116\ \delta\ D_{out}}{[dB]} \qquad ------ (4.5)$$

where Pave = average power rating for 23°C temperature rise of the outer conductor (62°C rise of inner), watt.

D_{out} = Outside diameter of line, mm

dB = 1.85α   where α is measured attenuation, dB/100 m (1.85 is increase in at elevated temperature)

δ = Heat-emissivity coefficient of outer conductor, watts/25.4 mm

Fig. 4.6 shows average power ratings for various types of transmission lines.

Table 4.2 shows heat-emissivity coefficients.

Table 4.2 Heat Emissivity Coefficient of Outer Conductor

Outside diameter of outer conductor (mm)	9.5	22.2	41.3	79.4	132.2	155.6	228
Nominal transmission line	–	WX-20D	WX-39D	WX-77D	WX-120D	WX-152D	–
Heat emissivity coefficient (W/25.4 mm)	0.166	0.134	0.120	0.111	0.104	0.100	0.095

Equation (4.5) is obtained on condition that temperature rise of outer conductor is permissible up to 23°C whereas Fig. 4.7, in which power-handling capacity when permissible value of temperature rise is controlled at 23°C is taken as reference, shows increase and decrease of power-handling capacity in case where the other permissible temperature values are adopted.

Equation (4.5) is obtained based on an ambient temperature of 40°C whereas Fig. 4.8 shows relations of power-handling capacity at arbitrary ambient temperatures, with power-handling capacity at an ambient temperature of 40°C assumed as 1.

Practically a temperature rise in the transmission line system must be paid a particular attention from a viewpoint of maintenance and operation of transmitters, and the system is desired to be operated at a value lower than rated power from safety standpoint at the time of actual operation.

Furthermore, note that the transmission line system may develop in it a local temperature rise which often leads to suspension of broadcasting. This is greatly attributed to loose contacts at such joints as connectors, etc. Therefore, loose contacts at those joints must also be paid attention.

(d) Impedance Discontinuity

Actually what is employed by the rigid coaxial transmission line is a number of transmission lines, each of which (hereinafter called unit transmission line for short) is equally structured, short in length and connected one another as shown in Fig. 4.1. Impedance discontinuity at each joint of the unit transmission line, if any, will cause part of the signal to be reflected at such discontinuous points.

The reflected waves, though very small, from those discontinuous points are periodically super-imposed each other at certain frequency so that transmission line characteristics will be deteriorated.

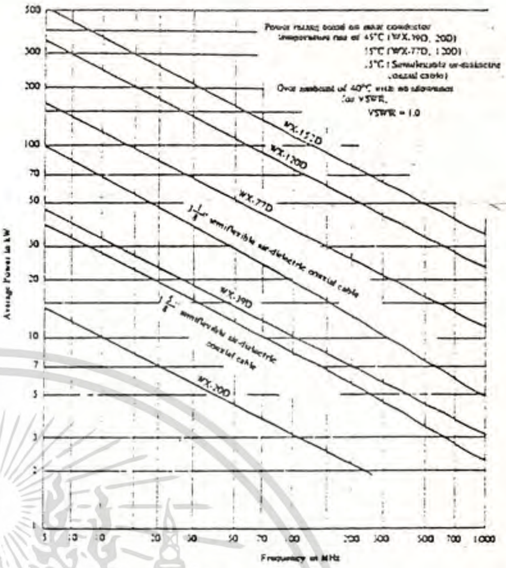


Fig. 4.6 Curves Illustrating Average Power Ratings for Several Sizes of Transmission Lines

Now, assume that N number of unit transmission lines are connected one another, and each is Lv in length and equal in structure. Suppose impedance discontinuities are present at the joints of the respective unit transmission lines, part of the signal is reflected from these discontinuous points.

Note that if the reflected waves from these discontinuous points are the same in amplitude and the discontinuous points are equally spaced, the reflected waves from these points will be superimposed at frequency corresponding to $f_0 = nVk_0/2Lv$, provided that V is velocity

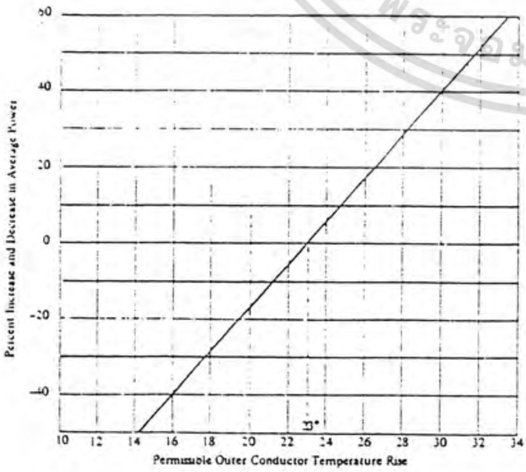


Fig. 4.7 Percent Increase of Decrease in Average Power to Permissible Outer Conductor Temperature Rise

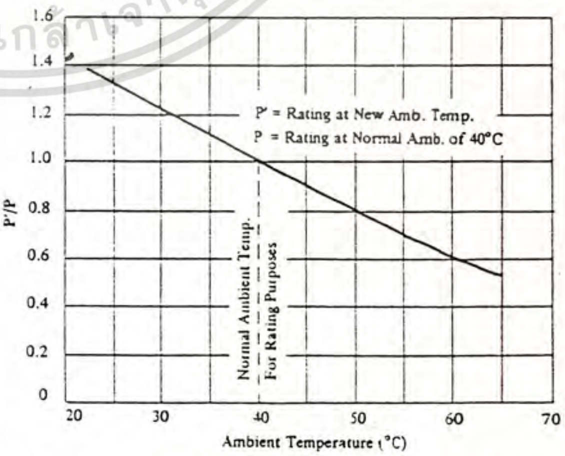


Fig. 4.8 Average Power Rating in Transmission Line for Variation in Ambient Temperature

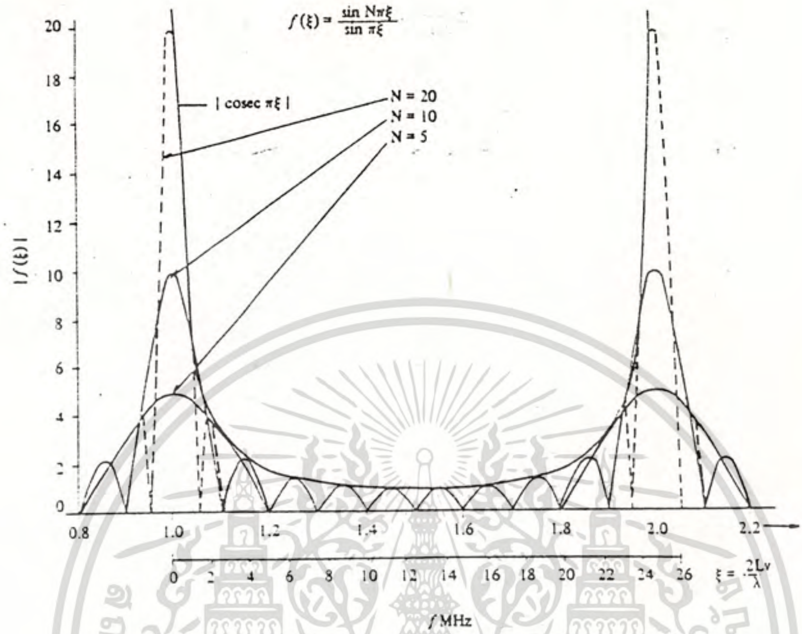


Fig. 4.9 Reflection Pattern for N Discontinuities Equally Spaced

of light and k_0 is velocity factor of the transmission line.

This is 99.8% for the unit transmission line having the structure shown in Fig. 4.1.

Such reflected waves are superimposed each other, for example, at 24.6 MHz when Lv = 6.096 m, at 25 MHz when Lv = 5.956 m and at 75 MHz when Lv = 1.489 m, and thus transmission line characteristic are deteriorated. Being very small, this characteristic deterioration is negligiable in the VHF band but sometimes may not be so in the UHF band.

Fig. 4.9 shows reflection patterns for N discontinuities equally spaced.

Fig. 4.10 (a) shows relation between length of unit transmission line and frequency at which superimposition of small reflections develops.

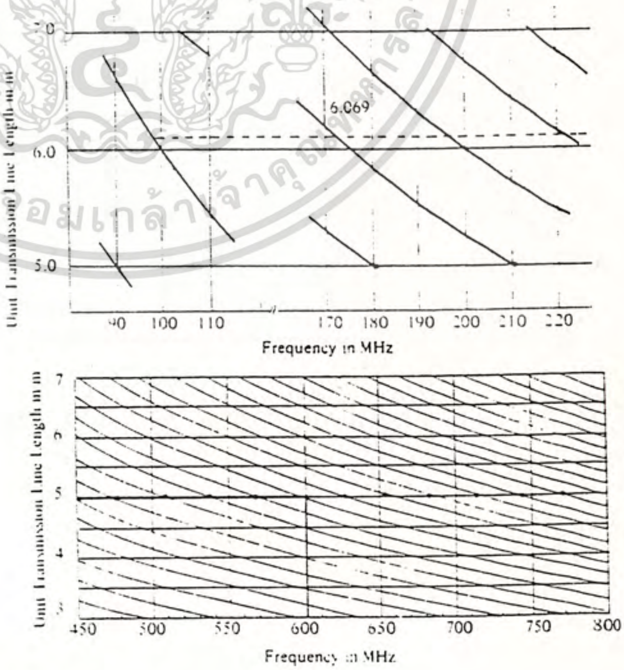


Fig. 4.10 (a)

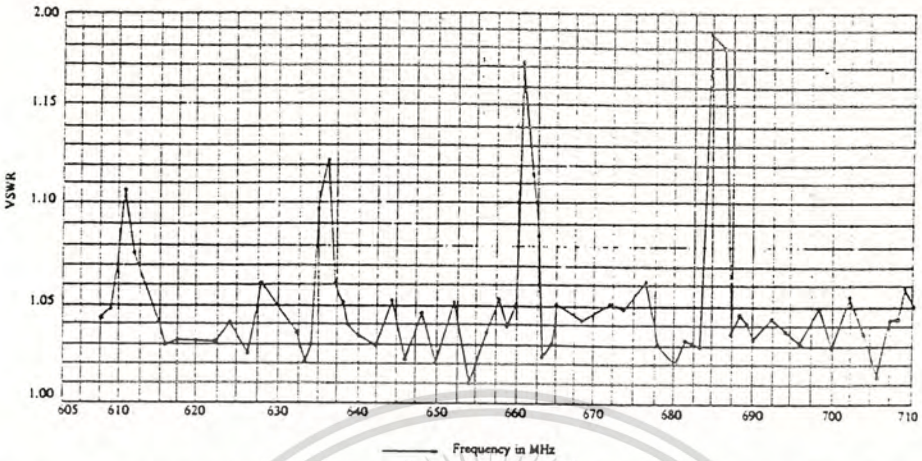


Fig. 4.10 (b) An Example of A Poorest Connection of 20 Transmission Lines of 6.096 m Long (WX-77D) (Size of beads to support the inner conductor is not suitable.)

And the same Fig. (b) shows superimposition of small reflections due to inadequate dimension of the undercut section of the beads supporting the inner conductor.

The reflections from impedance discontinuous points develop not only because of impedance discontinuities at joints of the unit transmission lines, but also in the bead section supporting the inner conductor.

We still feel it very difficult to completely eliminate such a superimposition of small reflections through techniques of today.

Practically, length of unit transmission line is chosen according to working frequency in an attempt to eliminate the superimposition of reflections.

(e) Cutoff Frequency of TE_{11} Mode

No problem is posed while the diameter of the transmission line is very small compared with wavelength. But, if the diameter increases to that comparable with wavelength, higher modes other than TEM mode will develop in the transmission line.

TEM, which is the fundamental mode and travels in the transmission line, is without cutoff frequency, however, higher modes other than this have cutoff frequencies, the lowest of which is owned by TE_{11} mode.

In the transmission line of 50Ω in impedance, the cutoff frequency of TE_{11} mode, when the insulating material is air, can be calculated from the following equation:

$$fe\ (GHz) = \frac{136}{Din} \qquad \ldots\ldots\ldots\ldots (4.6)$$

where D_{in} is inside diameter (mm) of outer conductor.

Actually various higher modes will develop above cutoff frequency of TE_{11} mode, which sharply deteriorates transmission line characteristics.

Higher modes tend to occur when discontinuities are present in the transmission line, and the occurrence is conspicuous at the undercut section or the overcut section of the transmission line. Consequently, frequency range in which the transmission line can be actually used depends on the dimension of the undercut or the overcut section of the transmission line.

Table 4.3 shows cutoff frequencies of TE_{11} modes in various transmission lines.

Table 4.3 TE_{11} Mode Cutoff Frequency for Air Dielectric Coaxial Lines (500 HMs)

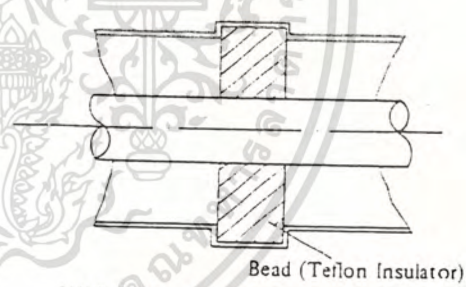
EIAJ Standard Type	TE_{11} Mode Cutoff Frequency (GHz)				
	Air Line	Undercut Teflon	Overcut Teflon	Undercut Polyethylene	Overcut Polyethylene
WX-152D	0.895	0.686	0.472	0.640	0.390
WX-77D	1.768	1.355	0.932	1.264	0.770
WX-39D	3.505	2.686	1.847	2.506	1.526

Note: Values of relative dielectric constant used in Table
Teflon: 2.11, Polyethylene: 2.544

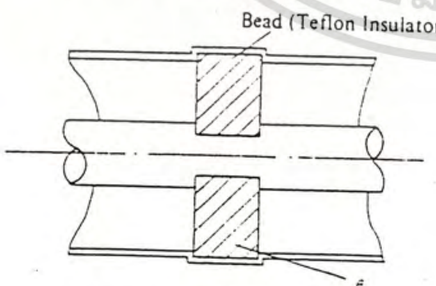
4.2 Undercut and Overcut

On a transmission line equipped with insulators to support inner conductors as shown in Fig. 4.3, when the frequency becomes high its characteristics may sometimes be deteriorated by the insulators. This is because electrostatic capacitance is effectively given to only the points where insulators are equipped and these behave as a kind of low-pass filters.

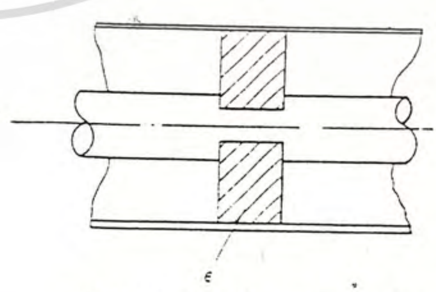
The effect with electrostatic capacitance thus effectively given is usually compensated, as shown in Fig. 4.11, by reducing the diameter of the inner conductor or increasing the inner diameter of the outer conductor, of the portion where insulators are equipped.



(b) Overcut Support Insulator



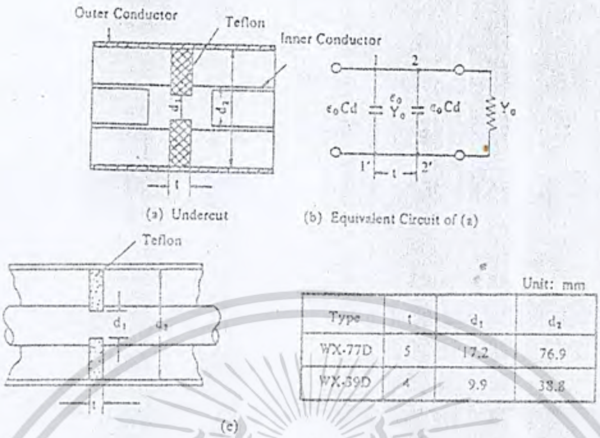
(a) Undercut Support Insulator



(c) Undercut and Overcut Support Insulator

Fig. 4.11 Dielectric Supports the Diameter Ratios of which are Enlarged for Compensation

$$D/d > \exp\left(\sqrt{\epsilon}\,\frac{Z}{60}\right)$$



Unit: mm

Type	t	d_1	d_2
WX-77D	5	17.2	76.9
WX-39D	4	9.9	38.8

Fig. 4.12 Dimensions of Undercut of Coaxial Transmission Cable

The former to reduce the diameter of the inner conductor is called undercut, and the latter to increase the inner diameter of the outer conductor is overcut.

In Fig. 4.12, the section (b) shows the equivalent circuit of the portion with undercut on a coaxial line of which inner conductor is supported by an insulator of dielectric constant ϵ_0 and thickness t shown in (a) in the figure. In short, as the diameter of the conductor discontinuously changes, electrostatic capacitance is effectively given to the portion.

In this figure, Cd denotes electrostatic capacitance without insulators and ϵ_0Cd is additional electrostatic capacitance with insulators.

The section (c) in the figure shows the dimensions of the portion with actual undercut, and the tolerance for the accuracy of dimensions is required to be under 0.2 mm. In general, dimensions of portions with undercut or overcut are determined with experiments.

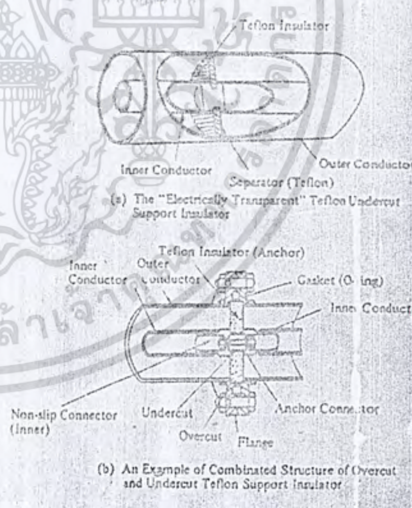


Fig. 4.13 Actual Construction of Undercut and Overcut

Fig. 4.13 shows examples of actual construction of undercut and overcut.

4.3 Semi-flexible Air-dielectric Cable

Semi-flexible air-dielectric cable is available for a long line of cable, and it does not produce any overlapping of reflected waves caused by connection of many short coaxial tubes on a rigid coaxial transmission line. Accordingly, it has broad-band characteristics and it can be bent for a radius of about 200 times its outer diameter.

As for the construction of semi-flexible air-dielectric cable, its inner conductor is made of soft-temper copper wire (in case of the outer diameter of 10 mm or less) or copper pipe, and the outer conductor is of aluminum or copper sheath of high purity with better anticorrosiveness, or some of them are of corrugate metallic sheath.

Fig. 4.14 (a) shows various types of semi-flexible air-dielectric cables with insulation. Fig. 4.14 (b) shows examples of cables.

Today, semi-flexible air-dielectric cable is available for the main feeder line between the transmitter and the transmitting antenna with characteristic impedance of 50Ω and 75Ω, and 72Ω for branch cable between junction box and radiators.

As for attenuation and rated power, its attenuation is a little larger and rated power is a little smaller than those of copper coaxial feeder of the same outer diameter.

4.4 Solid-dielectric Cable

Solid-dielectric cable are comprised of solid or stranded conductor, plastic insulating material, and a braided sheath which serves as the outer conductor.

Examples of construction and electrical characteristics of this cable are shown on Table 4.4.

Table 4.4

Type of Line (EIAJ)	Nominal Imp., ohms	Capacity mμF/km	Dielectric	Velocity Factor	Outside Diam. (mm)	Inner Conductor Size (mm)	Attenuation (dB/km)			
							80 MHz	100 MHz	200 MHz	700 MHz
7C-2V	75 ± 3	67	Solid Polyethylene	67%	10.2	7/0.4	6.4	7.2	10.4	2.0
10C-2V	75 ± 3	67	Solid Polyethylene	67%	13.4	7/0.5	5.3	5.9	8.4	16.5
20C-2V	75 ± 3	67	Solid Polyethylene	67%	24.7	2.9	2.6	2.9	4.3	8.8
8D-2V	50 ± 2	100	Solid Polyethylene	67%	11.5	7/0.8	5.9	6.6	9.5	18
10D-2V	50 ± 2	100	Solid Polyethylene	67%	13.7	2.9	4.2	4.8	6.8	13
20D-2V	50 ± 2	100	Solid Polyethylene	67%	26.1	6.0	2.2	2.5	3.8	7.7

In the broadcast field, its use is generally limited to samplines, jumper connections, and occasionally as the main feeder line. In FM and TV installations, it is rarely used except for the receiver system.

Solid-dielectric cable is frequently used in translator service because of short-length requirements.

4.5 Waveguide

For the UHF-TV broadcast, the use of waveguide from the transmitter to the antenna provides a lower attenuation than any coaxial line.

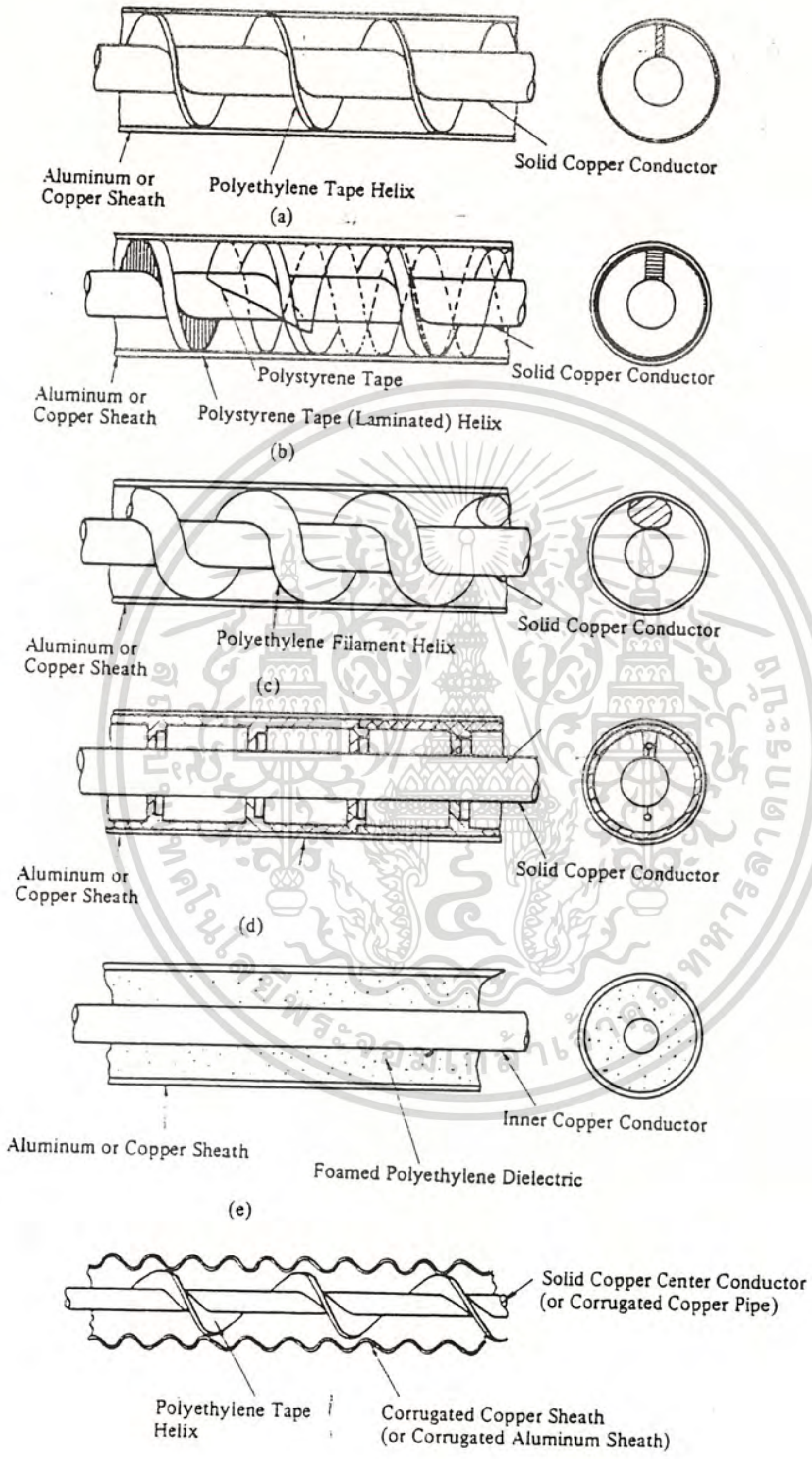


Fig. 4 14 (a) Semiflexible Air-dielectric Coaxial Cable

Fig. 4.14 (b) Various Types of Semiflexible Air-dielectric Cables

Table 4.5

EIA Designation		WR-975	WR-1150	WR-1500	WR-2100
Waveguide Inner Dimension	[in]	$4\frac{1}{8} \times 9\frac{3}{4}$	$5\frac{3}{4} \times 11\frac{1}{2}$	$7\frac{1}{2} \times 15$	$10\frac{1}{2} \times 21$
Outer Length of Flange	[in]	$8\frac{3}{8} \times 13\frac{1}{4}$	$8\frac{3}{8} \times 14\frac{1}{2}$	$10\frac{1}{2} \times 18$	$14\frac{1}{8} \times 24\frac{5}{8}$
Standard Length	[ft]	10	10	10	20
Weight	[lb]	90	104	124	300
Material		Copper-clad Steel	Copper-clad Steel	Copper-clad Steel	Copper-clad Steel
Frequency Range	[MHz]	750 ~ 1120	640 ~ 960	490 ~ 750	350 ~ 540
Power Rating	[kW]	150	215	425	780

It is manufactured, using sheet-metal processes, from copper-clad steel or aluminum.

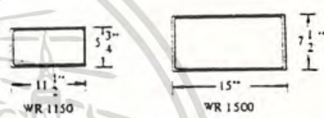


Table 4.5 shows the construction of flat waveguide.

Aluminum flat waveguide is actually in use at NHK Ikoma UHF-TV Station (output – 50 kW) in Japan.

As many waveguides of short length are connected for practical use, like in the case of rigid transmission line small reflection at connected points are sometimes overlapped at certain frequencies.

4.6 Installation of Transmission Line

(1) Rigid Transmission Line

There are two methods of installing rigid transmission line to a steel tower; one is to install the lines separately to a tower as shown in Fig. 4.15 (a), and another is to fix two lines in parallel together to a tower as shown in (b) in the same figure.

In both methods, the top portion of the transmission line is fixed with a fixed hanger to the tower, the vertical portion of the line is supported by the tower with spring hangers at intervals of about 3 meters and the horizontal portion is supported with roller supports or horizontal hangers at intervals of about 3 meters.

While, when a feeder line is to be installed through the wall of the station building into the inside, it must be fixed to the wall with horizontal anchor.

A 90° elbow is applied for the portion where the line is to be bent for a right angle.

When a transmission line is thus installed outdoor, its one end is connected with a fixed hanger

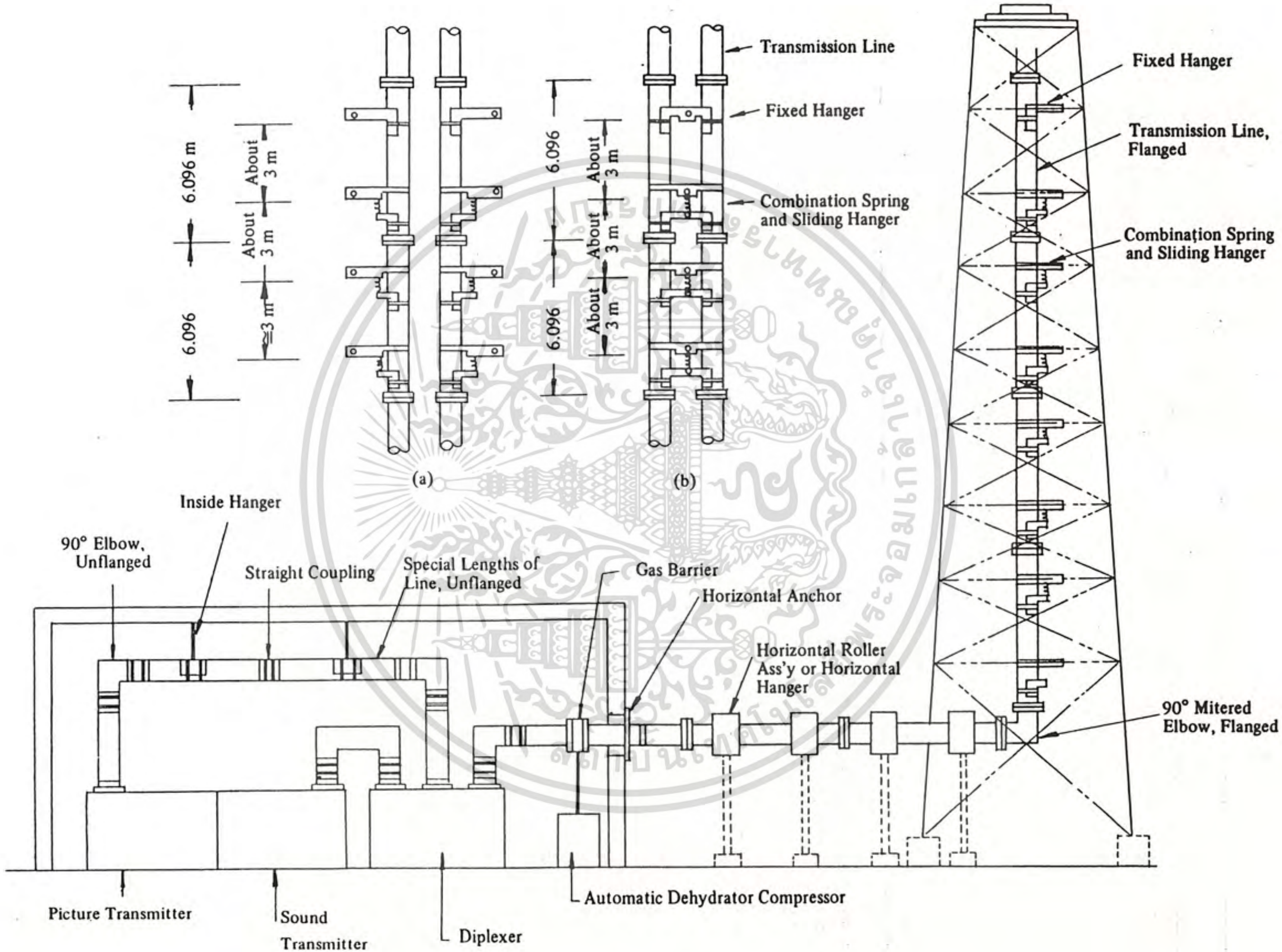


Fig. 4.15 (a) Installation and Layout of Transmission Lines

Fig. 4.15 (a) Installation and Layout of Transmission Lines

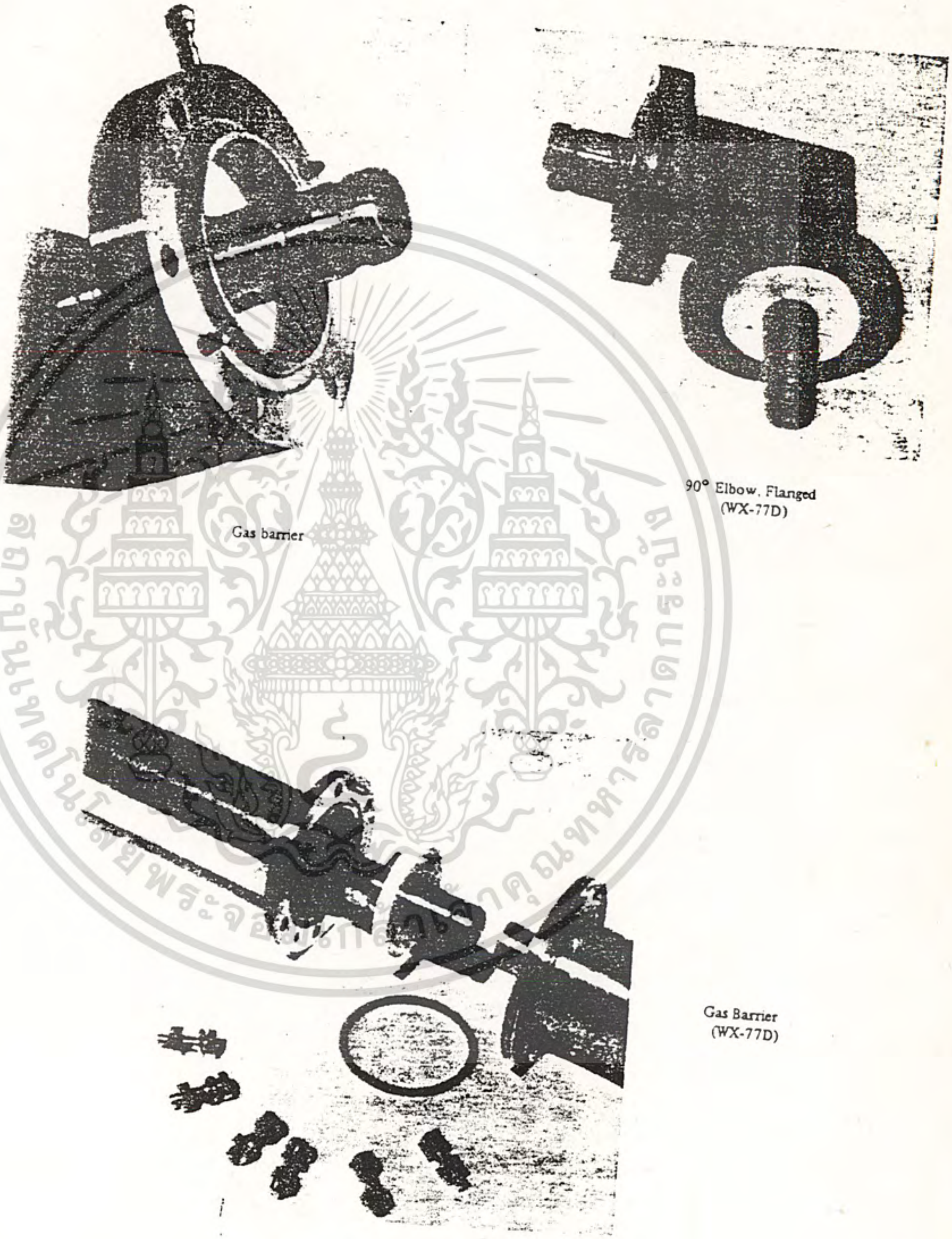
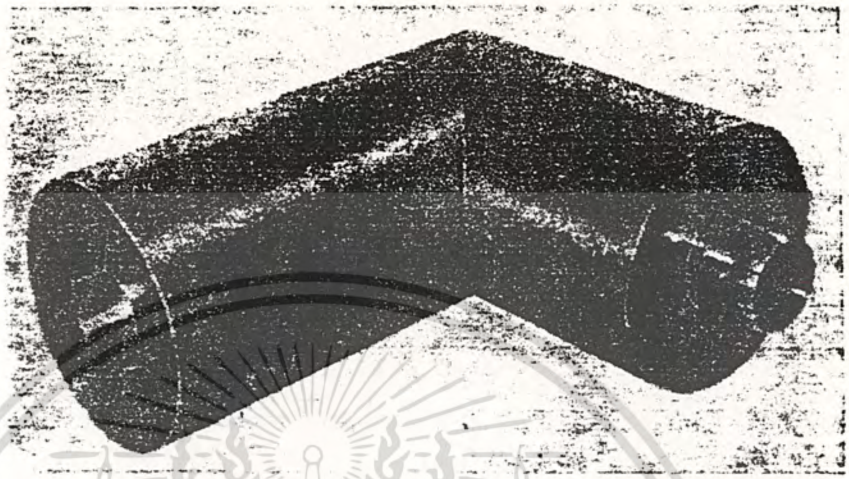
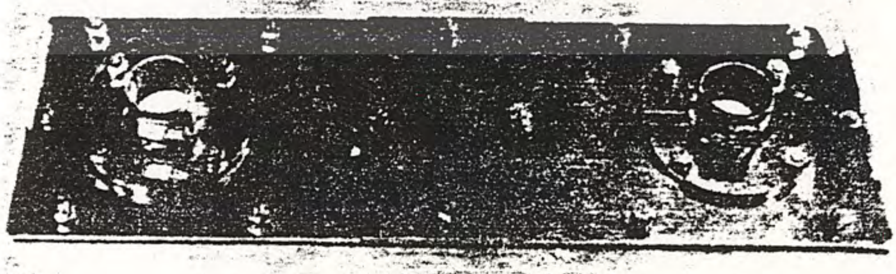


Fig. 4.15 (b) Parts for Rigid Transmission Line Assembly



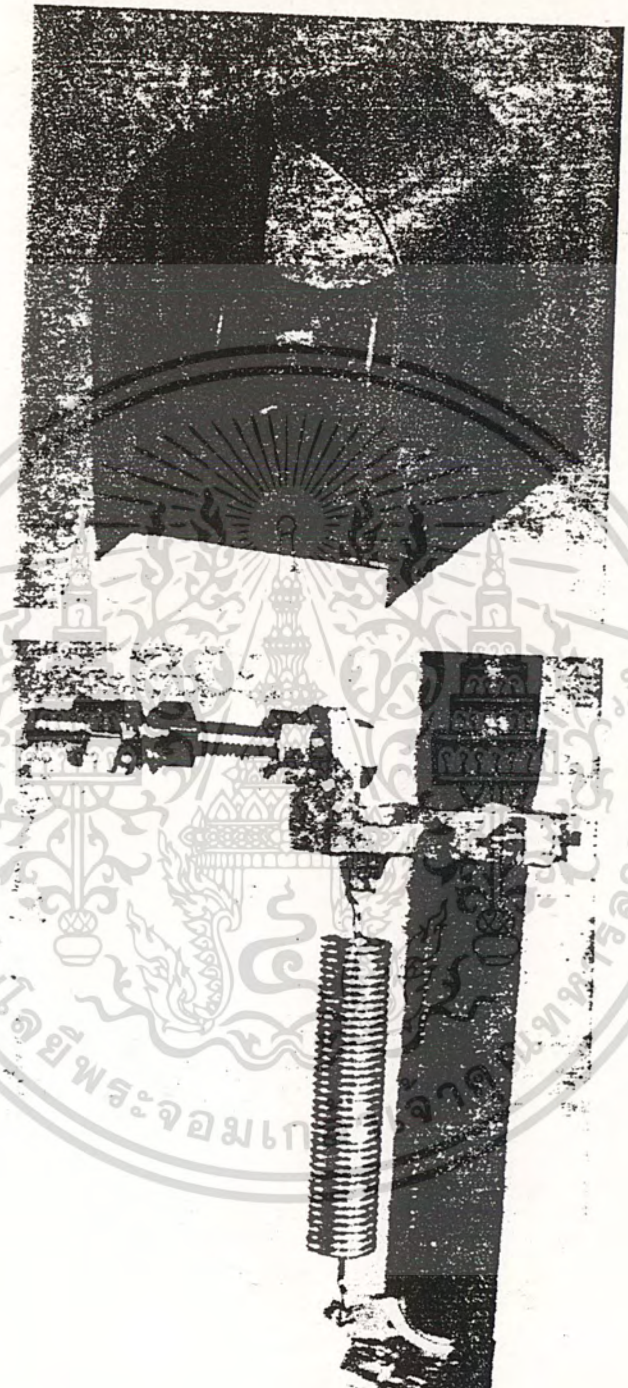
90° Elbow, Unflanged (WX-77D)

Straight Coupling (WX-77D)



Horizontal Anchor (WX-39D)

Fig. 4.15 (c) Parts for Rigid Transmission Line Assembly



Horizontal Roller
(WX-77D)

Combination Spring and Sliding Hanger
(WX-77D)

Fig. 4.15 (d) Parts for Rigid Transmission Line Assembly to the tower and the other end is fixed with horizontal anchor to the building, and the in-between portion is so made as to be movable along the direction of the line.

This is because, expansion or shrinkage of the line by ambient temperature between the line and the tower, or elongation of the line by thermal expansion by power supply to the line be absorbed by the bending of the coaxial cable around the connection of the vertical portion and the horizontal portion.

Dried air is sealed into a coaxial cable so that no moisture inside the feeder line becomes dew, and also penetration of moisture through the connected portion is prevented.

Dried air is always supplied by automatic dehydrator. Its pressure is $0.07 \sim 0.3\ kg/cm^2$.

(2) Semi-flexible Air-dielectric Cable

This cable is fixed with fixed hangers at places to the tower.

After installation, like the case of rigid transmission line an automatic dehydrator is used to supply dried air into the cable.

A-67

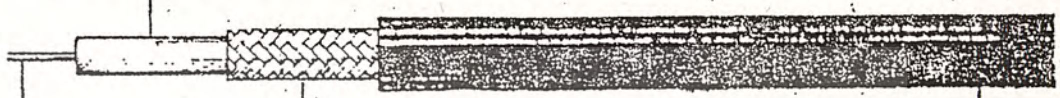
Published by : Japan International Cooperation Agency (JICA)

First published 1984. *S.K*

ภาคผนวก B-1

B-1 ชื่อเรียกและคำย่อเกี่ยวกับสายโคแอกเซียลที่ควรรู้

ฉนวนหรือสารไดอิเล็กทริก (insulation หรือ dielectric) มักจะเป็น PE (โพลีเอธีลีน) หรือ โฟม (cellular PE)



ตัวนำตรงกลาง
ner conductor
o center conductor)

ชีลด์หรือตัวนำภายนอกหรือลวดทองแดงถัก (shield หรือ outer conductor หรือ braided copper wire)

เปลือกหุ้ม (jacket หรือ sheath) มักจะเป็น PE (โพลีเอธีลีน-มักจะเป็นสีดำหรือสีธรรมชาติของสาร) หรือ PVC (โพลีไวนิลคลอไรด์ - มักจะเป็นสีเทาหรือดำหรือขาว) หรือ NMV (non-migratory PVC - มักจะเป็นสีเทา หรือดำ)

ย่อมาจากคำว่า Radio Guide ซึ่งหมายถึงสายนำคลื่นวิทยุ

ย่อมาจากคำว่า Utility หรือ Universal ซึ่งหมายถึงใช้งานทั่วไป

RG-8A/U

เป็นตัวเลขแสดงเบอร์ของสายโคแอกเซียล

ตัวอักษร A,B,C (อาจมีหรือไม่มีแล้วแต่กรณี) แสดงว่ามีการเปลี่ยนแปลงเพิ่มเติมอย่างใดอย่างหนึ่ง เช่น วัสดุทำเปลือกหุ้มเปลี่ยนไป, จำนวนลวดตรงกลางต่างกัน, อิมพีแดนซ์ต่างกันเล็กน้อย, อัตราการสูญเสียต่างกันเล็กน้อย ฯลฯ

ตัวเลขแสดงเส้นผ่านศูนย์กลางภายนอกโดยประมาณของสารไดอิเล็กทริก

แสดงค่าอิมพีแดนซ์
C = 75Ω (เปลือกหุ้มมักจะเป็นสีดำหรือขาว)
D = 50Ω (เปลือกหุ้ม PVC มักจะเป็นสีเทาหรือขาว ถ้าเป็น PE มักจะเป็นสีดำ)

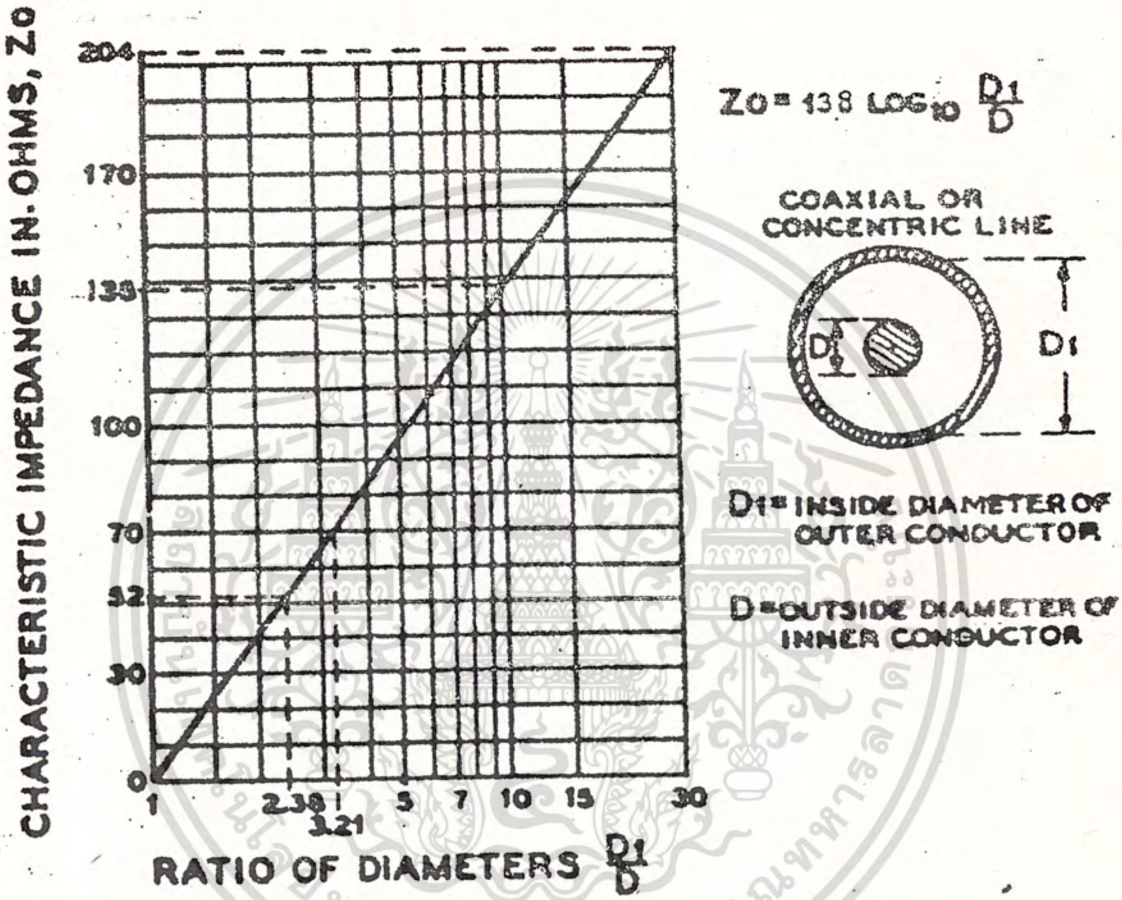
3C-2V

แสดงลักษณะของชีลด์ + เปลือกหุ้ม เช่น
B = ชีลด์ทองแดง + ชีลด์อะลูมิเนียม + PVC
E = ชีลด์ทองแดง + PE
L = ชีลด์อะลูมิเนียม + PVC
N = ชีลด์ทองแดง + ไนล่อนถัก
V = ชีลด์ทองแดง + PVC
W = ชีลด์ทองแดง 2 ชั้น + PVC

แสดงชนิดของสารไดอิเล็กทริก
2 = PE
F = โฟม

ตาราง B-1 แสดงคุณสมบัติของสายนำสัญญาณเบอร์ต่าง ๆ

เบอร์ของสาย	อิมพีแดนซ์ (Ω)	เส้นผ่านศูนย์กลางสาย (มม.)	จำนวนลวดตัวกลาง	ตัวคูณความเร็ว	อัตราการสูญเสีย (dB) ที่ความยาว 100 เมตร 10 MHz	30 MHz	50 MHz	100 MHz	145 MHz	200 MHz	400 MHz	1 GHz	ความจุไฟฟ้า (pF/เมตร)	แรงดันใช้งานสูงสุด (V_{rms})	บาท/เมตร
RG-8/U	52	10.3 (PVC)	7	0.66	2.0	3.7	5.2	7.2	8.8	10.5	15.4	29.2	96.8	4000	23 – 25.50
RG-8/U โฟม	50	10.3 (PVC)	1	0.78	1.5	2.9	3.9	5.9	7.4	8.9	13.8	23.4	85.3	1500	
RG-8A/U	52	10.3 (NMV)	7	0.66	2.0	3.7	5.2	7.2	8.8	10.5	15.4	29.2	96.8	4000	28 – 29.50
RG-11/U	75	10.3 (PVC)	7T	0.66	2.0	3.6	5.2	7.2	9.0	11.0	15.7	25.6	67.3	4000	25 – 25.50
RG-11/U โฟม	75	10.3 (PVC)	1	0.78	–	2.5	3.3	–	5.6	–	9.8	–	55.4	1600	
RG-11A/U	75	10.3 (NMV)	7T	0.66	2.0	3.6	5.2	7.2	9.0	11.0	15.7	25.5	67.3	4000	
RG-58/U	53.5	4.9 (PVC)	1	0.66	4.1	7.6	10.2	14.6	18.6	22.3	32.8	55.6	93.5	1900	10 – 12
RG-58A/U	50	4.9 (PVC)	19T	0.66	4.3	8.1	10.8	16.1	19.9	23.9	37.7	70.5	101.0	1900	10 – 15
RG-58A/U โฟม	50	4.9 (PVC)	1	0.78	–	–	10.5	14.9	17.8	21.0	29.5	47.6	85.3	600	
RG-58C/U	50	4.9 (NMV)	19T	0.66	4.3	8.1	10.8	16.1	19.9	23.9	37.7	70.5	101.0	1900	12
RG-59/U	73	6.1 (PVC)	1	0.66	3.6	6.9	7.9	11.2	13.6	16.1	23.3	39.7	68.9	2300	
RG-59/U โฟม	75	6.1 (PVC)	1	0.78	2.3	4.8	5.9	8.5	10.4	12.3	17.8	28.9	56.7	800	
RG-59B/U	75	6.1 (NMV)	1	0.66	3.6	6.9	7.9	11.2	13.6	16.1	23.0	39.4	68.9	2300	18
RG-174/U	50	2.5 (PVC)	7	0.66	12.8	–	21.7	29.2	34.3	39.4	57.4	98.4	101.0	1500	
RG-213/U	50	10.3 (NMV)	7	0.66	2.0	3.7	5.2	7.2	8.8	10.5	15.4	29.2	101.0	4000	
RG-214/U (ชิลด์ 2 ชั้น)	50	10.8 (NMV)	7S	0.66	2.0	3.7	5.2	7.2	8.8	10.5	15.4	29.2	101.0	5000	
RG-218/U	50	22.1 (NMV)	7	0.66	0.78	1.5	–	3.0	3.9	4.9	–	–	98.8	11000	
1.5C-2V	75	3.1 (PVC)	1	0.66	9.8	14.5	–	–	33.0	39.0	–	–	69.0	300	
2.5C-2V	75	4.0 (PVC)	1	0.66	5.2	9.0	–	–	21.0	25.0	–	–	60.0	500	
3C-2V	75	5.8 (PVC)	1	0.66	4.4	7.7	–	–	17.4	20.8	–	–	67.0	1000	5 – 7
(3C-2V)	75	5.8 (PVC)	7	0.66	4.8	8.8	–	–	19.4	22.9	–	–	67.0	1000	
5C-2V	75	7.5 (PVC)	1	0.66	2.6	4.9	–	–	11.2	11.7	–	–	67.0	2000	8 – 12
(5C-2V)	75	7.5 (PVC)	7	0.66	3.3	5.8	–	–	13.4	15.9	–	–	67.0	2000	
7C-2V	75	10.2 (PVC)	1	0.66	1.8	3.2	–	–	7.6	9.0	–	–	67.0	4000	23 – 40
(7C-2V)	75	10.2 (PVC)	7	0.66	2.1	3.7	–	–	8.9	10.6	–	–	67.0	4000	
10C-2V	75	13.4 (PVC)	1	0.66	1.4	–	–	–	6.2	7.4	–	–	67.0	5000	
(10C-2V)	75	13.4 (PVC)	7	0.66	1.8	3.1	–	–	7.2	8.6	–	–	67.0	5000	
1.5D-2V	50	2.9 (PVC)	7	0.66	9.3	15.5	–	26.3	34.2	40.0	–	100.0	104	300	
2.5D-2V	50	4.3 (PVC)	7	0.66	5.0	8.4	–	15.2	19.2	23.5	–	55.3	100	500	
3D-2V	50	5.5 (PVC)	1	0.66	4.4	7.7	–	13.6	17.0	–	–	50.5	100	1000	
(3D-2V)	50	5.7 (PVC)	7	0.66	4.6	8.0	–	15.6	19.0	22.5	–	56.3	100	1000	
5D-2V	50	7.5 (PVC)	1	0.66	2.6	4.6	–	8.8	10.6	12.5	–	33.6	100	2000	
(5D-2V)	50	7.5 (PVC)	7	0.66	2.6	4.9	–	10.0	12.2	14.5	–	37.3	100	2000	
8D-2V	50	11.5 (PVC)	1	0.66	1.5	–	–	5.6	7.0	–	–	22.7	100	4000	
(8D-2V)	50	11.5 (PVC)	7	0.66	2.0	3.3	–	6.3	7.9	9.5	–	24.9	100	4000	
10D-2V	50	13.7 (PVC)	1	0.66	1.4	2.4	–	4.7	5.6	5.5	–	19.7	–	5000	
(10D-2V)	50	13.7 (PVC)	7	0.66	1.4	–	–	5.3	6.8	–	–	21.4	–	–	
5D-LFV (โฟม)	50	8.0 (PVC)	1	0.78	–	–	–	–	15.4	–	27.6	–	–	–	13 – 18
5D-FB (โฟม, ชิลด์ 2 ชั้น)	50	7.5 (PVC)	1	0.79	–	–	–	–	7.8	–	13.6	–	–	–	18 – 22
8D-FB (โฟม/ชิลด์ 2 ชั้น)	50	11.1 (PVC)	1	0.79	–	–	–	–	5.0	–	9.0	–	–	–	47 – 50
10D-FB (โฟม/ชิลด์ 2 ชั้น)	50	13.0 (PVC)	1	0.79	–	–	–	–	3.8	–	7.0	–	54	–	65 – 73
12D-FB (โฟม/ชิลด์ 2 ชั้น)	50	15.4 (PVC)	1	0.79	–	–	–	–	3.2	–	5.8	–	54	–	170 – 121
hard line $\frac{3}{8}$" Alumi Foam	52	–	1	0.81	–	1.8	2.4	–	4.3	–	7.5	–	52	–	
hard line $\frac{1}{2}$" Alumi Foam	52	–	1	0.81	–	1.4	1.8	–	3.3	–	5.6	–	42	–	
heliax แบบโฟม $\frac{3}{8}$"	50	11.2	1	0.85	1.0	1.8	2.3	3.4	4.1	4.9	7.1	11.5	–	–	
heliax แบบโฟม $\frac{1}{2}$"	50	16.0	1	0.88	0.7	1.3	1.7	2.5	3.1	3.7	5.4	8.0	–	–	
ทวินลีดอย่างดี	300	10.3	7	0.85	–	–	–	–	5.0	–	–	–	–	–	3



CHARACTERISTIC IMPEDANCE OF AIR-FILLED COAXIAL LINES

If the filling of the line is a dielectric material other than air, the characteristic impedance of the line will be reduced by a factor proportional to the square-root of the dielectric constant of the material used as a dielectric within the line.

TABLE B-2 TRANSMISSION LINES

	1	2	3	4	5	6	7	8	9	10	11		12
Type of Line	Nominal Imp., ohms	RG/U Type	Mfrs. No.	Outside Dia inches	Jacket	Inner Cond. Size	Dielectric	Cap. per ft. pF	Velocity Factor	Max. rms Voltage	Power Rating, Watts Up to		Connector Series
											30 MHz	400 MHz	
Flexible Coaxial Medium	52	8		.405	I	7/21	SP	29.5[t]	.66	5000	1720	465	UHF, N
	52	8A		.405	IIA	7/21	SP	29.5	.66	5000	1720	465	UHF, N
	50		621-111	.405	I	7/19	FP	24.5	.80	1500			UHF
	50		T-4-50	.407	X	10	FP						UHF
	75	11		.405	I	7/26	SP	20.5	.66	5000	1400	340	UHF, N
	75	11A		.405	IIA	7/26	SP	20.5	.66	5000	1400	340	UHF, N
	75		621-100	.405	I	14	FP	16.5	.80	3000			UHF
	75		JT-204	.407	X	14	FP						UHF
Small	53.5	58		.195	I	20	SP	28.5	.66	1900	580	135	UHF, BNC, N
	50	58A		.195	I	19/.0071	SP	30	.68	1900	550	105	UHF, BNC, N
	53.5	58B		.195	IIIA	20	SP	28.5	.68	1900	560	135	UHF, BNC, N
	50	58C		.195	IIA	19/.0071	SP	30	.66	1900	550	105	UHF, BNC, N
	73	59		.242	I	22 cw	SP	21.5	.66	2300	720	185	UHF, BNC, N
	75	59B		.242	IIA	.023 cw	SP	21	.66	2300	720	185	UHF, BNC, N
	73		621-186	.242	P	20 cw	FP	17.3	.80	1000			UHF, BNC
	93	62		.242	I	22 cw	SSP	13.5	.84	750	550	230	UHF, BNC, N
Parallel Conductor Flat or Oval	75		214-023			7/21	SP	20	.71		1000		
	300		214-056			7/28	SP	5.8	.82				
	300		214-022			16 cw	SP	3.0	.82				
Tubular	300		214-271			7/28	PA		.82		500		
	300		214-076			7/26	PA	3.9	.82		1000		
	300		214-103			7/28	FP*						

Column 3: T-4-50 and JT-204 are manufactured by Times Wire & Cable, Wallingford, Conn. Other numbers are types made by Amphenol, Chicago, Ill.

Column 5: I – Polyvinyl chloride (PVC), black. IIA – Noncontaminating PVC, black or gray. IIIA – Polyethylene, black. Noncontaminating and abrasion-resistant. Recommended when cable is to be buried underground. P – Polyethylene. X – Xelon.

Column 6: Conductors are copper unless followed by CW (copper-weld). Decimal numbers give wire diameter in inches; others are standard copper-wire gauge except when preceding a virgule, when the figure indicates number of strands: e.g., 7/21 means 7 strands of No. 21 copper wire.

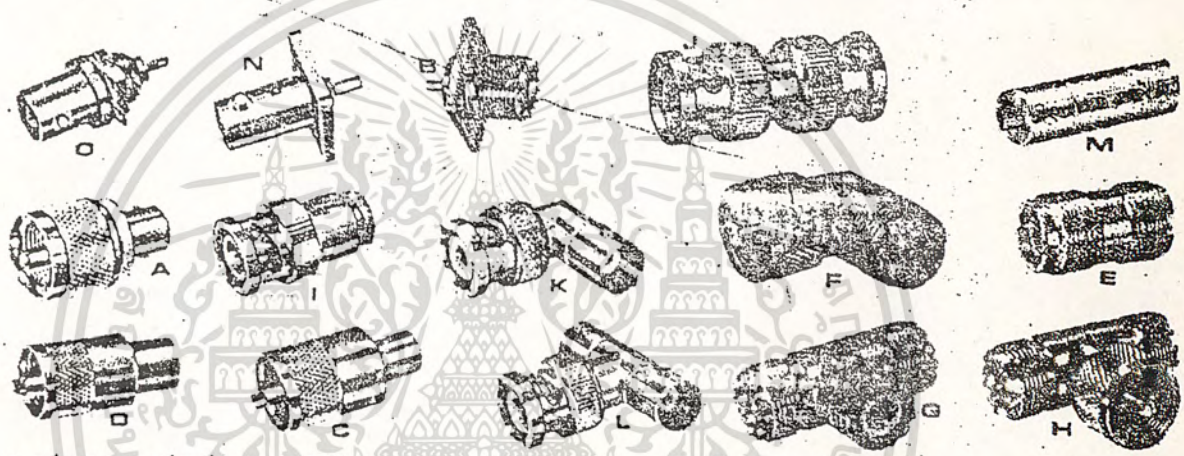
Column 7: SP – Solid polyethylene. SSP – Polyethylene strand wound around inner conductor; enclosed in solid tube of same material. FP – Foamed polyethylene. FP* – Foamed polyethylene surrounding each conductor; outer enclosure solid polyethylene. Type 214-103 is intended for use under adverse moisture and salt-spray conditions. PA – Polyethylene tube with air core.

Column 9: Open parallel-conductor line has a velocity factor of 0.95 to 0.975, depending on number of spacers and dielectric material of which they are made. Polyethylene spacers used in types listed.

Column 12: Only connectors in common use by amateurs are included.

Connectors

BNC & UHF SERIES PLUGS AND SOCKETS



O...แจ็ค BNC แบบยึดแท่น ฐานกลมใช้ต่อสาย

N...แจ็ค BNC แบบยึดแท่น ฐานสี่เหลี่ยม มีรูยึดสกรู 4 ตัว ใช้ต่อสาย

B...แจ็ค SO259 แบบยึดแท่น ฐานสี่เหลี่ยม มีรูยึดสกรู 4 ตัว ใช้ต่อสาย

J...ปลั๊ก BNC หัวท้าย

M...แจ็ค BNC หัวท้าย

A...ปลั๊ก UHF PL-259 อีกด้านเป็นแจ็ค BNC.

I...Free Plug BNC แบบต่อสาย.

F...ข้องอปลั๊ก PL-259 ด้านท้ายเป็นแจ็ค SO-259

K...ข้องอปลั๊ก BNC อีกด้านเป็นแจ็ค BNC

E...ข้อต่อตรงแจ็ค PL-259 หัวท้าย

D...หัวต่อปลั๊ก UHF PL-259 ท้ายเข้าสาย 5C

C...หัวต่อปลั๊ก UHF PL-259 ท้ายเข้าสาย 3C

L...BNC T Adaptor แบบ Free Plug BNC 1 ทาง เป็นแจ็ค BNC 2 ทาง

G...Coaxial Cable Connector แจ็คหัวต่อ 3 ทาง UHF PL-259

H...Coaxial Cable Connector ข้อต่อ 3 ทาง UHF PL-259 และ SO-295

ระบบการส่งและรับโทรทัศน์สี