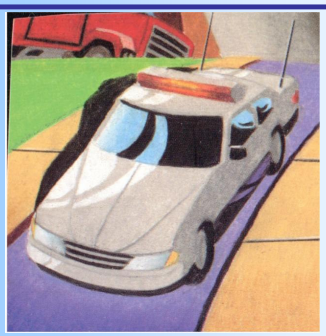
Wireless Internet Systems

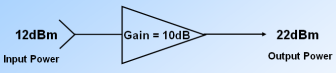


Definitions

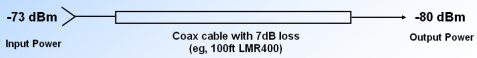
dB	Difference (or ratio) between two signal levels. Generally used used to describe the effect of system devices on signal strength.
dBm	A signal strength level. 0 dBm is defined as 1 mW of power. Small signals are negative numbers. (e.g. - 83 dBm)
dBi	The gain of an antenna relative to an isotropic radiator. Used in calculating ERP and range. NOTE: dB, dBm and dBi are used because systems' powers, gains and losses can be calculated by simply adding and subtracting.
ERP	Effective Radiated Power, equal to the antenna gain added to the power into that antenna. (Technically, called EIRP.)

Examples of Gain and Loss

Amplification



Signal Loss



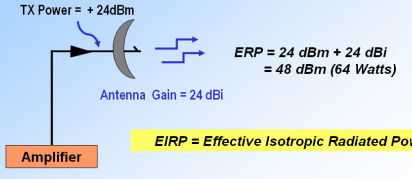
Coax Loss

Transmission Cables

Type of Cable	Description	Loss per 100 ft. at 2.4 GHz	Price per ft.	Pair of Connectors
LMR400	Low loss 3/8" foam cable	6.7 dB	$0.98	$42.00
LMR500	Transmission line, 1/2" foam cable	5.4 dB	$1.14	$86.00
LMR600WT	Transmission line, flooded braid 1/2" foam cable	4.4 dB	$1.70	$86.00
LCF-5/8	Transmission line, 5/8" foam cable	2.8 dB	$4.07	$158.00
LCF-7/8	Transmission line, 7/8" foam cable	2.06 dB	$5.06	$173.00

Effective Radiated Power (ERP)

EIRP = Transmitted Antenna gain (dBi) + TX power into it (dBm)



EIRP = Effective Isotropic Radiated Power

dBm vs. Watts

dBm	Power
0	1.0 mW
1	1.3 mW
2	1.6 mW
3	2.0 mW
6	4.0 mW
10	10.0 mW
15	32.0 mW
20	100 mW
30	1 Watt
33	2 Watts
36	4 Watts
40	10 Watts
50	100 Watts
60	1000 Watts

$$dBm = 10 \log \frac{Power}{1\ mW}$$

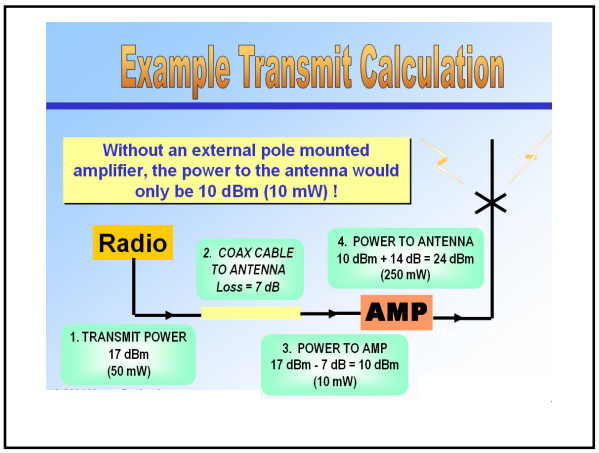
Example: Convert 250 mW to dBm

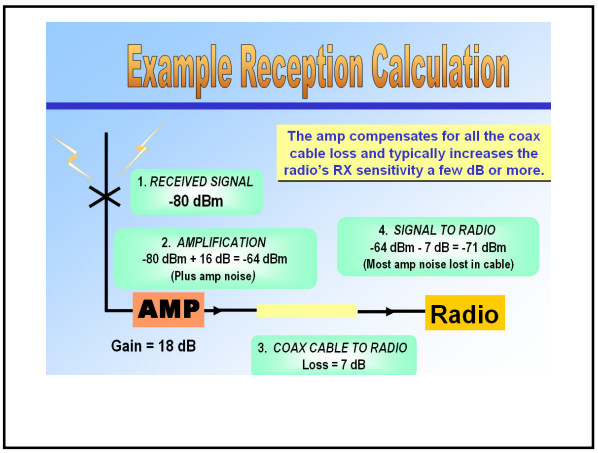
$$10 \log \frac{250}{1\ mW} = 10 \times 23.97 = 24\ dBm$$

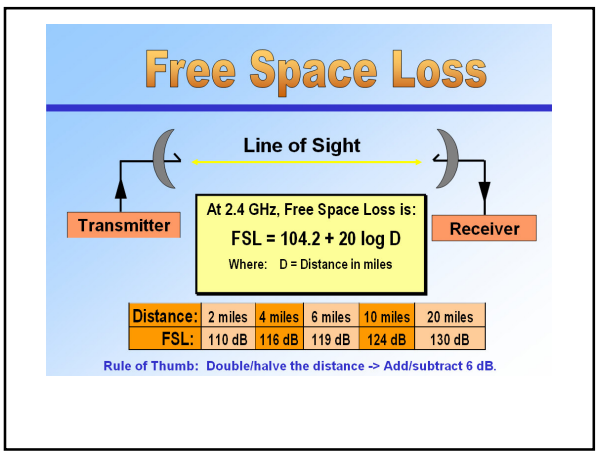
Rule of Thumb

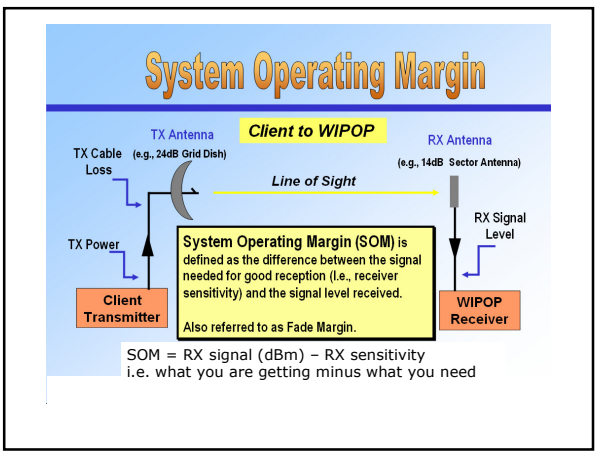
Double/Half Power → Add/Subtract 3dB

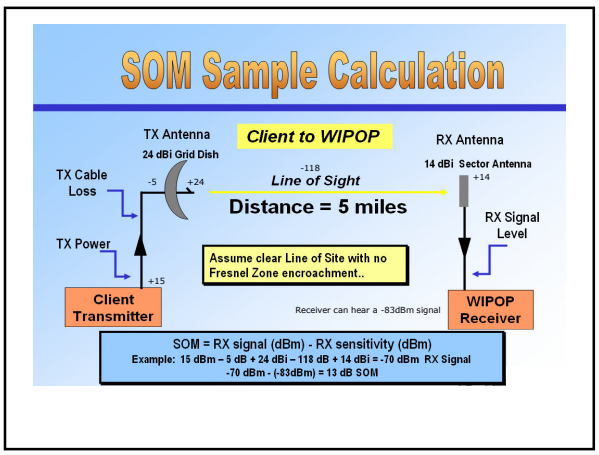
Ten Times/One-tenth power → Add/Subtract 10dB

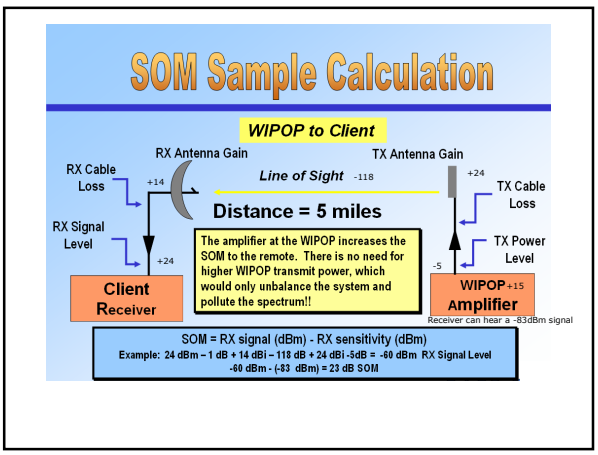

Example Transmit Calculation
Without an external pole mounted amplifier, the power to the antenna would only be 10 dBm (10 mW) !
Radio
2. COAX CABLE TO ANTENNA Loss = 7 dB
4. POWER TO ANTENNA 10 dBm + 14 dB = 24 dBm (250 mW)
AMP
1. TRANSMIT POWER 17 dBm (50 mW)
3. POWER TO AMP 17 dBm - 7 dB = 10 dBm (10 mW)


Example Reception Calculation
The amp compensates for all the coax cable loss and typically increases the radio's RX sensitivity a few dB or more.
1. RECEIVED SIGNAL -80 dBm
2. AMPLIFICATION -80 dBm + 16 dB = -64 dBm (Plus amp noise)
4. SIGNAL TO RADIO -64 dBm - 7 dB = -71 dBm (Most amp noise lost in cable)
AMP
Radio
Gain = 18 dB
3. COAX CABLE TO RADIO Loss = 7 dB

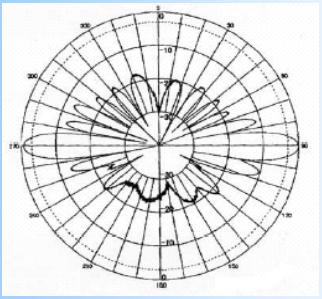

Free Space Loss
Line of Sight
Transmitter
Receiver
At 2.4 GHz, Free Space Loss is:
FSL = 104.2 + 20 log D
Where: D = Distance in miles
Distance: 2 miles 4 miles 6 miles 10 miles 20 miles
FSL: 110 dB 116 dB 119 dB 124 dB 130 dB
Rule of Thumb: Double/halve the distance -> Add/subtract 6 dB.


System Operating Margin
Client to WIPOP
TX Antenna
TX Cable Loss
(e.g., 24dB Grid Dish)
RX Antenna
(e.g., 14dB Sector Antenna)
Line of Sight
TX Power
RX Signal Level
System Operating Margin (SOM) is defined as the difference between the signal needed for good reception (i.e., receiver sensitivity) and the signal level received.
Also referred to as Fade Margin.
Client Transmitter
WIPOP Receiver
SOM = RX signal (dBm) – RX sensitivity
i.e. what you are getting minus what you need


SOM Sample Calculation
Client to WIPOP
TX Antenna
24 dBi Grid Dish
RX Antenna
14 dBi Sector Antenna
TX Cable Loss
-5
+24
-118
Line of Sight
+14
Distance = 5 miles
RX Signal Level
TX Power
Assume clear Line of Site with no Fresnel Zone encroachment..
+15
Client Transmitter
Receiver can hear a -83dBm signal
WIPOP Receiver
SOM = RX signal (dBm) - RX sensitivity (dBm)
Example: 15 dBm – 5 dB + 24 dBi – 118 dB + 14 dBi = -70 dBm RX Signal
-70 dBm - (-83dBm) = 13 dB SOM

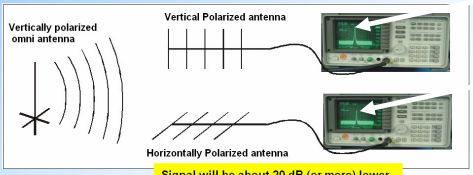

SOM Sample Calculation
WIPOP to Client
RX Antenna Gain
TX Antenna Gain
RX Cable Loss
+14
Line of Sight
-118
+24
TX Cable Loss
Distance = 5 miles
RX Signal Level
+24
The amplifier at the WIPOP increases the SOM to the remote. There is no need for higher WIPOP transmit power, which would only unbalance the system and pollute the spectrum!!
TX Power Level
-5
Client Receiver
WIPOP +15 Amplifier
Receiver can hear a -83dBm signal
SOM = RX signal (dBm) - RX sensitivity (dBm)
Example: 24 dBm – 1 dB + 14 dBi – 118 dB + 24 dBi -5dB = -60 dBm RX Signal Level
-60 dBm - (-83 dBm) = 23 dB SOM

Omni Vertical Pattern



Antenna Polarization Protection

Horizontally polarized sector antennas will greatly reduce interference from existing systems deployed in the area that have vertically polarized antennas.



Signal will be about 20 dB (or more) lower when the antennas are crossed polarized.

Coaxial Cabling Terms

Coaxial Cabling is a two conductor closed transmission medium that is primarily used for the transmission of Radio Frequency energy. The system offers tight control over electrical impedance. This yields excellent performance at high frequencies and superior EMI control/shielding. Coaxial cabling is commonly found in test environments as well as in broadcast, video and networking systems. Listed below are some common terms and definitions that are related to coaxial cabling:

Attenuation (Insertion Loss): Loss of power. Attenuation is usually measured in dB loss per length of cable (ex. 31.0 dB/100Ft.). Attenuation increases as frequency increases.

Center Conductor: The solid or stranded wire in the middle of the coaxial cable. The conductor diameter is measured by the American Wire Gauge (AWG).

Coaxial Adapter: A device used to change one connector type to another or one gender to another (ex. BNC to SMA Adapter).

Coaxial Cable: A two conductor cylindrical transmission line typically comprised of a center conductor, an insulating dielectric material and an outer conductor (shielding). Coaxial cable can be flexible (typical to the assemblies found in this catalog), semi-rigid or rigid in nature.

Coaxial Connector: The interconnection device found at each end of a coaxial cable assembly. There are many common types of coaxial connectors such as: BNC, SMA, SMB, F, etc.

Dielectric: The insulating material that separates the center conductor and the shielding.

Electromagnetic Interference (EMI): Electrical or electro-magnetic energy that disrupts electrical signals.

Frequency: The number of times a periodic action occurs in one second. Measured in Hertz.

Impedance: The opposition to the flow of alternating or varying current. Measured in Ohms. Two common impedance values are 50 Ohms used primarily for data and 75 Ohms used to transmit video signals.

Jack: The female connector usually containing a center socket.

Plug: The male connector usually containing a center pin.

RF (Radio Frequency): A frequency band from 3 MHz to 3 GHz. Primarily used for transmission of radio and television signals.

RG/U: Symbols used to represent coaxial cable that is built to U.S. government specifications (R=Radio Frequency, G=Government, U=Universal Specification).

Shielding: Conductive envelope made of wires or metal foil that covers the dielectric and the center conductor.

Twinaxial: An offshoot from coaxial cabling. Two center conductors with one dielectric and braided shielding.

VSWR (Voltage Standing Wave Ratio): The ratio of the maximum effective voltage to the minimum effective voltage measured along a RF transmission line. This value generally increases with frequency and higher values are not desirable.

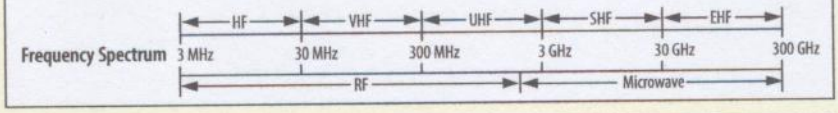
Plugs are considered male gendered connectors which utilize a center pin. Jacks are considered female gendered connectors utilizing a center socket.

A PLUG utilizes a center pin = MALE GENDER

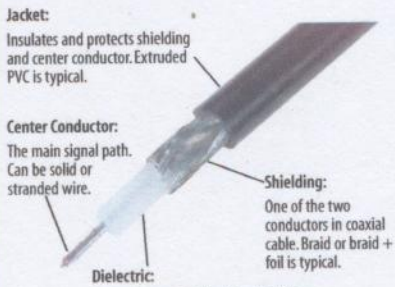
A JACK utilizes a center socket = FEMALE GENDER

Frequency Band Data

Coaxial products listed in this section are generally intended for use in the RF frequency band as illustrated here.

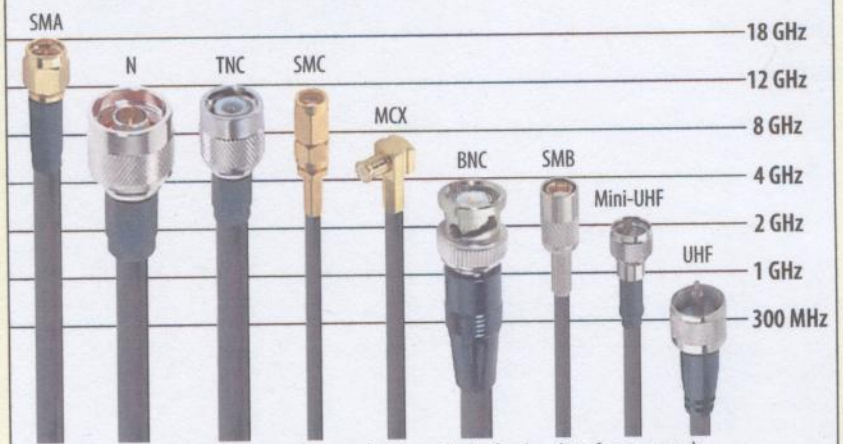


Typical Coaxial Cabling (Exploded View):



Typical Coaxial Connector (BNC Exploded View):

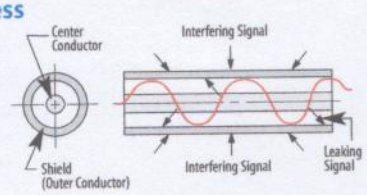
Connector Interface Frequency Chart



This chart illustrates the upper frequency limit of various interface types only. Actual frequency limits of cable assemblies are dependent on various other factors.

Understanding Shielding Effectiveness

Shielding Effectiveness is the relative ability of a shield to screen out undesirable interference. In the case of a coaxial cable, the outer conductor provides a shield to keep interfering signals from getting in and to keep signal from leaking out to become undesirable interference for nearby devices. Shielding Effectiveness is measured in dB with higher values indicating better shielding properties.



The table below illustrates the relative shielding properties of various shielding types. Notice as the shielding density increases there is a correlated increase in the shielding effectiveness value. The best shielding effectiveness value can be found in a rigid coaxial cable due to the solid tube construction of the outer jacket. In this type of cable the limiting factor for shielding effectiveness is the quality of the connector attachment.

Shielding Type			
Single Braid Shield (95% coverage)	Single Braid Shield (60%) + Foil Wrap (100%)	(2) Braids (60%) + (2) Foil Wraps (100%)	Conformable Cable
			
-55dB	-90dB	-110dB	-150dB
Approximate Shielding Effectiveness Value			

JEFA Tech
Wireless Technology Solutions

Low Loss 400 Cable

1.0 **SCOPE**: This document establishes the specifications for a flexible coaxial cable specifically designed to perform in any application requiring an easily routed, low loss RF cable.

2.0 **REQUIREMENTS**: This document contains test values for all import mechanical and electrical parameters, and as such, is the basis for all incoming inspection and acceptance.

3.0 **DIMENSIONS**:

- 3.1 Center conductor: 0.108in. (2.74mm) BCCAL
- 3.2 Dielectric: Foam polyethylene 0.285in. (7.24mm)
- 3.3 Outer conductor: Aluminum tape 0.291in. (7.39mm)
- 3.4 Overall braid: Tinned copper 0.320in. (8.13mm)
- 3.5 Jacket: Black polyethylene 0.405in. (10.29mm)

4.0 **MECHANICAL SPECIFICATIONS**:

4.1	Min Bending Radius:	1.0in.	25.4mm
4.2	Bending:	0.5ft lbs	0.68 N-m
4.3	Weight:	0.068 lbs/ft	0.10 kG/m
4.4	Tensile strength	160 lbs	72.6 kG
4.5	Flat plate crush	40 lb/in	0.71 g/mm

5.0 **ELECTRICAL SPECIFICATIONS**:

- 5.1 Cutoff frequency: 18.2 GHz
- 5.2 Velocity of propagation: 85%
- 5.3 Voltage withstand: 2500 VDO
- 5.4 Peak power: 16 kW
- 5.5 DC Resistance:
  - 5.5.1 Innder conductor, ohms: 1.02/1000ft (4.56km)
  - 5.5.2 Outer conductor, ohms: 185/1000ft (5.41km)
- 5.6 Capacitance: 23.9 pF/ft (78.40 pF/m)
- 5.7 Inductance: 0.060 uH/ft (0.20uH/m)
- 5.8 Jacket spark: 8000 VRMS
- 5.9 Shielding effectiveness: >90 dB
- 5.10 Phase stability: <10 ppm/degrees C

6.0 **ENVIRONMENTAL SPECIFICATIONS**:

- 6.1 Installation temperature range: -40/+185F (-40/+85C)
- 6.2 Storage temperature range: -94/+185F (-70/+85C)
- 6.3 Operating temperature range: -40/+185F (-40/+85C)

Frequency (MHz)	Attenuation dB/100ft	Attenuation dB/100m	Avg Power kW
30	0.7	2.2	3.3
150	1.5	5.0	1.5
450	2.7	8.9	0.83
1500	5.1	16.8	0.44
2000	6.0	19.6	0.37
2500	6.8	22.2	0.33

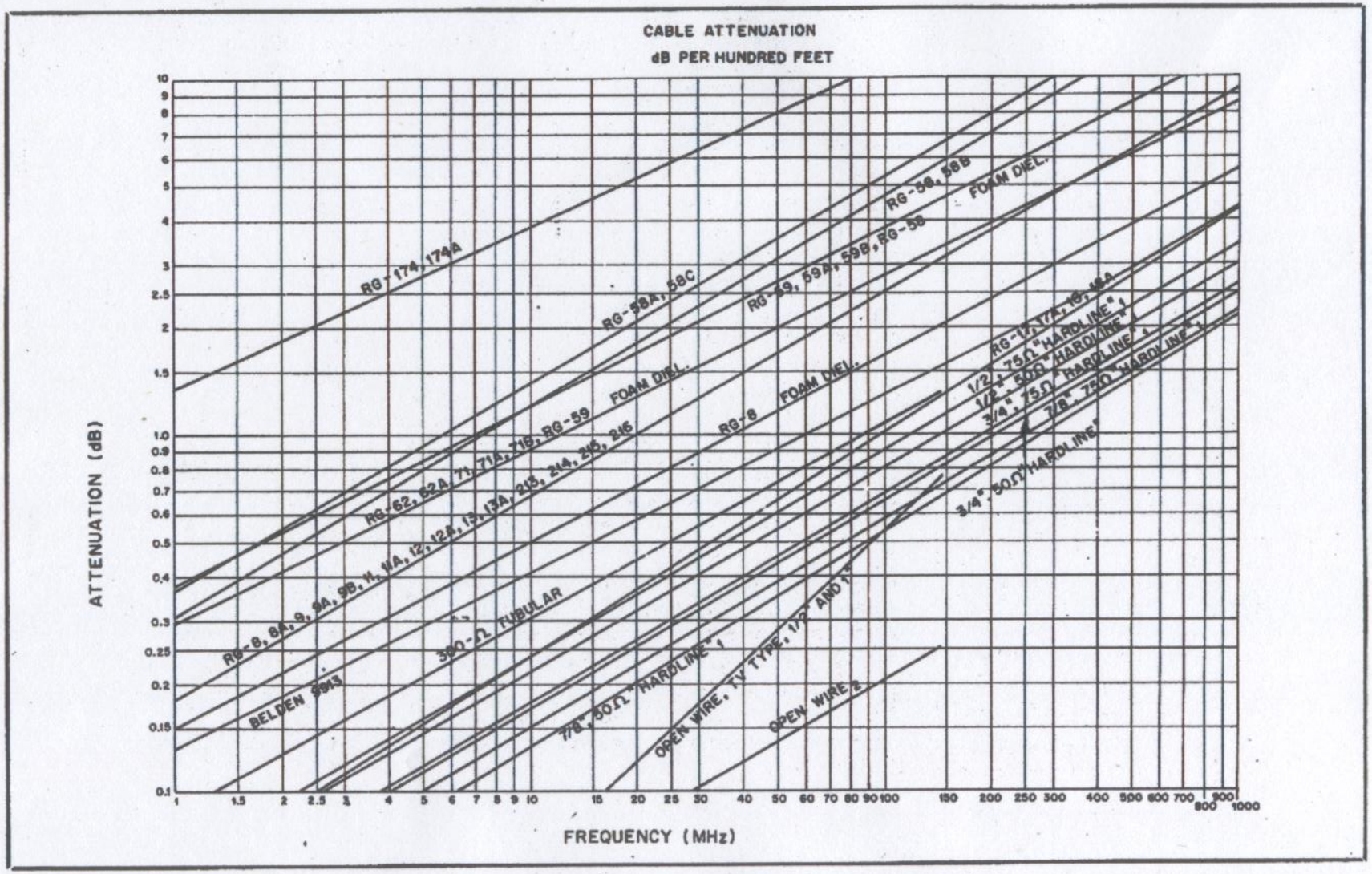


Fig. 22 — This graph displays the attenuation in decibels per 100-foot lengths of many popular transmission lines. The vertical axis represents attenuation and the horizontal axis frequency.