Amphenol
Broadband Solutions

Cable 101 Training Series

Cable Math

dBmV

mV

2 to 1

$dB = 10 \times \log_{10}(P2/P1)$

Metric system

10^2

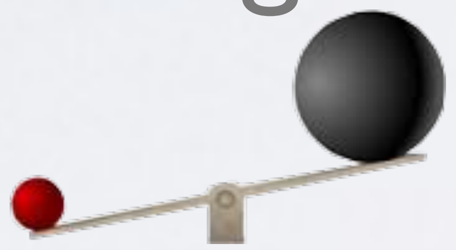
2 + 2 =?

Cable Math
Learning Objectives

- Metric System
- Powers of 10
- Logarithms
- dB and dBmV
- Cable Loss
- HFC and Drop Caculations

Metric System

- Metric system is used in most of the world, except the USA
- Measures volume(liters), 

 weight(kilograms) and  distance(meters) 
- Smaller or larger units of measure are all based on the power of 10 
- Only one basic unit for distance, the meter 

- 1 Kilometer = 1,000 Meters = 10,000 decimeters = 1,000,000 centimeters
- 1 Mile = 1,760 Yards = 5,280 Feet = 63,360 Inches

Powers of 10

- Powers of 10 is used in the decimal system that we use everyday
- 10 is the basic number in our numbering system, just like the meter is the basic unit of measurement in the metric system

- Express very large or small numbers in a compact and easy to calculate way
- 10^2 (10 squared) = 10 X 10 = 100 (Exponent: 2; Base: 10)
- 10^3 (10 cubed) = 10 X 10 X 10 = 1,000
- 10^6 = 10 X 10 X 10 X 10 X 10 X 10 = 1,000,000
- 10^9 = 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 = 1,000,000,000

Powers of 10

- Numbers less than zero can be expressed using negative powers of 10
- $10^{-3} = .001$
- $10^{-6} = .000,001$
- $10^{-9} = .000,000,001$

Powers of 10

Power of 10	Number	Decimal	Metric Prefix	Metric Symbol
10^{12}	1,000,000,000,000	Trillion	Tera	T
10^{9}	1,000,000,000	Billion	Giga	G
10^{6}	1,000,000	Million	Mega	M
10^{3}	1,000	Thousand	Kilo	K
10^{2}	100	Hundred	Hecto	H
10^{1}	10	Ten	Deca	D
10^{0}	1	One		
10^{-1}	0.1	Tenth	deci	d
10^{-2}	0.01	Hundredth	centi	c
10^{-3}	0.001	Thousandth	milli	m
10^{-6}	0.000,001	Millionth	micro	μ
10^{-9}	0.000,000,001	Billionth	nano	n
10^{-12}	0.000,000,000,001	Trillionth	pico	p

Metric System

Metric Prefix	Metric Symbol	Common Nomenclature
Tera	T	TB = Terabyte
Giga	G	GHz = Gigahertz
Mega	M	MHz = Megahertz
Kilo	K	KHz = Kilohertz
Hecto	H	
Deca	D	
deci	d	dB = decibel
centi	c	cm = centimeter
milli	m	mV = millivolt
micro	µ	µV = microvolt
nano	n	nm = nanometer
pico	p	pf = picofarad

Metric System

1 Kilometer = 1,000,000 Meters = 0.62 Miles

1 Meter = 3.28 Feet

1 centimeter = .01 meters = 0.39 Inches

Channel 2 = 55.25MHz = 55,250,000 Hertz

0 dBmV = 1millivolt = 0.001 volt

32GB = 32Gigabyte = 32,000,000,000 byte's

Metric System

32,400 µV (microvolt)	32,400	= 32.4 mV
0.7 V (Volts)	0.700	= 700 mV
860 mV (millivolts)		= 860 mV
		= 1,592.4 mV

Logarithms

- The logarithm (log) is the number to which the base must be raised in order to produce that number
- Logs express large numbers simply
- Simplifies calculations because the addition and subtraction of logarithms is equivalent to multiplication and division
- Logarithms can be expressed as powers of any number, most cable applications uses the power of 10
- Used for decibels, gain, loss, signal levels, carrier-to-noise and noise figures

Logarithms

1 Kilometer

= 1,000 Meters

= 10 X 10 X 10

= 10^3

= log 3

Logarithms

10,000 = log 4

log 10

100,000 = log 5

log 10

1,000,000 = log 6

log (10)

1,000,000,000 = log 9

1,000,000,000,000 = log 12

log -3 = .001

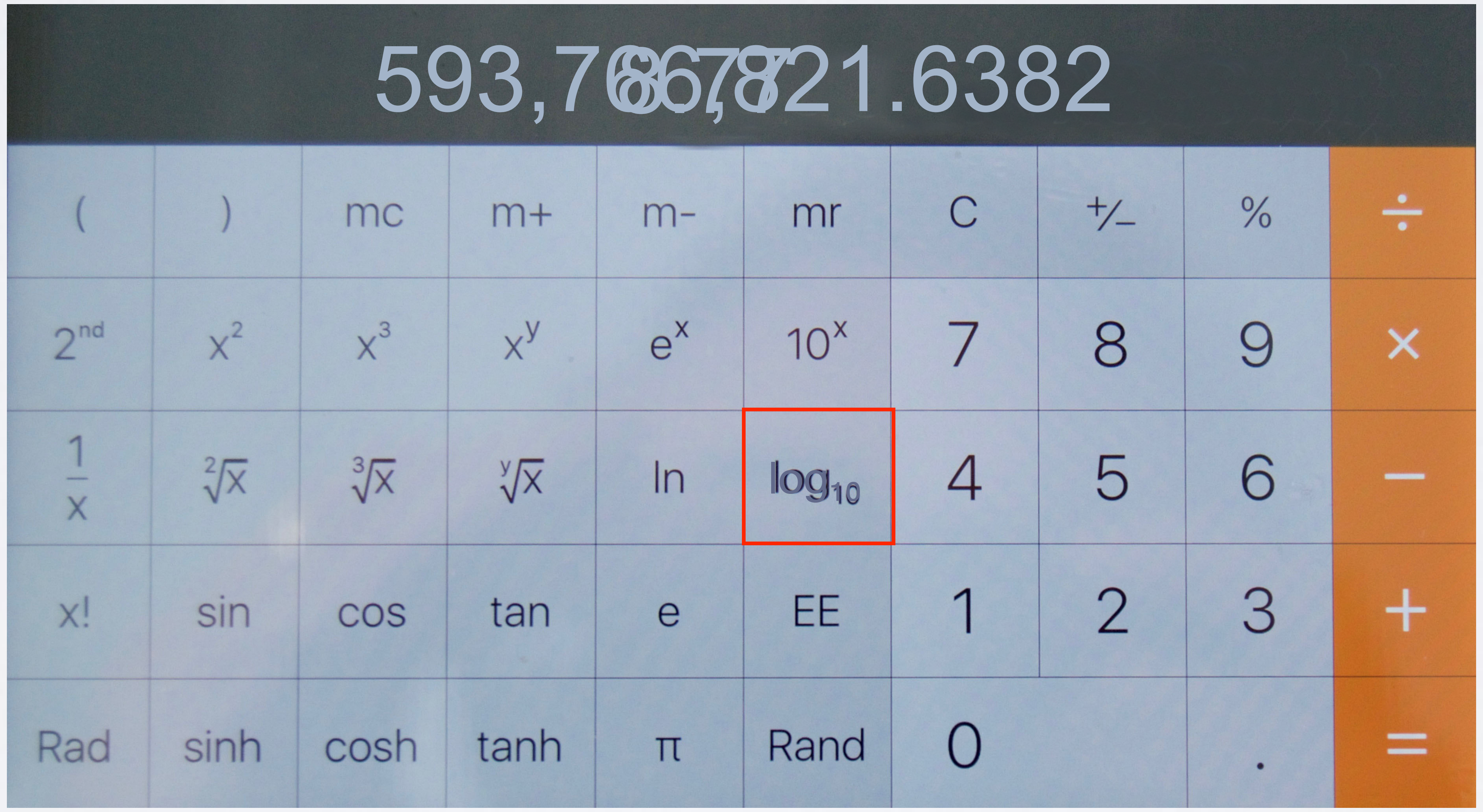
log -6 = .000,001

log -9 = .000,000,001

Logarithms

593,766,821.6382

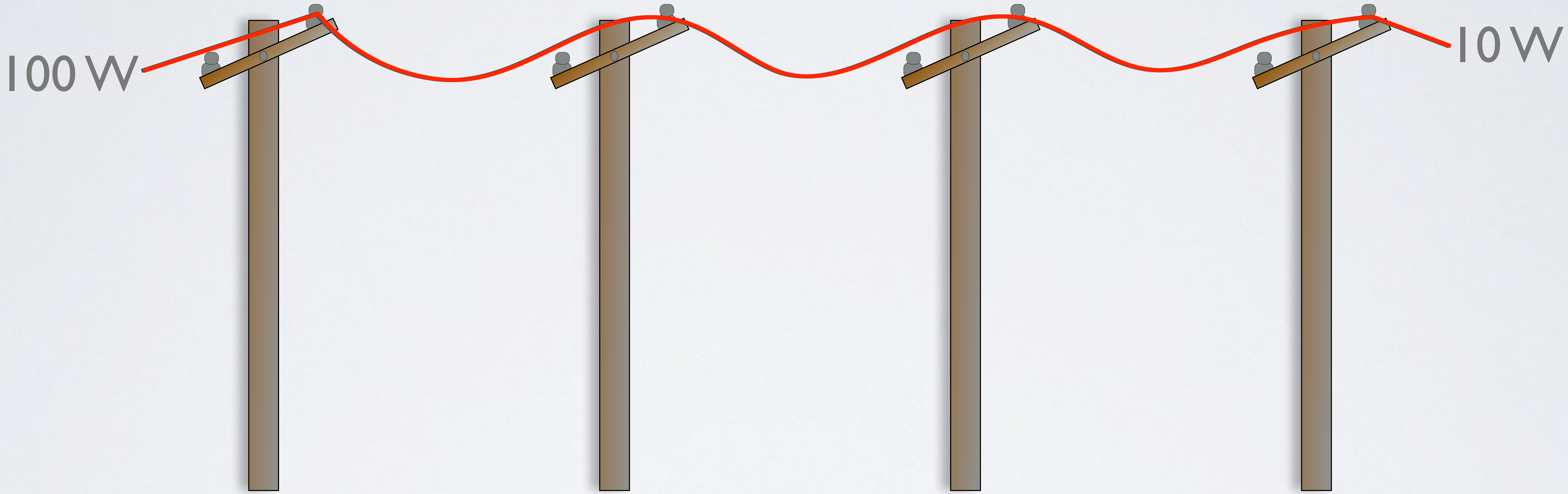
8.77



Decibels

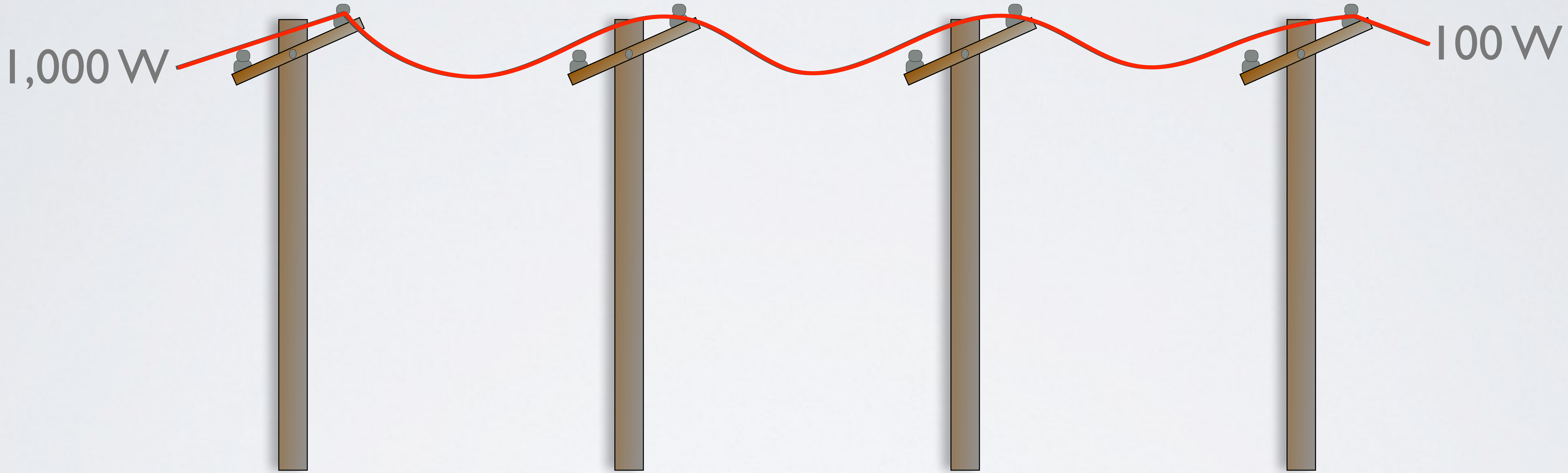
Decibel is one tenth of a bel and is a ratio that compares any two power or voltage levels such as input level to output level, video carrier to noise floor, etc

bel



100 W input / 10 W output
10 to 1 ratio

bel



1,000 W input / 100 W output
still 10 to 1 ratio

Decibels

The bel was found to be too large to use for cable communication applications so the decibel, one tenth of a bel, was established

Written as dB

Power Ratio	Value in Bels	Value in decibels
1 to 1	0	0
2 to 1	0.3	3
10 to 1	1	10
100 to 1	2	20
1,000 to 1	3	30

Decibels

- dB represents the logarithm of a ratio of two signal power or voltage levels
- dB is a relative measurement
- dB = 10 x $\log_{10}$(P2/P1), Power
  - P1 = Input
  - P2 = Output
- dB = 20 x $\log_{10}$(V2/V1), Voltage
  - V1 = Input
  - V2 = Output

Decibels

50 Watts

100 Watts

$$dB = 10 \times \log_{10} (P2/P1)$$

$$dB = 10 \times \log_{10} (100/50)$$

$$dB = 10 \times \log_{10} (2)$$

$$dB = 10 \times 0.301$$

$$dB = 3.01$$ Louder (Gain)

Decibels

10 Watts ———————— 5 Watts

$$dB = 10 \times \log_{10} (P2/P1)$$

$$dB = 10 \times \log_{10} (5/10)$$

$$dB = 10 \times \log_{10} (0.5)$$

$$dB = 10 \times -0.301$$

$$dB = -3.01 \text{ Loss}$$

dBmV

Measured in
millivolts (mV)

Very small and cumbersome numbers
3.1623 mV

dBmV

Experiments were made in the early days of television to determine the minimum signal strength needed to produce a noise free picture

dBmV

1 millivolt was established as the minimum signal level needed to produce a good noise-free video picture

1milli-volt measured across 75 ohms equals 0 dBmV, this is the standard we use today

dBmV

dBmV is a reference related to voltage and is an absolute measurement

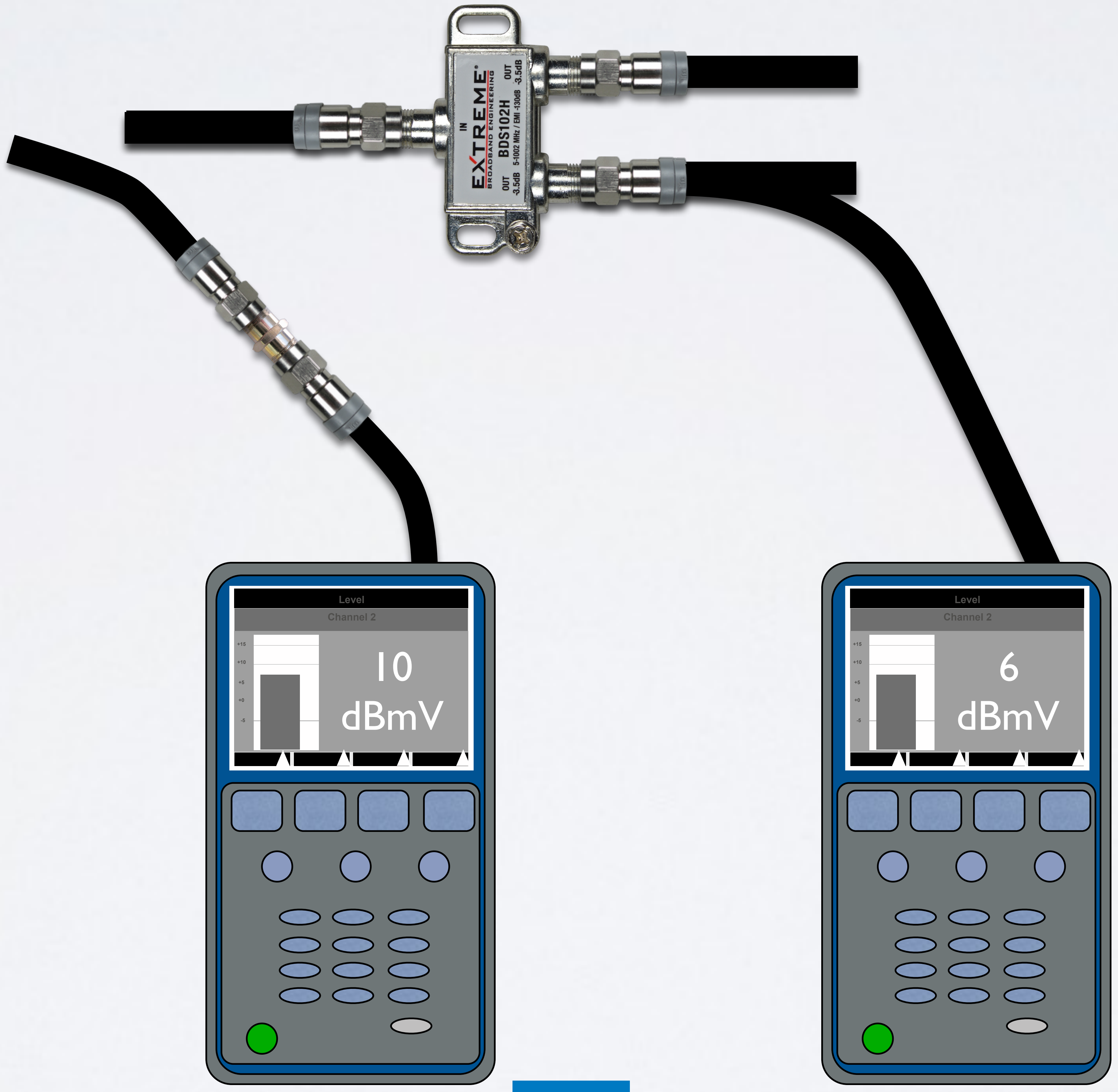
Each 6db increase doubles the voltage; each 6dB decrease halves the voltage

dBmV	mV
40	100
20	10
18	7.9
12	4
6	2
5	1.8
4	1.6
3	1.4
2	1.3
1	1.1
0	1
-6	0.5
-12	0.25

20 dB changes produce a 10-fold change in voltage

dBmV

dBmV is a reference related to voltage and is an absolute measurement



dB & dBmV

3.1623 mV in

2.1135 mV out

2.1135 mV out

3.1623 mV in
2.1135 mV out

1.0488 mV loss

dB = 20 x log(2.1135/3.1623)
dB = 20 x log(.67)
dB = 20 x (-.17)
dB = -3.4

dB & dBmV

10 dBmV in

6.5dBmV out

6.5dBmV out

10 dBmV in
6.5 dBmV out
3.5dB loss

dB & dBmV

10 dBmV in
25 dBmV out
15dB gain

10 dBmV in

25 dBmV out

dB & dBmV

If you can measure it, it's "dBmV"

Absolute signal measurement

0 dBmV = 1mV across 75 ohms

If you have to calculate it, it's "dB"

Ratio between two power or voltage levels

Represents Gain or Loss

Cable Attenuation

One of the essential steps in the troubleshooting process is how to calculate the amount of attenuation that a length of coaxial cable has

To determine the loss you need to know 3 things:

1. Type of cable
2. Frequency used
3. Cable length

Cable Attenuation

Cable manufactures provide cable loss tables that indicate the loss of cables in dB per 100 feet at different frequencies

Cable Loss Per 100 Feet					
MHz	RG-59	RG-6	RG-11	0.625	0.875
5	0.77	0.58	0.38	0.13	0.09
45	1.75	1.39	0.89	0.4	0.29
55	1.88	1.54	0.96	0.45	0.32
330	4.5	3.74	2.35	1.14	0.82
450	5.3	4.4	2.75	1.35	0.97
550	5.9	4.9	3.04	1.51	1.09
750	6.96	5.54	3.65	1.79	1.29
870	7.54	6.11	4.06	1.95	1.41
1000	8.09	6.55	4.35	2.11	1.53

Cable Attenuation

How to calculate cable loss:

1. Use the cable loss table to find the loss thru 100 feet of cable
   - loss through RG-6 cable at 550MHz = 4.9dB

2. Divide the length of the cable by 100
   - 140’ (cable length) ÷ 100 = 1.4 (the multiplier)

3. Multiply the result from step 2, by the cable loss in step 1
   - 1.4 X 4.9 = 6.86 dB

Cable Attenuation

Example 1, calculate the loss through 118 feet of RG-6 cable at 870 MHz

1. Using the cable loss table find the loss thru 100 feet of RG-6 cable at 870 MHz
   - 6.11 dB

2. Divide the length of the cable by 100
   - 118 /100 = 1.18

3. Multiply 1.18 by the cable loss per 100 feet (6.11)
   - 1.18 X 6.11 = 7.21 dB cable attenuation

Cable Attenuation

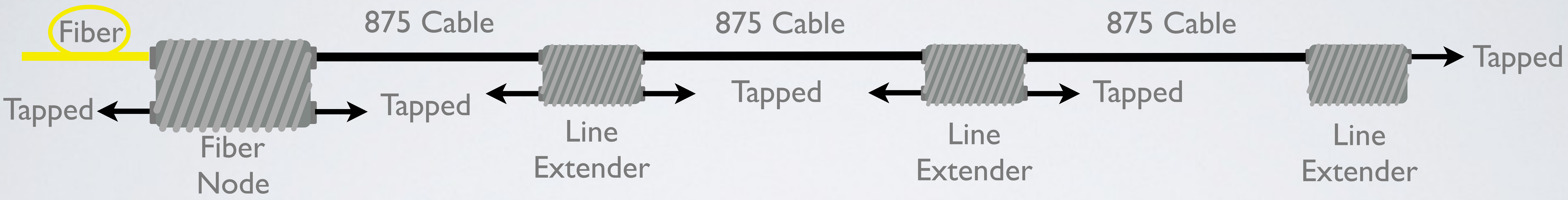
Example 2, calculate the loss through 56 feet of RG-6 cable at 45 MHz

1. Using the cable loss table find the loss thru 100 feet of RG-6 cable at 45 MHz
   - 1.39dB
2. Divide the length of the cable by 100
   - 56 / 100 = 0.56
3. Multiply 0.56 by the cable loss per 100 feet (1.39)
   - 0.56 X 1.39 = 0.78 dB cable attenuation

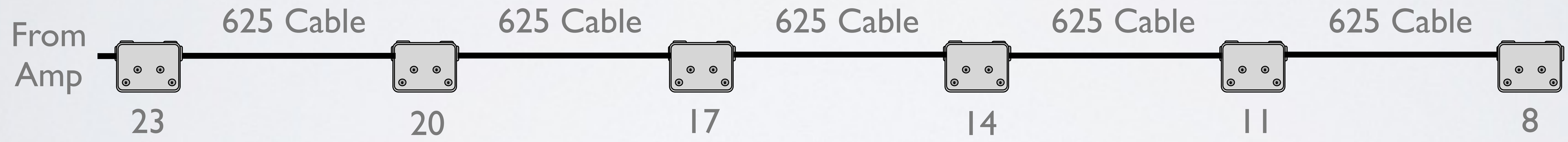
HFC Plant

HFC Plant

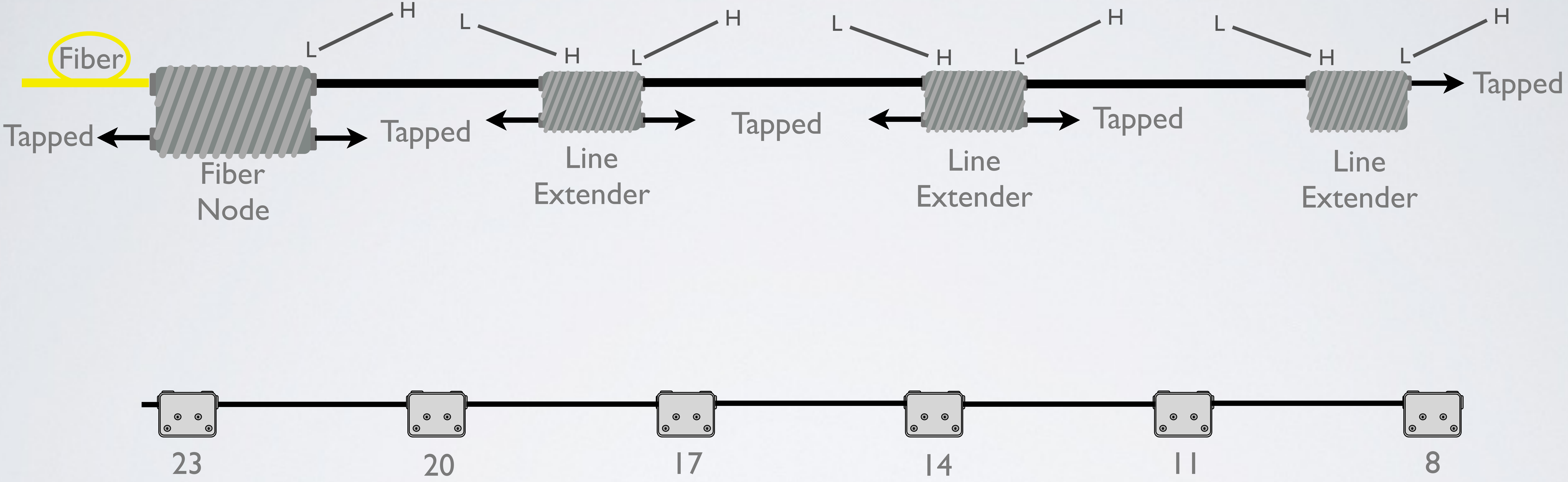
Express Feeder



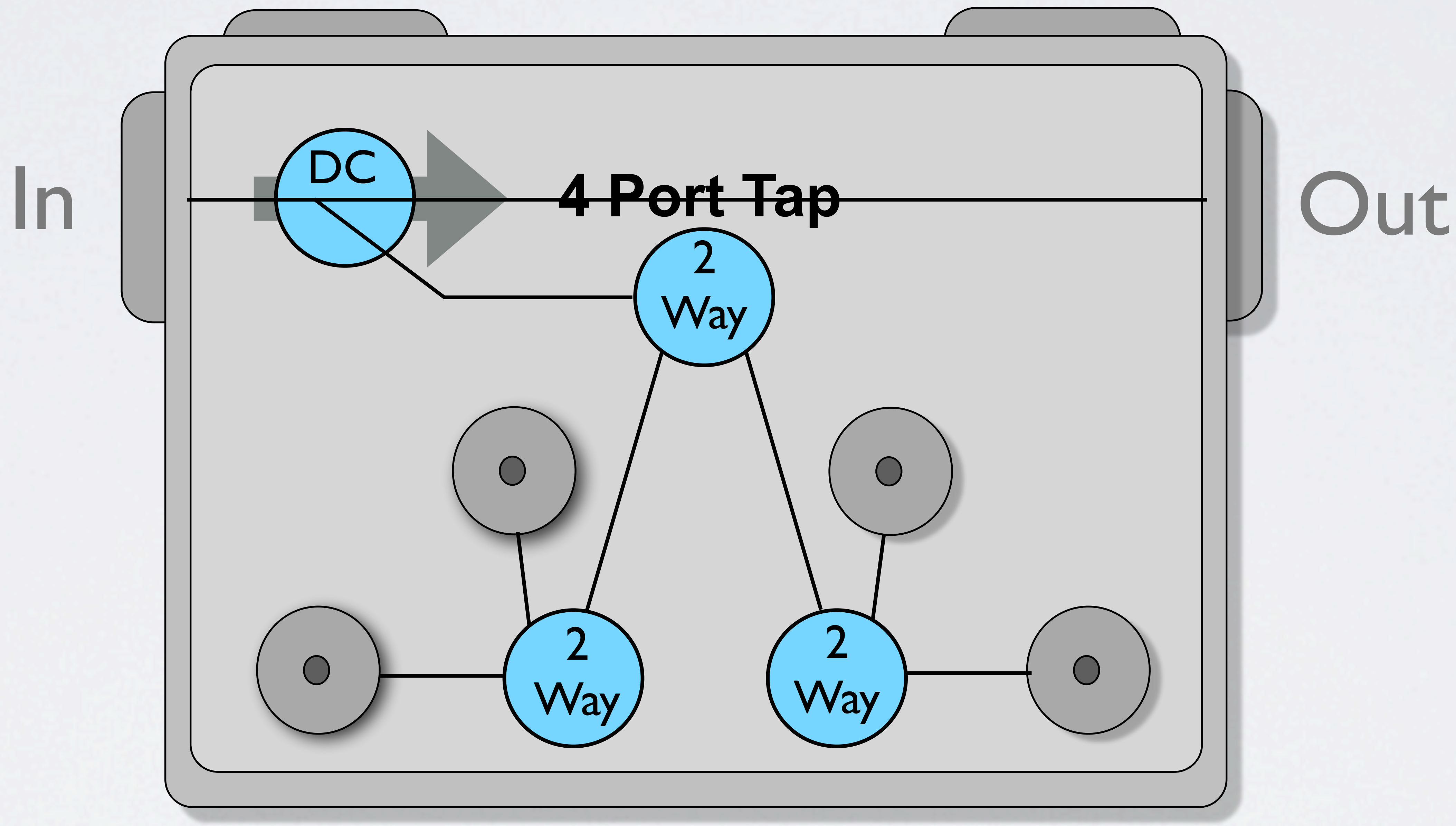
Distribution Feeder



HFC Plant


Fiber
Tapped
Fiber Node
L
H
Tapped
L
H
L
H
Line Extender
Tapped
L
H
L
H
Line Extender
Tapped
L
H
L
Line Extender
Tapped
23
20
17
14
11
8

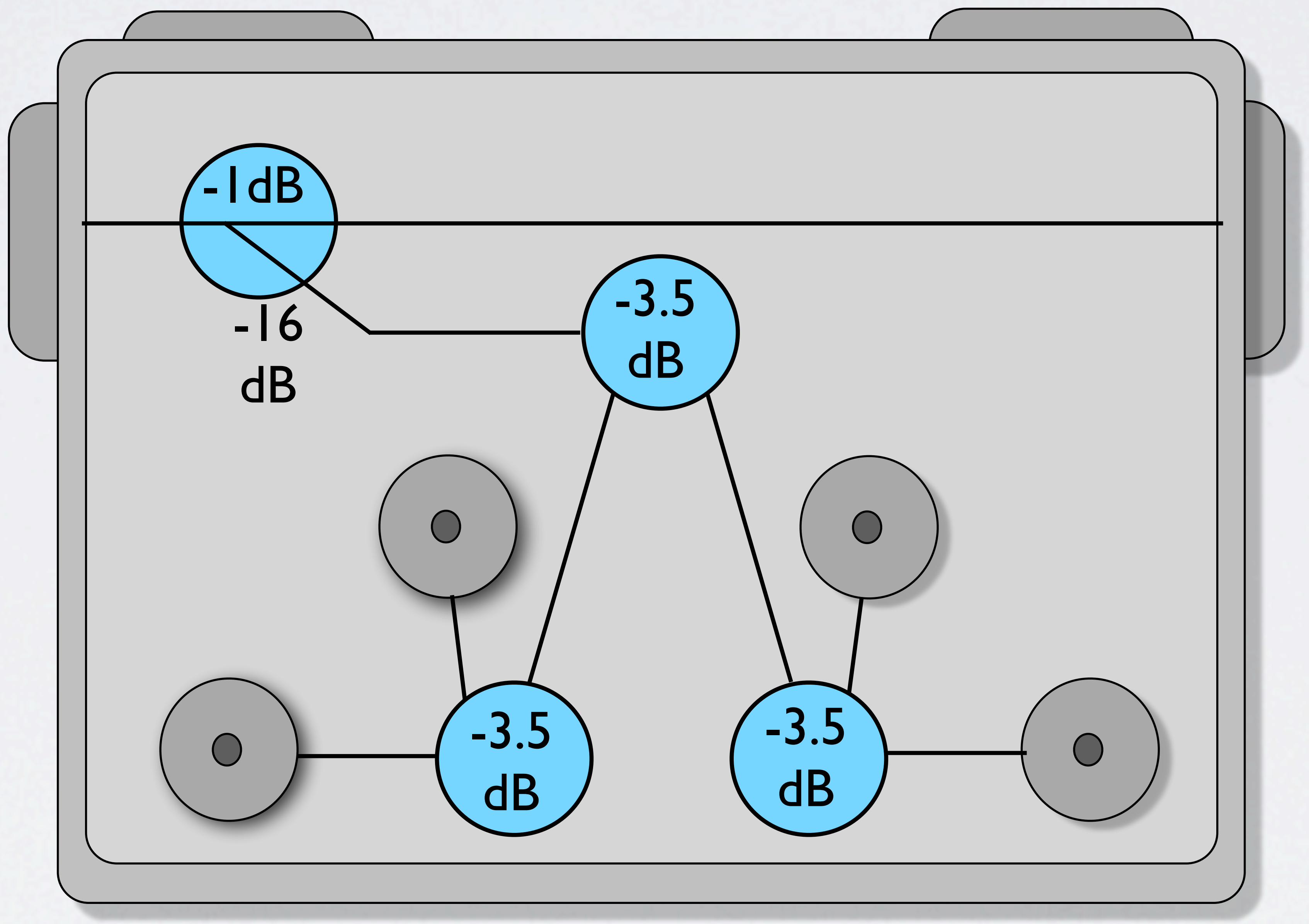
Taps



Taps

23 Tap

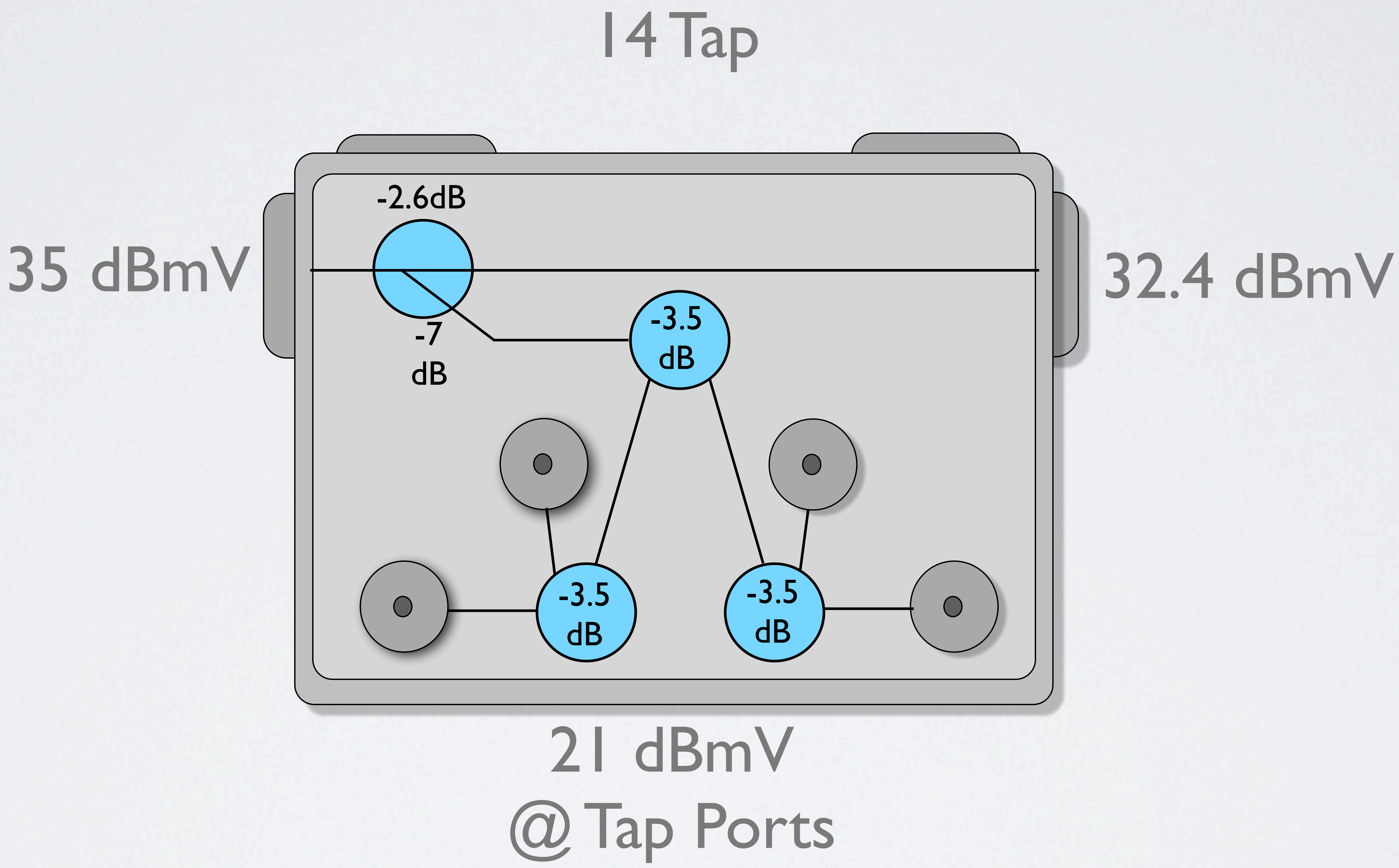
45 dBmV In



Out 44 dBmV

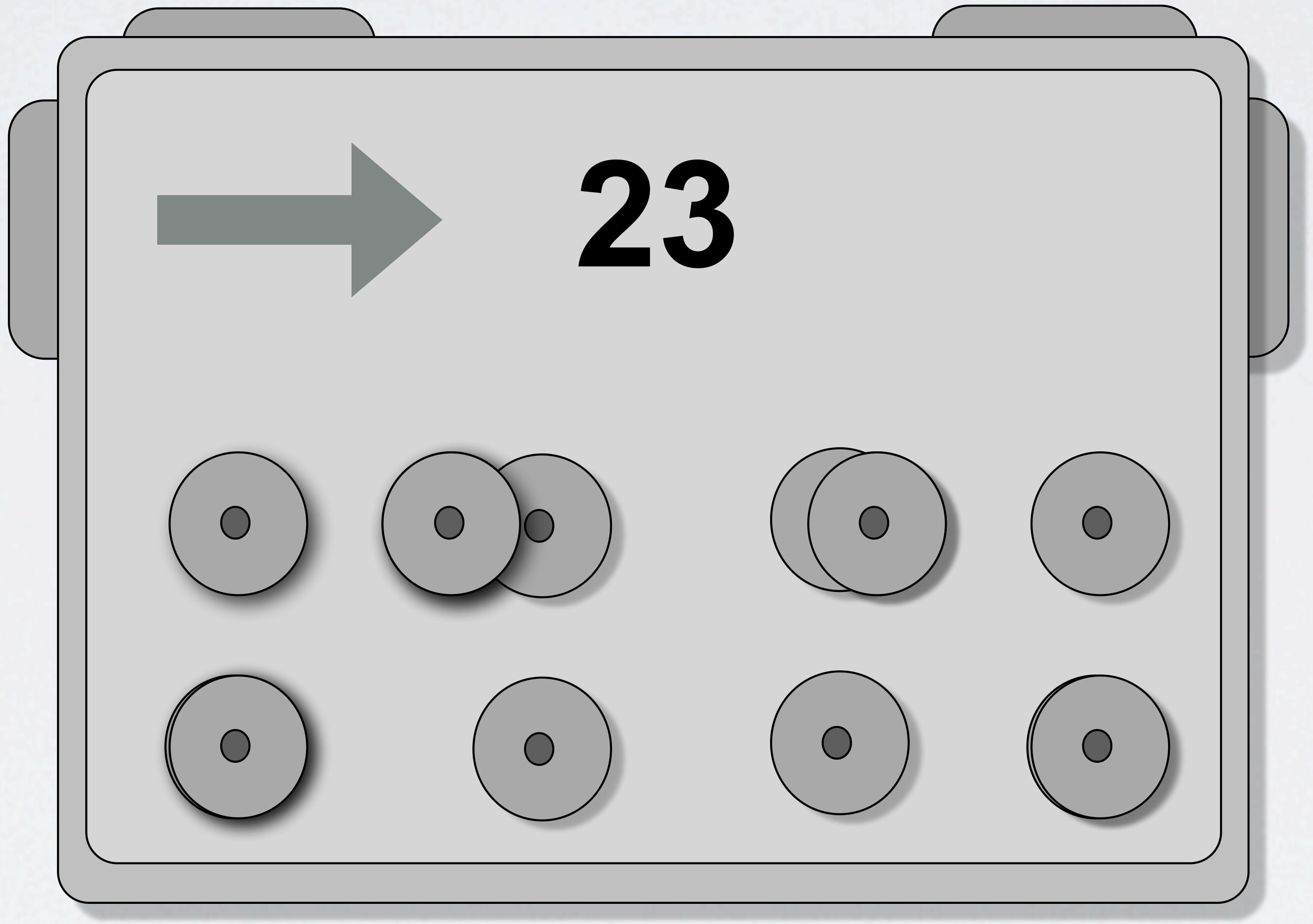
22 dBmV
@ Tap Ports

Taps

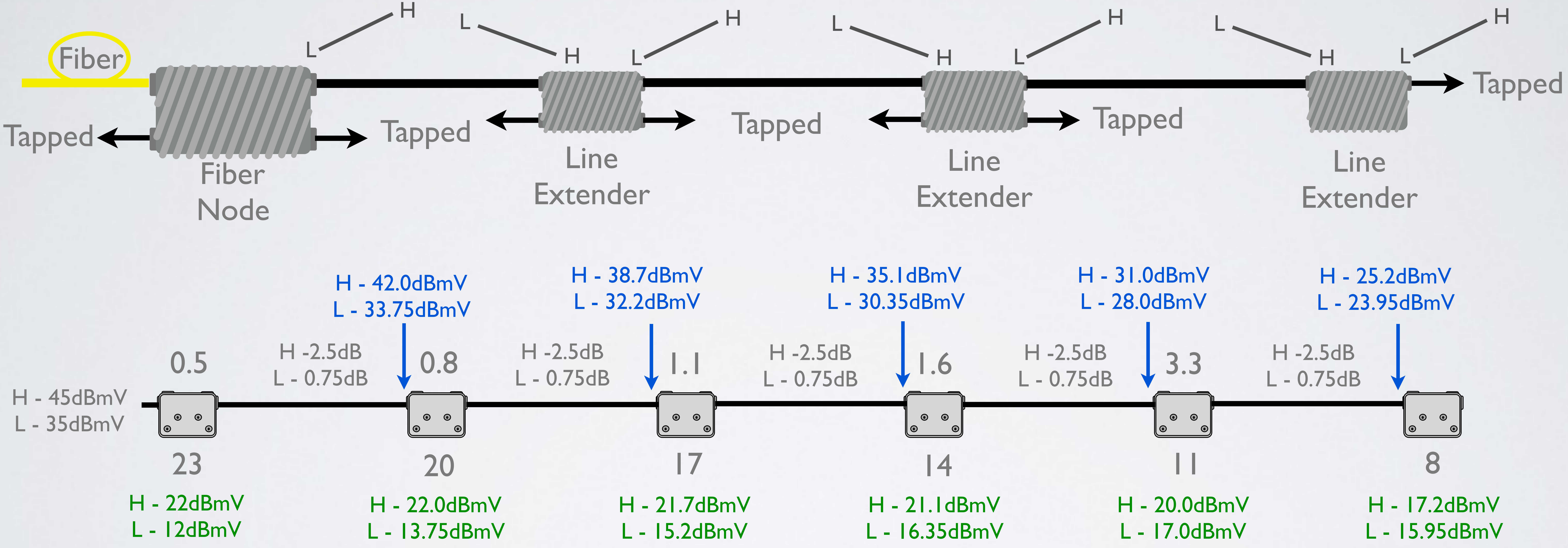

14 Tap
35 dBmV
-2.6dB
-7
dB
-3.5
dB
-3.5
dB
-3.5
dB
32.4 dBmV
21 dBmV
@ Tap Ports

Taps

23, 20, 17, 14, 11, 8 Values

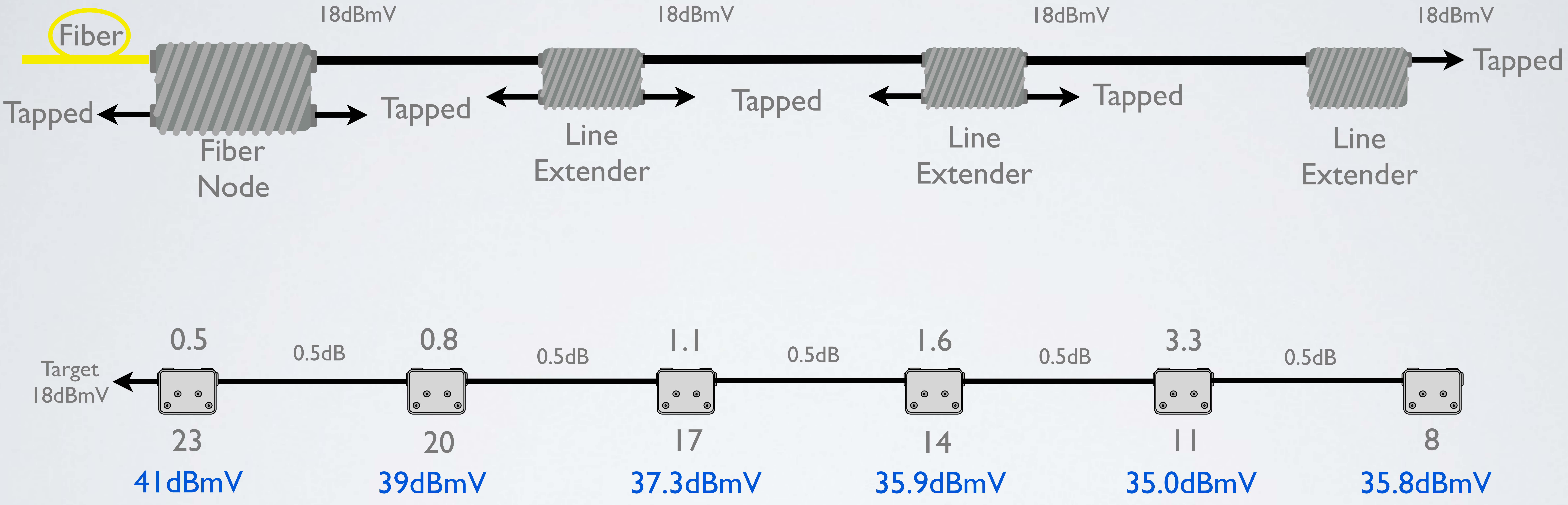


HFC Plant



Fiber
Tapped
Fiber Node
Tapped
Line Extender
Tapped
Line Extender
Tapped
Line Extender
Tapped
H
L
H - 45dBmV
L - 35dBmV
0.5
23
H - 22dBmV
L - 12dBmV
H -2.5dB
L - 0.75dB
H - 42.0dBmV
L - 33.75dBmV
0.8
20
H - 22.0dBmV
L - 13.75dBmV
H -2.5dB
L - 0.75dB
H - 38.7dBmV
L - 32.2dBmV
1.1
17
H - 21.7dBmV
L - 15.2dBmV
H -2.5dB
L - 0.75dB
H - 35.1dBmV
L - 30.35dBmV
1.6
14
H - 21.1dBmV
L - 16.35dBmV
H -2.5dB
L - 0.75dB
H - 31.0dBmV
L - 28.0dBmV
3.3
11
H - 20.0dBmV
L - 17.0dBmV
H -2.5dB
L - 0.75dB
H - 25.2dBmV
L - 23.95dBmV
8
H - 17.2dBmV
L - 15.95dBmV

HFC Plant Return

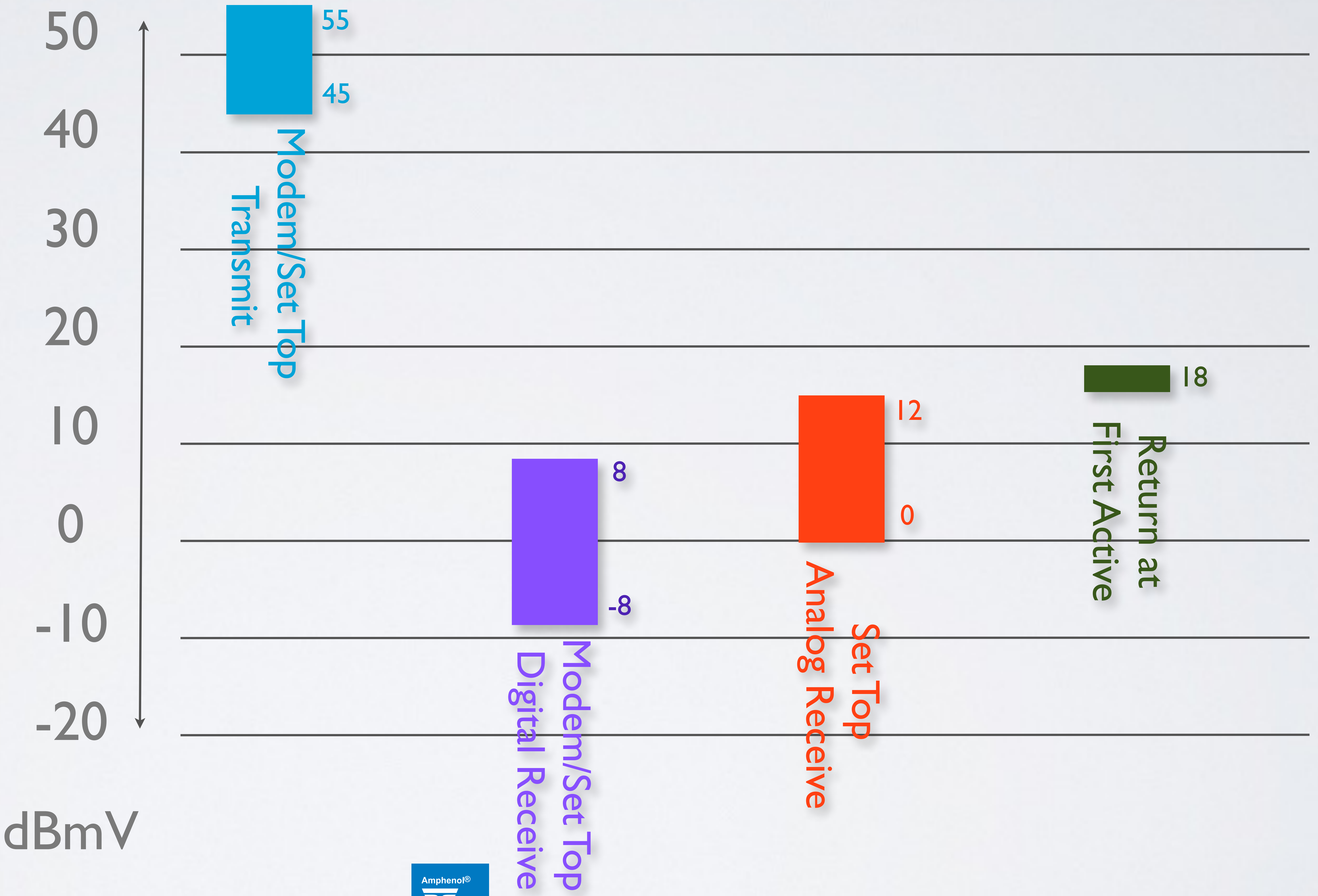


Levels in the Home

Forward and Return

Operating Windows

Use the following as average guidelines to calculate proper operating levels. Each system/operator will have different standards to follow but the math is the same

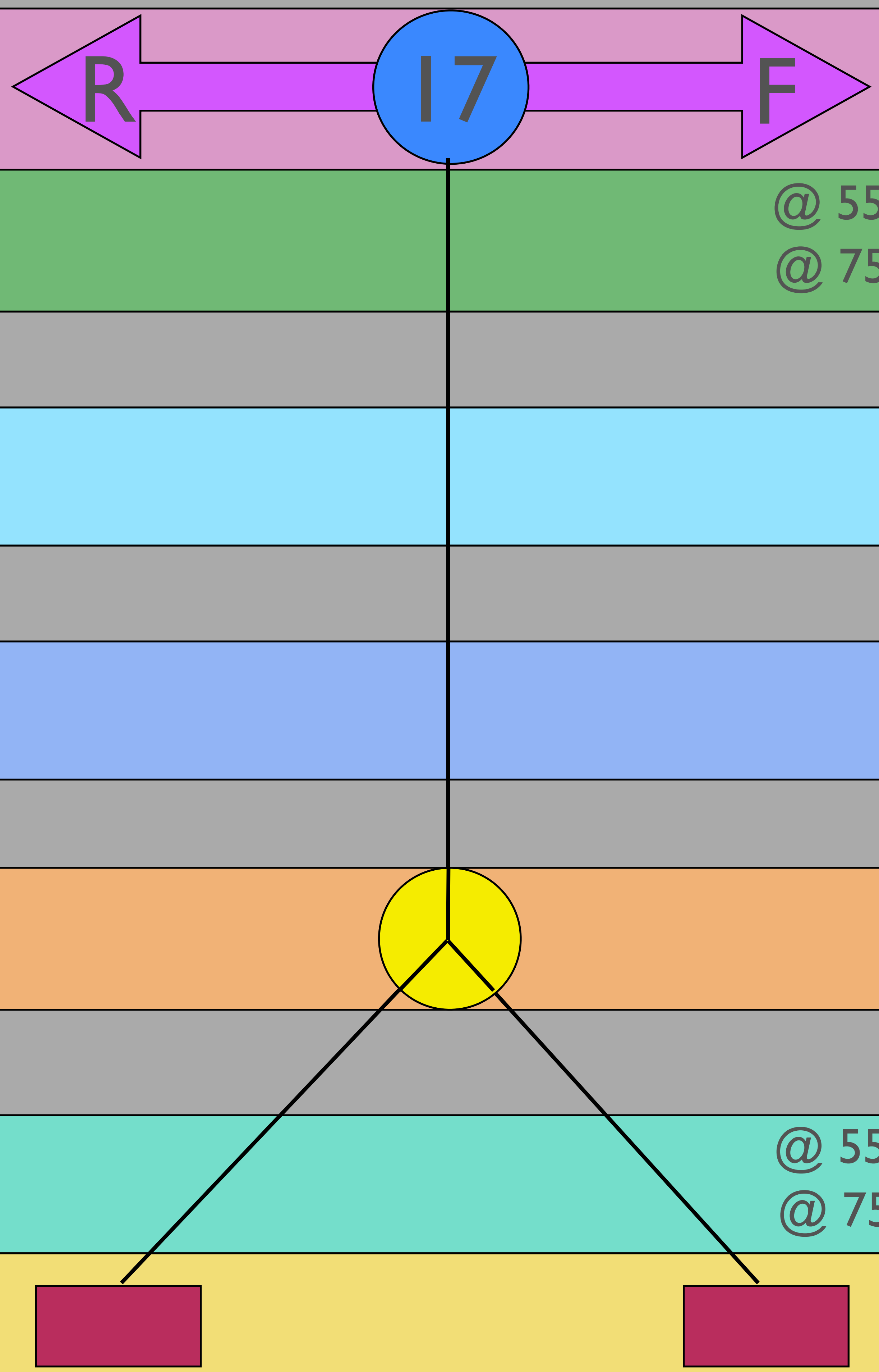


How is forward signal loss determined?

- Output levels at tap
- Length of drop and attenuation
- Passive devices in home
- House cable attenuation
- Active devices in home

Forward Exercise

	Analog	Digital
	55 MHz	750 MHz
Distribution Plant	10dBmV	15dBmV
Drop = 200'of RG6 — @ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-3dB	-11dB
	7dBmV	4dBmV
Data Splitter		
Amplifier/Gain		
Splitter = 2 Way	-3.5dB	-3.5dB
	3.5dBmV	0.5dBmV
Outlet Cable = 100'of RG6 — @ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-1.5dB	-5.5dB
CPE	2.0dBmV	-5.0dBmV

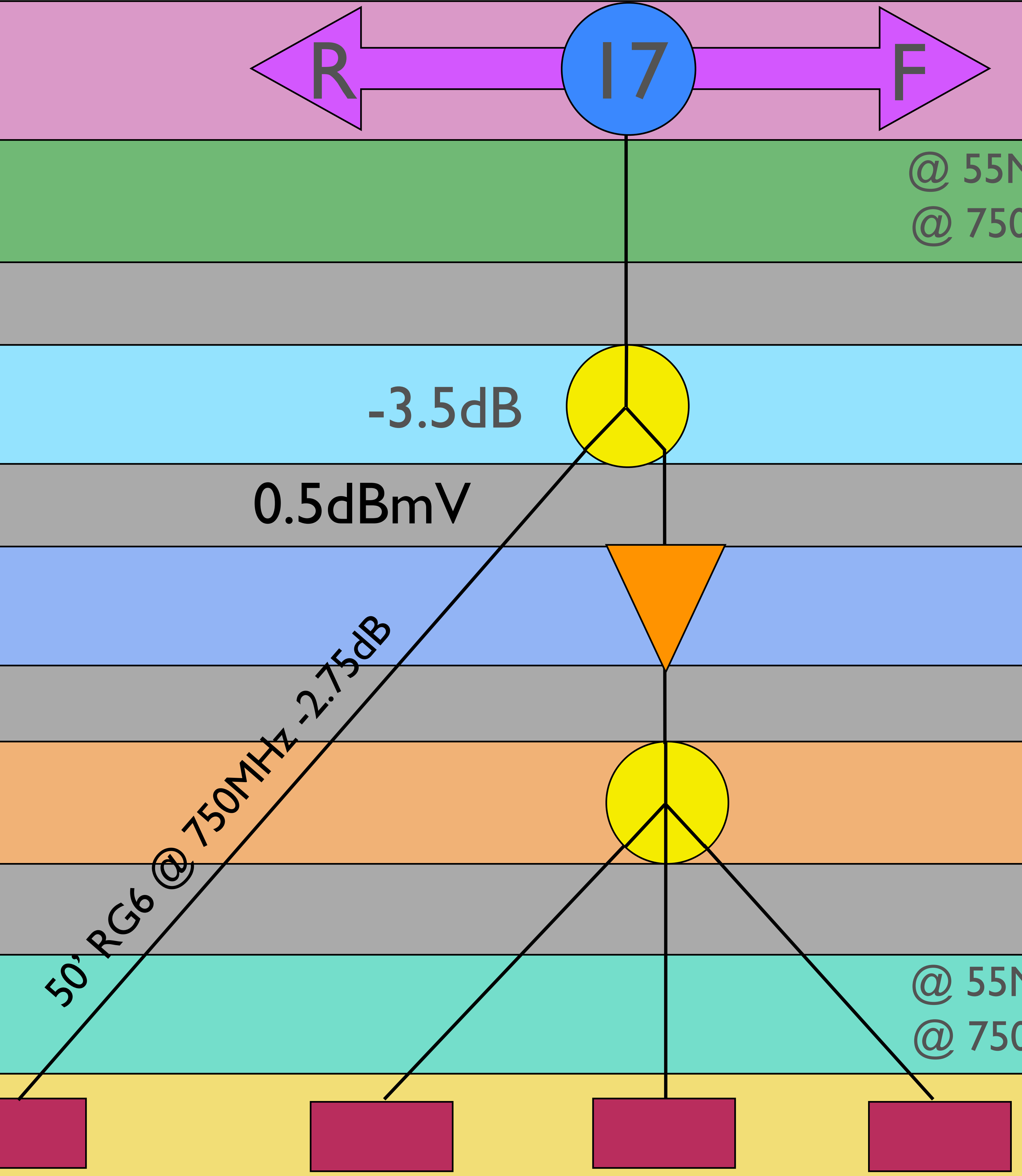


Forward Exercise

		Analog 55 MHz	Digital 750 MHz
Distribution Plant	R 17 F	10dBmV	15dBmV
Drop = 200'of RG6	@ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-3dB	-11dB
		7dBmV	4dBmV
Data Splitter = 2 Way	-3.5dB	-3.5dB	-3.5dB
	0.5dBmV	3.5dBmV	0.5dBmV
Amplifier/Gain			
Splitter = 3 Way Balanced		-5.5dB	-5.5dB
		-2dBmV	-5dBmV
Outlet Cable = 100'of RG6	@ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-1.5dB	-5.5dB
CPE	-2.25dBmV	-3.5dBmV	-10.5dBmV

50' RG6 @ 750MHz -2.75dB

Forward Exercise



		Analog	Digital
		55 MHz	750 MHz
Distribution Plant		10dBmV	15dBmV
Drop = 200'of RG6	@ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-3dB	-11dB
		7dBmV	4dBmV
Data Splitter = 2 Way		-3.5dB	-3.5dB
		3.5dBmV	0.5dBmV
Amplifier/Gain		15dB	15dB
		18.5dBmV	15.5dBmV
Splitter = 3 Way Balanced		-5.5dB	-5.5dB
		13dBmV	10dBmV
Outlet Cable = 100'of RG6	@ 55MHz -1.5dB/100' @ 750MHz -5.5dB/100'	-1.5dB	-5.5dB
CPE		1-3.5dBmV	4.5dBmV -10.5dBmV

EXTREME BROADBAND ENGINEERING

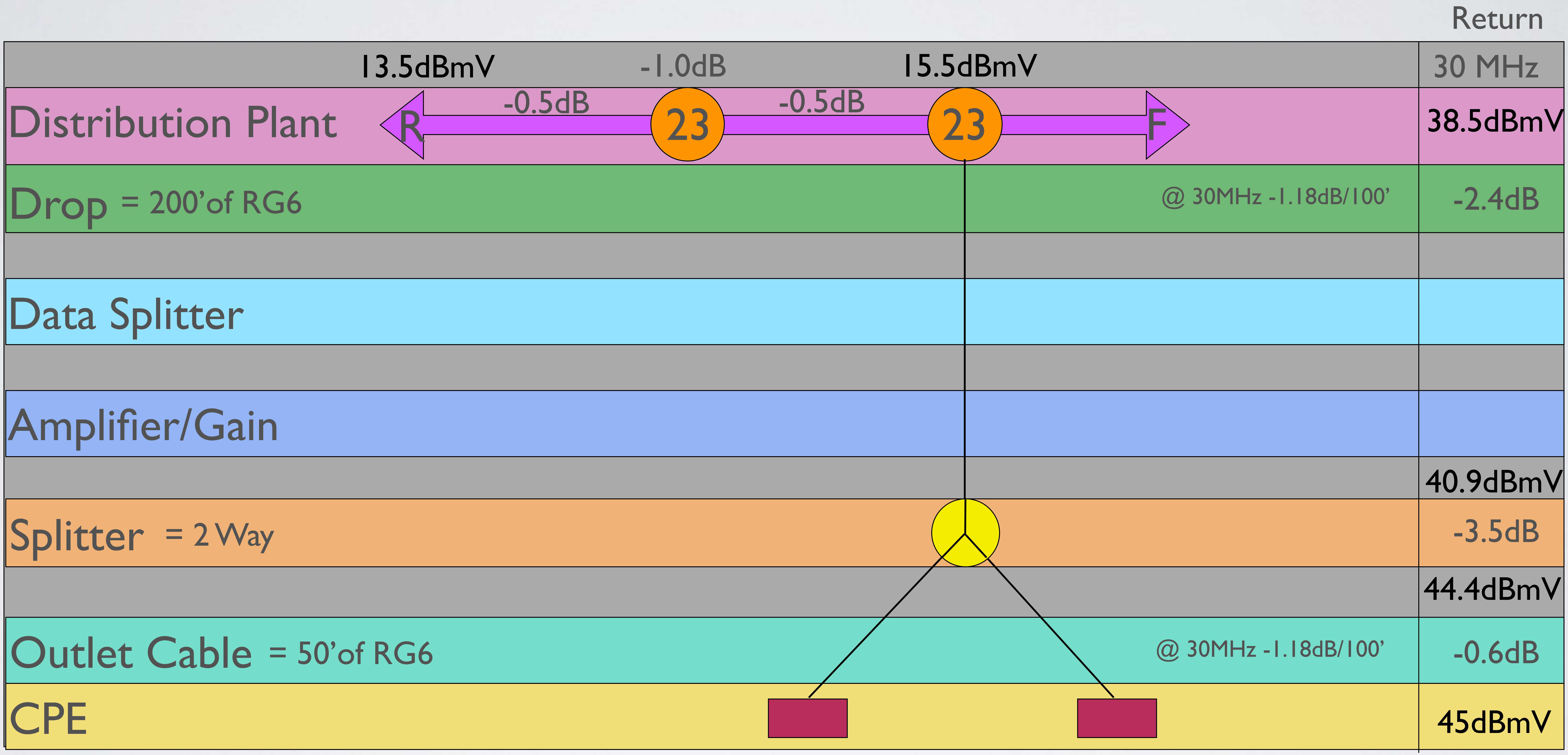
Amphenol TFC

HOLLAND Electronics an Amphenol company

How is return signal loss determined?

- Output level of device
- Cable attenuation
- Passive loss
- Active gain
- Tap value
- Tap thru put loss
- Feeder cable attenuation
- Input requirement at first active

Return Exercise



4.5dB low - CMTS request modem to turn up 4.5 dB to 49.5dBmV

Cable Math Summary

- Metric prefix's are used for system measurements
- Powers of 10 tells us how may times we have to multiply 10 by itself
- Logarithms express large numbers simply
- dB represents the logarithm of a ratio of two signal power or voltage levels
- dBmV is an absolute signal measurement where 0 dBmV = 1mV across 75 ohms

Thank You For Attending This Training On

Cable Math

For Additional Training Topics See Our Website At

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