

**Antenna Systems
for the
Recently Licensed Ham
--3 Talks--
BVARC Meeting
May 10th, 2012**



Understanding the Cardinal Rules of the Ham Radio Antenna System

Rick Hiller -- W5RH



Utilizing Your New Found Practical Antenna System Knowledge

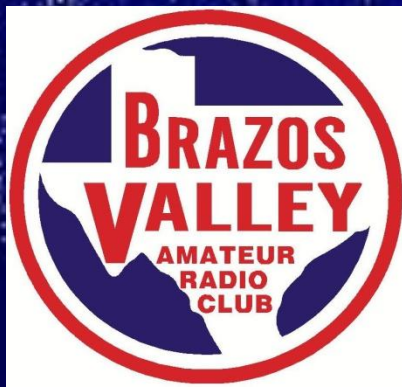
<http://www.youtube.com/watch?v=f0cvcf-VW9k>

Tom Morton – W5TOM



Deploying Simple Antennas

Pete Sauermilch – KD5QPX



Understanding the Cardinal Rules of the Ham Radio Antenna System

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Antennas

- **10 cents on the antenna is worth \$1 spent on the radio**



Antennas

–“The physics doesn’t change but the application does”



Antenna attributes

- Antenna attributes and characteristics are very similar to baking a cake.
- You have:
 - raw materials
 - a recipe, and
 - the end result

Antenna Attributes

- **Basic Characteristics – the raw material**
 - Resonant length(s)
 - Feed Z (Impedance) /Radiation Resistance
- **Controlling Characteristics – the recipe**
 - Standing Waves – Current Distribution
 - Polarization
 - Height Above Ground
- **Performance Characteristics – the cake**
 - Gain and gain pattern
 - Angle of (primary) radiation

Characteristics – Intro

- Resonant Length(s)
- Feed Z / Radiation Resistance
- Standing Waves – Current Distribution
- Polarization
- Height Above Ground

Performance Characteristics

The Cake – for what we strive

- Gain
- Angle of Radiation

More Cardinal Rules

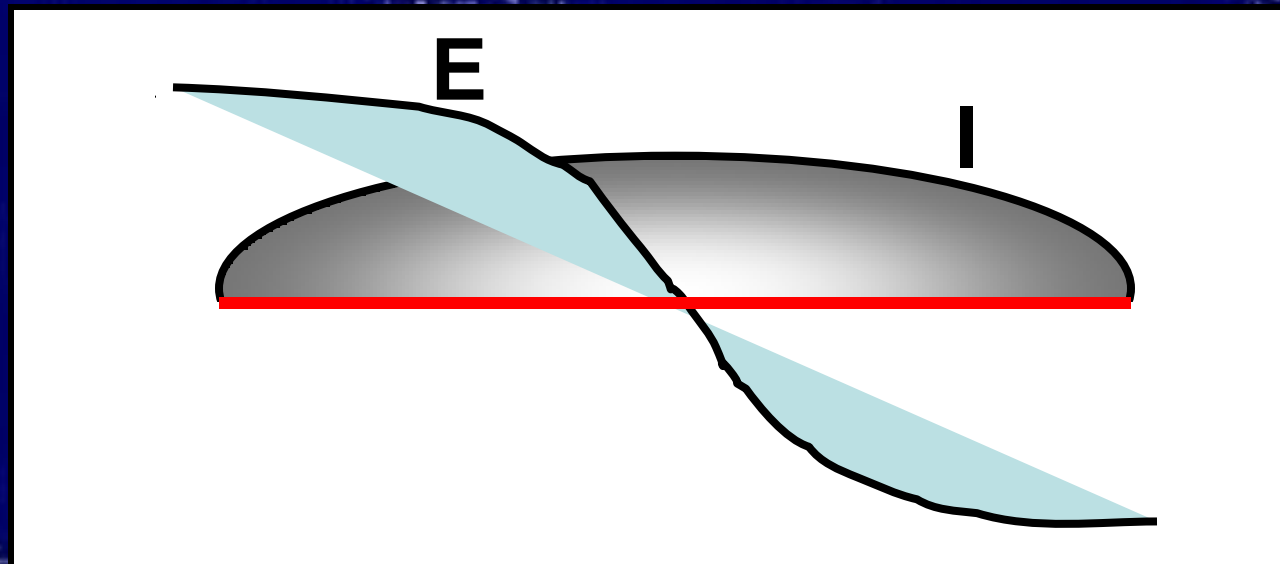
- The shortest resonant antenna 'system' is $\frac{1}{2}$ wavelength (basic building block)
- Current doesn't flow where there isn't any wire – standing wave distribution
- Resonance repeats with the addition of every half wavelength

$\frac{1}{2}$ wavelength is the physical distance that a “charge” moves in $\frac{1}{2}$ of a cycle

- **186,000 miles per second**
– **982×10^6 feet per second**

Charge flow cannot happen where there is no wire

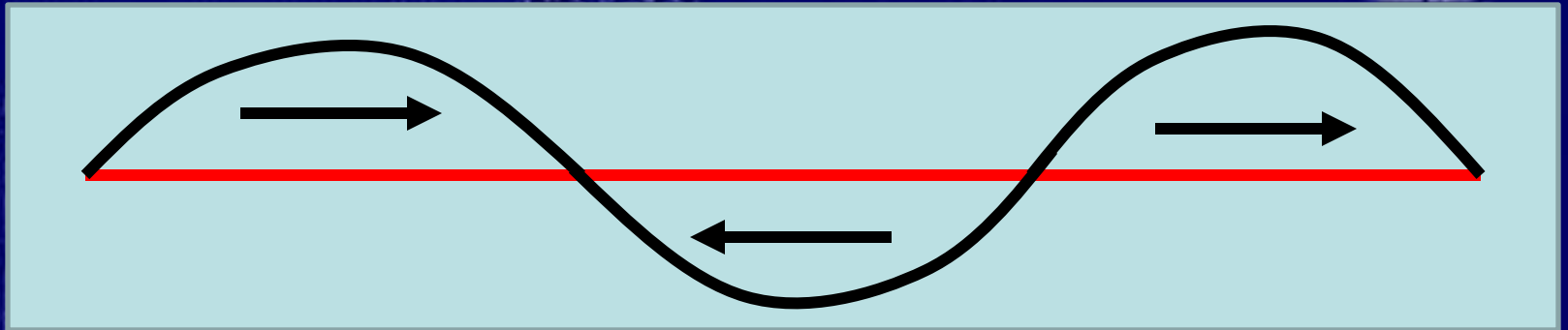
- A current node (minimum) is always at the end of an element



- E -- Voltage Standing Wave
- I -- Current Standing wave

Current Distribution

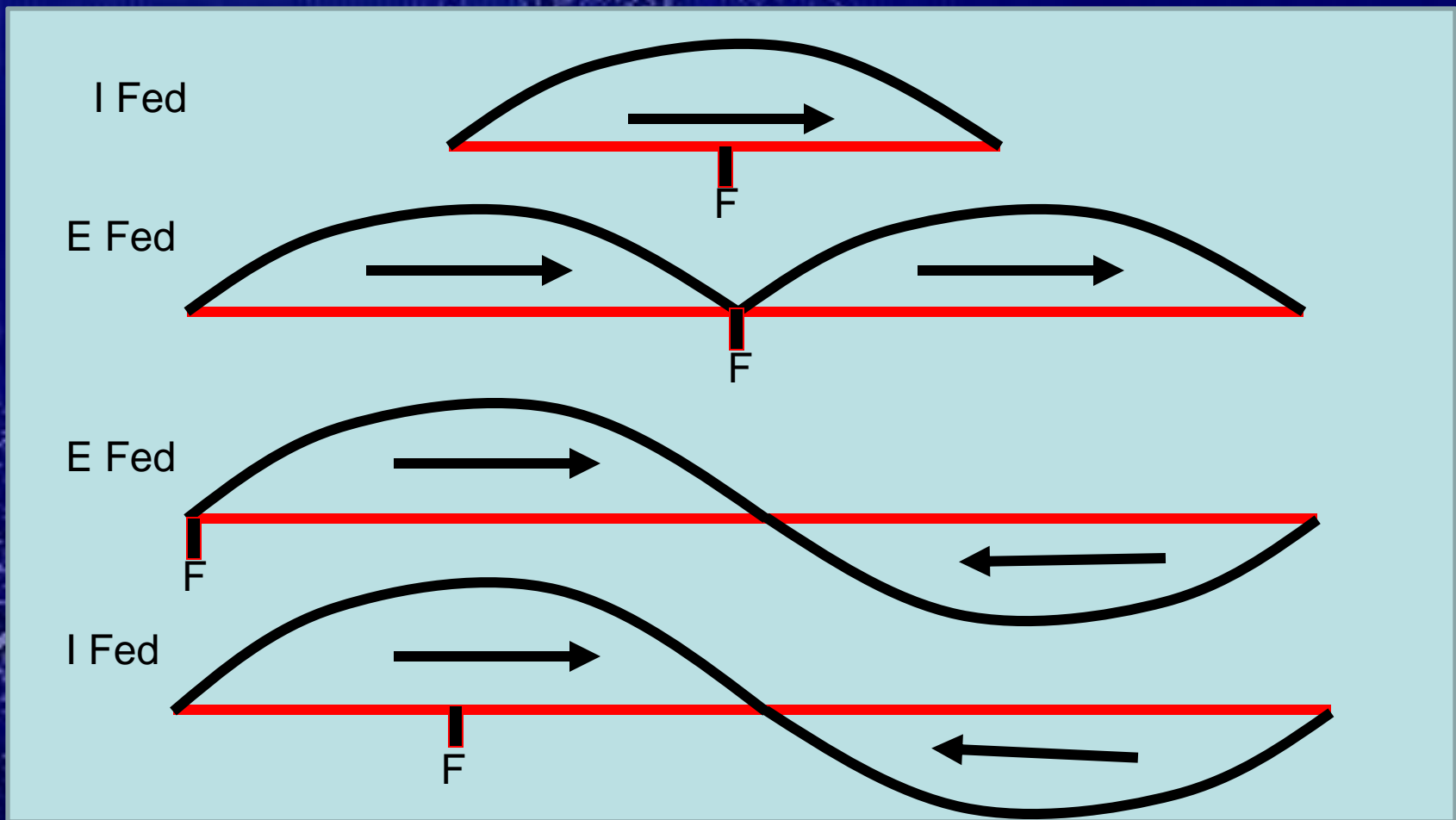
- Current changes orientation in each half wave length



- “Phasing” is the orientation of like sections for a beneficial effect

Current Distribution

- Based on feed point location



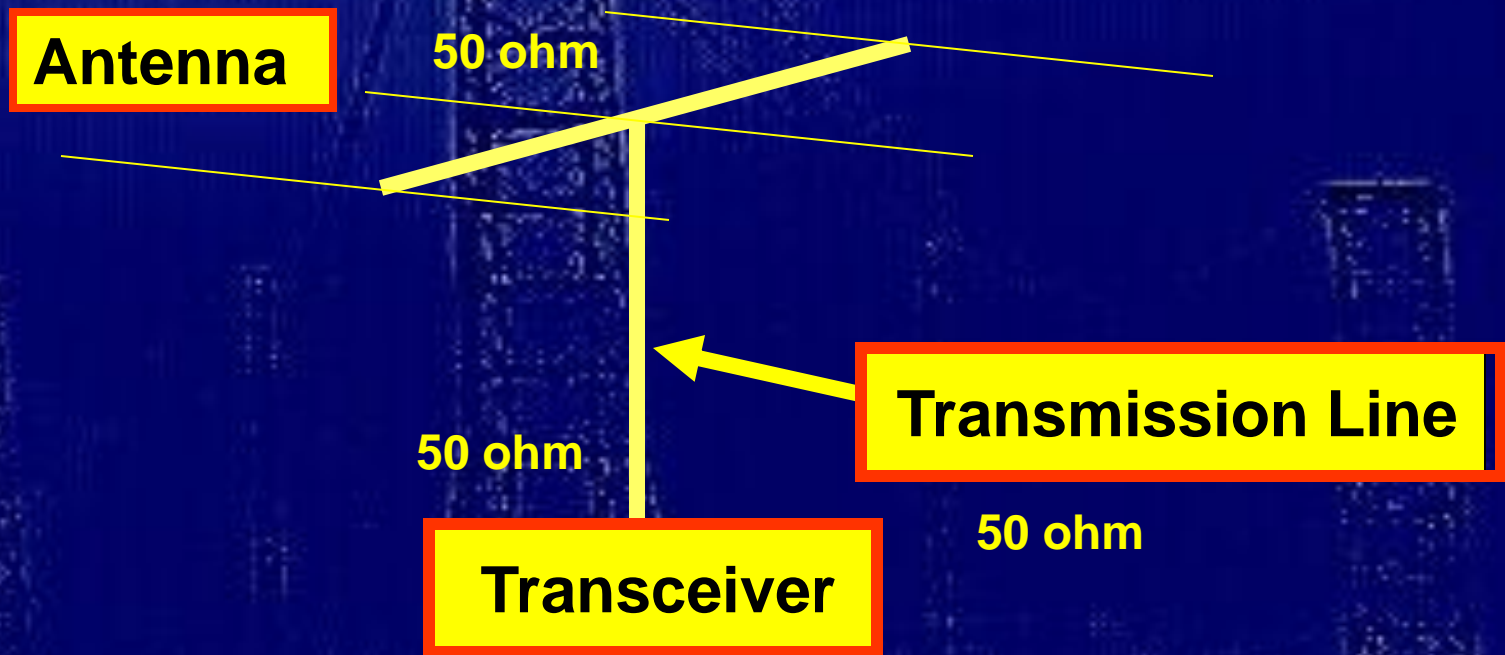
What is “Antenna Gain” ?

An example of gain is:

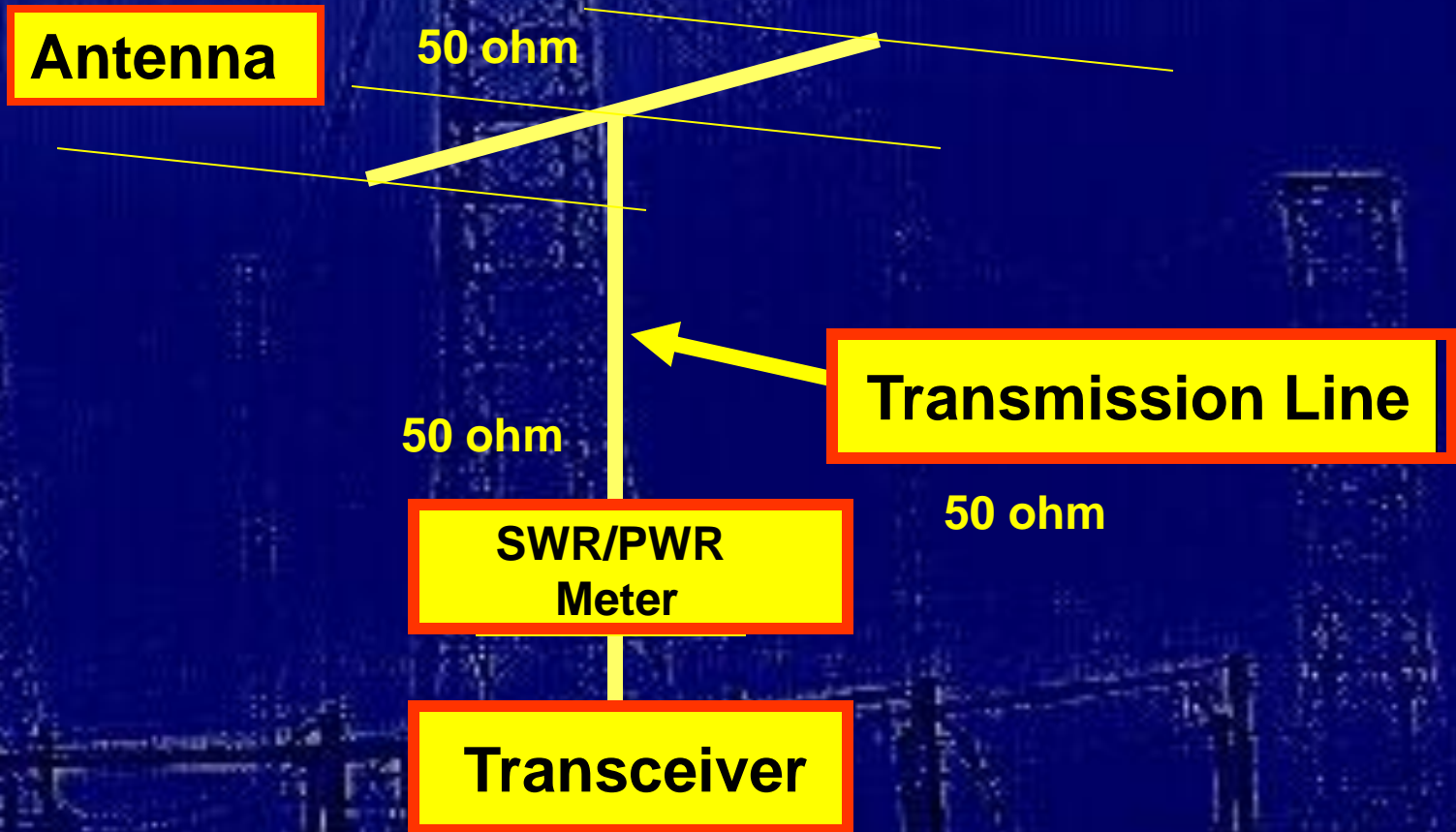
a light bulb by itself compared to a flashlight – a light bulb with a reflector

The total amount of light does not change, but the light is focused in one direction

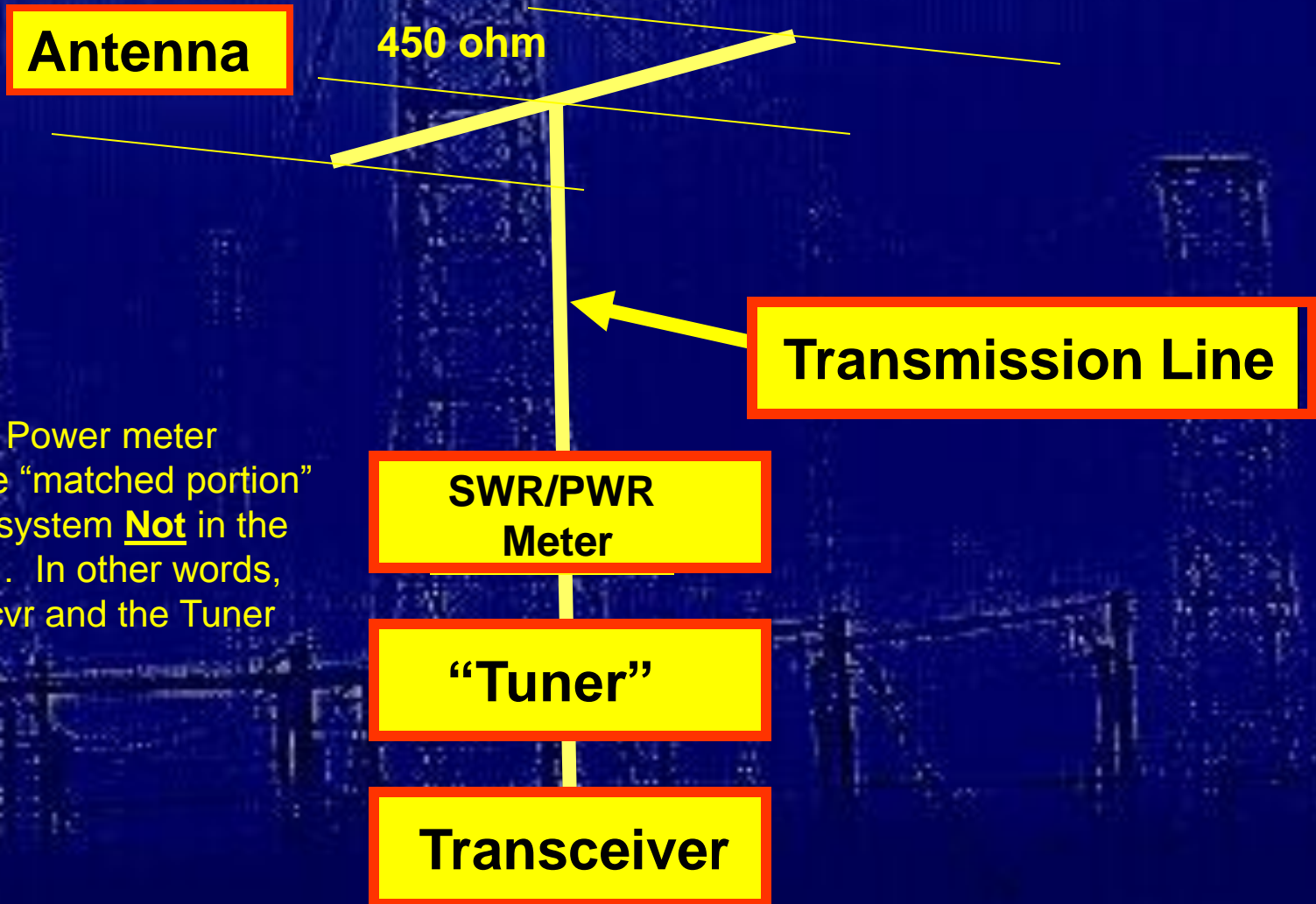
Basic Antenna “Matched” System



Basic Antenna “Matched” System with metering



Antenna System using “Tuned Feeders”



Correction

Note: the SWR Power meter should be in the “matched portion” of the antenna system **Not** in the “tuned section”. In other words, between the Xcvr and the Tuner

Definitions

- Tuning an antenna – to make resonant
 - Eliminate the j or imaginary X_c / X_l component
- Matching – to create a network juncture that provides for maximum power transfer



How long should my coax be?

**As long as it needs to be to
connect the transceiver output
to the antenna feed point**

Maximum Power Transfer Theorem

–Maximum power transfer is obtained when the load resistance (antenna) matches the source impedance (transmitter)

Matched Condition

- A transmission line terminated in its characteristic Z creates a matched condition
 - **Condition of lowest loss**
 - All transmission lines have some loss

Matched loss

- **Inherent loss (in dB) that is generally given by the manufacturer (per 100 feet)**
 - **Varies with frequency**
 - **Varies with length**
 - **Varies with cable type, construction, materials, etc**

Transmission Line Goal *Comment*

The goal is to get the maximum amount of power from your transmitter to your antenna and have it influence the radiation strength of the antenna.

Loss -- dB vs Watts

100 watt reference

dB watts

0 = 0

-1 = 10

-2 = 37

-3 = 50 – half power

-4 = 40

-5 = 69

-6 = 75 – 1 'S' Unit

-10 = 90

dB and your S-meter

1 S unit = 6dB = Factor of 4 power difference

**If a signal is S9 and you lower power by 75%:
Signal will be S8**

**....BUT....what if your signal is S5 with
an S4 noise level....if you reduce your
power by 6dB you will be in the noise....hence
MAXIMIZE your Power to your antenna**

dB Loss Comment

Don't let "low dB loss numbers" belittle the fact that lost power is just that – lost power....Gone...never to be used again and especially never to be utilized by your antenna to radiate.

Conjugate Match Theorem

- If a complex conjugate Z is applied at one point in a network, then all points within the network, will have applied, their complex conjugate Z , hence, resonating the system
- A Tuner supplies a Conjugate match.

Skin Effect

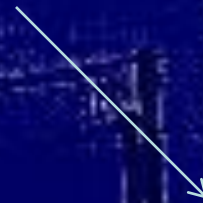
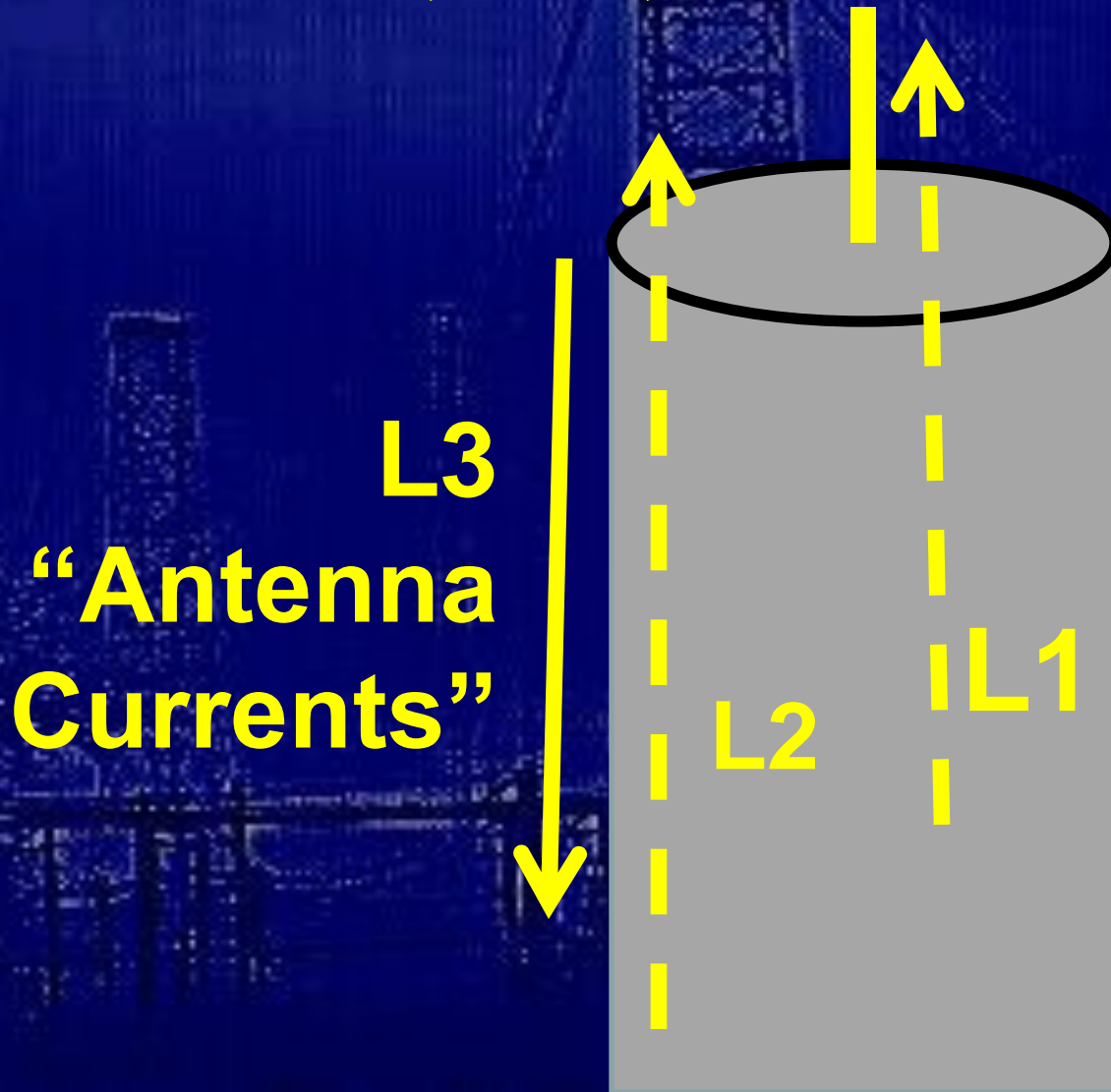
- Property for RF current flowing near the surface of a conductor

Skin Effect

- Coaxial cable is self shielding
- The 2 main conductors being the center wire and the inside” of the shield conductor
- The “outside” of the shield is independent of the inside surface – the “3rd wire”

Bal-un

L1, L2, L3 currents



Use a Balun?

Don't use a Balun?

- Most Hams need more like a “Choke” than a Balun or matching transformer

What about un-matched line and load?

- Incident (forward power) waves travel to the load.
- If the load is NOT equal to the line Z_0 , then a reflected wave is generated, which is proportional to the mis-match.

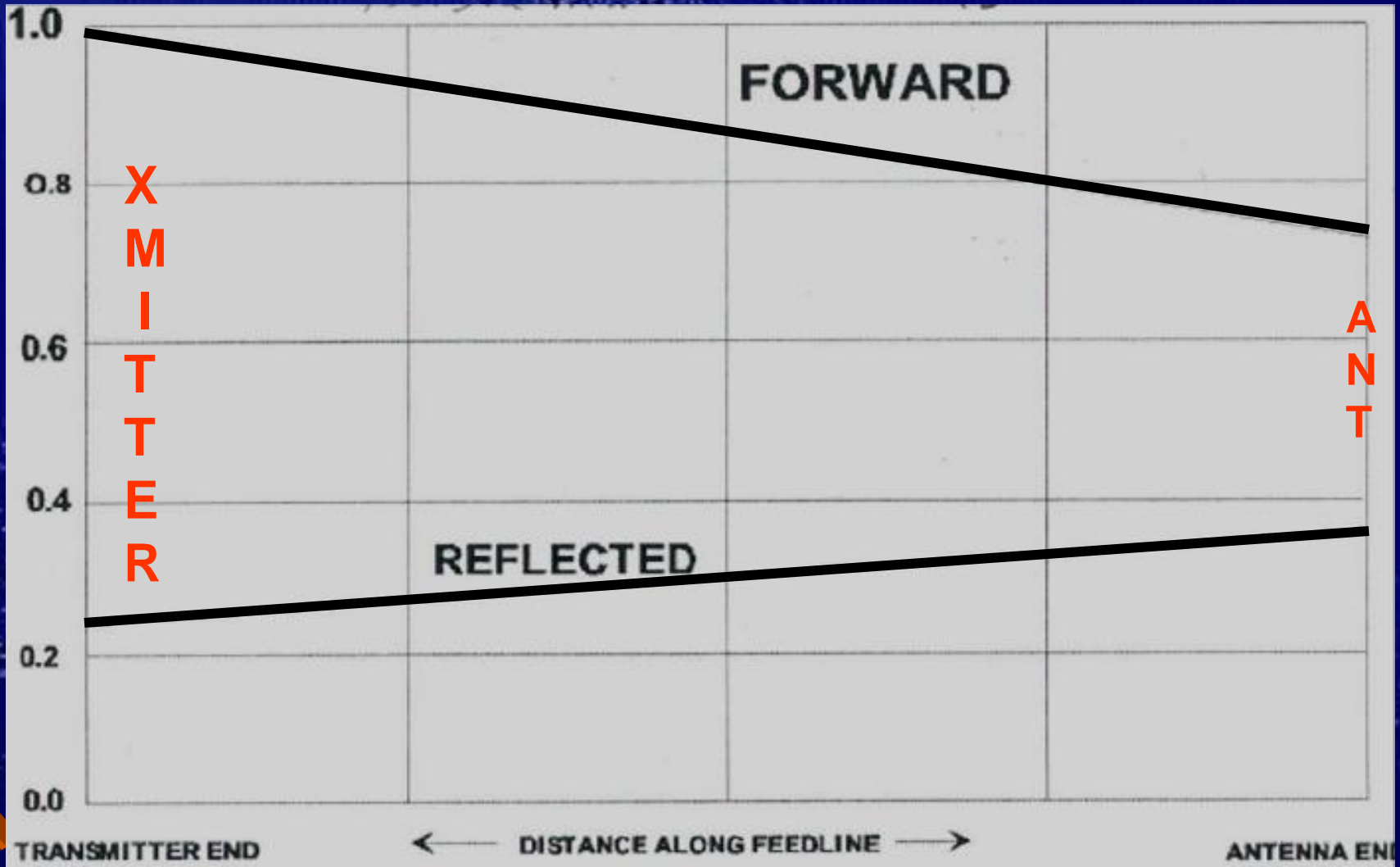
What is SWR?

- **Standing Wave Ratio (singular)**
- It is the “ratio” between “incident (forward) and reflected” power/ current or voltage along a transmission line
- Lowest at the point of resonance, no matter what the “R” feed resistance value.

SWR

- **Always determined by the load**
 - **Load vs Z_o of line**
- **Monitored within the output circuits of the transceiver to limit the power out if SWR should rise above a preset limit (1.5 typ)**
- **REMEMBER: SWR is ALWAYS determined by the load**
 - **Load vs Z_o of the transmission line**

Voltage attenuation due to Line Loss



Defacto Standards

- **50 ohm (nominal) coax is the most commonly used in RF.**
 - **Transmitter outputs designed for 50 ohms**
 - **Antennas are commonly designed for 50 ohms**
 - Most common single element antennas are close to 50 ohms

Antenna System Philosophy

- The good thing is that Hams have “bands of frequencies” to use
- The bad thing is that hams have “bands of frequencies” to cover

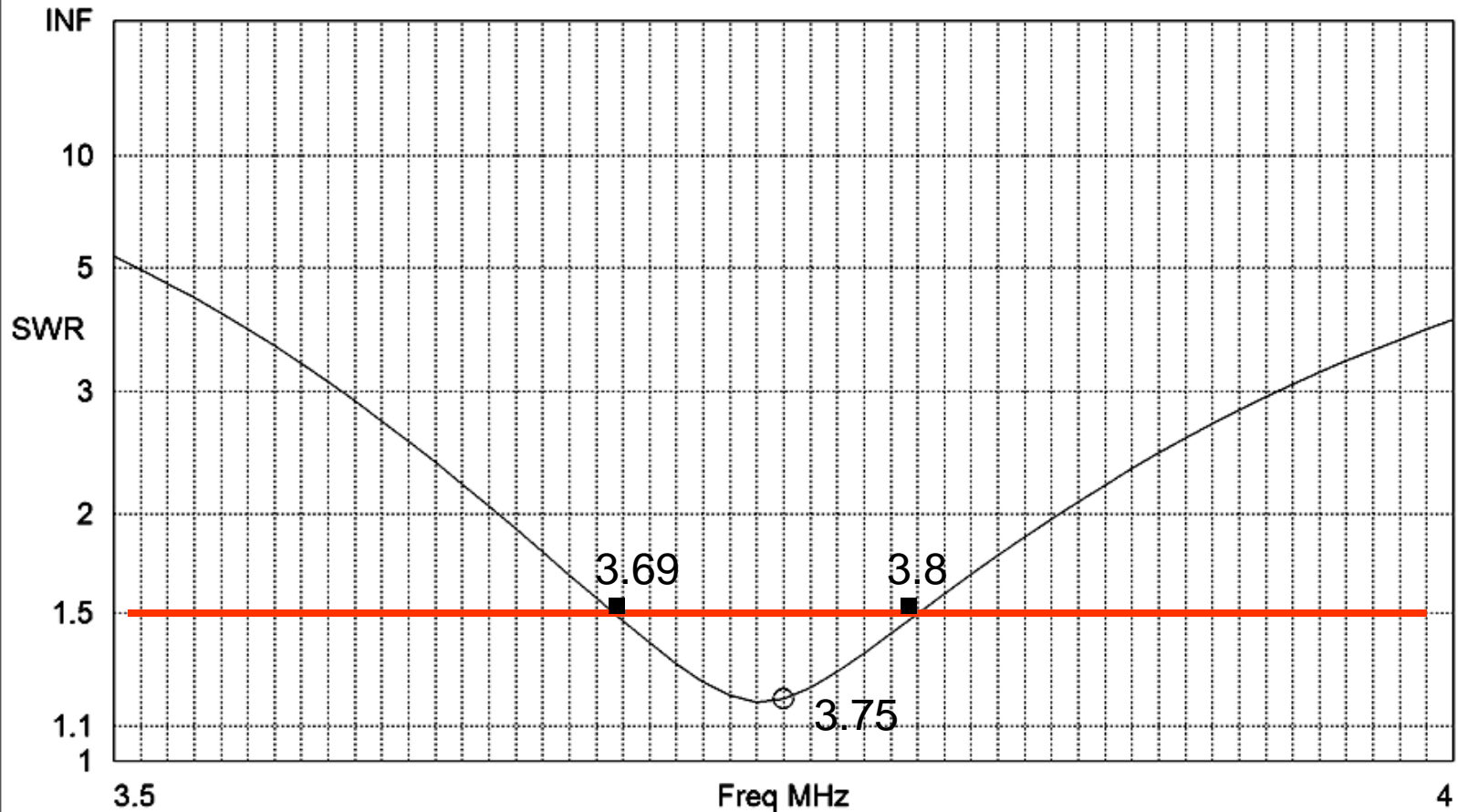
Antenna load Z's

- Unless you are rich and famous and own a self tuning antenna system (ie Stepper IR) then you do not have a resonant or matched antenna across the “Band”.
- Your antenna generates a range of input feed impedances which can vary to the extreme.

80 Meter Dipole Center Fed 123 feet long at 50 feet

File Edit View Options

Z0
50 ohms
Alt (75 ohms)
1
Source #



Freq 3.75 MHz
SWR 1.18
Z 59.07 + j 1.359 ohms
Ref Coeff 0.08406 at 7.81 deg

Source # 1
Z0 50 ohms

Cardinal Rules to Follow

- When using tuned feeders, add a few feet of coax / tl in order to accommodate the Z the matching network needs to see.
- Use an HF SWR meter for VHF by using only the forward port and switching input to output

Summary

- **Better Antenna Systems mean more contacts**
- **More contacts mean more fun**
- **.....and fun is what this hobby is all about !!!**
- **Contact me at**
rhiller@sdicgm.com



The End

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