Basic Electronics Part 5
Energy & Power

- Hamtronics
- Basic Electronics Part 5
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- @Sunlife ARC

Basic Electronics Part 5
Energy and Power

Energy and Power are <u>NOT</u> the same!

By definition Power is the Energy used per second.

Work and Energy are the same!

An example… We hire two people to do a job of work … cut a cord of wood.
Worker #1 finishes the cord in 40 minutes and
Worker #2 finishes the cord in 60 minutes.
Both have done the same amount of work, but
Worker #1 does this with a higher Power level.

Power = energy/time or P=Joule/second=Watt

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Units of Energy (work) and Power

Work/energy = Joule, calorie, BTU
Power= Watt, BTU/Hr, KW-Hr

Heat is also a form of energy.

Conversion of Heat Units

	calorie	BTU	Joule
1 calorie	1	3.97×10^{-3}	4.18
1 BTU	252	1	1,055
1 Joule	0.239	9.48×10^{-4}	1

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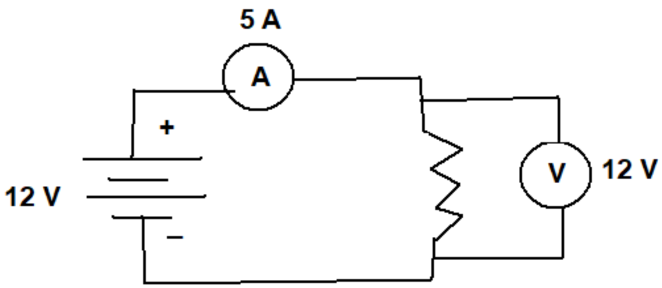
Let's do the math.



$I := 5$ A $\quad V := 12$ V

$P := I \cdot V$

$P = 60$ W

But, what of the energy used?

$t := 3600$ seconds

$Energy := P \cdot t$

$Energy = 2.16 \cdot 10^{5}$ Joules

1 hour = 3600 seconds

1 Watt is 1 Joule/second

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Let's do the math.

Let's Get some feeling for the scale of this energy. Say you lift a package of hot dogs from the meat case at Fry's. How much energy does this require?

$Mass := 12$ ounces

$Masslb := Mass \cdot \frac{1}{16}$

$Masslb = 0.75$ lbs

$lbs2kg := 2.2$

$Masskg := \frac{Masslb}{lbs2kg}$

$Masskg = 0.3409$ kilograms

$work := force \cdot distance$

$force := Masskg \cdot 9.8$

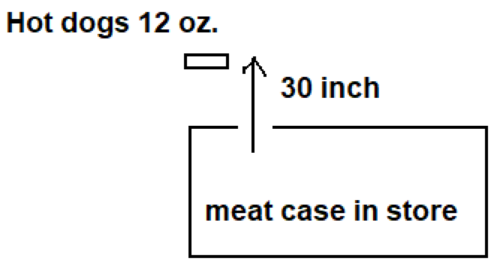
$force = 3.3409$ Newtons

$work = 2.5458$ Joules

$distancein := 30$ inches

$distance := distancein \cdot \frac{2.54}{100}$

$distance = 0.762$ meters



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This means you must lift... **(Energy=216,000 Joules in 60 W bulb)**

$work = 2.5458$ Joules to lift 1 pack of dogs

$$Liftnumbers := \frac{Energy}{work}$$

$Liftnumbers = 84846.537$ Packs of hotdogs per hour

I am tired... how about you?

So, you see our basic units are very small, to use electricity to do our bidding we need larger units! Hence units like KWHr instead of Joule, Ampere instead of electrons/second. Also, realize how small QRP, at 1 to 10 Watts, really is!

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So, what does that mean for us? We want to get as much of the power to the antenna as possible.

To transfer power from one system to another we get maximum transfer when the output impedance equals the impedance of the input system. This is the basis of SWR.

Where does the unused power go? Why do we care? Why does it exist?

All good questions!

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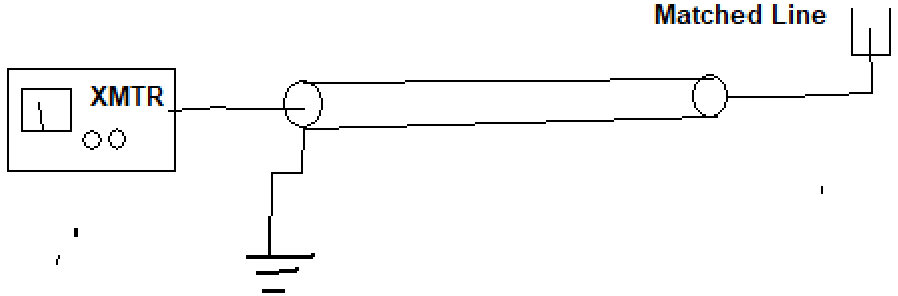
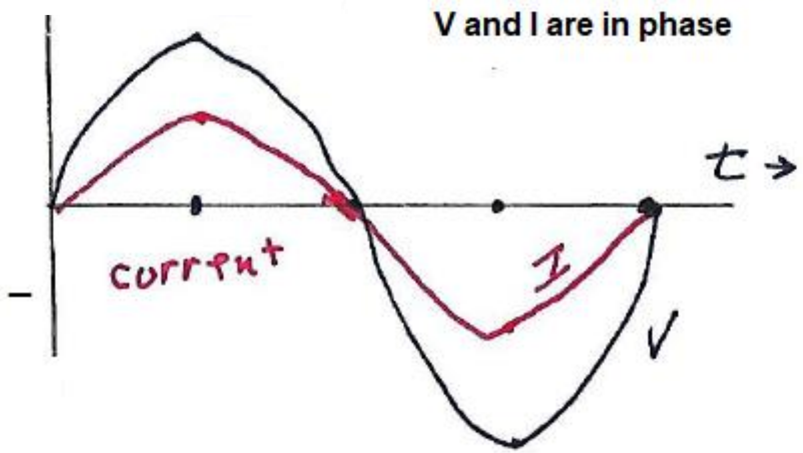
So, where does the reflected energy go? Let us look at two extremes... open and shorted lines.





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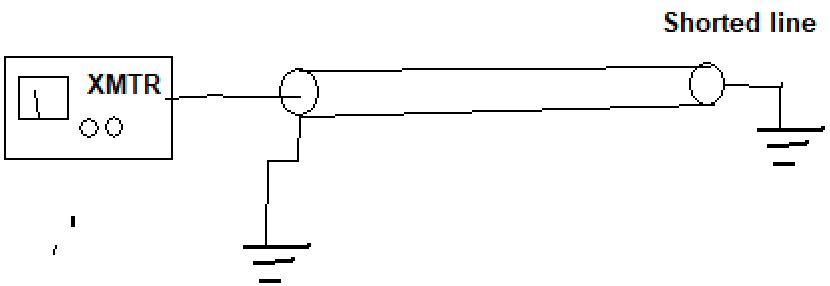
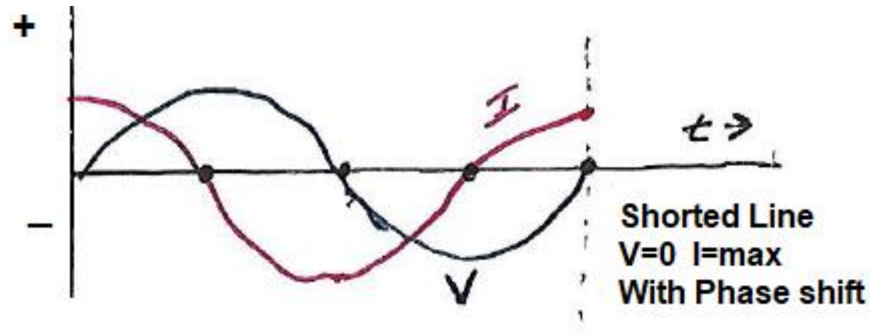
Here is what happens if the coax meet a short.





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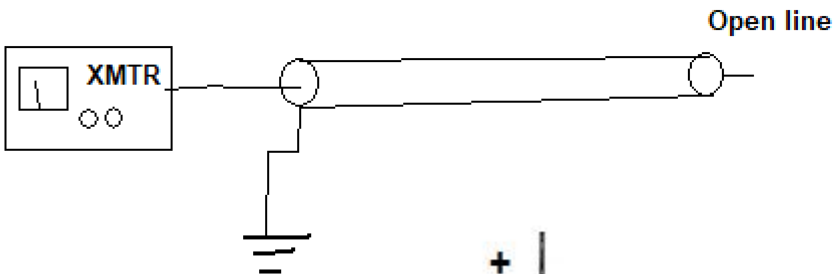
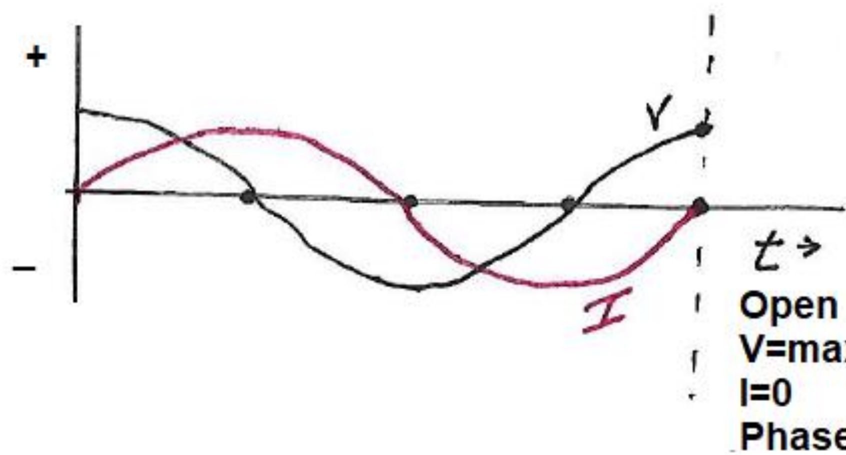
What about an open line?





Open Line
V=max
I=0
Phase shift

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Most situations are between an open and a short.

When a signal travels down and meets a change (however small) in impedance it will "bounce" back to the source.

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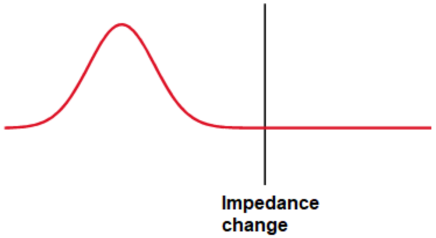

See video from Wikapedia…

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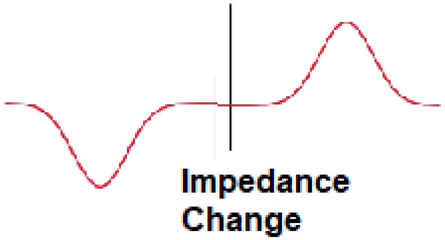

This reflected energy must be dissipated by the final of the transmitter. Modern transistor output stages can adjust the output automatically to reduce the possible damage to the output.

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Standing Wave Ratio or SWR

Definition of SWR

$$\rho := \sqrt{\frac{Pr}{Pf}}$$

$$SWR := \frac{(1+\rho)}{(1-\rho)}$$

Source: ARRL Handbook, 2017 pg. 20.4

Pr is Power reflected
Pf is Power forward

Forward power is what the antenna can send into the air.

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SWR READING	% OF LOSS	ERP*	WATTS AVAILABLE
1.0:1	0.0%	100.0%	4.00
1.1:1	0.2%	99.8%	3.99
1.2:1	0.8%	99.2%	3.97
1.3:1	1.7%	98.3%	3.93
1.4:1	2.8%	97.2%	3.89
1.5:1	4.0%	96.0%	3.84
1.6:1	5.3%	94.7%	3.79
1.7:1	6.7%	93.3%	3.73
1.8:1	8.2%	91.8%	3.67
1.9:1	9.6%	90.4%	3.61
2.0:1	11.1%	88.9%	3.56

Excerpt from: Firestik.com: Based on 4 Watt output.
http://www.firestik.com/Tech_Docs/SWRLOSS.htm

***ERP effective radiative power - the power the antenna can send into the air**

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3.0:1	25.0%	75.0%	3.00
4.0:1	36.0%	64.0%	2.56
5.0:1	44.4%	55.6%	2.22
6.0:1	51.0%	49.0%	1.96
7.0:1	56.3%	43.8%	1.75
8.0:1	60.5%	39.5%	1.58
9.0:1	64.0%	36.0%	1.44
10.0:1	66.9%	33.1%	1.32

According to the ARRL Handbook, 94 th Edition Section 20.4.6 Page 20.17 (2017) Anything below 6:1 will work. From the tables we can see the common idea of trying for 1.5:1 for only a 4% loss.

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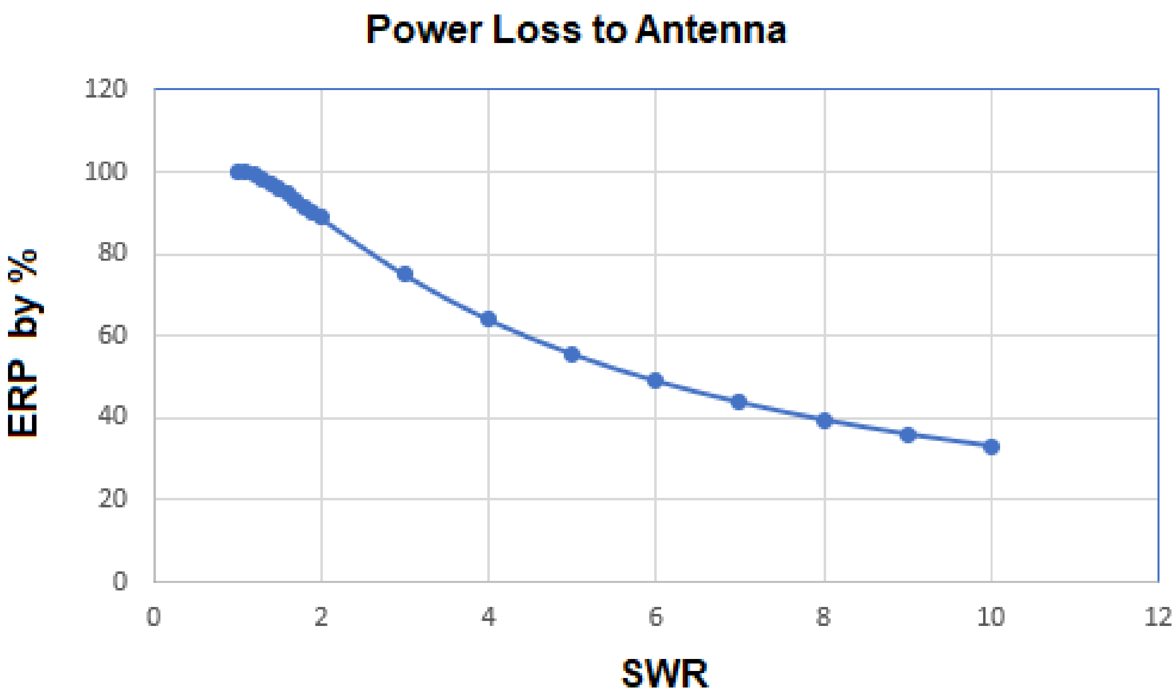

This is an exponential drop! So, it does pay to watch the SWR.

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Why does the loss exist?

Impedance mismatch.

Why do we care?

We want to get the most power possible to the antenna.

Where does the unused power go?

Back to the transmitter final stage.

Modern transmitters (transistor finals) have circuits to decrease the power if the SWR goes to high. But that's for a later discussion.

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Also, suggested topics to consider for future presentations in coming years.

Questions?

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