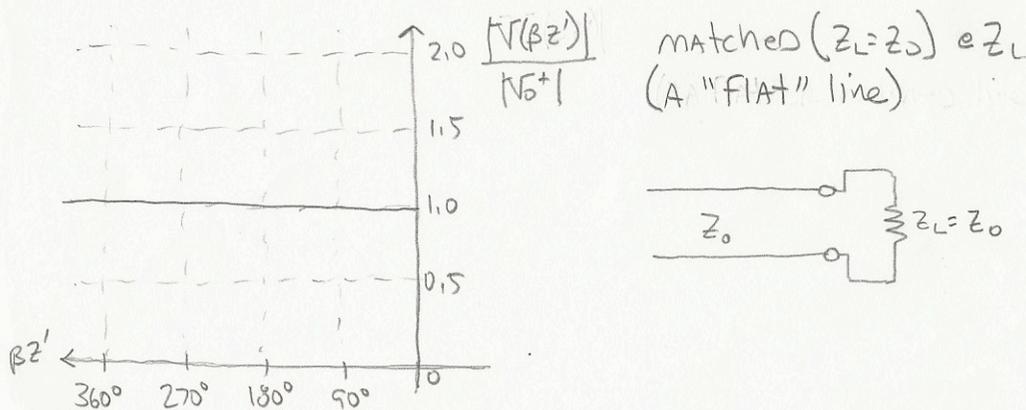
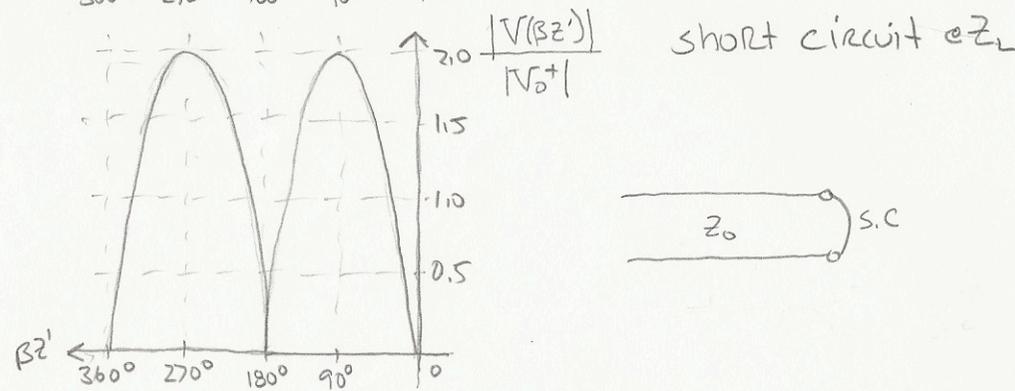
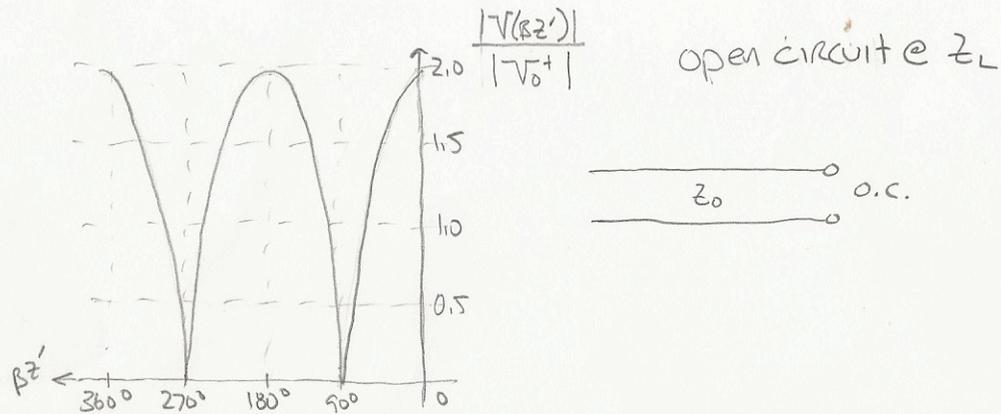


# Standing Wave Patterns And SWR

For 3 cases of T-line termination we see the following <sup>voltage</sup> magnitude patterns:

## Key Points



\* The sinusoidal envelopes of magnitudes of voltage or current across the length of the line are called standing waves.

\* Standing waves are caused by the interference of the forwards (incident) + backwards (reflected) waves.

\* The repetition period for standing wave pattern is  $\frac{\lambda}{2}$  when  $\lambda$  is the wavelength of the incident + reflected waves.

\* The standing wave does not move <sup>left or right</sup> on the T-line. Its maximum + minimum points are fixed.

What would an oscilloscope show if we probed the lines? Frequency? Amplitude?

# Standing Wave Patterns and SWR

If we place a  $100\Omega$  resistor as the termination for a  $50\Omega$  line we have:

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{100 - 50}{100 + 50} = \frac{1}{3}$$

This creates yet another standing wave pattern:

## Reflectometer from RF Mentor

### Reflectometer Calculator

Type a value in one of the fields below and hit 'enter':

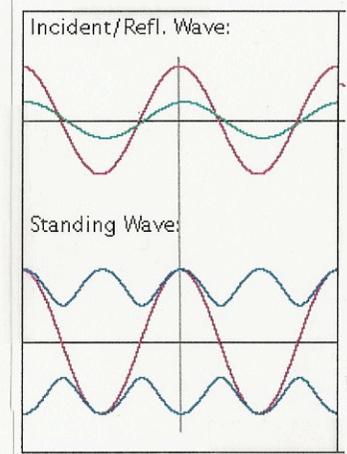
Reflection Coefficient	0.333
SWR	2.00
Return Loss	9.542
Mismatch Loss	0.512
eR	1
Z1	100

Show two interfaces

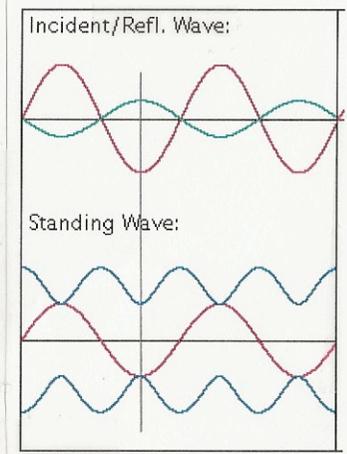
Resume

<p>Incident/Refl. Wave:</p> <p>Standing Wave:</p>	<p>Transmitted Wave:</p> <p style="font-size: small; color: blue;">smaller</p> <p>Standing Wave:</p>
---	--

Copyright 2004-14 BAI All Rights Reserved. Free Applets at [www.bessernet.com](http://www.bessernet.com)



Forward + reverse waves adding

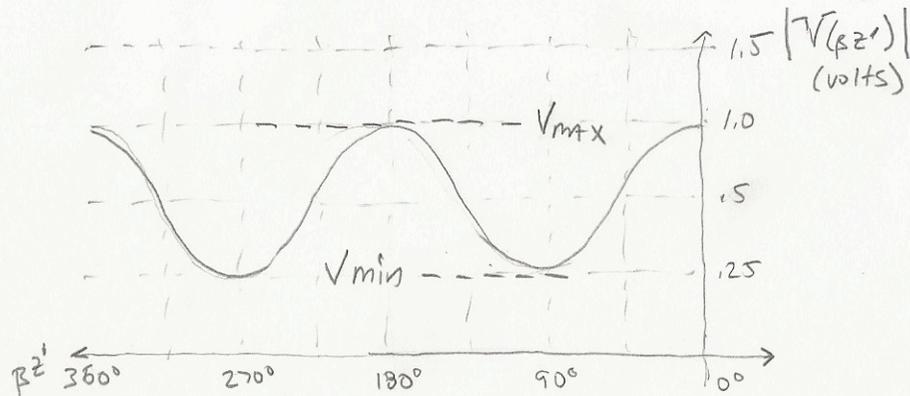


Forward and reverse waves subtracting

The standing wave pattern here is shown as an envelope. This envelope does not move.

# Standing Wave Patterns + SWR

Suppose we have a plot as shown below,



← different than what we see, on RFmentor.com

Once again, we are looking at the envelope of the magnitude of a voltage across a length of transmission line. This is a standing wave, note x-axis is in  $\beta z'$ .

- Each standing wave has an envelope with a  $V_{max}$  +  $V_{min}$ .  $V_{max}$  is not the maximum of the time domain waveform, but is the largest amplitude the time domain waveform reaches anywhere on the line.
- $V_{min}$  is the smallest <sup>absolute</sup> voltage the waveform reaches anywhere on the line.
- A quantity called the Voltage Standing Wave Ratio (VSWR) is defined as

$$VSWR = \frac{|V_{max}|}{|V_{min}|}$$

which is also equal to:

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

; it also follows that

$$|\Gamma| = \frac{VSWR - 1}{VSWR + 1}$$

Also,

$$|V_{max}| = |V^+| (1 + |\Gamma|)$$

$$|V_{min}| = |V^+| (1 - |\Gamma|)$$

↑ good to remember

- The plot above shows a line with a VSWR of  $\frac{1.0}{0.25} = 4$
- See AT+T Video (15:30-19:00)

## Standing Wave Patterns and SWR

HAVING A relationship between SWR +  $\Gamma$  is really useful. A measurement of  $|\Gamma|$  could be very difficult. However, taking a VSWR measurement is easy. A dual directional coupler can give a direct reading of SWR.

Google: W2AEW, YouTube, #208 (visualizing standing waves)  $V = b \sqrt{P_{avg}} / \sqrt{Z_0}$  by W2AEW  
#196 (directional coupler)

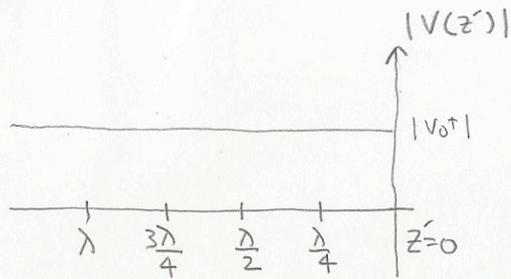
SWR is important in that it tells us how much power can be delivered to a load. An SWR of 1 indicates all the power is being delivered to the load. This corresponds to a  $|\Gamma| = 0$ .

An SWR of  $\infty$  indicates that none of the power is delivered to the load. This corresponds to a  $|\Gamma|$  of -1 or 1.

A high SWR also indicates that at  $\lambda/2$  distances, a very high current or voltage may be present on the T-Line. These conditions may cause melting or dielectric breakdown of the line.

Also, if power is not being delivered to the load, where does it go?  
Perhaps back to an expensive output amplifier tube!

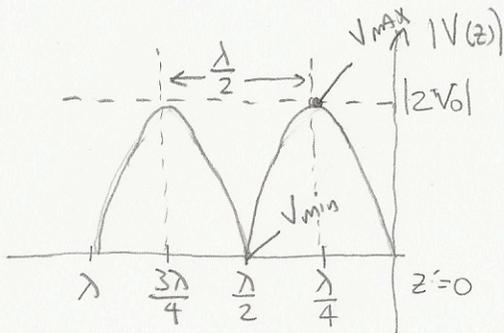
# Standing Wave Patterns and SWR



$Z_L = Z_0$  (matched line)

$SWR = \frac{|V_{max}|}{|V_{min}|} = 1$

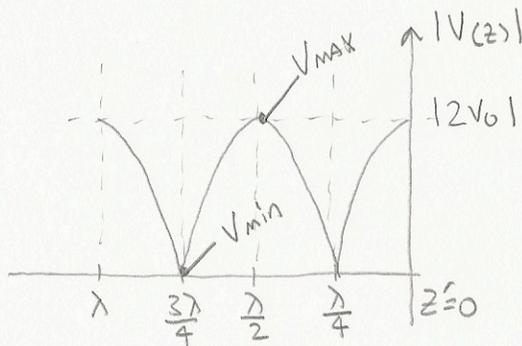
best case scenario  
All power delivered to load



$Z_L = 0$  (short circuit)

$SWR = \frac{|V_{max}|}{|V_{min}|} = \frac{|2V_0^+|}{0} = \infty$

One, worst case scenario  
No power delivered to load



$Z_L = \infty$  (open circuit)

$SWR = \frac{|V_{max}|}{|V_{min}|} = \frac{|2V_0^+|}{0} = \infty$

Another worst case scenario  
no power delivered to load

High SWR indicates little power transferred to load  
" " "  $|\Gamma|$  is large, approaching 1