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Author: Peter J. Schuch, WB2UAQ

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Technical Correspondence

Edited by **Paul Pagel, N1FB** • Associate Technical Editor

DIODE "PROTECTION"

By Ken Stuart, W3VVN, ARRL Technical Advisor, 1235 Hillcreek Rd, Pasadena, MD 21122-2460, e-mail **stuartkl@erols.com**

◊ In the early days of diode manufacturing, a high reverse voltage across a diode junction could result in arcing, either internal to the junction, or across the surface of the junction. This arc caused a high-current leakage path, destroying the diode.

To protect diodes in series-connected strings (where unequal leakage resistances between diodes can exist) it was common practice to force equal voltage sharing by swamping these internal leakages with lower-value external-resistor strings. By so doing, each diode sees only its share of the total voltage across the string.[1]

For the last couple of decades, however, diode manufacturers commonly add protection against arcing by creating an avalanche reverse mode—similar to that seen in a Zener diode. With this characteristic, the diode conducts with a reverse voltage at a potential that is lower than the arc voltage. Unlike an arc, which, once established, exhibits a high current and low voltage, the avalanche does *not* produce a low-voltage condition. Therefore, avalanche diodes connected in a series string will *not* allow a dangerous internal junction arc to occur. Also, it is common practice for rectifier manufacturers to produce high-voltage rectifiers by combining a number of individual diodes in the rectifier package, and internal shunting resistances are *not* used. With this reverse-avalanche mode, resistors are not needed because each diode self-protects against excessive voltage.

Equipment builders who want to shunt diodes with resistors should be aware that most resistors have only a 300-V maximum rating. If the reverse voltage across each of the "protected" diodes exceeds this level, the resistors can fail and destroy the rectifier string!

Shunting capacitors across diodes is *not* recommended. Momentary dielectric breakdown in capacitors is not uncommon, and this can overstress the other diode/capacitor pairs in the string causing catastrophic failure.

THE SWR ANALYZER AND TRANSMISSION LINES

By Peter J. Schuch, WB2UAQ, 9 Sturr Ln, Florida, NY 10921

◊ The September and October 1996 issues of *QST* contain articles on the application of hand-held SWR and impedance analyzers.[2,3] I'd like to add to the collection of ideas for use of these handy instruments.

I needed to determine when a given length of transmission line (in this case, coaxial cable) is an electrical 1/4 or 1/2 λ long at a given frequency. Using the analyzer, making this determination is easy because it isn't necessary to be concerned with the velocity factor or characteristic impedance (Z_0) of the cable.

You'll need your SWR analyzer, a **T** adapter and a low-SWR 50 Ω load. Connect the **T** adapter to the analyzer. To one arm of the **T**, connect the 50 Ω load; connect the cable under test (CUT) to the other arm. If you are checking for a 1/4 λ line, *short* the far end of the line. If you're checking for a 1/2 λ line, leave the far end *open*. Starting at a low frequency—a frequency too low to create a 1/4 λ or 1/2 λ response—slowly tune the analyzer frequency upward until the SWR decreases *to a minimum*, or equals 1:1. (Low-loss cable will show a lower SWR than lossy cable.) At the frequency of minimum SWR, the CUT is an electrical 1/4 λ or 1/2 λ, depending on whether the far end of the CUT was shorted or open, respectively.

This occurs because a *shorted* 1/4 λ line—or *open* (unshorted) 1/2 λ line—presents a very high impedance circuit to the analyzer. This high impedance effectively removes the CUT from the **T**, allowing the SWR analyzer to see only the 50 Ω dummy load. This occurs regardless of the cable's characteristic impedance (Z_0), even though the reference impedance of your analyzer is 50 Ω. If you are stacking antennas and make a cable harness from lines that are odd multiples of a 1/4 λ at the frequency of operation, you can use 70 Ω transmission line even in a 50 Ω system.

To determine the velocity factor of a transmission line, find the frequency at which a sample of the line is electrically 1/4 λ long, then measure the line's physical length. Divide the line's physical length by the line's free-space quarter wavelength. The result is the line's velocity factor.

If your analyzer can measure the magnitude of impedance, the line's Z_0 can be determined by taking advantage of a simple formula: $Z_0 = \sqrt{Z_i + Z_l}$, where Z_i is the input impedance of the line and Z_l is the load impedance. Here's how to use this procedure to find the Z_0 of a 1/4 λ transmission line. After finding the 1/4 λ line frequency, remove the 50 Ω load from the **T**. Remove the short at the far end of the CUT and replace it with the 50 Ω load. Without changing the SWR analyzer's frequency, measure the magnitude of the impedance. If the impedance measured is 50 Ω, the cable's Z_0 is 50 Ω. If the magnitude of the impedance is other than 50 Ω, use Equation 1, substituting the impedance just measured for Z_i; Z_l is 50 Ω. As an example, if Z_i is 100 Ω, $Z_0 = \sqrt{100 \times 50} = 70.7\ \Omega$.

The foregoing relationships hold up fairly well at low frequencies where the connectors and **T** are of negligible length. At VHF and above, the lengths and velocity factors of connectors and adapters become significant and must be considered.

It is also possible to determine the Z_0 of a line if your analyzer can only measure SWR; it just takes a bit of reasoning, as the following example illustrates. When the measured SWR of the line is 2:1, Z_i can be 100 Ω or 25 Ω as both values result in a 2:1 SWR (ie, 100 ÷ 50 = 2 and 50 ÷ 25 = 2). With Z_l equal to 50 Ω (the dummy load constant), substituting a value of 100 Ω for Z_i in the formula yields a Z_0 of 70.7 Ω (a likely characteristic impedance), but using 25 Ω for Z_l yields a Z_0 of 35.4 Ω, an unlikely value.

[1]For other comments on this subject, see Steven D. Katz, WB2WIK, "Diode Failure," Technical Correspondence, *QST*, Apr 1988, pp 46-47.—*Ed.*

[2]Paul Pagel, N1FB, "SWR Analyzer Tips, Tricks and Techniques," *QST*, Sep 1996, pp 36-40; see also Feedback, *QST*, Dec 1996, p 71.

[3]Fred "Fritz" Hauff, W3NZ, "The Gadget—an SWR Analyzer Add-On," *QST*, Oct 1996, pp 33-35.

Feedback

◊ Please see "A New(?) Serial Communication Protocol Discovered . . .", Technical Correspondence, *QST*, Apr 1997, p 70. Although Sam (N4UAU) Ulbing's signature spells 73 in binary, to agree with the protocol mentioned in the item, the correct representation is 11000 00011 DE N4UAU.