

# APPLICATION NOTES

## A guide to the selection of RF coaxial cable *(continued)*

of required components and cables with the appropriate characteristic impedance is usually the prime factor in selecting a given system impedance.

### B. SIGNAL REFLECTION: VSWR, RETURN LOSS, REFLECTION FACTOR & IMPEDANCE UNIFORMITY

There are three things that happen to RF energy input into a coaxial cable assembly:

1. It is transmitted to the other end of the cable, as is usually desired.
2. It is lost along the length of the cable either by being transformed into heat or by leaking out of the cable.
3. It is reflected back towards the input end of the cable.

Reflections back towards the input end of the cable are caused by variations in impedance along the length of the cable assembly. This includes differences in impedance between the cable and the devices to which it is attached. Typically the connectors and the interface between the connectors and the cable will be major contributors to the reflection. The cable itself can also contribute to the reflections. One source of cable reflections is periodic variations in impedance which result from the manufacturing process and add up at a specific frequency. When viewed in a sweep over a range of frequencies this will show up as a spike. An example of a spike is shown in Figure 1.

The magnitude of a reflection can be expressed in several ways. Perhaps the most familiar is VSWR or Voltage Standing Wave Ratio. A value of 1.0:1 or just 1.0 indicates no reflected power or a perfect cable. Alternatively, the reflection can be expressed as return loss—the ratio of the reflected power to the input power usually expressed in decibels. Table 1 gives the formulas to convert between VSWR, return loss and reflection coefficient. A tabulation of the equivalent values of all three measures is also provided in Table 2.

The lack of reflected power (or low VSWR) is often used as a figure of merit for coaxial compo-

nents, including cables, connectors and cable assemblies. It is indicative of how well the uniformity of the cable is maintained along its length, whether the connectors are properly designed and attached and how well the transitions between line sizes are compensated for in the connectors. It is generally a function of frequency, with reflections generally getting higher as the frequency increases.

In many applications, low reflected power is critical for proper system performance. In these cases, it is essential that this be considered in the

**Table 2**  
**VSWR Conversions**

VSWR (:1)	Return Loss (dB)	Reflection Coefficient	Mismatch Loss (dB)	Match Efficiency (%)
1.011	45	0.006	0.000	100.00
1.020	40	0.010	0.000	99.99
1.036	35	0.018	0.001	99.97
1.065	30	0.032	0.004	99.90
1.074	29	0.035	0.005	99.87
1.08	28	0.400	0.007	99.84
1.09	27	0.045	0.009	99.80
1.11	26	0.050	0.011	99.75
1.12	25	0.056	0.014	99.68
1.13	24	0.063	0.017	99.60
1.15	23	0.071	0.022	99.50
1.17	22	0.079	0.027	99.37
1.20	21	0.089	0.035	99.21
1.22	20	0.100	0.044	99.00
1.25	19	0.112	0.055	98.74
1.29	18	0.126	0.069	98.42
1.33	17	0.141	0.088	98.00
1.38	16	0.158	0.110	97.49
1.43	15	0.178	0.140	96.84
1.50	14	0.200	0.176	96.02
1.58	13	0.224	0.223	94.99
1.67	12	0.251	0.283	93.69
1.78	11	0.282	0.359	92.06
1.92	10	0.316	0.458	90.00
2.10	9	0.355	0.584	87.41
2.32	8	0.398	0.749	84.15
2.61	7	0.447	0.967	80.05
3.01	6	0.501	1.256	74.88
3.57	5	0.562	1.651	68.38
4.42	4	0.631	2.205	60.19
5.85	3	0.708	3.021	49.88

Match efficiency - e.g. 100 Watts Forward Power at 1.33:1 VSWR yields 98 Watts Output (i.e. 2 Watts Reflected)