Solid VS. Stranded Center Conductors

Introduction:
Have you ever wondered which type of cable center conductor will perform best in your system? Should I use a solid or stranded center conductor? Which conductor offers the best electrical and mechanical performance? This technical document will answer the age old question of center conductor selection.

Cable Construction:
Modern RF and microwave systems push the limits of performance. System environments are very demanding requiring a high degree of component reliability. That is why state of the art materials and processes are required for high performance microwave cable.

A typical microwave cable construction is detailed below in Figure I. Center conductors are typically solid or stranded silver-plated copper wire per ASTM B-298. Stranded conductors generally have 7 or 19 strands. Dielectrics are typically solid or low density PTFE per MIL-C-17, with dielectric constants ranging from 1.4 to 2.03. Inner shields are most often composed of helically wrapped silver-plated copper tape per ASTM B-298, with adjacent layers overlapped for outstanding flexibility and 100% coverage. Outer shields are tightly applied round wire braids manufactured from silver-plated copper per ASTM B-298. This outer braid adds strength to the cable while offering additional RF shielding. The jacket is comprised of Fluorinated Ethylene Propylene (FEP).

A typical microwave coaxial cable is a composite structure consisting of metal conductors separated by a polymer dielectric. The entire assembly is then encapsulated with a polymer jacket as shown in Figure I . The behavior of these various materials with temperature, and their interactions with one another will govern the overall phase versus temperature response of the assembly.

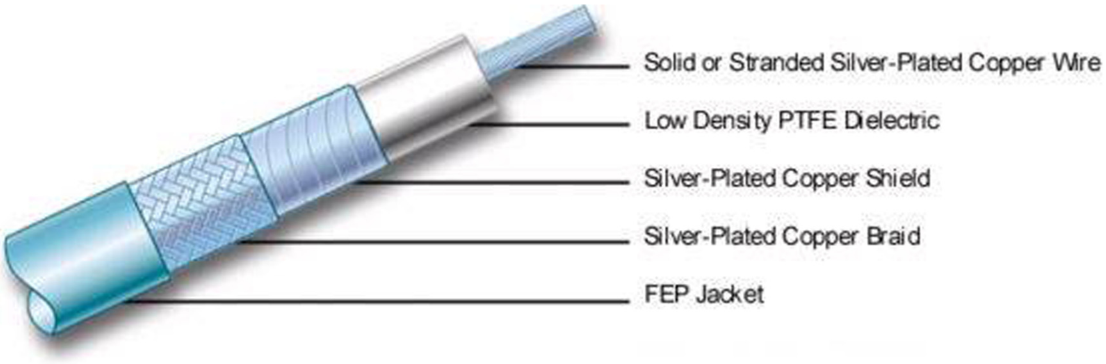

Figure I. Typical microwave cable construction.

Center Conductors Compared:

Micro-Coax part numbers UFA210A, UFA210B and UFA210C will be used to demonstrate the inherent electrical and mechanical differences between solid and stranded center conductors. All three cables use identical designs except for the center conductors. The UFA210A utilizes a solid silver plated copper wire, the UFA210B a 19-strand wire and the UFA210C a 7-strand center conductor as shown in Figure II. All cables have equivalent effective center conductor outer diameters.

Solid center conductor cable is easier to manufacture because there are fewer variables to control in manufacturing. The outer diameter of the center conductor must be held to a tight tolerance for impedance to remain constant. The stranded center conductor must have each wire in the strand held to tight dimensional tolerances as well as the overall outer diameter in order to maintain a constant impedance. This is a much harder task but is accomplished by twisting the individual strands using a high precision process to achieve the desired overall outer conductor diameter. This process makes stranded center conductor cable more expensive to produce. Also, in theory the stranded center conductor's impedance should not be as precise because of the gaps between wire strands causing non-uniform capacitance and slightly higher impedance, but experimental results prove this effect is negligible. However, the stranded center conductor has many advantages including durability, flexibility and others.

The electrical and mechanical performances of these three cable types are compared in the following sections. Each test assembly is 24-inches long, terminated with SMA connectors and tested in frequency from DC – 18 GHz.

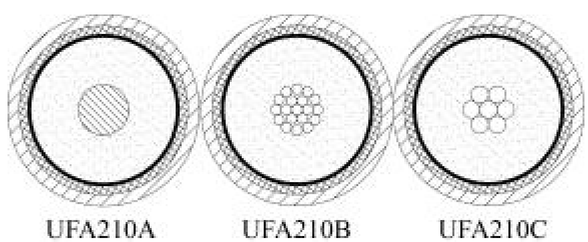

Figure II. Cable Cross-section.

Attenuation:

Attenuation is a function of signal frequency, cable length, size and construction. Attenuation increases with frequency and cable length. For similar constructions, the larger diameter cable will have lower attenuation. Figure III compares signal insertion loss by holding frequency and cable length constant. The solid center conductor is the lowest with its smooth and continuous surface. The stranded center conductors have a contact resistance effect which adds to the loss. The 7-strand center conductor has less contact resistance than the 19-strand which leads to lower signal loss. Attenuation increases with the number of center conductor strands. An increase in ambient temperature and/or pressure will also increase cable attenuation.

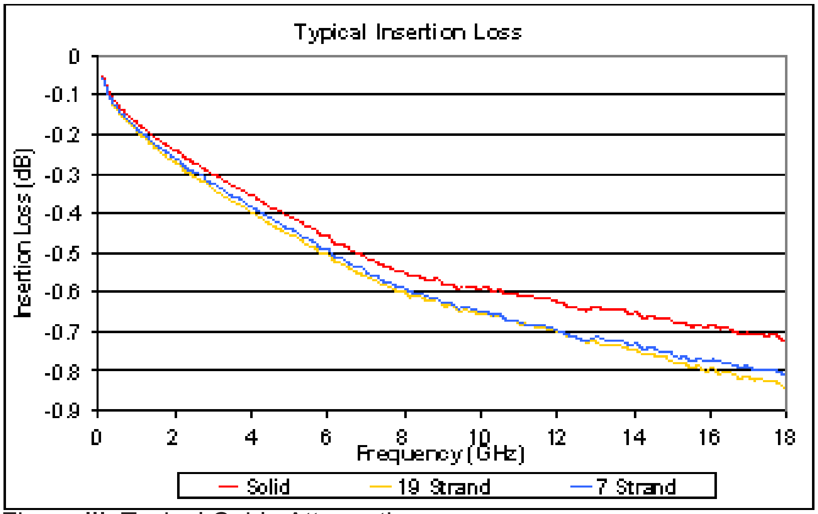

Figure III. Typical Cable Attenuation

<u>Phase Stability</u>:
Phase stability, also known as electrical length stability, is defined as the change in electrical length of the cable with temperature, flexure and other environmental conditions. Phase stability with flexure is measured by wrapping the cable once (360-degrees) around a 2-inch diameter mandrel and measuring the phase change from the cable at rest position. Figure IV shows the phase change of the different cable types. Stranded center conductor cable is less sensitive to phase change versus flexure due to the added flexibility and resilience of the stranded center conductor.

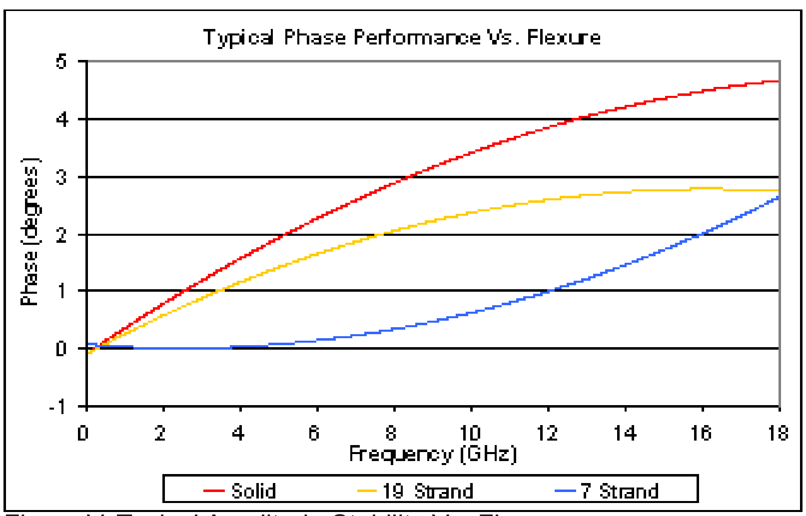

Figure V. Typical Amplitude Stability Vs. Flexure

<u>Power Handling</u>:
Maximum power handling of a coaxial cable is directly related to the amount of heat generated and the ability of the cable to dissipate it. Most of the heat is generated around the center conductor and is a critical component in power handling. The heat generated in the cable is a result of attenuation. Higher cable attenuation results in lower power levels. Solid center conductors have the lowest attenuation and generate the least amount of heat attributing to the highest power handling capabilities.

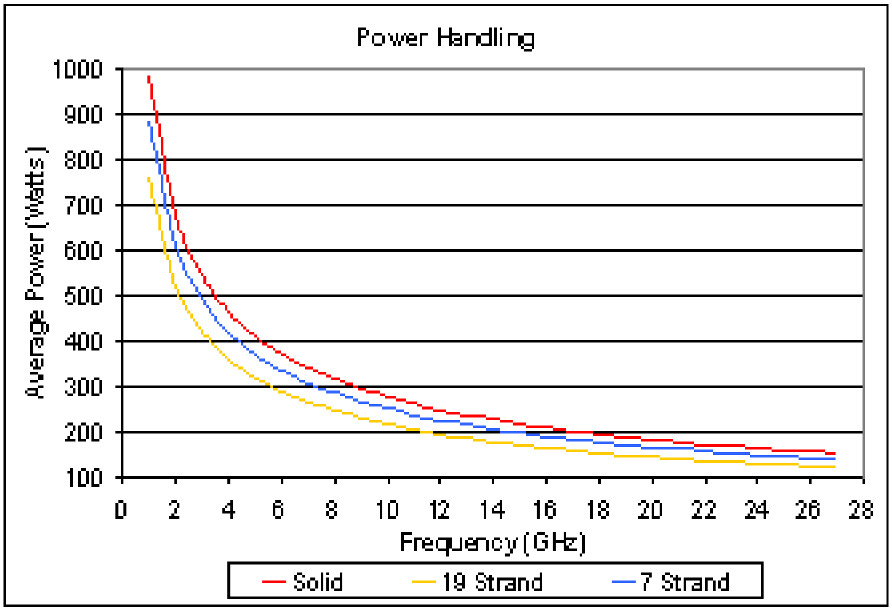

Figure VI. Power Handling

Flex Life:
The flex life of the cable greatly effects its lifespan. Stranded center conductors are much more flexible than solid center conductors. The solid center conductor tends to fatigue at much lower levels when tested with a flex test shown in Figure VII. Typically the solid center conductor of UFA210A tends to fail after 10,000 flexures. The stranded conductors show no significant electrical or mechanical degradation after 100,000 flexures. If your application calls for a cable that will not be installed as a static assembly or will be handled regularly, a stranded center conductor cable is highly recommended to increase the life of the assembly.

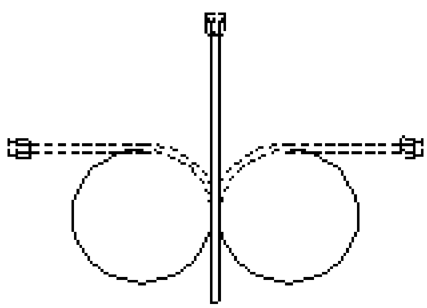

Figure VII. “Tic-Toc” Flex Test

Conclusion:
The best performing conductor will be based on your application and requirements. Both solid and stranded types have advantages and disadvantages. Figure VIII below summarizes the results of the tests discussed in this technical document and can be used as a quick guide in selecting cable type.

	Solid Center Conductor	19-Strand Center Conductor	7- Strand Center Conductor
Lower Attenuation	Best	Good	Better
Phase Stability Vs. Flexure	Good	Better	Best
Amplitude Stability Vs. Flexure	Best	Better	Good
Power Handline	Best	Good	Better
Flex Life	Good	Best	Better