Transmission Lines

Is your coax genuine M17/74 or generic RG-213?

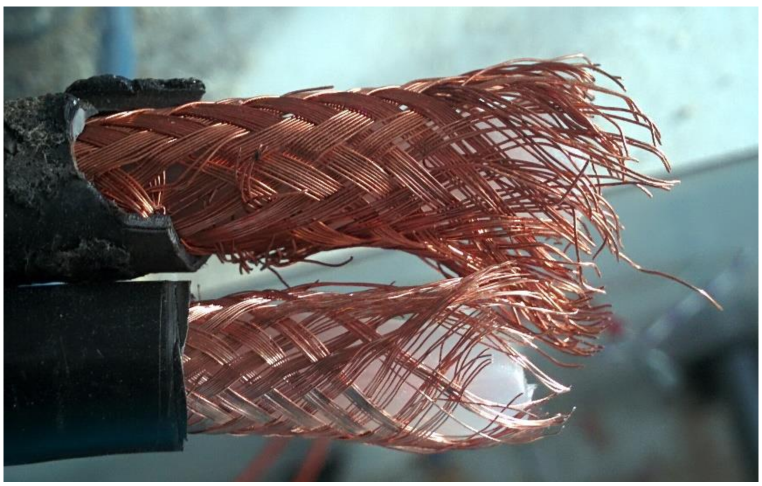
By Avner Drory, 4X1GE

Introduction

About 20 years ago I wrote a series of articles in “HaGal“ [newsletter of the IARC] on the subject of cables and I thought I had completed the series. I was apparently mistaken as it turns out that I did not mention what should be checked when buying coaxial cable. I hope that this article provide useful information on the subject.

Why now? A short time ago I bought some RG-213/U coax because I needed some and because the price was attractive. When I started using the new coax I ran into difficulty soldering on connectors. When I compared it to an old coax cable I noticed several differences but mainly in the density of the shield.

Before continuing let’s look at two examples of coax cable. The top cable is M17/74-RG213 and the one underneath it is RG213/U.



To be perfectly clear - both cables that I compared were marked RG213/U.

The old cable (top) was labeled: "Motorola 30-02343C02 M17/74 RG213” clearly identifying the military designation M17/74 and the supplier of the cable. The new cable (bottom) was labeled: “RG-213/U MIL-C-17 Coaxial Cable” without a manufacturers name or trademark.

Specifications

Since WWII is has been the convention to label electronic components with a two letter prefix, a number and the symbol “/U”. In our example RG is used as a prefix for all coaxial cable and a number describing the type of cable (in our example 213) and the suffix /U – indicating that the cable is for general “universal” use as compared to a component that is specific to one special system.

US Army purchasing specifications, knows as "Mil Specs", set out the requirements for all acquisitions by the army. These specifications are clear on all important parameters and are widely used all over the world.

The military specification accepted today for coaxial cable is called Mil Spec MIL-C-17. In the previous versions of the specification, there was a direct connection to the cable names, as most of us know them, RG8/U, RG11/U, RG58/U, RG213/U~~,~~ and many more. For the purposes of this article these are the “generic names”.

Every new coaxial cable that lacks an old generic name will have a new designation related to the specification number and a catalog number, for example, M17/189, which will be discussed in the following paragraphs.

The cable designation is suffixed with an additional number that helps differentiate between similar cables. For example M17/189-00001 UNARMORED or M17/189-00002 ARMORED.

While it would seem that the RG designations should disappear from use, they have been maintained both in the military and civilian markets because they have become general use names that go back generations, both in the military and civilian markets. Therefore the RG designations may still be found today.

Everyone knows RG213/U while the new designation, M17/74 is less familiar -- so it is common practice to mark the cables with both designations.

This designation may be found in many documents for example the following table that I found on the internet:

M17/MIL-C-17 Coaxial Cable Specifications

M17 Part No.	M17 QPL	TMS Part No.	Conductor inches (mm)	Dielectric inches (mm)	Shields inches (mm)
M17/72-RG211	No QPL'd Source	AA-3405	BC 0.192 (4.88)	PTFE 0.620 (15.75)	32BC 0.657 (16.69)
M17/73-RG212	17-1104-85	AA-3406	SC 0.0556 (1.41)	PE 0.185 (4.70)	34SC:34SC 0.243 (6.17)
M17/74-RG213	17-804-77	AA-3408	BC 7/.0296" 0.0888 (2.26)	PE 0.285 (7.24)	33BC 0.318 (8.08)
M17/74-RG215	17-804-77	AA-3407	BC 7/.0296" 0.0888	PE 0.285	33BC 0.318

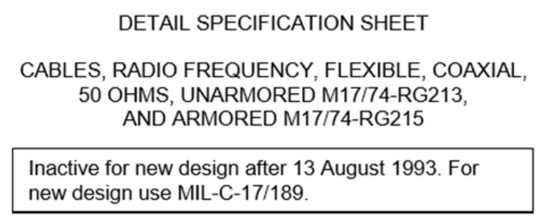
Let’s go back for a minute to the cables I mentioned at the outset. The new cable only has RG213/U marked on it while the older cable has both RG-213 and the military designation M17/74. From this we can conclude that a generic RG213 cable does not necessarily conform to a published specification.

By the way - don’t expect a cable manufacturer/vendor that does not mark his name and the MIL-C-17 cable type to conform to all the details of the specification like cable diameter and the number of strands of copper in the shield. You will notice that some advertisements specifically avoid these details.

So far we have only mentioned RG213 but it is taken as a representative example of all the "RG" type coax cables. Further information on cable labeling may be found in the MIL-C-17 general specification and/or in MIL-DTL-17 (where "**DTL**" is a contraction for **Details**).

Recent publications also cite MIL-W-17.

Since we have been discussing RG213 – M17/74 it is worth mentioning that this specification has not been used for new system design since August 1993.


DETAIL SPECIFICATION SHEET

CABLES, RADIO FREQUENCY, FLEXIBLE, COAXIAL, 50 OHMS, UNARMORED M17/74-RG213, AND ARMORED M17/74-RG215

Inactive for new design after 13 August 1993. For new design use MIL-C-17/189.

At present the valid specification is MIL-C-17/189, as shown on the tag shown on the right.

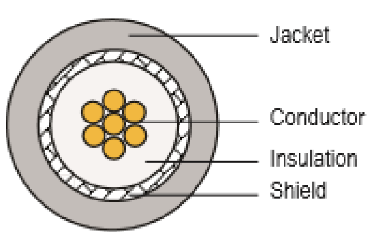
The reason is the addition of a metal foil to improve shielding and more important changing the flame retardant in the dielectric to products that do not off-gas toxic chemicals in the event of fire (FR rating).

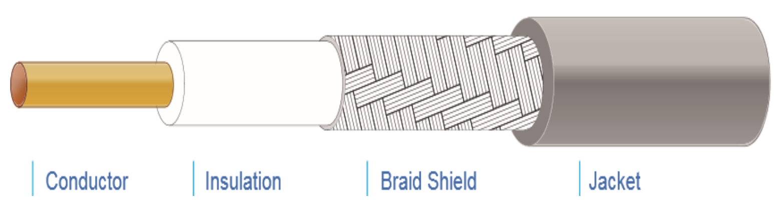
Design and construction of coaxial cable

Transmission lines are designed to carry radio frequency energy at minimum loss. In real world cases there is always some loss and so it is necessary to choose the cable that will do the best job in a cost effective way. Loss is principally due to: resistive loss of the conductors, energy radiated from the cables and losses in the dielectric.

It is worthwhile considering the differences between legitimate cables and clones. To understand the differences let's review the basic structure of a cable and the design parameters.

This diagram illustrates the internal structure of a typical coaxial cable:





The cable is composed of a central conductor, insulator, shield and jacket. We will shortly discuss the parameters of these elements, mainly the center conductor and the shield, and how they could affect overall cable performance.

The cross sectional area of the center conductor and of the braid should be sufficiently large to reduce resistive ("Ohmic") loss. Their dimensions also have to insure that the inductance and capacitance per unit length give the desired impedance, in most cases, 50 Ohms.

The center conductor is composed of a number of strands of copper wire twisted together. The shield is composed of a number of bundles of fine copper wire braided together. This structure defines the electrical characteristics of the cable.

Most hams do not have access to measuring instruments specifically designed to test coaxial cable such as a TDR (Time Domain Reflectometer) permitting direct measurement of the impedance so we will therefore start with physical measurements that use a common caliper or micrometer.

Occasionally it is possible to see differences with the naked eye however using a caliper and micrometer will permit a sufficiently exact measurement to verify conformance to the published specification.

The author has a good selection of calipers and micrometers and is also fortunate to have access to a TDR instrument. I used these tools to make the measurements shown in the table below:

Parameters and Measurements

Cable photo			
Parameter	**MIL-C-17** **SPEC**	**"RG-213"** **MEASURED**	**M17/74** **MEASURED**
Center Conductor			
Number of strands	7	7	7
Strand diameter	0.74mm	**0.70mm**	0.74mm
Screen			
Number of stands	24	**18**	24
Strands/bundle	8	8	8
Total strands	192	**144**	192
Strand diameter	0.18mm	**0.11mm**	0.18mm
coverage	95%	???	95%
Insulation diameter	7.24mm	**7mm**	7.24mm
Cable diameter	10.29mm	**9.83mm**	10.18mm
Capacitance/meter	104-99 pf/m	116 pf/m	116 pf/m

Interpreting the Measurements

The most important finding of the measurements was the savings in copper that result in increased resistance and as a consequence a reduction in density or coverage of the shield.

1. Radiation from the cable that could cause interference
2. Increased sensitivity to RFI
3. Increase in resistance that could result in losses
4. Decrease in capacitance between the inner conductor and the shield
5. Use of the cable as a matching section, for example, should take into account a different velocity factor

Reduction of the capacitance has a direct effect on the impedance which is compensated for by reducing the diameter of the insulator bringing the conductors closer together and reducing the breakdown voltage. This is probably not very critical if the application is a receiving antenna however it will be important if used for transmitting at high power levels.

One of the most interesting findings of the measurements was the impedance determined with the TDR and set out in the table below:

Impedance [SD = standard deviation]	**Specification**	**M17/74**	**RG-213**
	50±3% Ω	Avg 49.92 [--0.15%] SD 0.10 Max 50.36 Min 49.82	Avg 52.33 [+4.66%] SD 0.02 Max 52.42 Min 52.30

It turns out that adjusting the insulation thickness brought the impedance quite close to the specified value with a deviation of 4.66% compared with the 3% permitted in the specification. Therefore impedance is not a major issue with the specific coax tested here.

Conclusions

The RG-213/U label is only a generic name and even if there is reference to MIL-C-17 it is only a distraction because this designation has not been valid for many years. MIL-C-17 is occasionally still used but only when describing a new cable that replaces the older types.

The shield braid in the tested cable is too sparse and raises concerns of interference in both directions and the lower amount of copper used raises concerns for resistive losses that exceed specifications.

Recommendations

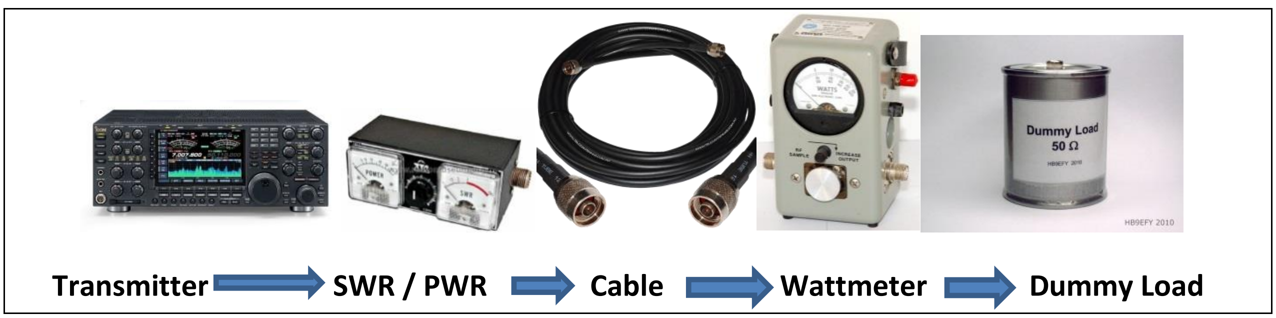
First you must define the application for the coax cable that you are planning to buy and how flexible you are willing to be balancing quality and performance against price.

Check what is available on the market and do not be tempted by too low a price which may get you a cat in the bag […*acheter (un) chat en poche* (to buy a cat in a bag)].

Verify that you are buying a correct and fully labeled cable from a reputable manufacturer/vendor. The cable should be labeled "M17/74-RG213". When you go to purchase coax cable take a pocket knife with you in order to peel back the insulating jacket allowing you to examine the shield and compare it to a short length of verified genuine good cable that you brought with you.

If you find cables marked only RG-213 without the M17/74 and they look good on inspection then *caveat emptor.* One possibility is that you are being offered an old cable that may have increased loss and therefore should be tested further.

An SWR measurement alone is not a sufficient test; you may well get a 1:1 SWR reading precisely because the cable is high loss. A preferred test method is to put a dummy load + watt meter at the far end of the cable and a SWR bridge/power meter at the transmitter end. In a good cable what goes in will come out.



We can conclude that "generic" cables have their place in an amateur station, especially if they are really cheap and used for short runs to connect receiving antennas for the low bands. On the other hand they should be avoided when planning to connect VHF/UHF antennas, or long runs to HF antennas, especially at high power levels.

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