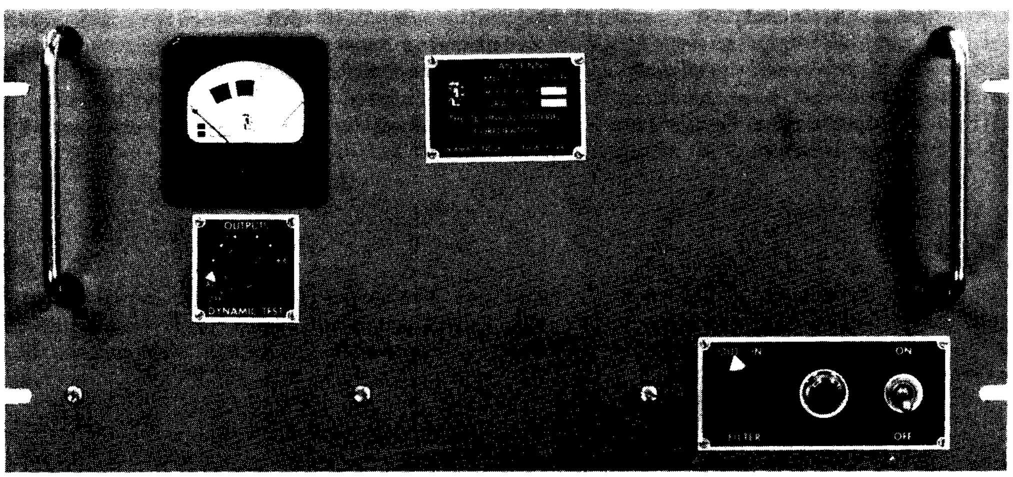
Field Engineering Bulletin

TITLE	BULLETIN NUMBER
Notes On Receiving Type Antenna Multicouplers And Testing Procedures	5



Front View, Model AMC-6-5

When results of electronic equipment evaluation tests are used as a basis for comparing several units, it is highly desirable that the same test procedures and methods be employed for all the units. Ideally, comparative tests should be performed by the same individual, at approximately the same time, and using the same high quality test equipment throughout the duration of the test. Unfortunately, this is not always possible. Therefore, it becomes even more important to understand testing methods and the meaning of performance characteristics usually stated in electrical specifications. By juggling the frequency, voltage or other test parameters, it is quite possible to present a picture that, at least on casual observation, may be at great variance with fact.

For example, assume that two test signals each with a magnitude of A volts, are fed into the input of a unit being tested for intermodulation distortion. The distortion products at the output will vary in magnitude as a function of the magnitude of the test signals. Generally speaking, as the voltage of the test signals is increased, the magnitude of the distortion products will also increase. Consequently, if test voltages less than A volts in amplitude are used for the measurements, the distortion products produced will be lower, and will present a false picture when compared directly with the results obtained when using the larger test signals. It should be pointed out, however, that multi-couplers can be more or less separated into two catagories. The first being characterized by high gain and low noise (AMC-6-2), the second group requiring a general compromise to optimize all characterisitcs with low gain and good intermodulation qualities (AMC-6-5). It is a common practice to use a lower level test signal for measurements on multicouplers in the first group than the second. This is because a high gain multicoupler will over load more easily than one with less gain. Therefore, by using a test signal similar to the live signal that the multicoupler is designed to be used on, a more accurate indication of its performance is obtained. In practice, two common test voltages are .01 volt for multicouplers described as falling in group one and .25 volt for those falling in group two. The point is to compare similar multicouplers on a like basis.

Generally speaking, there are three design criteria that are closely interwoven in the design of any amplifier, including multicouplers. These are; intermodulation and noise figure and how they are effected by gain. In general, the noise figure improves as the gain is increased, but at the same time the various intermodulation distortion products are increased. In other words, the noise figure is directly proportional to gain (other things being equal) while good intermodulation characteristics are inversely proportional to gain. Because of this interdependent relationship, the design of a multicoupler is necessarily a compromise based on the customers specific requirements, or the design objective is to optimize all characteristics within the compromise framework. Such a design is usually a unit that has a gain of about 3 db referenced to an imput signal of 2.5 millivolts rms, a noise figure less than 10 db, and an intermodulation characteristic of about 55 to 60 db when measured at a signal level of 250 millivolts. The AMC-6-5 is of this latter type.

A few words concerning noise figure are appropriate. The noise figure of an amplifier is a measure of the deterioration of the signal to noise ratio by an amplifier. This deterioration of the signal is a result of noise generated by the tubes and other noise producing components used in the circuit. Noise figure is defined as;

$$\text{Noise figure} = F = \frac{\text{Signal-to-noise power ratio of ideal system}}{\text{Actual signal-to-noise power ratio of output}}$$

Thus, a noise-free amplifier would have a noise figure of unity.

When two multicouplers are cascaded or a receiver and multicoupler are cascaded, the overall noise figure (F_{12}), that is the noise figure for both units in cascade, will be dependent on the individual noise figures (F_1 and F_2) and the amount of gain of the receiver or first multicoupler (G_1).

To express this we say that:

$$F_{12}\,(\text{db}) = 10 \log 10\, F_1 + \frac{F_2 - 1}{G_1}$$

Where;

F_{12} = Overall noise figure in db.
F_1 = Noise figure of first unit expressed as a power ratio.
F_2 = Noise figure of second unit expressed as a power ratio.
G_1 = Available power gain, of the first unit.

From this it is evident that the first unit of a cascade arrangement largely determines the noise figure, particularly if the first unit has a high gain. A pertinent example of this is many receivers that have high gain RF stages. In many cases, the remainder of the receiver may be neglected when considering the noise figure, without great error.

In the case where a multicoupler is cascaded with a receiver, usually the overall noise is increased. This is reasonable if we consider that well designed receivers in use today usually have lower noise figures than comparable multicouplers, mainly because of the high gain of a receiver. Multicouplers, on the other hand, are low gain devices.

It is possible, however, that the overall noise figure of a receiver and multicoupler may be reduced if the receiver has a very high noise figure and the multicoupler has a high gain. This is not the usual case, however, because most receivers today have fairly good noise figures and most modern receiving type multicouplers are low gain devices (about 3 db) to keep intermodulation distortion at a minimum. Two examples follow to illustrate these two cases.

1. Receiver with low noise figure .

2. Receiver with high noise figure.

Case 1.

F_1 = Noise figure of multicoupler = 8 db.
F_2 = Noise figure of receiver = 4 db.
G_1 = 3 db.

Convert to power ratios to use formula.

F_1 = 6.3
F_2 = 2.51
G_1 = 2.0

$$F_{12}\ (\text{db}) = 10 \log_{10} \left[6.3 + \frac{2/51 - 1}{2} \right] = 10 \log_{10}\ (6.3 + .755)$$
$$= 10 \log_{10}\ 7.1 = 10\ (.85) = 8.5 \text{ db.}$$

Case 2

F_1 = Noise figure of multicoupler = 8 db.
F_2 = Noise figure of receiver = 20 db.
G_1 = 10 db.

Convert to power ratios to use formula

$F_1 = 6.3$
$F_2 = 100$
$G_1 = 10$

$$F_{12}\,(\mathrm{db}) - 10 \log_{10} \left[6.3 = \frac{100-1}{10} \right] = 10 \log_{10} \; 16.2 - 12.1 \text{ db.}$$

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Adapted from a brief on the same subject by M. Yurko, Sales & Systems Engineer TMC (Canada) Limited.