Technical Analysis

of

HIGH FREQUENCY RECEIVING ANTENNA MULTICOUPLER

Series AMC-8

A4.0302-8
0976

GENERAL DESCRIPTION AND FEATURES

The AMC-8 antenna multicoupler is a broadband antenna-to-receiver coupling device which permits the use of a common antenna by up to eight communication receivers. The multicoupler is small, compact and completely solid state - ideally suited for both ship and shore installations in either commercial or military applications. No tuning, switching or peaking is required for proper operation since one of the basic design factors used is that the AMC-8 operate continuously in an unattended station. The multicoupler will provide completely dependable services over a long period of time with minimum maintenance.

Each AMC-8 antenna multicoupler consists of a broadband transistorized preamplifier, a series of eight output modules, a power supply, and a bandpass (2-32MHz) input filter. All that is needed for proper operation is the application of AC power and connection of both receiver and antenna leads.

The following sections cover the multicoupler in more detail.

PHYSICAL DESCRIPTION

The AMC-8 is designed for mounting in a standard 19-inch rack. Each unit is supported by four retaining screws on the front panel. All controls including fuses are brought out to the front panel. For the AMC-8, these consist of two indicating fuses, a power on/off switch, a power indicator lamp, and two spare fuses (in holders). The antenna input connector, eight output connectors to the associated receivers, and primary power cable are mounted on the rear panel. The overall dimensions of the AMC-8 are:

19" wide x 1-3/4" high x 14" deep
48.3cm wide x 4.4cm high x 35.6cm deep
Weight: 8 lbs. (3.8 kg)

Internally, the majority of discrete components and semi-conductors are mounted on printed circuit boards securely fastened to the chassis. Certain larger power supply components are also fastened to the chassis directly. Cooling is by normal convection. If the AMC-8 multicouplers are cascaded, an axial fan assembly is added to force air cool the cabinet.

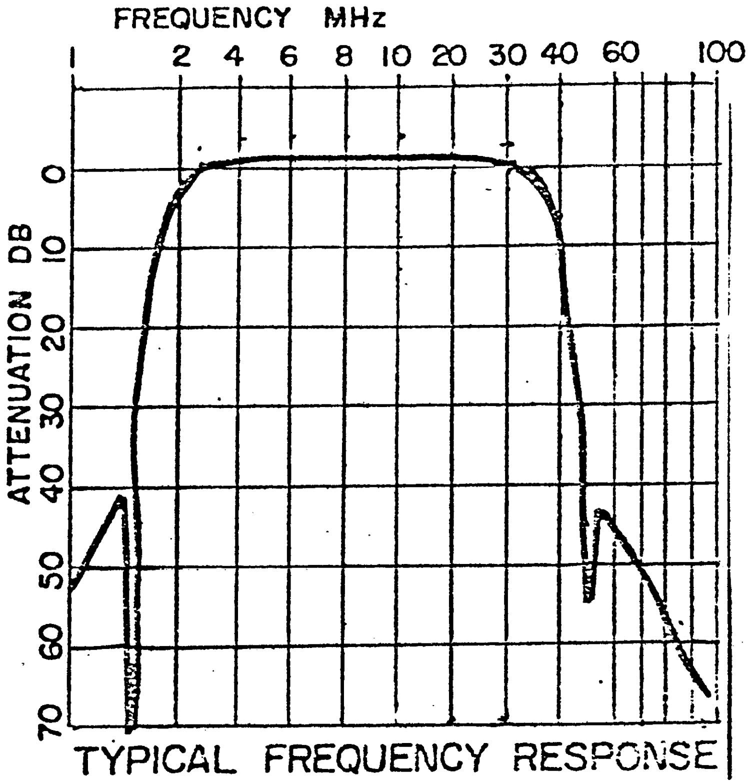
FUNCTIONAL DESCRIPTION

The AMC-8 is an eight-output antenna multicoupler designed to operate as a broadband distribution system between a single antenna and up to eight antenna terminating points of communication receivers. Both the input and output impedance (50 or 75 ohms nominal) are flat over the specified operating frequency range to ensure quality performance when used in a communications receiving system.

The input to the multicoupler is connected to a preamplifier board assembly through an input bandpass filter. The filter is designed to attenuate incoming signals outside the 2 to 32MHz frequency range. It is a seven-pole bandpass design that introduces negligible ripple as shown on the attached response curve while providing a input-output phase correlation of ±1%. A neon lamp is used to prevent damage to the AMC-8 components due to lightning surges in the antenna. This lamp fires for any voltage at the input in excess of 40 volts, thereby providing a ground for the lightning surge.

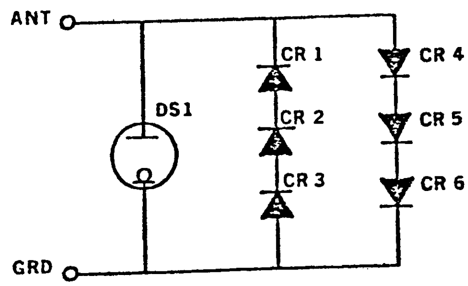
The preamplifier is a low-noise, wideband, solid-state amplifier with an input impedance of 50 or 75 ohms nominal and a gain of 8db. The output of the preamplifier is connected to the input of the eight-output assembly. Each output from this assembly is terminated at the eight output connectors on the rear panel with an overall insertion gain of 2db for each output.

The built-in power supply converts the AC supply into DC and then regulates it to the required voltage for operating the preamplifier and the output assembly networks. The power supply is designed to operate from a 115 or 230 volt AC, single phase, 48 to 400Hz primary power source. Changeover from 115 to 230 volt operation can be made by simple modification to the input power transformer wiring. Line filters are added to remove residual RF content from the AC supply. All power circuits are fused to protect both personnel and equipment.

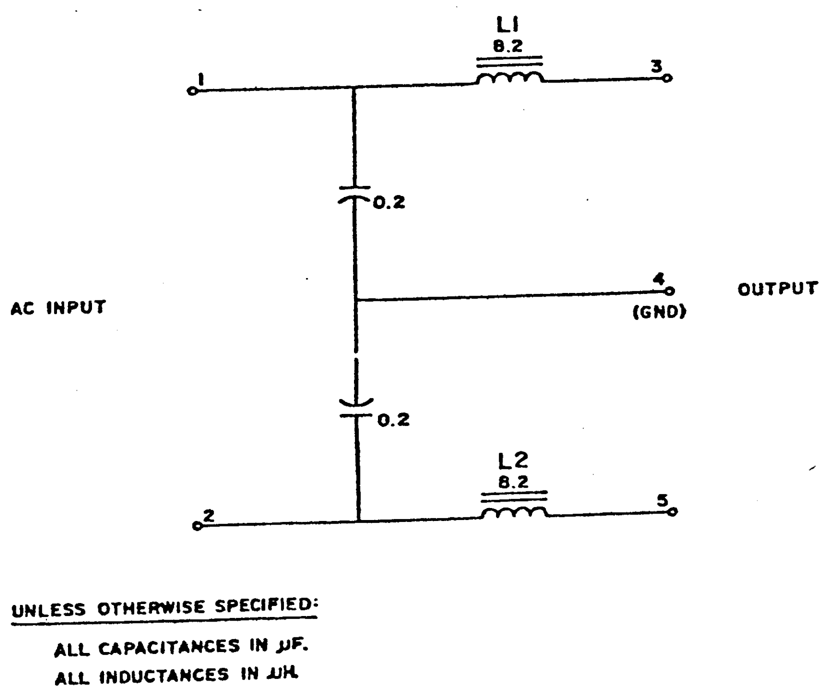

FREQUENCY MHz
1
2
4
6
8
10
20
30
40
60
100
ATTENUATION DB
0
10
20
30
40
50
60
70
TYPICAL FREQUENCY RESPONSE

AMC-8

AMC-32



Lightning Protection



AC Line Filtering

OPERATING PROCEDURES

The AMC-8 antenna multicoupler requires no external adjustments before operation. Once the antenna, communication receivers, and primary power are properly connected at the rear panel, the unit is ready. The power switch is then placed in the ON position and the power lamp will light. Normal operation is indicated first by the signal detected by the receiver.

If the received signal is weak or otherwise inaudible, the multicoupler should be checked first for proper connections and secondly by a qualified technician on a test bench. Due to the conservative design factors used, the multicoupler is extremely reliable. However, excessive heat in the equipment cabinet may accelerate a failure in a solid state component, thereby increasing the chance of malfunction in that circuit. Under these conditions, the unit can be removed from the rack for maintenance. Since common assemblies are used throughout, the signal path may be changed by simply connecting the communications receiver to an alternate connector at the rear of the multicoupler. This is particularly useful under maintenance or emergency conditions.

MAINTAINABILITY

Technical Manual

TMC technical manuals perform an important function in successfully maintaining AMC multicouplers. As a minimum, each manual consists of seven sections:

1) General Information
2) Installation
3) Operating Procedures
4) Principles of Operation
5) Maintenance and Troubleshooting
6) Replacement Parts
7) Drawings and Schematics

This breakdown simplifies the maintenance function by providing a ready reference for both operator and technician. Each manual is based on the actual equipment supplied and is updated by addenda sheets as changes in design occur. The manual can also be used as a training guide and as a reference for the ordering of spare parts.

Preventive Maintenance

A key factor in the successful operation of this multicoupler is the degree to which preventive maintenance is performed. Dust, dirt or other destructive elements can cause the equipment to fail if conditions are allowed to continue over an extended period of time.

At periodic intervals, the equipment should be pulled out for internal cleaning and inspection. The wiring and all components should be visually inspected for accumulations of dirt, dust, corrosion, grease and other harmful substances. Removal of these elements by dusting or treating with a solvent is essential to extending the useful life of the equipment.

Troubleshooting and Repair (MTTR)

An important feature of the TMC mutlicoupler is the front panel indicators visible to the operator. The use of these indicators simplifies the troubleshooting process by directing attention to a specific area. Corrective action can then be taken immediately with a minimum of down time.

The technical manual also assists in troubleshooting by devoting attention to fault indications, to probable causes, and to suggested remedies. All low power circuits are mounted on removeable circuit cards. The higher power circuits are composed of a series of interlocking assemblies that can easily be removed from the chassis mounts. Test points are located in full view of the technician at specific locations throughout the equipment. These test points are clearly shown on technical manual schematics.

The Mean-Time-To-Repair (MTTR) is nominally ten (10) minutes for the multicoupler and is based on actual test times taken in the engineering laboratory under operating conditions. This MTTR figure will vary depending on the degree of the failure and the availability of spare parts. Interchangeable assemblies can be used to reduce MTTR further.

RELIABILITY

Equipment and Circuit Design

Designed into all TMC products is quality. From the time a circuit is first sketched on a drafting table, meticulous attention is given to minimizing the number and density of components while maximizing the functions performed. Whenever possible, solid-state components including large scale integrated (LSI) circuits are used. All of the modern TMC equipment is solid state except for the final tube circuits in the higher power linear amplifiers (1KW and above). This includes such sub-systems as the exciter, driver amplifiers, power supplies, and control circuits as well as such accessory equipment as frequency shift keyers and test generators. Maximizing the use of solid state components increases overall reliability by reducing the number of components needed to perform a given function and reducing the power requirement (stress) on the system. This improvement in reliability is reflected in a higher MTBF value (see below). Costs also decrease as the overall reliability improves since downtime, maintenance and the requirement for spare parts are all reduced. With each proven advance in modern technology, TMC modifies its designs to reduce cost and improve reliability while maintaining compatibility with older systems. Consequently, the reliability of TMC equipment, already well-known, improves with age as modern technologies are incorporated in designs. This attention to designing reliability into its transmitter systems is one reason why TMC equipment is selected more often to perform the most demanding jobs.

The reliability of electronic equipment is defined as the probability the equipment will perform properly for a desired length of time under the conditions (operational and environmental) for which it is designed. There are basic assumptions which underlie the construction of a mathematical model to be used to predict the reliability of equipment:

(1) Part failure rates are constant;
(2) Probability of part survival or part reliability follows a Poisson or exponential distribution;
(3) Parts within a particular equipment or the equipment within a particular system have a series relationship. That is, each part or each equipment must operate properly so that the function for which they are used can be performed.

Mathematically, the reliability of an item of equipment or a complete system is a function of the sum of the failure rates of the parts constituting the equipment or the equipment constituting the system. Normally, failure rates can be predicted for specific parts. However, for equipment in systems, failure rates are less precise since the time interval for which the equipment reliability is being determined is usually not well defined. Mean-Time-Between-Failure (MTBF) is used in this latter case and is equal to the reciprocal of the failure rate for the equipment.

The following steps were taken to calculate the reliability and the MTBF of the multicoupler:

(A) A list of all parts used in the design of the multicoupler was compiled from material lists stored on magnetic disks on an IBM computer system.

(B) The failure rate of each part was determined using MIL-HDBK-217 Reliability Stress and Failure Rate Data for Electronic Equipment. In the case of equipment for whcih adequate test time was not available, a list of components with typically average failure rates was used. This list appears at the end of this Section.

(C) The predicted failure rate of each part was recorded on a magnetic disk. The summation of these failure rates yielded the failure rate for the entire equipment.

(D) The MTBF was then calculated by taking the reciprocal of the summation of the failure rates. Since the multicoupler has been operating well over 10,000 hours in the field, failure rates were calculated by computer and then modified to reflect actual performance.

The data for MTBF on the AMC-8 multicoupler was derived from actual installations in the following areas:

Madrid, Spain	Government of Spain/Navy/Air
New Delhi, India	Government of India
Ottawa, Canada	Government of Canada
Lisbon, Portugal	NATO-Iberlant
Geneva, Switzerland	United Nations

Experienced over a period of 1,000 to 10,000 hours after acceptance, the average failure rates in terms of percent per 100,000 hours of operation is 0.044. The calculated MTBF is 24,390 hours. Calculated from a computer analysis using known stress values, the MTBF becomes 22,727 hours.

The difference in values can be attributed to the type of service the multicoupler is used in. The computer analysis assume 24-hour per day operation at fully rated loads under severe environmental conditions. In actual fact, such conditions are rarely met, serving to extend the useful life of the system.

Two important factors further affect MTBF values: (1) the age of the equipment, and (2) the degree of preventive maintenance. TMC has found through experience that new equipment (less than one year operating) and old equipment (greater than seven years operating) have more failures than normal for a given period of time. The "burning in" of new parts and the normal wear of old parts are the primary factors which contribute to this condition. Once corrected, the multicoupler gives extremely reliable service particularly if the basic preventive maintenance procedures are conscientiously followed throughout the 20-year life of the equipment.

TYPICAL AVERAGE FAILURE RATES*

Components	Estimated Failure Rates % per 100,000 Hours of Operation
Capacitors (general purpose)	0.01 - 0.6
Capacitors (electrolytic)	0.02 - 2.0
Crystal diodes	0.05
RF inductors	0.05
Integrated circuits	0.1
Meters	0.2
Motor/generators	0.04
Potentiometers	0.3
Relays	0.001 - 0.5
Resistors, fixed	0.01 - 0.3
Switches	0.01 - 0.1
Transformers	0.05 - 2.0
Transistors	0.2
Tubes (receiver types)	1.0 - 2.0
Tubes (high power, transmitting)	1.0 - 20.0
Soldered joints (dipped)	0.0001
Wrapped joints	less than 0.0001

*Based on actual performance from TMC field engineering and maintenance records

TECHNICAL SPECIFICATIONS

The AMC-8 receiving antenna multicoupler is used to couple a single antenna input to eight communication receivers. The electrical and mechanical characteristics of the unit are as follow:

Frequency Range

The operating frequency range is 2 to 32MHz, continuous coverage, using an internal bandpass filter. Without this filter, the range can be extended from 100kHz to 60MHz.

Frequency Response

The response with input filter is ±1db over 2 to 32MHz.

Number of Outputs

Eight (8) fixed outputs are provided. BNC-type connectors are used.

Number of Inputs

One fixed, BNC-type input connector is provided.

Input/Output Impedance

75 ohms nominal is provided as standard. 50 ohms nominal is available on request.

Nominal Gain

2db for each output.

Noise Figure

Less than 7db over the frequency range.

Isolation

Minimum -55db, output to input. Minimum -40db, output to output.

Desensitization

An undesired signal of 4 volts peak will reduce a 100 microvolt desired signal by less than 3db.

Phase Differences

Within ±2 degrees between any two outputs.

Intermodulation

Second order minimum -65db down from 0.5V RMS input.
Third and higher order minimum -70db down from 0.5V RMS input.

VSWR

Maximum 1.5:1 at the input. Maximum 1.2:1 at the output.

Off-band Rejection

Minimum -30db outside 2-32MHz.

Line Filtering

Provides a minimum RF attenuation of -40db from 14kHz to 150MHz.

Mean Time Between Failure

Minimum 22,727 hours.

Overload Protection

Internal indicator network prevents damage to components by a high RF voltage at the input.

Primary Power Source

115 or 230 volt, ±10%, Single phase 48 to 400Hz.
Power consumption does not exceed 25 watts.

Environmental

Operates reliably between 0^{o}C and $+50^{o}$C up to 90% relative humidity. Will not be materially affected if stored between -30^{o}C and $+85^{o}$C up to 90% relative humidity.

Cooling

Normal convection cooling. Airflow requirements may change if multicouplers are "stacked" in a 19-inch rack.

Size and Weight

19" high x 1.75" wide x 14" deep
48.3cm high x 4.4cm wide x 35.6cm deep
8 pounds (3.75 kg)

Protection

The entire power supply is AC fused for protection. All hazardous voltages are protected from exposure by cover plates. Signs on the chassis warn of the presence of high voltages. In addition, all controls and switches are held at ground potential.