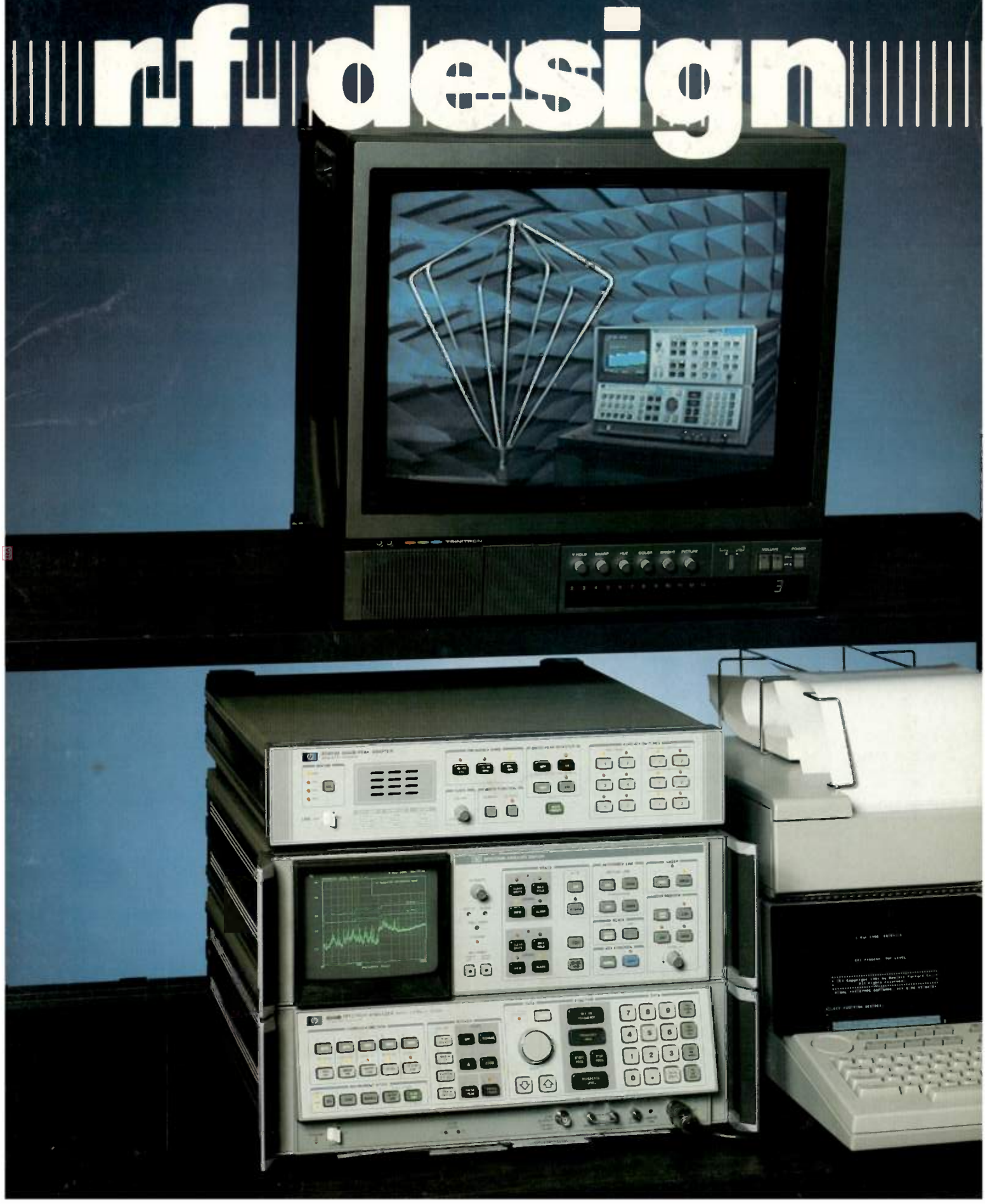
July/August 1984

A Cardiff Publication

rf design



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Type	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package
BLU98	0.5	900	9.0	12.5	SOT-103/E1
BLV90	1	900	7.5	12.5	SOT-172
BLV91	2	900	6.5	12.5	SOT-172
BLU99	4	900	7.3	12.5	SOT-122
BLV92	4	900	8.0	12.5	SOT-171
BLV93	8	900	6.0	12.5	SOT-171
BLV94	15	900	6.0	12.5	SOT-171

400 to 512 MHz	MOBILE APPLICATIONS				
BLU60/12	60	470	4.8	12.5	SOT-119
BLU45/12	45	470	5.1	12.5	SOT-119
BLU30/12	30	470	6.0	12.5	SOT-119
BLU20/12	20	470	6.5	12.5	SOT-119
BLW82	30	470	5.0	12.5	SOT-119
BLW81	10	470	6.0	12.5	SOT-122
BLU99	5	470	10.5	12.5	SOT-122
BLW80	4	470	8.0	12.5	SOT-122
BLW79	2	470	9.0	12.5	SOT-122
BLX65	2	470	6.0	12.5	TO-39

175 MHz	MOBILE APPLICATIONS				
BLV75/12	75	175	7.0	12.5	SOT-119
BLV45/12	45	175	6.5	12.5	SOT-119
BLV30/12	30	175	8.2	12.5	SOT-119
BLW60C	45	175	5.0	12.5	SOT-120
BLW31	28	175	9.5	12.5	SOT-120
BLY89C	25	175	6.0	12.5	SOT-120
BFQ43	4	175	12.0	12.5	TO-39E
BFQ42	2	175	10.5	12.5	TO-39

30 to 900 MHz	BASE STATIONS				
Type	Power (W)	Freq. (MHz)	Gain (db) min.	VCC (V)	Package
BLW96	200	30	13.5	50	SOT-121
BLV25	175	108	10.5	28	SOT-119
BLV80/28	80	175	6.5	28	SOT-119
BLV33F	85	225	10.5	28	SOT-119
BLV36	120	225	10.0	28	SOT-161
BLU53	100	400	6.5	28	SOT-161
BLV97	30	860	6.5	24	SOT-171
BLV57	38	860	6.5	25	SOT-161

66 to 870 MHz	AMPLIFIER MODULES FOR LAND MOBILE				
Type	Freq (MHz)	P In (MW)	P Out (W)	VCC	Package
BGY32	68-88	100	20	12.5	SOT-132
BGY33	80-108	100	20	12.5	SOT-132
BGY35	132-156	150	20	12.5	SOT-132
BGY36	148-174	150	20	12.5	SOT-132
BGY43	148-174	150	13	12.5	SOT-132B
BGY40A	400-440	100	7.5	12.5	SOT-132C
BGY41A	400-440	150	13	12.5	SOT-132C
BGY40B	440-470	100	7.5	12.5	SOT-132C
BGY41B	440-470	150	13	12.5	SOT-132C
BGY40A	470-512	100	7.5	12.5	SOT-132C
BGY41C	470-512	150	13	12.5	SOT-132C
BGY45A	68-88	150	30	12.5	SOT-301-A-03
BGY45B	144-175	150	30	12.5	SOT-301-A-03
BGY46A	400-440	30	1.5	9.6	SOT-26NC
BGY47A	400-440	45	2.2	9.6	SOT-26NC
BGY47B	430-470	45	2.2	9.6	SOT-26NC
BGY47C	460-512	45	2.2	9.6	SOT-26NC
BGY22	380-512	50	2.9	12.5	SOT-75A
BGY23	380-480	2.5 WATTS	7	12.5	SOT-75A

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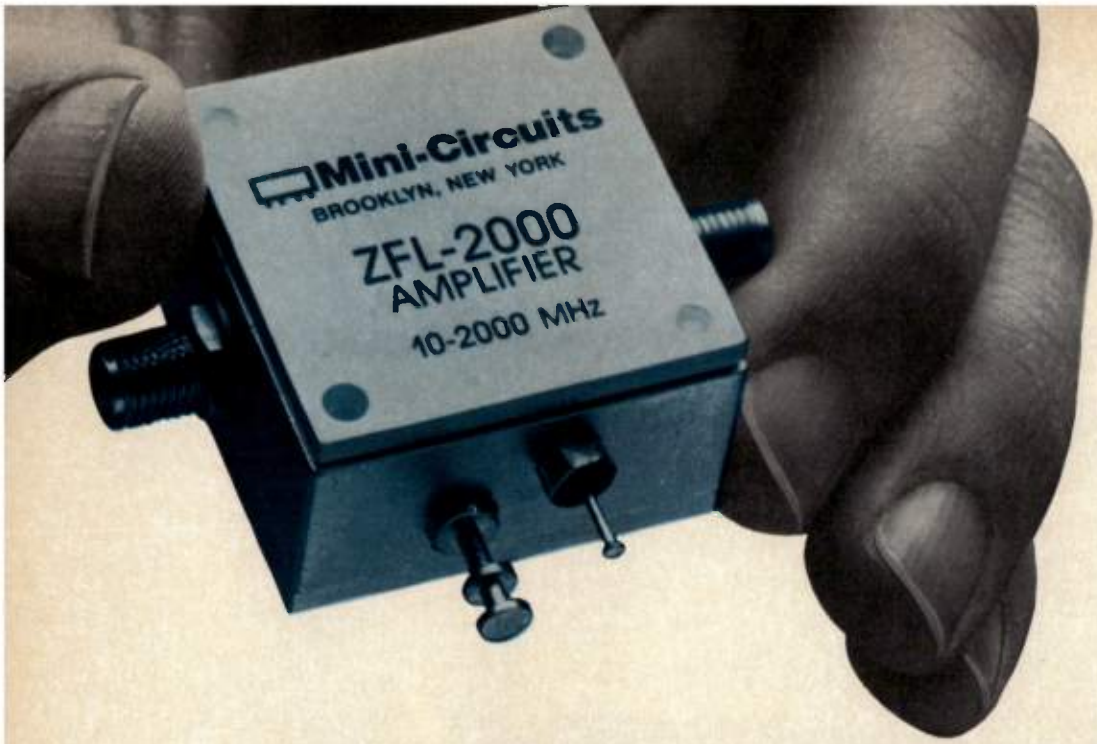

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- Increasing the dynamic range of spectrum analyzers.
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Meets MIL-STD 202, these units operate from −55°C to +100°C.

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For complete specifications and performance curves refer to the Goldbook, EEM, EBG, or Mini-Circuits catalog

ZFL-2000 SPECIFICATIONS

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GAIN	20 dB
GAIN FLATNESS	±1.5 dB
OUTPUT POWER (1 dB compression)	+17 dBm
NOISE FIGURE	7.0 dB
INTERCEPT POINT (3rd order)	25 dBm
VSWR, 50 OHMS	2:1
DC POWER volt, current	+15 V, 100 mA
HEAT SINK	Internal
OPERATING TEMP	−55°C to +100°C

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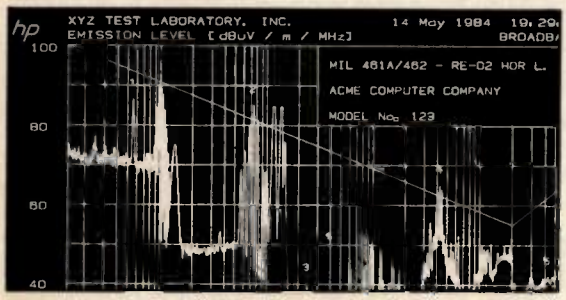
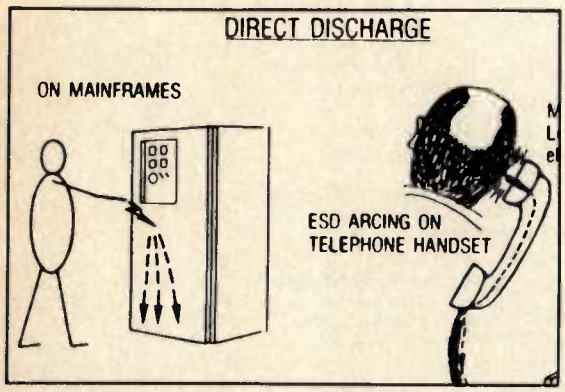
INFO/CARD 3

July/August 1984



Automated EMI Measurements, p. 13.



ESD Control, p. 24.

Fiber Optic Connectors, p. 36.

Cover

July/August Cover — This month's front cover shows a test system for automated EMI measurements. A video monitor shows the inside of the test chamber where an instrument is being tested. More discussion about automated EMI measurements are included in the article "Automated EMI Measurements Using A Spectrum Analyzer and Desktop Computer." This cover photo was courtesy of the Hewlett-Packard Company.

Features

Departments

R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published bi-monthly plus one extra issue in June. July/August 1984, Volume 7, No. 4. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (1-800-346-0085). Subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $15 per year in the United States; $25 per year in Canada and Mexico; $25 per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.00 each (in the U.S.). This publication is available on microfilm/fiche from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106 USA (313) 761-4700.
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publisher's notes

"Andy:" A Mentor for RF Technology Expo 85

Last month we announced in this column an event which, according to research among you readers, is going to meet with your overwhelming favor: the first annual RF TECHNOLOGY EXPO, to be held January 23, 24, and 25 at the Disneyland Hotel in Anaheim, California. The only condition you asked to be met in order for large numbers of you to come was that the technical sessions be at least on a plane with the articles in *r.f. design* magazine.

Now we want to announce the appointment of a program chairman whose attention to this task ought to assure the meeting of that condition. He is Vice-President of development for A.R.F. Products, Inc., located at the company's R&D Laboratory in Boulder, Colorado. . .Andrzej B. Przedpelski.

Regular readers of *r.f. design* will find that name a visually familiar one, even if they never tried to pronounce it. (For the record, make the first name "Andy," and the second "P-shed-*pel*-ski.") Andy has contributed some of our most widely read, quoted and discussed articles, perhaps setting the tone of the "practical design tips" approach which has made the magazine so popular with RF engineers throughout the world.

It may come as no surprise that Andrzej B. Przedpelski was born in Warsaw, Poland. He fled his native land in September, 1939, when Russian troops invaded, and later went to Polish high schools in Bucharest and Tel Aviv. He came to the U.S. in 1941, entered M.I.T. in 1943, and graduated in 1946, at the age of eighteen, with a degree in Chemical Engineering and extra credits in electrical engineering. After a stint in the U.S.A.F. as a radar repairman, he joined A.R.F. Products, Inc., and worked as a junior EE while attending graduate school at Northwestern and DePaul.

Over the past thirty years Andy has been involved with the design of military LF, MF, VHF and UHF RF equipment, mainly in missileborne MDI instrumentation, including the instrumentation for the Nike-Zeus and Safeguard tests. He has had technical articles published in Interavia, Electronic Industries, Electronic Design, Microwave Journal, and Microwaves and R.F., in addition to his articles in *r.f. design*.

Andy approaches his task as program chairman of RF TECHNOLOGY EXPO 85

Andrzej Przedpelski

with several innovative ideas. . .such as many short papers, rather than fewer long ones. The papers will be grouped into similar "tracks," allowing the attendee to pursue an interest in depth without running from room to room.

Topics to be pursued in the session have been partly guided by reader response to a mail survey conducted in April among readers of *r.f. design*. The survey revealed an extensive interest in the basic techniques of RF circuit and system design, such as phase-locked loops, oscillator design, and filter design. . .indicating, perhaps, that some RF designers have been pressed into service without much background in RF work and need some fundamental "catch up." As a correlation, the survey also revealed a widespread interest in computer-aided design (CAD) for RF circuits.

Among other topics, the subject of low noise receivers was the most universally interesting to readers. . .an interest probably connected to a high interest in satellite communications. Test topics also ranked high, especially EMI/RFI test, and communications/microwave test. Antennas, SAW devices, and digital communications are other subjects that RF engineers want to explore.

Andy is busy right now developing a program to give the right kind of knowledgeable attention to these subjects. If you can supply a paper that would fit into this context, he wants to hear from you right away. You can call him at (303) 443-4844. . .or, use the "call for papers" card on the page facing this column.

In any event, come to the EXPO. We all need to know each other.

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Or, if you wish to present a paper at RF TECH EXPO, use the card at right and send it to Program Chairman Andrzej B. Przedpelski, VP Development at ARF Products, Inc. But act immediately. The earlier your paper is submitted the beter its chance for accepatance.

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INFO/CARD 6

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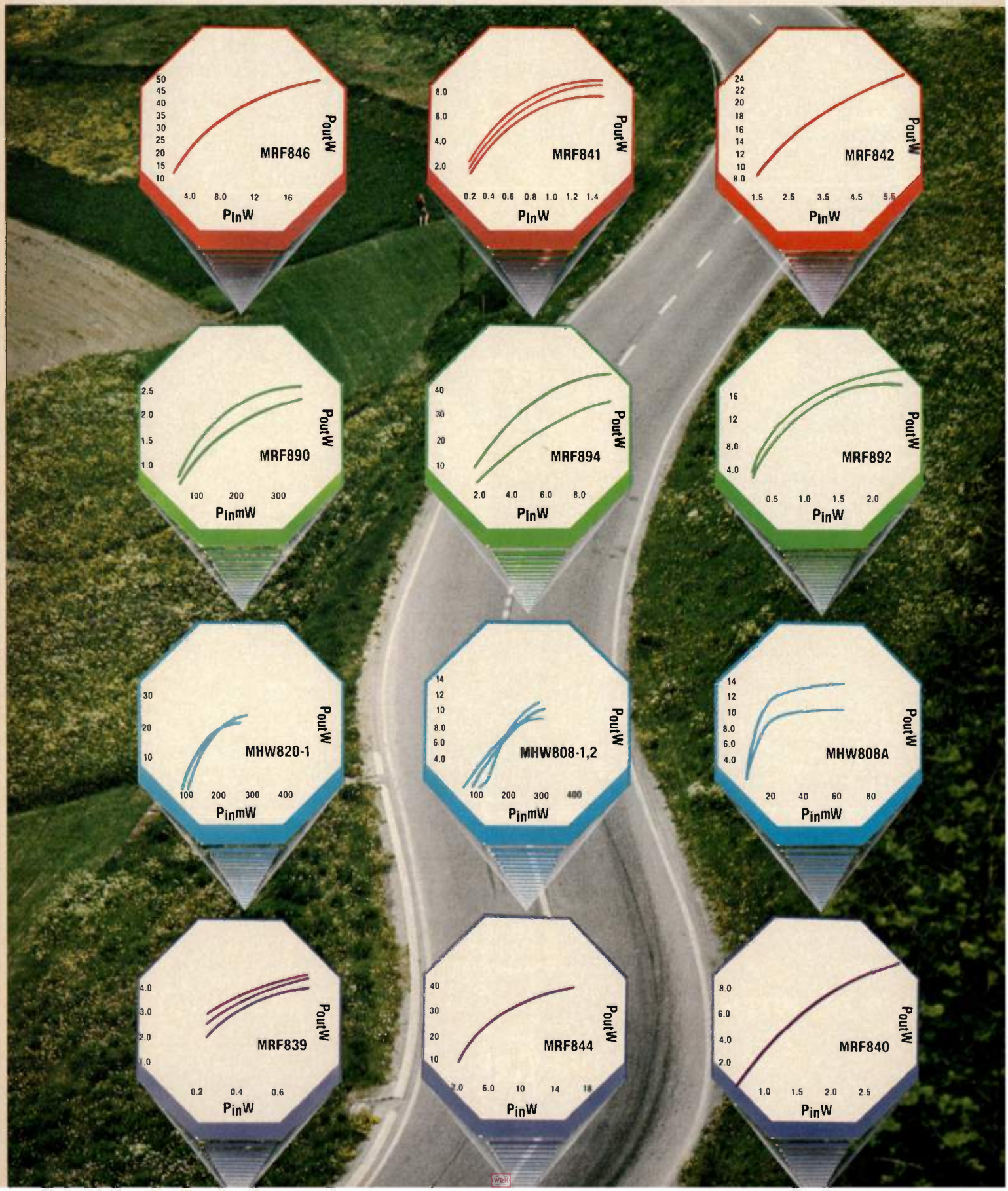

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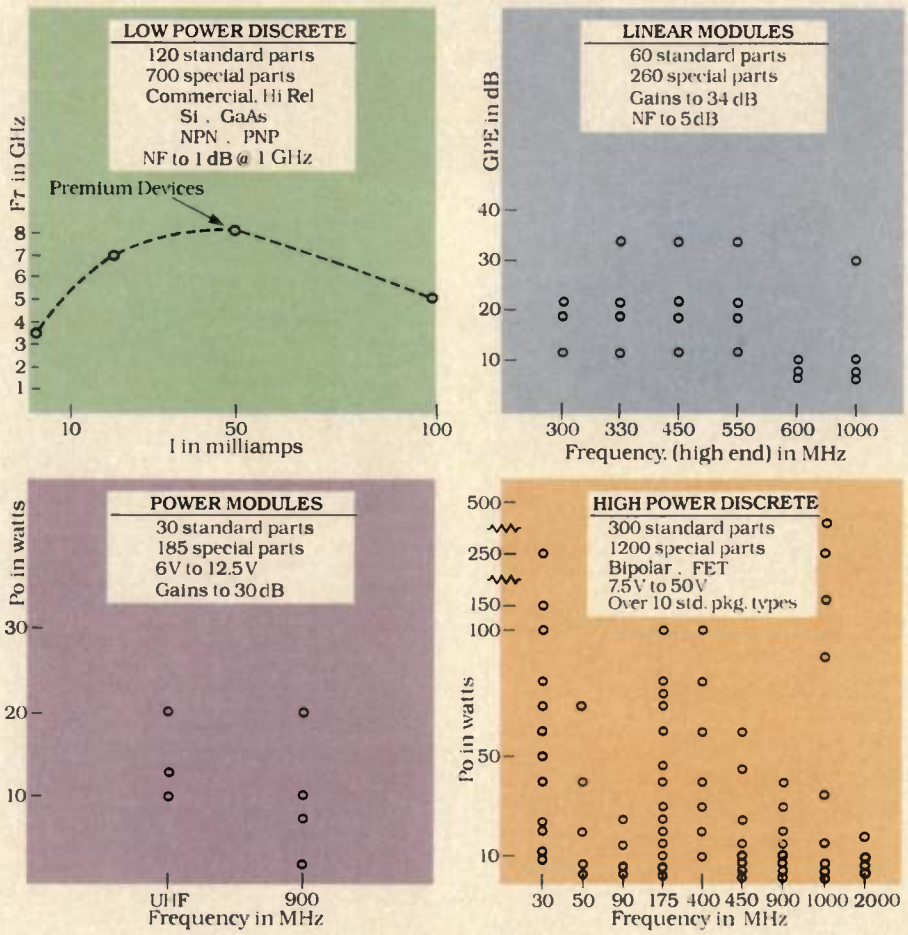

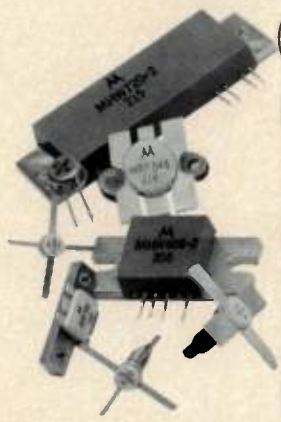

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INFO/CARD 7

Automatic EMI Measurements Using A Spectrum Analyzer And Desktop Computer

By Erik Diez and Barry Taylor
Hewlett-Packard Company
Santa Rosa, California 95401

The proliferation of electronic devices in our society have increased the need to regulate and control electromagnetic emissions. EMI measurement systems are incorporating greater degrees of automation to meet these needs. This article describes a computer program which controls an automatic EMI measurement system used to make EMI tests.

When designing a product, virtually every engineer would like to pass all applicable EMI limits the first time his or her product is tested for compliance. Unfortunately, this rarely seems to happen. Given this fact of life, the best thing to do is test a device early and often in the design process to help pinpoint problem areas as soon as possible. This helps eliminate or at least minimize costly rework and redesign of a product at the end of its development cycle.

Manual methods of measuring electromagnetic emissions are often very time consuming and laborious procedures. Automating an EMI test however, offers several advantages which can make the procedure more attractive to the user:

1. The time required to make a test and generate hard copy results can be greatly reduced.
2. For long tests, the measurement can proceed even if left unattended.
3. Repeatability of the measurement is enhanced because the test is performed the same way each time.

Computer programs which drive automatic EMI measurement systems to perform various military and commercial EMI measurements have been written by several manufacturers. This article describes one such program, the Hewlett-Packard 85864A EMI Measurement Software. Written for the HP series 200, Models 226 and 236 computers, it controls an HP 8566A/B or 8568A/B Spectrum Analyzer and various other peripheral equipment such as printers, plotters, RF attenuators, and the HP 85650A Quasi-peak Adapter. This program is written in BASIC, a language designed as a high level interface language. Its ability to control instruments using real time interrupts, high speed binary transfers, and I/O register control, make it the language of selection for scientific instrument control, as well as research and development. HP Pro-BASIC, unlike most basics, allows isolated context capability so that subprogram modules can perform functions using their own local variable names and yet also control global common variables. It is highly structured language with such

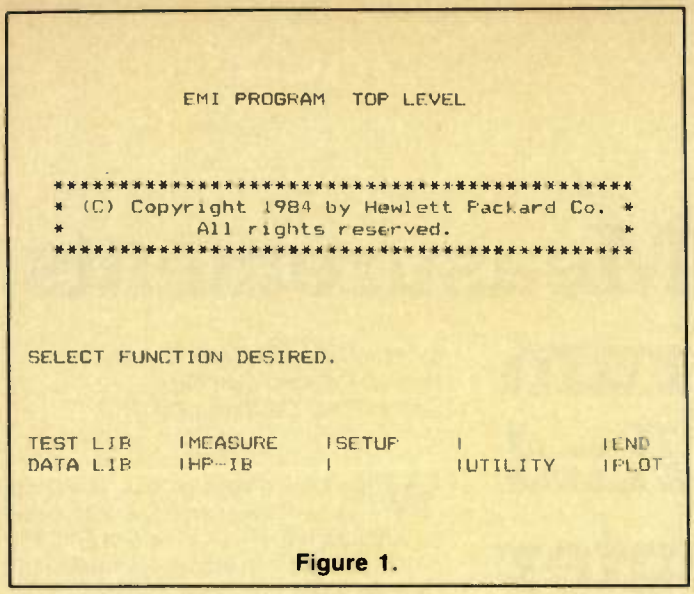

Figure 1.

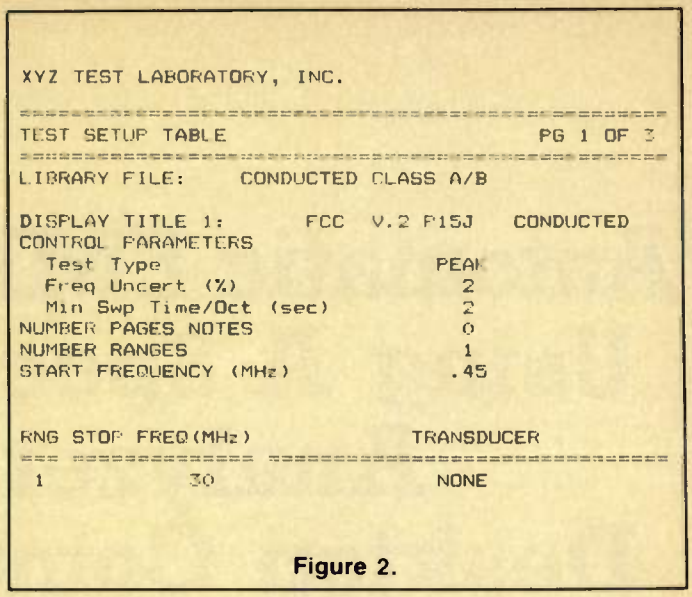

Figure 2.

commands as SELECT/CASE, LOOP/EXIT IF, REPEAT/UNTIL, IF THEN ELSE. There is also a rich graphics command set. This program has over 13,000 program lines and about 300 contexts. A brief overview of the program will be followed with some examples of various measurements that the system can perform.

Organization of the Program

The program consists of four major sections: the Test Library, the Data Library, the Measurement section, and the Test Setup table. In addition to these sections, several convenience features are included. One is a plotting routine that controls a graphics plotter to obtain hard copy results of the measurement data. A Utility section contains a routine to compute the impulse bandwidths of the resolution bandwidth filters in the spectrum analyzer, a time/date setting function, and a provision to add the user's facility/company name to the display. The transducer and limit libraries are used to store antenna factor values and commonly used emission limits.

The various sections are structured by "levels" which can be accessed by pressing one of the ten soft keys on the HP series 200 computer. At every level, there is a key labeled "RETURN" which allows the user to go back to the previous higher level. After loading the program, the top level menu appears, as shown in Figure 1.

The Test Setup Table

The Test Setup table is the area where an EMI measurement can be defined or an existing one from the Test Library can be modified. To illustrate how the Test Setup table works, we will use an FCC part 15 Subpart J Conducted Emissions test as an example. After pressing the SETUP key in the top level menu, the display shown in Figure 2 appears. Here, the display title appearing in the upper right hand corner of the spectrum analyzer is entered. There are two test types available: Peak (referring to the fact that we are using peak detection), which will be used here, and Narrowband/Broadband, which is often used in Mil Standard tests. Frequency uncertainty can be set between 0.1% and 2.0%. There is a tradeoff involved in the selection of frequency uncertainty in that better frequency accuracy comes at the expense of increased measurement time. This is because the spectrum analyzer must take several overlapping sweeps to cover the frequency range in order to maintain the desired accuracy. For the purpose of this program, a frequency range is defined as being a region of the frequency band under test in which the hardware used to make the test remains unchanged. For example, a VDE conducted test requires using 200 Hz resolution bandwidth filter from 10 kHz to 150 kHz and a 9 kHz filter from 150 kHz to 30 MHz. This results in a test with two ranges. Another example is a radiated test that uses several antennas. This requires that we define a range for each antenna. The FCC-conducted emissions test does not have any hardware changes in the middle of the test, therefore it only needs one range to perform the measurement. The transducer in this test is a Line Impedance Stabilization Network (LISN). Since readings are taken directly from the LISN by the spectrum analyzer without any correction, the transducer listed is "NONE." (For test using a transducer such as an antenna, which has correction factors that must be applied to the data, the correction factors would be entered at this point.)

Pressing the "NEXT PG" softkey takes us to the next page of the setup table, shown in Figure 3. Here the units of amplitude and the reference level of the display are entered. This is also the page where the test limits for the measurement can be entered. The FCC conducted test has two limits: The Class A limit for commercial and industrial computing products and the Class B limit for computing products intended for home use. By pressing the "GET LIM" key, we arrive at the page where the limit points can be entered. If a limit is already stored in the limit library, it can be loaded directly into the measurement.

Pressing the "NEXT PG" key once again brings us to the last page of the setup table (see Figure 4). It is here where various spectrum analyzer hardware states are set. If an HP 85650A Quasi-peak Adapter is included in the system, its bandwidth is defined here. For tests where a preamplifier or external attenuator is used, their values are entered here also. For each measurement range defined on page 1, a page just like this must be filled out in order to completely characterize the measurement.

Within a measurement range, the user can define several setups. A setup can be described as a situation where the hardware used to measure a range remains unchanged, but their positions change. For example, in a radiated test, the EUT is often mounted on a turntable which must be rotated in order to find the maximum emissions coming from the device. If we wanted to test a device at 45 degree intervals, then we would make the number of setups equal to eight. Tests requiring that the antenna be raised and lowered can also make use of multiple setups. Within a setup, the number of sweeps can be set to increase the probability of intercepting transient signals.

At each setup the user has the option of presenting a message, branching to a

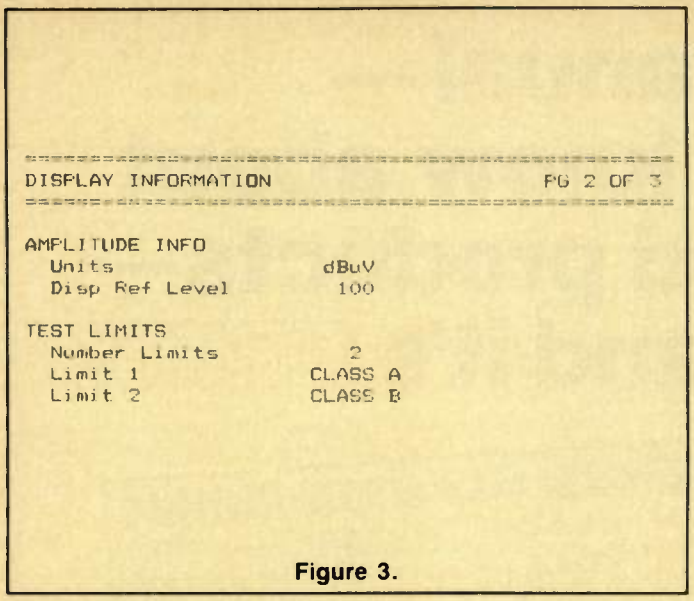

Figure 3.

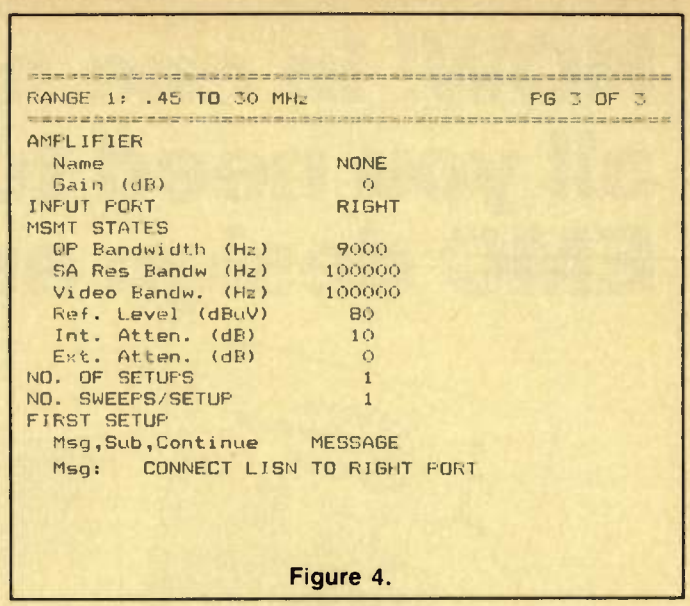

Figure 4.

user-written subprogram or simply continuing without performing any action. Messages are useful as prompts to remind an operator to connect the proper equipment, rotate a turntable, etc. For users who want fully automated systems, the subprogram branch allows access to user-written routines to control programmable antenna masts, automatic turntables, coaxial switches to switch antennas, etc.

Test and Data Libraries

A good measurement system should be judged on its ability to not only make measurements quickly and accurately, but also on its ability to help maintain and organize the test setups which are defined and the data which is measured by the system. In the past, it sufficed to keep a lab notebook or journal which was used to define the objectives of the measurement, the setup required to make these measurements and the raw data which would be used in the analysis. Finally, the data would be analyzed and the results presented, usually graphically, or statements derived from the analysis of the measurements. Little has changed except the complexity of the measurements. The requirements are still the same. The same information is required whether the measured data comes from manually nulling a wheatstone bridge or using a complex computer-configured measurement system.

There will always be the need to be able to reconstruct the original test and look at the raw data used to formulate the analysis. The concept of an electronic lab notebook may seem radical when considering the methods of the past, but in a complex computer-based measurement system all the same requirements could apply. It is still essential to be able to reproduce the original measurement configuration along with the data taken by the system. If this cannot be done, the "scientific approach" principles have been violated and questions regarding the data cannot be answered or the data verified. Therfore, any computer-based measurement system should contain the essence of the original lab notebook.

Measurements made on an EMI measurement system can be so complex that each one might constitute an entire notebook of setups, data and analysis. So, we might consider each set of measurements as a notebook of information. How do we keep track of it all? The concept of a library where information is stored in an organized manner and categorized by type such as (in our scientific case) "test setups" and "data" makes sense. There may also be other types of libraries required; for example, to keep track of commonly used correction factors or various test limits which are used often to define a test setup. The idea of various types of libraries then makes sense for an organized system. The one drawback to this is that in a complex system, such as an EMI test system, before long these libraries could become quite large and unwieldy. In a short time there could be literally hundreds of files to keep track of and maintain. A further partition seems in order to address this problem.

Using the EMI system as an example, consider each piece of equipment under test (EUT) as a separate measurement problem. Certainly each device should be tested for its unique requirements, which need to be documented. If it was easy to establish a complete set up library for each EUT and store these libraries in a filing system external to the measurement system, it would be easy enough to categorize the devices tested with a label and locate that EUT's library. These libraries could be floppy discs, the common storage medium today. The total filing cost would then be reduced to a few dollars for a floppy disc.

This is the approach taken in the EMI test system described. To properly use this system, a little front end work is required by the test engineer. He must first initialize and assign a disc to the device to be tested. Further, he must decide which tests are to be performed on the device. From a master file (a library of common test setups) a Test Library is established. Each test to be performed is loaded and stored on the device library. These test setups can be modified as required and notes associated with the test setup incorporated into the test libary. The need for this duplication will become clear as we begin to use these test setups to make measurements and analyze the results.

After the test library is established for the device to be tested, much of the front end work is done and the organized testing method is established. Of course, new test setups can be added as the testing process requires.

Now we can proceed with the actual measurement process. The test desired is loaded into the system from the Device Library. Measurements are made and stored in the data library as desired. When it is desired to store the data in the data library, there is provision for notes to be recorded along with the data. These notes are separate from the notes which are stored with the test setup and can relate to the actual data taken. When data is stored in the Data Library, it is cross referenced to the test setup, preserving the link between the data and the test setup. Any changes made to the test setup require restoring the test setup. This preserves the integrity between previous measured data and its associated test setup. Whenever data is loaded into the system for review or analysis, the test setup used to take that data is also load-

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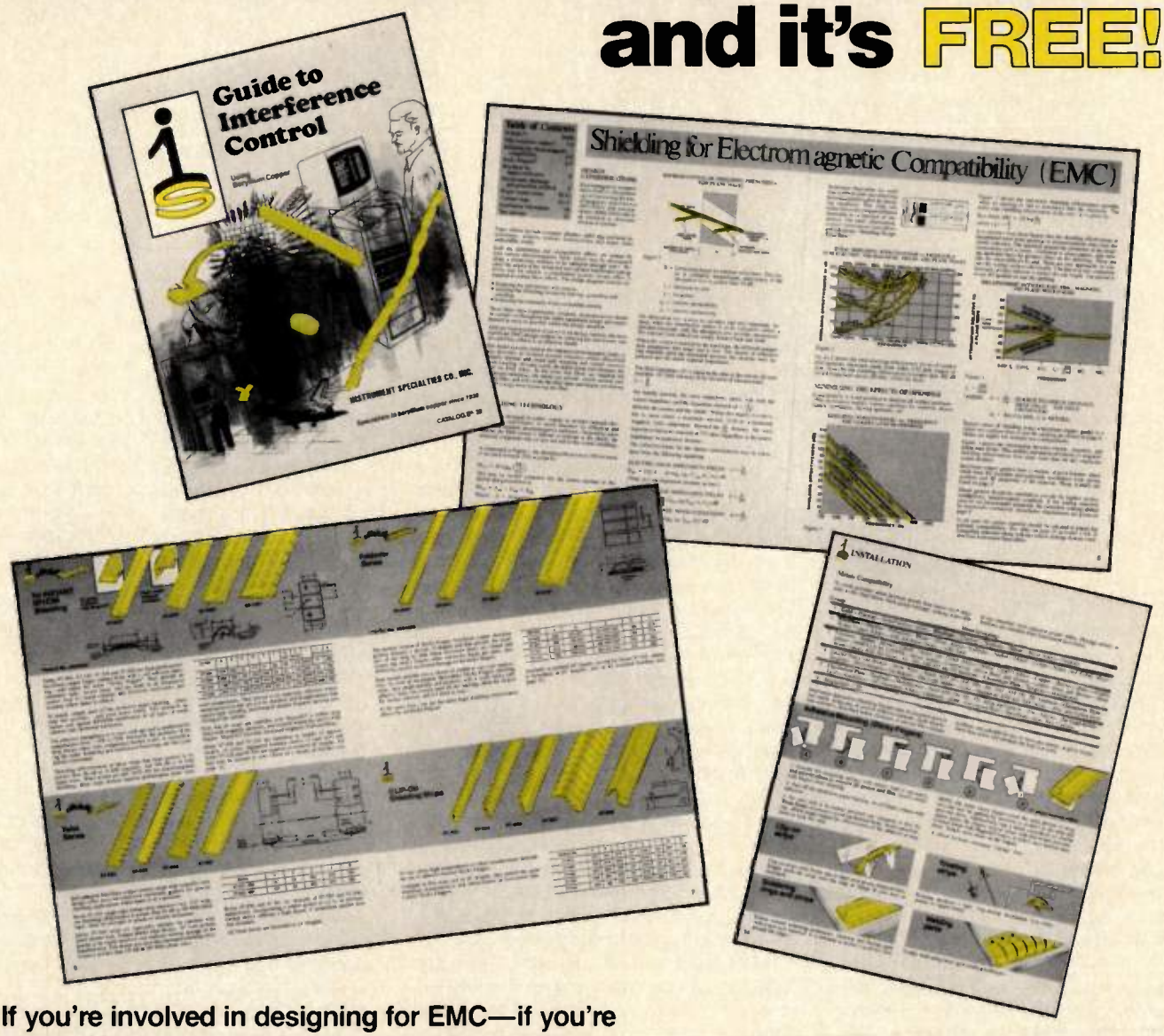

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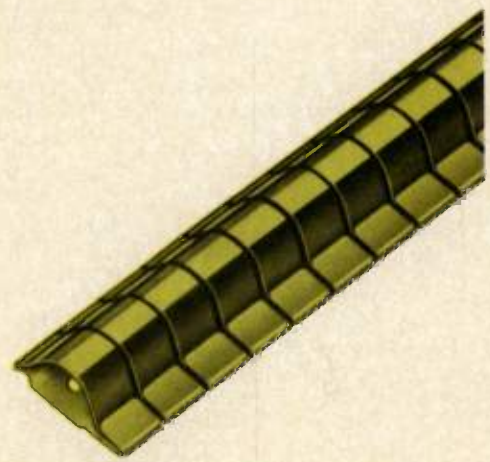

```
TEST LIBRARY: EMI MEASUREMENTS

   1. FCC V.2 PART 15J
      1.1  RADIATED  CLASS A/B
      1.2  CONDUCTED CLASS A/B
   2. VDE 0871 / 3.68
      2.1  RADIATED  LEVEL A/B
      2.2  CONDUCTED LEVEL A/B
   3. MIL-STD 461A / 462
      3.1  CE-03   20kHz  TO  50MHz
      3.2  RE-02   14kHz  TO   1GHz
      3.3  RE-02    1GHz  TO  10GHz
```

Figure 5.

ed. This insures a correspondence between data and setup.

A closer look at the library structure reveals a common structure for all types of libraries. The Test Library, the Data Libraries, the transducer factor and limit line libraries all have a common human interface, the same keys and format of the library index of the library including the ability to LOAD, STORE, RESTORE, RENAME & PURGE files. The library index which appears on the screen includes category headings which allow the files to be grouped together as desired (see Figure 5). The actual files are listed under a heading and are selected via a scrolling arrow. A parallel may be drawn at this point between the library index and its headings and a card file for a book library. The card file contains subject cards such as the heading does and the associated subject books are located behind this card. The associated files are located beneath the subject headings.

When the MEASURE key is pressed on the top level, the display shown in Figure 6 appears. For multi-range measurements, the user can select to measure over a single frequency range, some of the ranges, or all the ranges defined for this test by using the RANGES key. The second line of text appearing in the annotation box in the upper right hand corner of the final display can be entered here by pressing the TITLE 2 key.

Often it is desirable to take a final quick look at the setup just prior to doing the measurement to check if the device under test is powered up and operating in the proper functional mode, to make sure that the spectrum analyzer reference levels chosen in the Setup tables are adequate for the signal levels being received, and check for the presence of overload conditions in the measurement system. The preview mode causes the spectrum analyzer to sweep over the desired range and display the uncorrected data on the analyzer's CRT for viewing and interpretation.

Pressing the MEASURE key a second time initiates the actual measurement process. The basic scheme of the measurement is to have the computer read in the trace data from the spectrum analyzer at the end of a sweep, initiate the next sweep, and process the data from the previous sweep while the current sweep

Some Questions You Should Ask Your EMI/RFI Test Equipment Supplier

How long has your company been in the EMI/RFI Testing Equipment business?

The Electro-Mechanics Company has been designing and manufacturing EMI/RFI Test Accessories for over 25 years.

We began with Magnetic Field Instruments and Radio Frequency Antennas for the military. Since the mid-sixties we have been working closely with the military and industry standard setting groups, and EMCO now has one of the broadest lines of Test Antennas and EMI/RFI Test Accessories in the World.

What exactly is your major product line?

EMCO's primary business is Test Antennas for use in Emissions and Immunity (Susceptibility) Testing as required for MIL Standard, FCC, VDE, and CISPR Test Procedures.

Typical Military Antennas for Radiated Immunity (RS) and Emissions (RE) Testing cover the frequency ranges from **30 Hz to 18 GHz**, and are noted in MIL STD 462, Notice 3, Table 1. EMCO currently manufactures **Magnetic Field Loops**, the 41" **Rod Antenna**, **Parallel Strip Line**, both

Biconical Antennas, the **Conical Log Spirals** and the **Double Ridged Guide Antennas** shown on this table.

Antennas which are currently acceptable for use in FCC Volume II, Part 15 Emissions Testing include, **Adjustable Element Dipole Sets**, Broadband **Biconical Antennas** and Broadband **Log Periodic Antennas**. EMCO manufactures all of these separately or can include them as part of an FCC "Class A" and "Class B" **Antenna Test System**.

What differentiates your antennas from your competitors?

One major difference is Calibration. Each Antenna is calibrated using NBS Traceable Testing Equipment, on our own FCC open field test site. Calibration data includes Antenna Factor, Numeric Power Gain, and dBi Gain for each individual Antenna. For Immunity Testing Antennas we include Field Strength measurements in Volts Per Meter, and Radiation Patterns where applicable.

Another difference is Design and Construction. Each Antenna is designed to be durable and long-lasting, yet functional in varied applications, such as in Anechoic Chambers or Outside Test Sites. Antennas and accessories are machined and constructed "in-house" for Optimum Quality Control.

One last difference and maybe the most important, is EMCO's continual Product improvement thru Research and Development. For example, our **Dipole** and **Biconical Balun** design is much improved from the old DM-105 and military designs . . . and we are continually researching and redesigning to make EMI/RFI Testing simpler and more accurate.

What other Test Equipment and Accessories do you offer?

EMCO adds efficiency to EMI Testing with an **Antenna Positioning Tower** (1-6 meters) and an **Equipment Testing Turntable**. Both are suitable for outside or indoor use, come with a standard Digital Readout Controller and are available with **IEEE-488 Bus** Option.

For Conducted Emissions Testing, EMCO manufactures **Line Impedance Stabilization Networks** to satisfy FCC and VDE requirements. Our unique design allows production of as many as 4 separate lines (three phase) in one unit.

Other Related Equipment include: **Signal Rejection Networks, Acceptance Networks, Magnetic Field Intensity Meters, Magnetometers** and **Helmholtz Coil Systems.**

Why should my company buy your EMI/RFI Test Equipment?

The Electro-Mechanics Company is more than just another manufacturer. We realize that in order to grow and help improve EMI/RFI Testing we must constantly forge ahead . . . not live in the past.

As the FCC moves toward better and more Standardized Test Procedures, EMCO is staying close to ANSI (American National Standards Institute), NBS (National Bureau of Standards) and other standards groups so we can keep improving our equipment. Involvement with current and future industry needs also helps us plan for design of new equipment . . . an ongoing process at EMCO.

EMCO is committed to offering Technical Assistance, as well as Test Accessories, to help solve EMI Testing Problems. Part of that Technical Assistance is advice on purchasing only the equipment needed, not kits or systems with unnecessary items. We can also advise on various manufacturers of other complimentary test equipment.

If you have more questions and are looking for Helpful Answers, Call us at (512) 835-4684.

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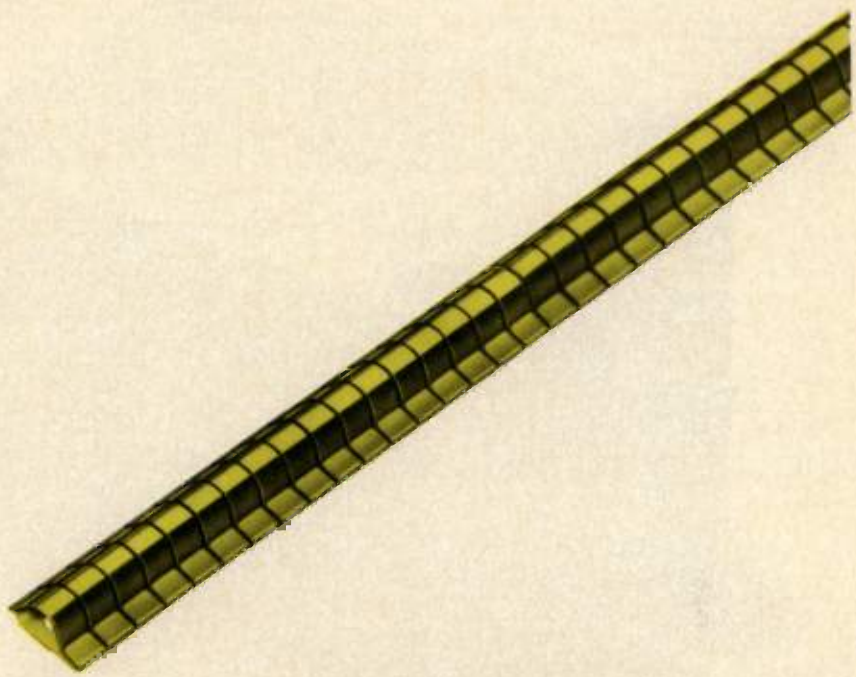

```
                    MEASUREMENT

      1. FCC V.2 PART 15J
         1.2  CONDUCTED CLASS A/B

      RANGE CONTROL (measure ranges indicated by *)
          * All Ranges
            Range  1 :  .45  -  30  MHz


       TITLE 2 IS:  PROTOTYPE DEVICE #1


SELECT FUNCTION DESIRED.


RETURN     IMEASURE    IANALYSIS    IRANGES     ITITLE 2
DATA LIB   IPRE-VIEW   I            IVIEW CRT   I
```

Figure 6.

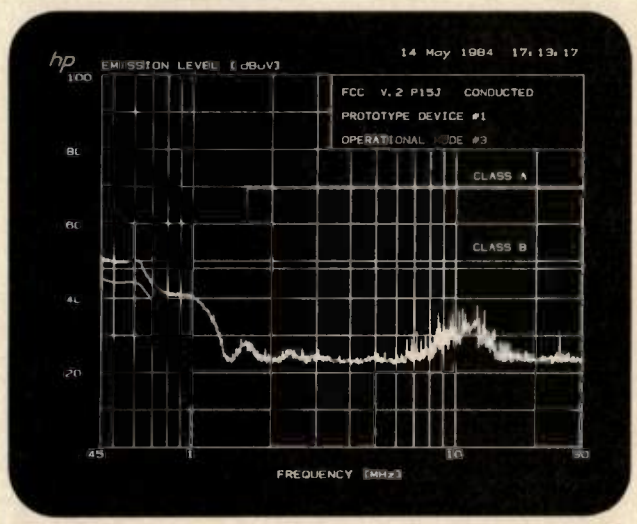

Figure 7.

is occuring. At the end of each sweep, the spectrum analyzer sends a service request to the computer, informing it that it can now read in the new data. As each set of sweep data is read in by the computer, it is corrected for transducer correction factor, pre-amplifier gain, and external attenuation, then plotted on the CRT of the computer. (For broadband measurements such as those found in many Mil Standard measurements, the data is also corrected for the impulse bandwidth.) This gives the operator visual feedback of how the test is progressing. All measurements are done using the peak detector of the spectrum analyzer to assure the fastest possible sweep time. If the operator wishes to stop the test before it is finished, pressing the ABORT key cancels the measurement and returns to the previous level, as seen in Figure 6.

When a test is finished, the results are displayed on the CRT of the spectrum analyzer log frequency format as shown in Figure 7. The data shown in this figure was taken from an FCC-conducted emissions test. The time required to perform this test was about 55 seconds. This is a tremendous improvement in measurement speed when compared to manual measurement methods. The results can then be stored on the data library disc for archival purposes and future reference.

The results of a measurement can often raise questions about the nature of

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500-1000 MHz	30 dB min.
1000-2000 MHz	25 dB min.
2000-2500 MHz	20 dB min.
SWR	1.5 max. ("on" state)
SWITCHING SPEED	1 μsec. (max.)
MAXIMUM RF INPUT	+20 dBm
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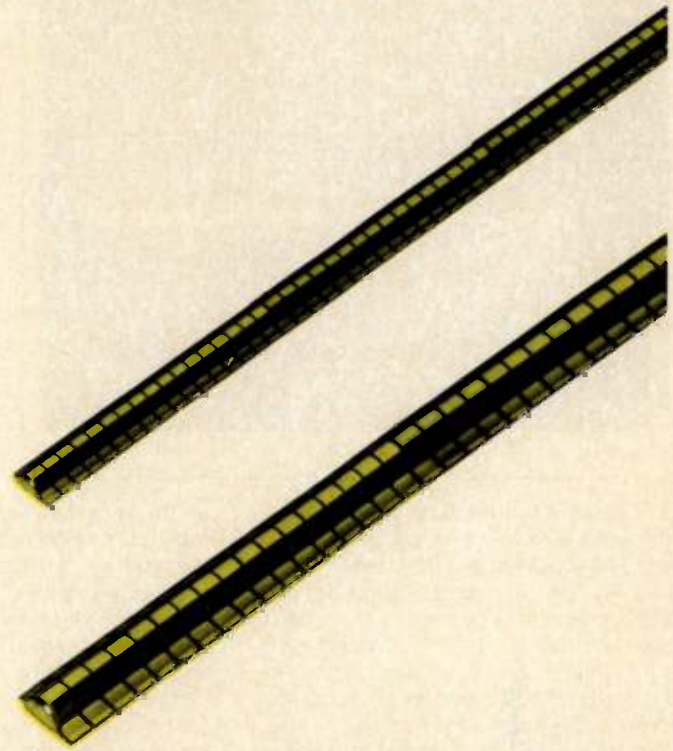

```
                DATA ANALYSIS:
            ->   Zoom Local
                 Print Peaks
                 Tune and Listen
                 Quasi-Peak Measurement
                 Mark trace

                 Notes


               DISPLAY OPTIONS:
                Peak Trace:        ON
                Quasi-Peak Trace: ON

            TITLE 3 IS:  OPERATIONAL MODE #3

     SCROLL WITH KNOB. SELECT FUNCTION DESIRED.


     RETURN      |SELECT    |        |           |TITLE 3
     DATA LIB    |          |        |VIEW CRT   |PLOT
```

Figure 8.

the emissions emanating from the equipment under test (EUT). For example, in this FCC-conducted emissions test, the test engineer may want to know what the Quasi-peak levels of emissions are over a particular portion of the frequency range. He or she may also be interested in taking manual control of the spectrum analyzer to further analyze a certain signal. These kinds of post-measurement capabilities can be accessed from the program's analysis level which appears on the computer CRT after a measurement has been completed, as seen in Figure 8.

In Figure 7, we observe that the EUT fails the Class B limit at the lower end of the frequency range. Since the measurement was made using the spectrum analyzer's peak detector, there is still a chance that the unit will pass the test if we can show that the quasi-peak emission level is below the limit. (For those readers unfamiliar with this type of detection, the quasi-peak circuitry weighs the incoming signal on the basis of its repetition rate. Signals with low repetition rates will yield a lower reading on a quasi-peak detector than signals with the same peak amplitude but a higher repetition rate. CW signals have the same amplitude with either detector type.) Upon selecting quasi-peak analysis, the user places two markers on the trace display to indicate the region over which the quasi-peak measurement is to be made. The spectrum analyzer/Quasi-peak Adapter combination then sweeps over this frequency range and displays the results on the same plot as the peak data to allow direct comparison. From Figure 7, we can see that in this case, the quasi-peak value is lower than the peak reading and better yet, is below the Class B limit.

Even if an EUT passes the test (and more importantly if it fails), it is often important to know something more about the nature of a particular signal than can be gleaned from the peak or quasi-peak test alone. For example, if a device we are designing fails a particular test, we need to know why it is over the limit so that corrective action can be taken. The source could be a clock on a printed circuit board, the power supply, a circuit that is not shielded properly, etc. By using the Zoom/Local mode of operation, the measurement system can provide some in-

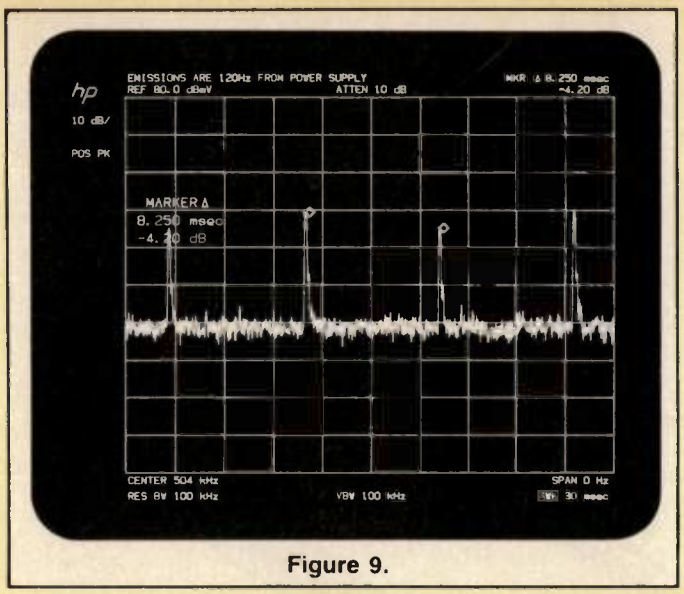

Figure 9.

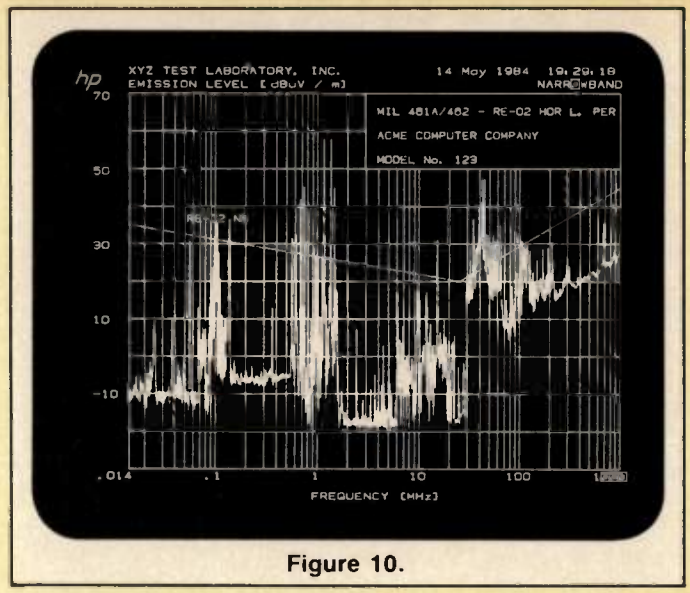

Figure 10.

sights into the source of the problem. The region that was over the limit (with peak detection) can be observed in the time domain, as shown in Figure 9. There it is apparent that the impulsive signals are power line related. Further investigation with a small probe or magnetic loop can help pinpoint the exact location of the problem. This knowledge can in turn, help minimize the turnaround time for a redesign of the product, since the designer has a very good idea of what area of the curcuitry needs to be modified.

A Mil Standard RE-02 Measurement

Besides conducted measurements, the other large class of EMI measurements are the radiated emissions tests. A typical one that we will use as an example here is the Mil Standard 461A/462 RE-02 test from 14 kHz to 1 GHz. Since this measurement covers such a wide frequency range, it is set up as a multi-range measurement as opposed to the single range used in the FCC-conducted measurement. As with other Mil Standard tests, all measurements are done using peak detection only. The quasi-peak adapter is not used at all in this test. Another difference is that the RE-02 test seeks to distinguish between narrowband and broadband signals since different limits apply to each.

The program begins by performing a narrowband measurement of range 1, correcting each set of trace data from the spectrum analyzer for antenna factor, preamplifier gain, and external attenuation (if any). The system then goes back to measure the same range again using the broadband measurement parameters specified in the Setup table. The same data correction factors are applied again, with the addition of an impulse bandwidth correction factor to normalize the broadband data to a 1 MHz reference bandwidth. Nominal values of impulse bandwidth correction factors are provided by the program, but they can be updated at any time by running a routine in the Utility section that measures the spectrum analyzer's resolution bandwidth filters and stores the newly computer correction factors on disc.

The automatic system proceeds with the measurement over each of the five ranges, first with the narrowband measurement setup, then with the broadband setup. If the narrow and broadband setup parameters for a given range happen to be identical, the program takes the narrowband data for that range and applies the impuse bandwidth correction factor to derive the broadband data. This shortens the time required to perform the measurement since duplication of spectrum analyzer sweeps under identical conditions are avoided.

The results of the RE-02 test are shown in the two plots in Figure 10. The time required to perform this test, using one setup per range, is about 7 minutes, not including the time required to change antennas between ranges. Upon finishing the test, the user may want to use the Zoom/Local capability to determine which signals are broadband, then use the Mark on those signals, as shown in Figure 11. The Print Peaks routine can also be used to list signals over a user specified amplitude threshold, as shown in Figure 12.

The Data Notes section, which is also accessed at this level, is useful to record comments about the data and the signal markers.

Since Mil Standard tests are conducted in a screen room, ambient signals are not present at the receiving antenna. However, many commercial radiated measurements are performed in an open field test site. This requires that we somehow distinguish between signals emanating from the EUT and those from nearby radio stations, airport radars, or any other ambient signal. A common method used by EMI test personnel is to tune to a suspect signal and listen to it via a loudspeaker to determine its nature. The Tune and Listen capability of the program uses the spectrum analyzer to tune to a user-selected signal and the audio output of the quasi-peak adapter to provide a demodulated output of the signal in question.

Hardcopy Output

Part of an effective measurement system is hardcopy output. Unless the results can be documented, a computer will be needed whenever the results are to be viewed. High fidelity plotters are available at very reasonable cost. These plotters can plot a complete EMI screen in 40-60 seconds in up to six colors. All the figures shown in this article were plotted on a HP7470A and are faithful reproductions of the high quality vector graphics system in the HP8566/68 spectrum analyzer, The EMI program has the capability to plot any EMI screens or the standard spectrum analyzer screen in three formats of 1, 2, or 4 plots per 8½ x 11 sheet. A pen control table lets the user plot annotation, graticule, limit lines, and traces in six different pens.

In addition, graphics printers can be used with the system. The HP200 series controllers such as GRAPHICS DUMP command which dumps its graphics screens to a graphics printer. The EMI screens can be viewed on the spectrum analyzer CRT, or the controller screen dumped to a printer or plotted onto standard paper, or even transparency material.

The EMI measurement system represents a state-of-the-art application of a computer configured instrument. Used properly, it is a powerful data gathering and analysis tool for frequency domain measurements. The data gathered by the

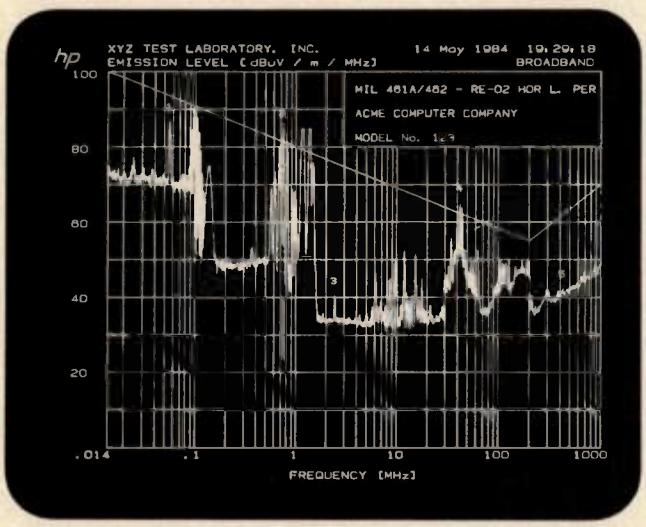

Figure 11.

XYZ TEST LABORATORY, INC. 14 May 1984 19:29:18

3. MIL-STD 461A / 462
3.6 RE-02 TEST #1

PEAKS FOUND ABOVE 40dBuV / m

PEAK #	FREQ (MHz)	AMPL (dBuV / m)
1	.68	42
2	.75	45
3	.82	41
4	1.17	58
5	1.36	58
6	1.47	45
7	42.44	47
8	44.37	47

Figure 12.

system is in the form of 1000 point integer arrays. Routines can be written for further analysis of the data.

Conclusion

Automated EMI measurement systems represent a quantum leap in convenience and performance over manual measurement methods. Reliability and repeatability of the data is enhanced because the computer conducts the test and corrects the raw data in exactly the same way each time. The library structures enable test and data storage to be handled in a convenient and orderly fashion. The addition of peripheral devices such as printers and plotters allow users to obtain clean and legible hard copy outputs of measurement results.

With the proliferation of electronic devices in our society and the increasing need to regulate their electromagnetic properties, the amount of EMI testing required by today's product designers will only increase. Because of this, EMI measurement systems will have to incorporate greater degrees of automation to meet these needs. Ultimately, the ideal solution would be one in which the test operator powers up the EUT, presses the START button on the measuring system and walks away, returning a few minutes later to find the final results. While there is no such system available yet, the day when such a beast appears is sure to come.

ESD Diagnostics and Control

By Michel Mardiguian and
Donald R.J. White
Don White Consultants, Inc.
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Many computers and microprocessor-based equipment experience malfunctions at their installation site, although they were declared "good for shipment" by the QC. These environmental problems become rapidly exasperating because of their generally intermittent and random nature. Typically after the first customer calls, a field technician inspects the machine, replaces some parts or cards, readjusts some settings which he estimated marginal and leaves (needless to say, there had been no malfunction during the time of his presence). He will probably report a "NTF" (no trouble found). Of course, the problems reoccur with the same unexpectable rate, correlated to nothing or to so many things that a clear explanation seems impossible. The customer asks for a higher level of assistance and the local field engineer comes to the rescue, then the district field engineer, etc . . . until someone calls the EMC specialist. Of this classical scenario, the ESD problems are taking a large share, especially since the computers have left

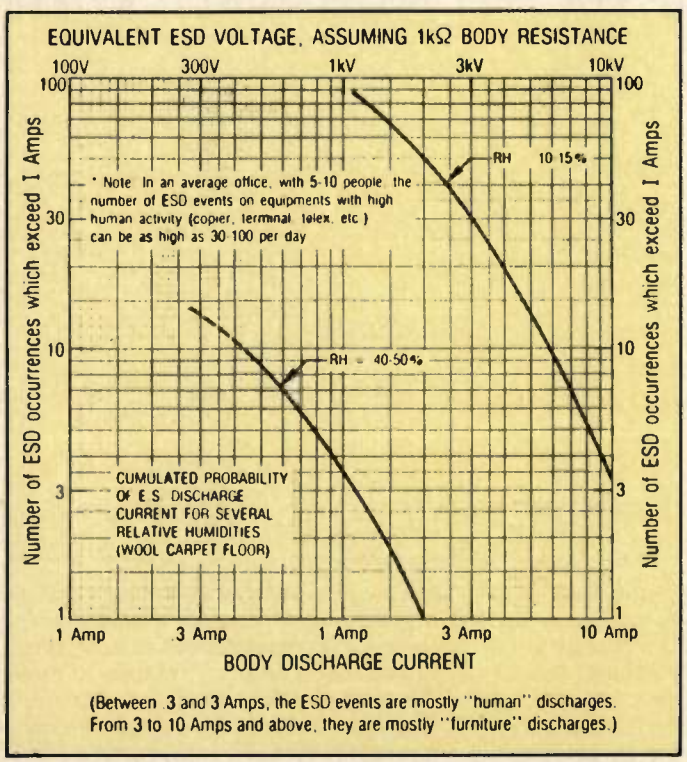


Fig. 1: Example of amplitude probability distribution ESD currents in offices having wool or synthetic carpeting.

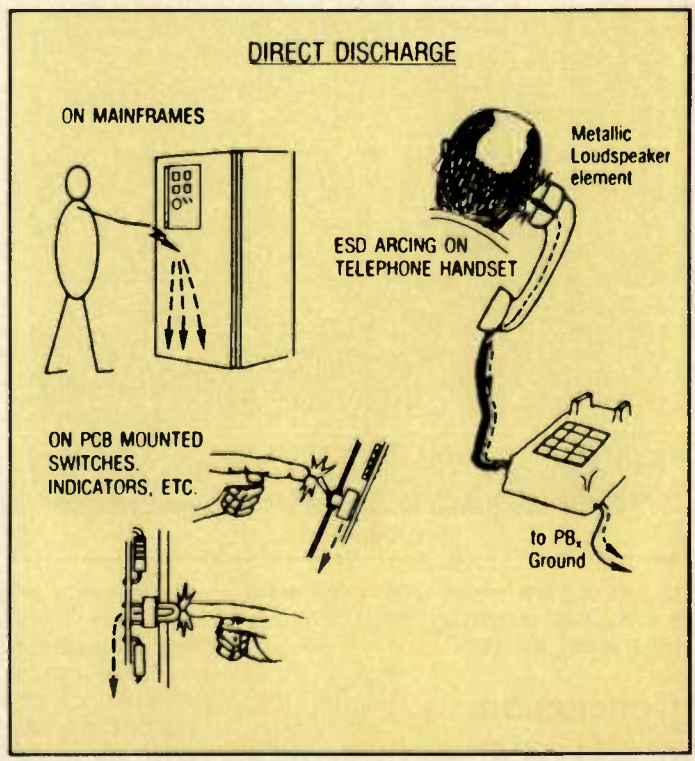
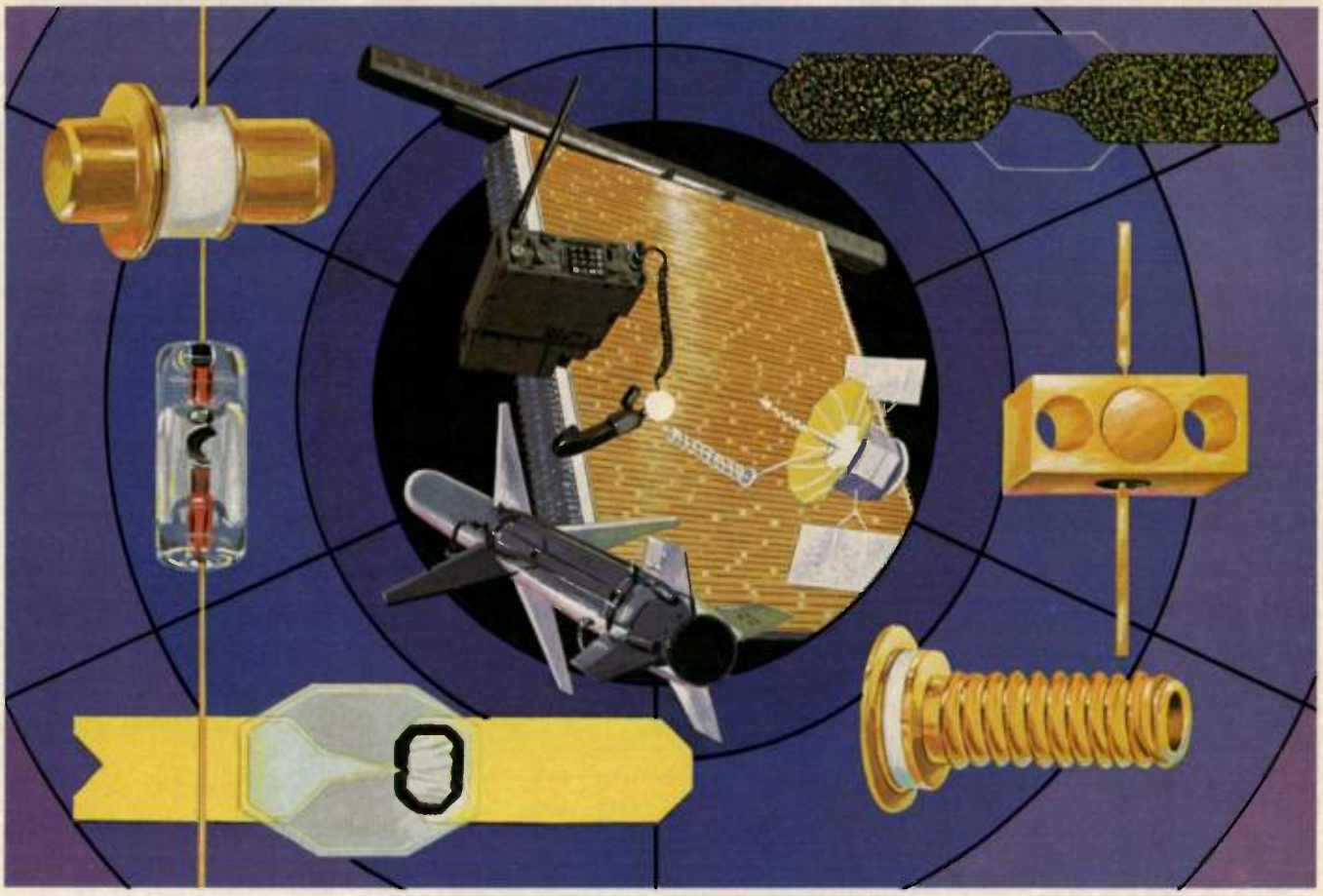


Fig. 2: Some typical ESD cases for EDP office/business products.

YOUR SINGLE SOURCE



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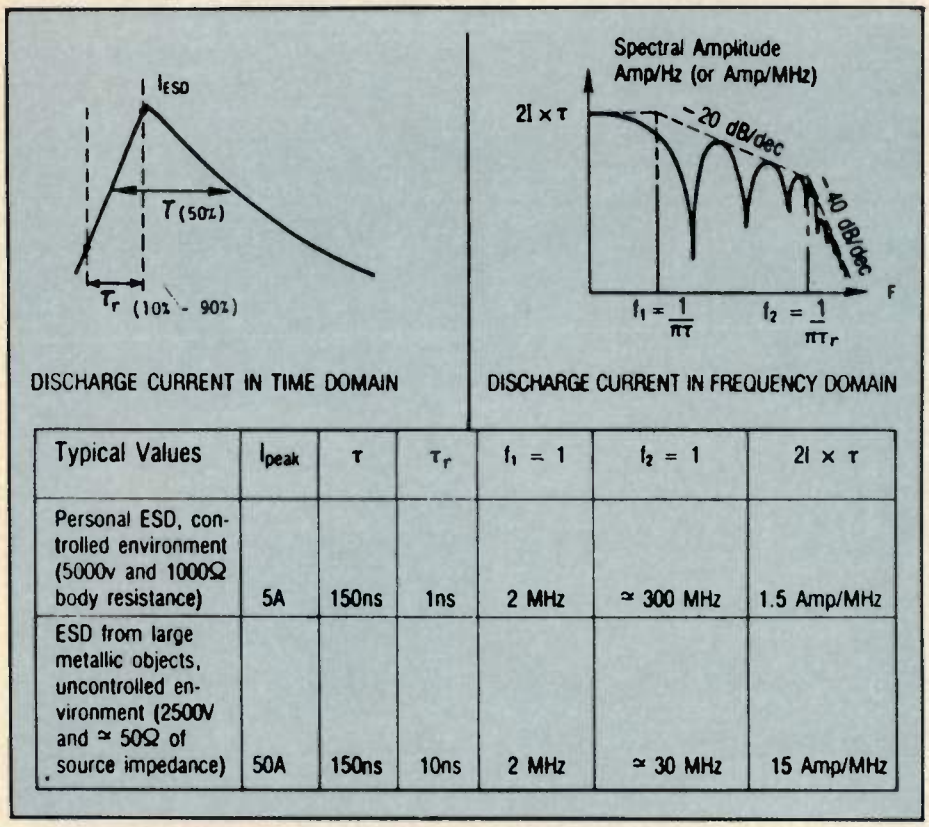
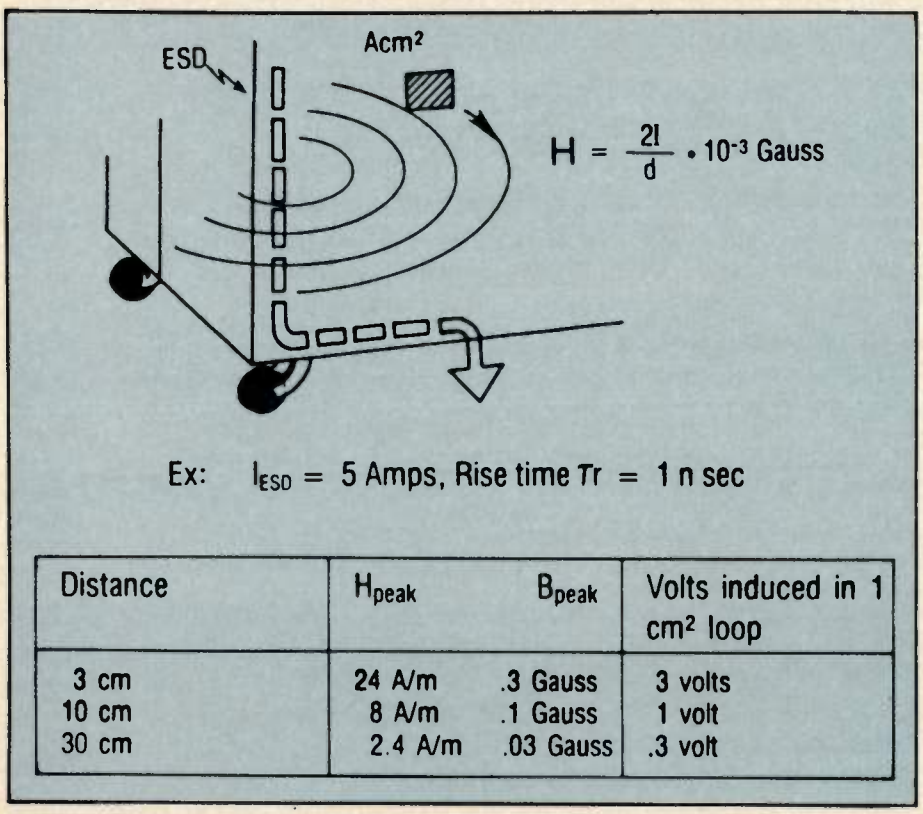


Typical Values	I_{peak}	τ	τ_r	$f_1 = 1$	$f_2 = 1$	$2I \times \tau$
Personal ESD, controlled environment (5000v and 1000Ω body resistance)	5A	150ns	1ns	2 MHz	≃ 300 MHz	1.5 Amp/MHz
ESD from large metallic objects, uncontrolled environment (2500V and ≃ 50Ω of source impedance)	50A	150ns	10ns	2 MHz	≃ 30 MHz	15 Amp/MHz

Fig. 3: Typical ESD waveform and spectrum.



Distance	H_{peak}	B_{peak}	Volts induced in 1 cm² loop
3 cm	24 A/m	.3 Gauss	3 volts
10 cm	8 A/m	.1 Gauss	1 volt
30 cm	2.4 A/m	.03 Gauss	.3 volt

Fig. 4: Electro Magnetic Field from ESD current sink (assuming current concentrated in a uniform path).

the well-protected computer room to go elsewhere.

The electrostatic discharge (ESD) situation is one developing from triboelectric materials. Basically, these insulating materials when rubbed against each other transfer electrons from one material to the other leaving opposite charges thereon. The extent is a function of the relative difference of the material in the triboelectric series, relative humidity, force and speed of the rubbing or sweeping action. More specifically, a human being approximates 120 picofarads which can be charged up to values approaching 30,000 volts when walking across a carpeted floor, especially in the winter or when slithering out of a chair having synthetic fiber upholstery. When the human or other objects (chairs, carts) is brought in contact with a grounded metallic surface, an ionizing spark develops which is the discharge energy of the human capacitor. The energy contained in the charge is approximately 3 orders of magnitude greater than that which will develop an upset condition for typical logic families.

The ESD generation problem can be summarized this way (more thorough explanations and models are found in Ref. 1, 2 & 4): People, or objects (chairs, carts, etc.) after having accumulated static charge which can reach 10 kVolt or more are prone to discharge themselves on any grounded, or ground-coupled, metallic part.

An example of the probability of occurrences of a given level is shown on Fig. 1 and Fig. 2 shows some typical ESD scenarios.

Although the ESD voltage is often given as a severity criteria, the real determinant parameters are the peak discharge current and its risetime, which are governed by the impedance of the discharging body. The ESD risk is aggravated by a non-conductive floor, a low RH and a high human activity.

The ESD Coupling:

It is important to understand the ESD coupling mechanism, (i.e., how a discharge pulse on a computer box (the cause) ends up as logic errors (the result). Some parameters of typical ESD waveforms are given in Fig. 3. They are derived from a large amount of existing data (Ref. 3), both on personnel and furniture discharge.

It is obvious that, due to their lower resistance, metallic objects deliver higher peak ESD current than personnel. On the other hand, rise time is much shorter (just because the time to peak is less) and the voltage build-up higher with personnel discharges. Although sophisticated models can be developed to predict the values of a radiated E & H fields near the discharge, a simple approach is shown on Fig. 4 which consists in considering the ESD drain path to ground as a uniform conductor, which is long compared to the observation point, in that case the victim PC card or flat cable. A simple derivation of the field over the rise time gives the open loop voltage induced per cm^2 of victim area. This crude model gives an approximation of the ESD induced voltage which is generally sufficient for a quick EMC prediction.

One sees that 2 PC traces separated by 1 cm, having a 10 cm parallel run and located at 30 cm from the ESD flow will see a peak transient of 3 volts, more than enough to create an erroneous bit in most of the logic technologies.

The ESD Test As A Wideband Stimuli:

The purpose of this preamble was to introduce the concept that, with its wide spectral occupancy covering several hundred MHz or more (Fig. 3) a properly stimulated ESD phenomena can excite and reveal much more on the weaknesses of a product than its simple vulnerability to static discharges.

Testing immunity to radiated EMI is usually a long and complex test which requires costly antenna, amplifiers and anechoic rooms. Although non-CW and not modulated, the ESD test can discover a lot of the susceptibility spots that a classical radiated susceptibility test would address.

The strong stimuli of the ESD pulsed field will detect:

- improper PCB layout, wire-wrap or cable runs;
- missing or loose ground connections;
- uncontrolled ground-loops and parasitic capacitances;
- improperly terminated cable shields and poor connector bonding;
- shield discontinuities, etc.

Furthermore, when applied on site at the time the computer is installed or after mysterious crashes, an ESD test will show up:

- improper grounding at facility level;

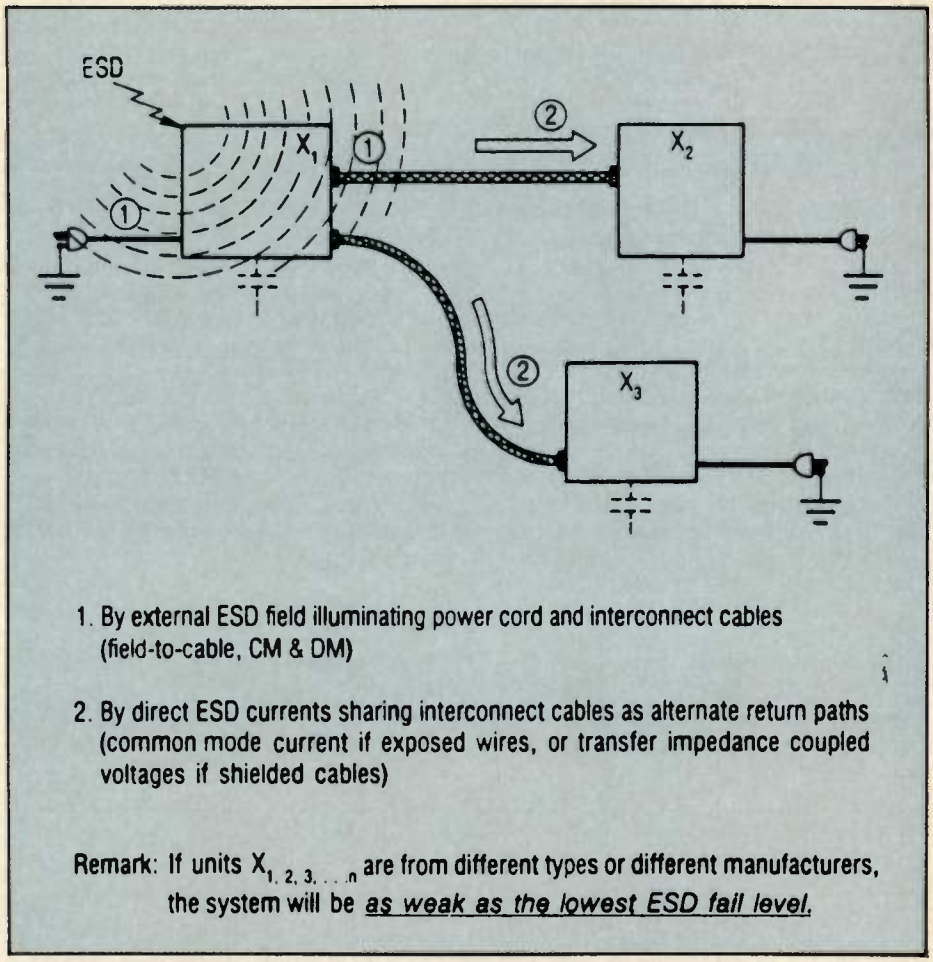


Fig. 5: Contribution of external cables to ESD coupling.

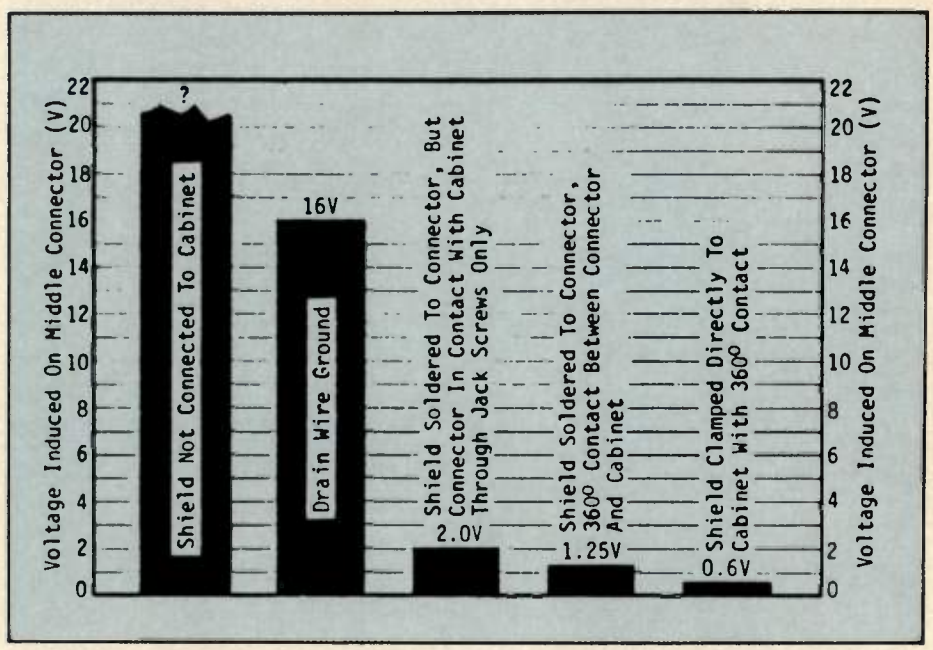


Fig. 6: ESD induced voltages in external flat cable (from report by Charlotte Palmgren — 3M). Effect of shield termination on induced voltage for 3517 type cable (wrapped shield).

• deficient OEMs attached to the unit;
• poorly shielded I/O cables, or genuine manufacturer's cables and connectors replaced by "equivalent" items;
• missing covers, gaskets and/or fingerstocks, etc.

The recommended routine is the following:

• virtually make a "zoning" by dividing each side of the equipment into approximately 0.1 m² (30 cm x 30 cm) areas. Mark or code each area.
• determine a clear, indisputable "malfunction" status which can be recognized *without the need for an external oscilloscope, data-logger, etc* . . . (hard error, wrong read-out, power down, inadvertent reset alarm).
• set an ESD level equal to (or correlatable to) the one used by the Quality Assurance of the Manufacturer, if it exists. (Or by defalut, select 7.5 kV for a simulator having about 1KΩ of internal resistance.)
• zap every coded area, plus or including every switch, key, protruding screw, etc., with at least 50 pulses.
• if the product is mainly plastic, stimulate an indirect discharge by zapping a metal plate at about 4 in" (10 cm) from every side.
• record and map the "pass" and "fail" areas.
• for each failed area, repeat the test with lower setting until reaching the GO/NOGO level.

What remains to do is, for each fail zone, inspect and critique the hardware immediately behind, and the cable nearby.

The input/output cables are privileged points of ESD entry because they act as efficient pick-up antennas for the ESD field radiated outside; then the induced common mode current is carried inside the unit by the shield leakages, pigtail braids, etc., as shown in Fig. 5. A radical improvement is generally obtained when ordinary or poorly shield I/O cables are replaced by solid shields plus metallic connector shells, bonded to the main frame (Figs. 6 and 7).

Summary

Electro static discharge is a very powerful test:

• by its wideband radiated spectrum, it addresses quickly, all at once, the design and packaging weak points.
• *at development stage,* even made on an unfinished breadboard prototype, it will reveal PCB layout and other design mistakes.
• *at customer's site,* used as a system + installation checker, it will:

A) Prior to system turn-key, detect installation defects (missing grounds, incorrect covers bonding, faulty cable shields and connectors, etc. . . .).

B) In case of latent customer problem, pin down system or sub-assembly degradation.

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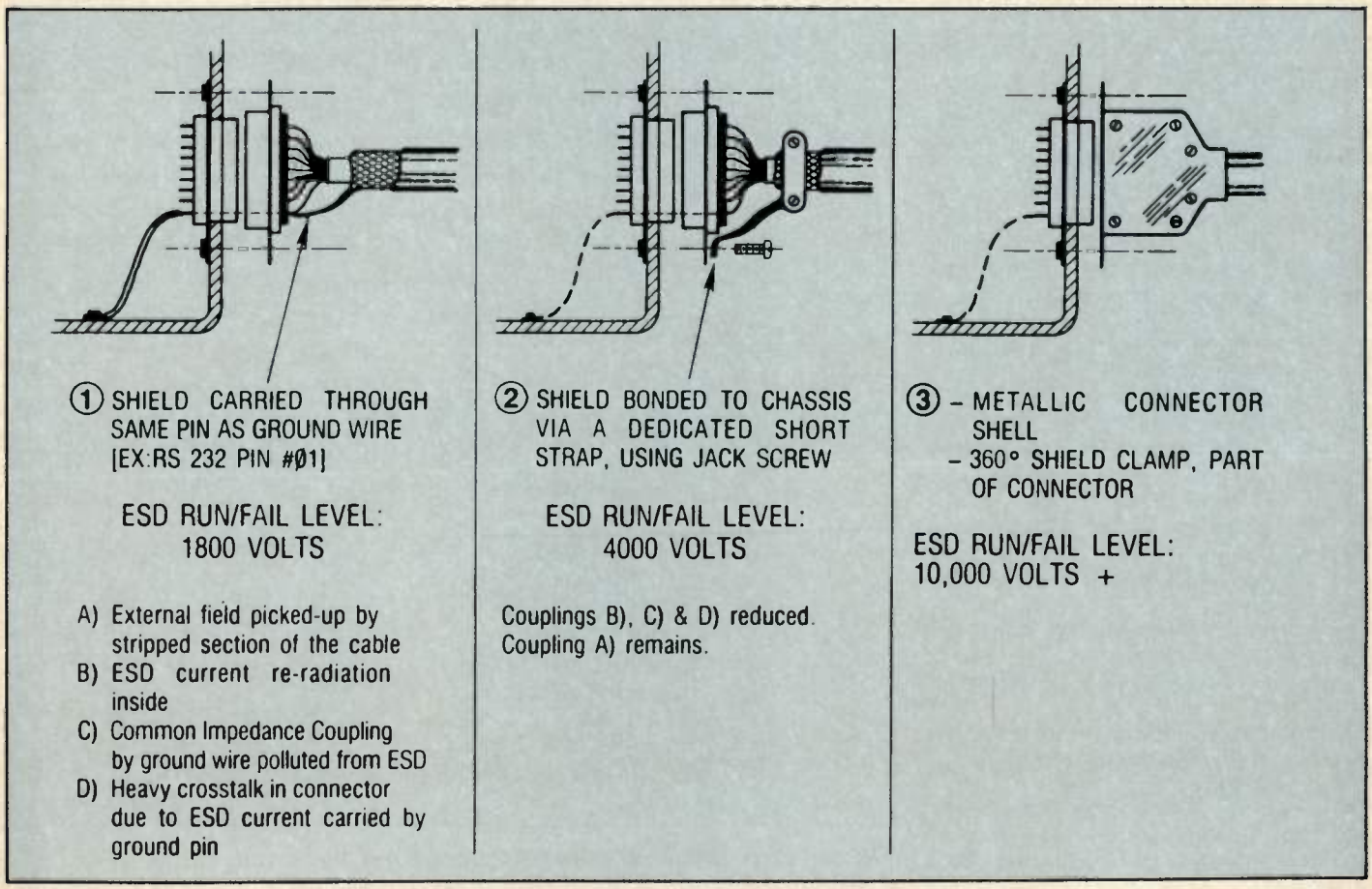

Fig. 7: Influence of shield termination on ESD immunity.

Low Transfer Impedance — A Key to Effective Shielding

By Thomas A. Jerse
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Santa Rosa, CA 95401

As the electromagnetic spectrum becomes increasingly crowded and the specification of synthesizer performance becomes more stringent, the design and implementation of effective EMI shields becomes more essential than ever. This article gives the basic principles behind good shielding including the powerful concept of transfer impedance. In addition, it shows a system for making meaningful shielding effectiveness measurements right on the design bench.

The most straight forward way to characterize the performance of a shield is in terms of its shielding effectiveness. The definition of shielding effectiveness is derived from the technique of its measurement. First, the coupling between a source and a receiver is measured without the shield in place. Then, a shield is installed and the coupling is measured again. The ratio of the shielded coupling to the unshielded is known as the shielding effectiveness of that shield. It is commonly expressed in dB. This definition applies to the shielding of both electric and magnetic fields.

The shielding effectiveness of a particular shield depends on many things: the shield materials, the shield geometry, the type of field, the frequency of the field, the distance from both the source and receiving antennas, the field strength, and the form of any discontinuities such as seams or holes. Imperfect shielding results from either penetration directly through the shield by the field or from coupling through the discontinuities in the shield. There are two principal mechanisms that attenuate the transmission of a propagating field through a conductive plate. The first is the absorptive loss introduced by the extremely poor dielectric characteristics of a conductor. The skin depth (d) of a conductor represents the depth at which a field impinging on the conductor is attenuated by a factor of e^{-1}, or 8.69 dB. The skin depth (d) varies with frequency, permeability (μ), and conductivity (σ) as:

$$d = \sqrt{\frac{2}{\omega\mu\sigma}}$$

The absorptive loss (A) experienced by a wave travelling through a conductive plate of thickness (t) is given by:

$$A = 8.69\frac{t}{d}\ [dB]$$

Except at very low frequencies, the skin depth of metal is quite shallow resulting in a large amount of absorptive shielding. For example, the skin depth of aluminum at 1 MHz is only 83 μm, and so a field would be attenuated by 105 dB when passing through a 1 mm thick aluminum sheet. At higher frequencies the attenuation would be even greater. Every time the frequency increases by a factor of four, the absorptive loss expressed in dB doubles, and so at 4 MHz the 1 mm plate of the example would exhibit, in theory, 210 dB of attenuation.

A second factor that contributes to shielding is the reflection that occurs due to the impedance discontinuity between

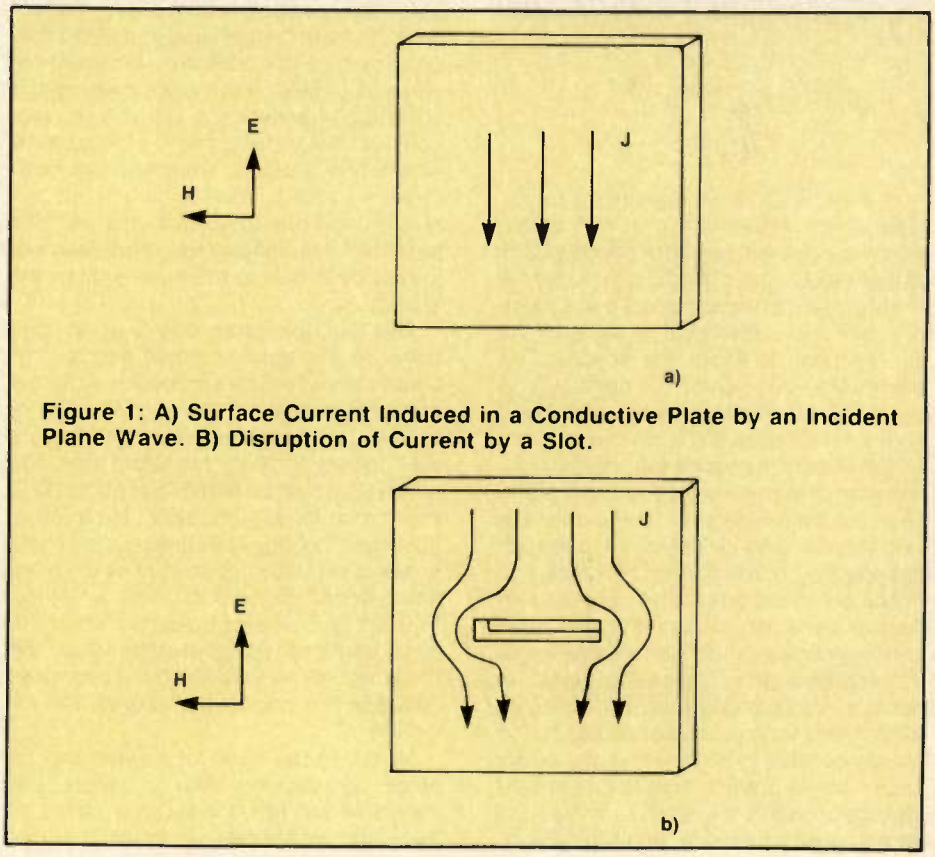

Figure 1: A) Surface Current Induced in a Conductive Plate by an Incident Plane Wave. B) Disruption of Current by a Slot.

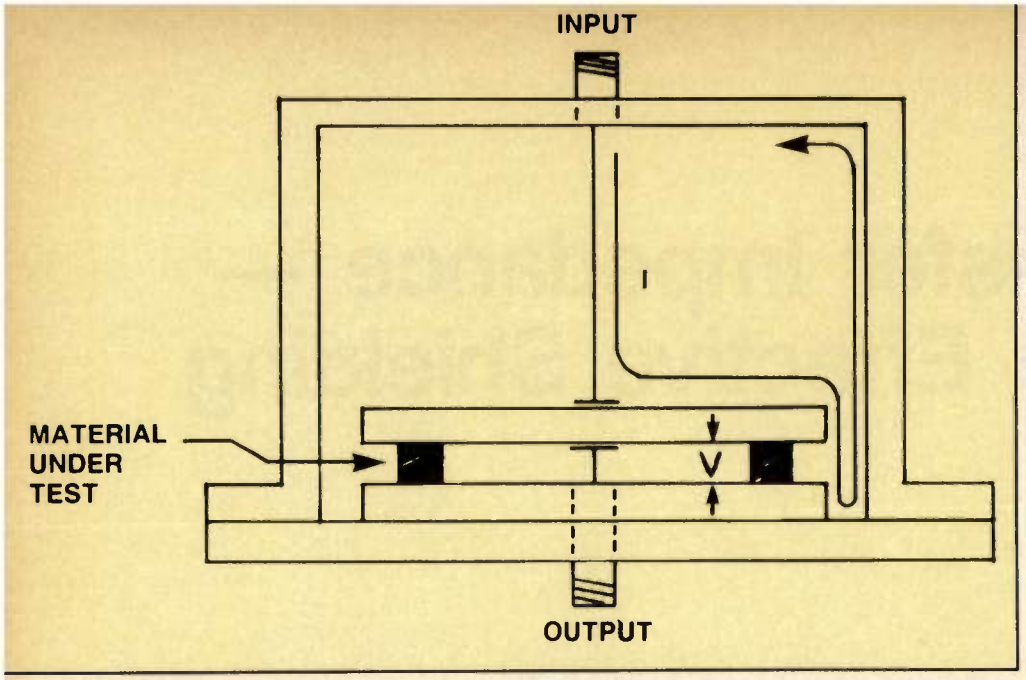

Figure 2: Coaxial Test Fixture for Measuring Transfer Impedance of Gasket Material.

the air and the conductor. Every wave can be characterized by an impedance — the ratio of its electric to magnetic field. The impedance depends on the type of medium containing the wave, the distance from the source of the wave, and the type of source. For a plane wave in free space, the wave impedance is 377 ohms — a value that closely describes the far-field characteristic of a plane wave in air. On the other hand, the characteristic impedance (Z_0) of a conductive medium is ordinarily quite small. It can be calculated from:

$$Z_0 = \sqrt{\frac{\omega\mu}{\sigma}}$$

The impedance of aluminum, for instance, at 1 MHz is 4.6×10^{-4} ohms. When a wave with an impedance of 377 ohms encounters a medium with such a low impedance, the impedance mismatch will reflect a substantial amount of the energy back towards the source. The energy that does enter the metal will be subject to the absorptive losses described above as it passes to the other side of the shield. Finally, a second reflection will occur when the wave exits the metal plate. Thus the field emerging on the opposite side of the shield will have been attenuated by a large mismatch loss.

The combination of absorptive and reflective losses ordinarily results in ample shielding against field penetration for all but low-frequency magnetic fields. In practice, measured values of shielding effectiveness for a particular configuration are almost always far less than the theory above would predict. This is due to field leakage through the seams, holes, and other discontinuities found in the shield. Thus, in most situations, the foremost determinant of shielding effectiveness is the mechanical design of the shield; that is, the way in which any discontinuities are handled.

When a wave strikes a shield, it induces a current on the surface of the shield as shown in Figure 1a. One may think of the process of shielding by visualizing the induced current as generating a field that opposes the impinging field. If the shield is perfect, the induced field will precisely cancel the incident field. However, any disruption of the current flow by a discontinuity will disturb the cancelling field and hence reduce the shielding effectiveness. As an example, consider the arrangement of Figure 1b where a rectangular aperture has been cut in the shield. The bending of the current around the aperture excites a "slot antenna" resulting in the re-radiation of the incident field to the other side of the shield.

This example represents a worst case because the current would like to flow across the aperture and hence suffers a maximal disruption. If the orientation of the incident field were such that current was induced along the slot, then the shielding would be somewhat better. But, to account for any arbitrary field orientation, the shielding effectiveness of a hole or slot is primarily determined by the maximum linear dimension of the aperture. The actual value of shielding effectiveness obtained will also depend on the thickness of the shield and the distances between the shield, the source and receiver.

Modeling the effect of a seam can be more complicated than a simple slot depending on how the seam is joined. In the past, particularly in military equipment, the seams were firmly joined with an imposing number of fasteners. Here, the seam was sometimes modeled as an array of slots where the length of each slot was taken as the distance between fasteners. This was somewhat successful because the fasteners exerted sufficient pressure to ensure very good electrical contact between shield parts in the region of the fasteners. However, modern packaging styles have tended to minimize the number of fasteners for reasons of aesthetics, serviceability, and manufacturing costs. This has usually resulted in designs characterized by long seams with anomalous points of contact and considerably less contact pressure between halves of the seams. This situation can significantly degrade the shielding effectiveness. It can also reduce the likelihood of obtaining repeatable levels of shielding because each time the package is opened and closed there may be different points of contact and different amounts of contact pressure. This behavior can prove particularly frustrating for the design engineer trying experimentally to reduce radiated signal levels. A change in shielding effectiveness measured after making a modification inside a package can sometimes be the result of a change in the contact qualities of a seam instead of the intended modification.

Transfer Impedance

Transfer impedance provides a useful means of characterizing the quality of electrical contact between parts of a shield. The idea of transfer impedance originated 50 years ago[1] as a means of quantifying the effectiveness of shielded cables. The concept has subsequently been extended to include the behavior of shield materials and interfaces including gaskets[2].

Transfer impedance relates the voltage (V) induced inside of a shield as a result of a current flowing on the outside of the shield. The ratio of the induced voltage to the excitation current determines the transfer impedance. Transfer impedance (Z_{tr}) is normalized by the length of the seam (ℓ), and so is given by:

$$Z_{tr} = \frac{V}{I\ell}$$

where the units are ohm/meter.

One standard method of measuring the transfer impedance of EMI gasket material[3] uses a coaxial test fixture as shown in Figure 2. The fixture allows pressurized air to be injected into the top chamber, enabling accurate, uniform control of the pressure exerted on the test sample. The coaxial structure makes it easy to determine the frequency dependence of the transfer impedance.

A simple, lumped model of the transfer

impedance at a gasketed joint is shown in Figure 3. Due to the capacitance between parts of the shield, the transfer impedance decreases with frequency. This effect can cause the shielding effectiveness to improve with frequency. For an engineer visualizing the model of the seam as an array of slots, this phenomenon can prove confusing since the radiation efficiency of a slot increases with frequency. However, the transfer impedance model easily explains this phenomenon. In fact, the measurement of poor shielding effectiveness at low frequencies can often be a salient indication of marginal electrical contact between parts of the shield.

Transfer impedance is a valuable concept because it facilitates analytical comparison of different shielding materials in the same configuration. Previously, manufacturers would characterize a particular material or gasket as giving X dB of shielding. This value was fully applicable only under the precise test conditions that were used in determining the value; that is, the same geometry (sometimes even the same shielded room), the same contact pressure, the same placement of source and receiving antennas, and so on. Thus, designers could not clearly compare the effectiveness of various materials in real-life applications. By contrast, transfer impedance values do not depend on the measurement configuration. A designer can select a gasket, for example, knowing that its shielding effectiveness will improve in proportion to $-20\log Z_{tr}$ where Z_{tr} is the transfer impedance normalized to one ohm.

The transfer impedance of a joint depends on many factors: the materials at the interface, the surface area of the contact, the amount of contact pressure, and the presence of any corrosion on the surfaces.

The most basic approach to obtaining low transfer impedance is to select an interface material with low surface resistance. The selection of material is also constrained by process and economic considerations. Tin has a particularly low surface resistance while still being within economic reason. It also has excellent corrosion characteristics. (See below.) High surface resistance has been the downfall of some of the conductive coatings applied to plastics. Their shielding to direct field penetration is adequate, but it can be difficult to secure an adequate transfer impedance at shield joints.

The transfer impedance across a seam can be lowered by increasing the contact surface area. This may come at the cost of a little more mechanical complexity, but the improvement in performance can be considerable. As an example, consider the seam between two conductive plates as shown in Figure 4a. If a "tongue-and-groove" detail can be included (Figure 4b), both the real and imaginary components of the transfer impedance will be smaller. A certain amount of surface roughness is desirable in the contact area. If the surface finish is too smooth, the number of potential microscopic points of contact will be reduced which will raise the transfer impedance.

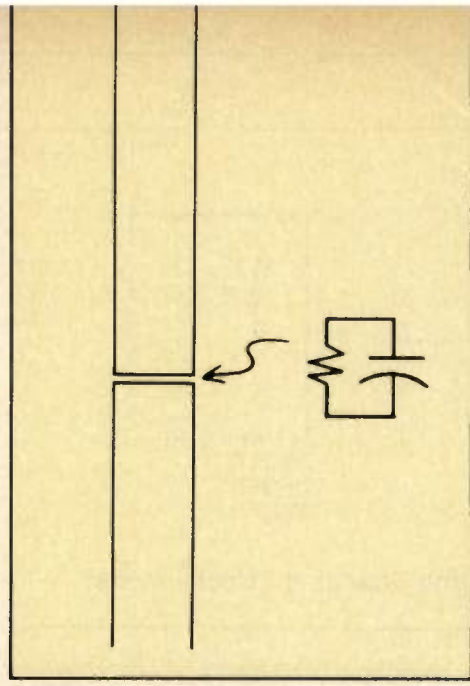

Figure 3: Lumped Model for Contact Impedance at a Shield Joint.

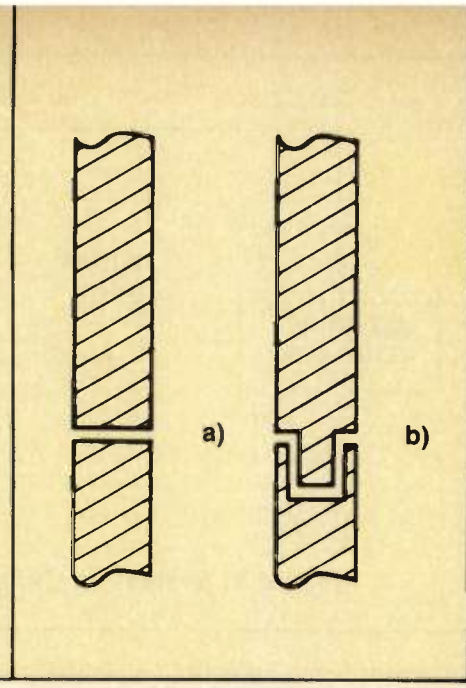

Figure 4: The Design of b) Creates More Surface Area for Contact.

Merely increasing the surface area will often not be sufficient. The transfer impedance can still be excessive due to insufficient contact pressure between the parts of the shield. In general, the pressure of merely the weight of one piece of metal lying on another will give inadequate performance. Additional pressure must be provided either by means of spring forces or through fasteners. The amount of pressure required can be determined from the specifications of the materials used in the seam or by experimental means. Once a minimum pressure has been defined, the design must guarantee that pressure even under the worst-case combination of dimensional tolerances.

An EMI gasket can be used both as a source of spring force and to take up any slack due to tolerances. However, keep in mind that the transfer impedance of most gaskets is a strong function of the applied pressure. The pressure provided must fall within the gasket manufacturer's recommended range over all possible conditions.

The presence of corrosion on the surfaces of a seam can severely degrade the transfer impedance of the seam. This ordinarily manifests itself as a reliability problem because the surface conductivity of metal tends to worsen with time, accelerated by exposure to high humidities and temperatures. In fact, under extreme conditions, a seam made from poorly chosen materials can become virtually non-conductive resulting in a major decrease in shielding effectiveness. Two effects are responsible for the degradation: oxidation and the action of galvantic cells. In either case the resistance to corrosion will depend on the materials used at the seam interface. Some metals, such as tin, are relatively slow to oxidize and their oxides also have a low surface resistance. Another approach to retarding oxidation while maintaining good conductive properties has often been to plate the surfaces with a noble metal such as gold. However, plated surfaces should not be placed in contact with other types of metals. For example, a shield plated with gold should not have a gasket covered with another material set into its seams. The placement of dissimilar metals in intimate contact creates a galvantic cell with its accompanying corrosion. The magnitude of the current produced by the cell and hence the severity of the corrosion depends on the relative standing of the two metals in the electromotive series; i.e., the difference in their electronegativities. A larger difference in potential connotes a more serious problem. A notably bad combination is gold and aluminum, which are found at opposite ends of the electromotive series. The best way to avoid galvantic corrosion is to use the same metal on all contacting surfaces. If this is not possible for other reasons, one should at least select metals which are close together in the electromotive series. Whatever the metallic system selected, its reliability should be verified through high temperature/humidity testing of the prototype shields.

A problem frequently encountered by those designing enclosures for electronic

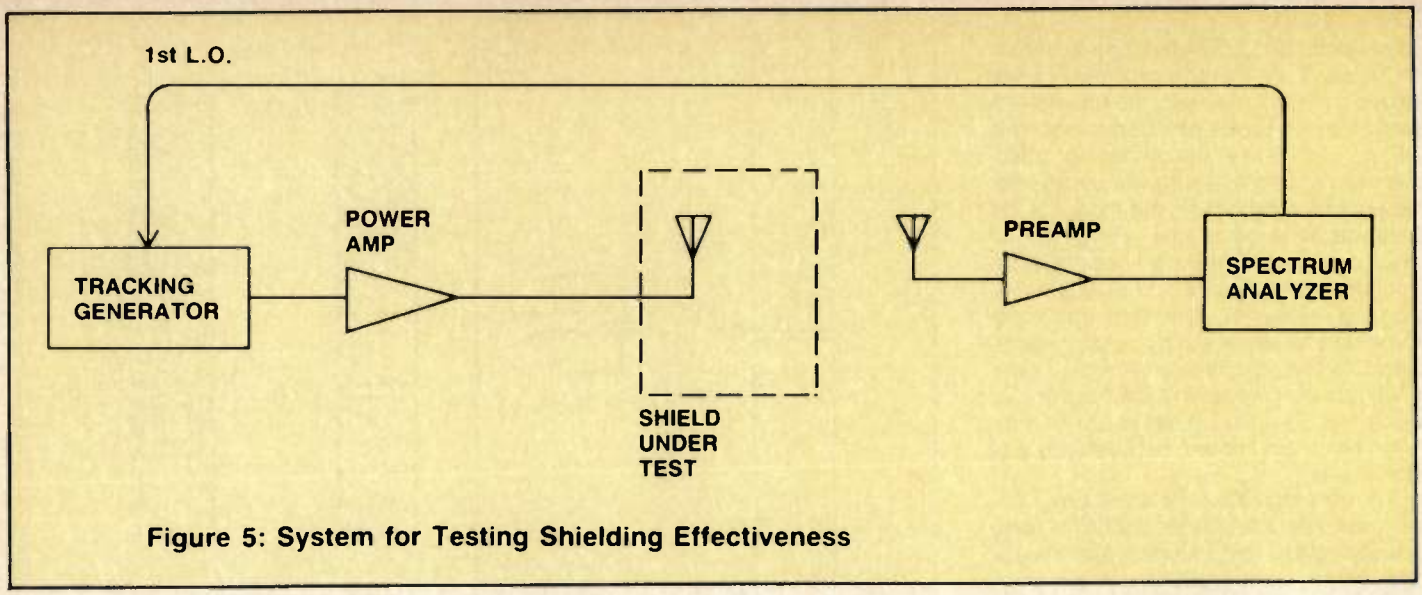

Figure 5: System for Testing Shielding Effectiveness

equipment is the necessity for parallel design of the circuitry. The packaging engineer is often told to create "something with good shielding" before the electronics to be shielded actually exists. At the same time, the engineer does not have direct access to a means of testing the shielding effectiveness, or of even making meaningful relative measurements. The availability of a system for making shielding effectiveness measurements right on the design bench greatly facilitates the design of optimal shields. Figure 5 details the block diagram of a high-dynamic range system which has been successfully employed in designing many shields. One or both of the amplifiers may be omitted depending on the dynamic range needed to characterize the shield under test.

Repeatable, high-dynamic range measurements require coaxial cables with excellent shields. Semi-rigid cables or those with multiple braids are preferred. Coax with a single shield will often have insufficient performance. The connectors must be well-made; 360-degree shield contact at the connector is essential.

The tracking generator puts out a signal at the same frequency as the current input frequency of the spectrum analyzer. The use of a swept-frequency measurement system is highly preferable to a system capable of measuring a fixed frequency at a time. This is due to the possibility of relatively high-Q resonances appearing in the shielding effectiveness. In an experimental situation, changes to a shield may effect slight shifts in the resonant frequencies. If the frequency of the fixed signal happens to be near a resonance, its level may rise or fall dramatically with just a small change in the resonant frequency. Designers can badly mislead themselves in this manner, thinking that they have significantly altered the shielding effectiveness in some way when in fact the broadband shielding characteristics have changed in an entirely different direction.

The two remaining elements in the test system are the source and receiving antennas. Inside the shield, a microstrip line makes a good source antenna. It simulates the principal radiators found in most equipment — the traces found on printed circuit boards. Such an antenna is simple to fabricate. A 50-ohm microstrip line forming three-and-a-half sides of a rectangle works well. A 50-ohm load terminates the line, imparting the antenna with a smooth frequency response over a broad bandwidth. The other end of the line is attached to a coaxial connector. When mounting the antenna to the shield to be tested, the outside of the connector must be well-grounded to the shield.

A relatively small receiving antenna (a probe) enables the engineer to locate imperfections in a shield. However, reducing the size of an antenna also diminshes its sensitivity, requiring a trade-off to be made between dynamic range and physical resolution. A small loop can make a good probe. However, the position of the coaxial cable connecting the loop to the receiver will often affect the measurement. This is primarily due to currents induced in the outside of the coaxial shield. These can be lessened by minimizing the sensitivity of the loop to electric fields by shielding or other techniques.

In most cases, the test system need not be used in a shielded room. Because the tracking generator is synchronous with the spectrum analyzer, the spectrum analyzer will display any extraneous signals (e.g., from a local radio station) with a distinctive pattern that is different from the responses created by signals from the tracking generator. Thus, such spurious data can be easily identified and ignored.

Repeatability is mandatory in any system used for making EMI-related measurements. Without this characteristic, meaningful experiments cannot be performed, making constructive progress difficult. In approaching a system, it is well worth the time spent in characterizing its repeatability before any measurements are taken. One should determine how sensitive the measurements are to things like the positions of the cables, the position of the operators, etc. If repeatable measurements cannot be made without extraordinary attention to detail, it is usually best to expend one's effort in finding ways to improve the system rather than trying to maintain exacting standards of physical placement.

Summary

In summary, in most situations the success of an EMI shield design depends on the manner in which the discontinuities in the shield are handled. The model of surface transfer impedance provides a good way of conceptualizing the effect of the discontinuities and of understanding the qualities of a good seam. Finally, optimum shields are more likely to be obtained when the shield designer has available a system for making repeatable, broadband shielding effectiveness measurements.

References

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2) Faught, A.N., "An Introduction to Shield Joint Evaluation using EMI Gasket Transfer Impedance Data," *IEEE International Symposium on Electromagnetic Compatibility*, pp. 38-44, August, 1982.

3) ARP-1705, "Coaxial Test Procedures to Measure the RF Shielding Characteristics of EMI Gasket Materials," *Aerospace Recommended Practice*, Society of Automotive Engineers, Inc., June 1, 1981.

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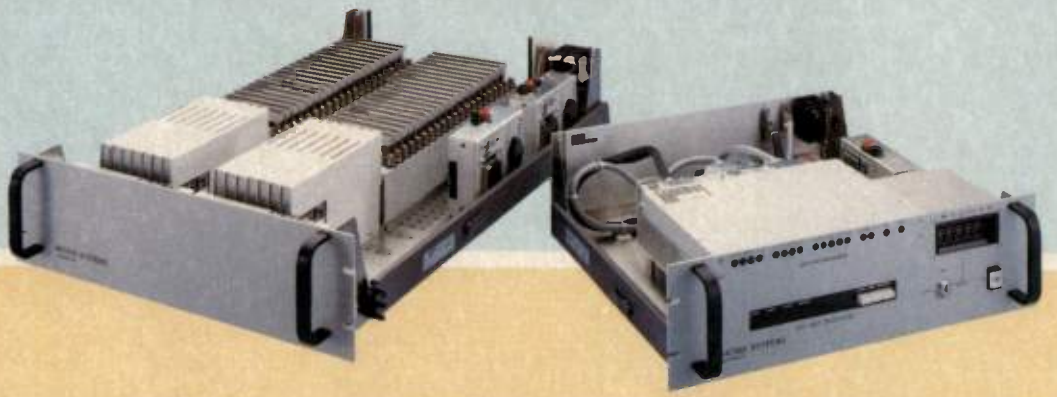

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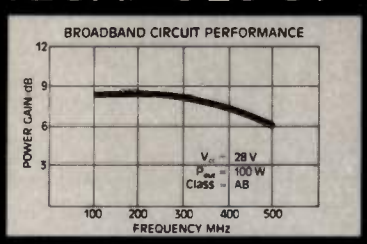

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POWER WITH A PURPOSE

Fiber Optic Connectors Control EMI/RFI

By Les Borsuk
Micro-Fiber Optics Division
ITT CANNON
Santa Ana, CA

The growing use of fiber optic technology is providing more and more advantages to the design engineering community. In telecommunications, military applications, and in aerospace, the lighter weight and higher bandwidth have greatly increased performance parameters. Fiber optics also has keynote advantages in the control of electromagnetic interference (EMI) and radio frequency interference (RFI). To fully appreciate these advantages, it will be necessary to outline what EMI and RFI consist of, and then examine traditional connector-intensive methods of control. Then it will be practical to examine fiber optic connectors, their advantages and some applications.

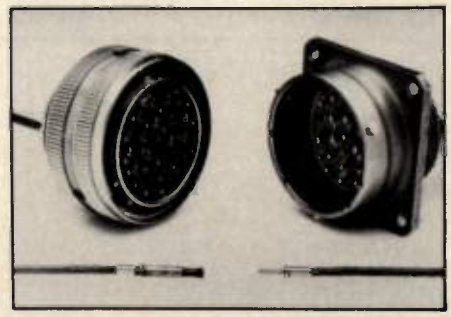
Radiation and Conduction

A hard wire system's vulnerability to EMI/RFI is well known. RF and electromagnetic interference are emitted in two ways, radiation and conduction. Radiated noise is the most common form of interference, because virtually any part of a circuit (discrete wiring, PC board trace, etc.) can act as a broadcast antenna. Conducted emission of RF noise most often is a problem where it reaches a part of the circuit where it can be radiated, or where it leaks back into the power or signal lines. At high frequencies, where the coupling between conductors can make a cable look like a dead short, this can be a major problem. At this point, it can reach any piece of unprotected equipment, and may upset the system momentarily or even burn out particular components.

Radiated interference can especially be a problem in digital electronics. The fast rise and high frequency characteristics of digital control signals makes them rich sources of harmonics, which complicates the problem of controlling EMI.

Traditional Methods of Controlling EMI/RFI

A designer has several methods of dealing with EMI, including case shielding, on-board filtering and multi-layer PC boards, to name but a few. Case shielding speaks for itself; no EMI control will go far without it. Multi-layer PC boards can be used to furnish a ground plane very close to any possible antenna element, thus limiting significant radiation to the very highest frequencies. This method, however, is an expensive one, and is rarely appropriate when redesign of a system becomes necessary to overbalance EMI problems. Conducted radiation can often be dealt with best by providing a filter network at the output of the board or subsystem generating the offending signal.

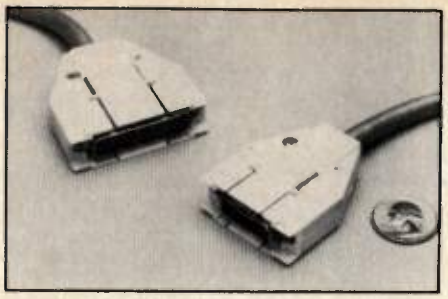


Fiber-optics contacts from ITT Cannon are interchangeable with size 16 pin and socket electrical contacts in MIL-C-38999 Series III (top) and other military and aircraft connectors.

Connector shielding can help control radiated or electromagnetic noise. Perfectly shielding an electronic system at every point will eliminate all radiated noise, but it will not affect conducted noise at all. Thus shielding alone will be sufficient only if you have control over the design of every piece of electronics connected with the system. This is rather unusual except in the case of some military applications where the electronics and interconnect are designed together. If a perfectly shielded piece of hardware is connected to an imperfectly shielded one, any RF noise generated in the shielded hardware will be conducted to the imperfect shielding and radiated out. Also, where systems are not self-contained, really well-shielded cable is prohibitively expensive.

Filtration is another common method for controlling conducted emissions. Filtering the signal to eliminate unwanted RF components will eliminate conducted noise, but without a very well-shielded design, radiation will still take place. In many cases, the signal itself will be the source of the interference, rather than the harmonics. In addition, the waveform of the signal will determine the ease of filtration, as a sinusoidal wavefrom is far more easily dealt with than other complex signals.

The efficiency and cost of each method is also strongly influenced by the power of the signal and its frequency. The higher the frequency, the smaller the escape route of the interference. . .and the harder it is to shield. At extremely high frequencies, the seam of a two piece connector shield may be enough to allow significant radiation. The power level of the interference is one parameter which will determine how far the offending signal



Shielded D-Subminiature connector closes EMI gaps between shielded cable and hardware.

will travel as well as how far it will be conducted. Filtering a high power signal is naturally more expensive.

Fiber Optics and EMI

Fiber optics is gaining more and more adherents in the area of EMI/RFI control. Although fiber optic systems are also subject to system upset or burnout, fiber optic cables do not act as antennas. Since fiber optics transmit information by means of a beam of light, there is total immunity to almost all forms of RF or electromagnetic interference. The only significant exception to this situation is nuclear electromagnetic pulse (EMP). The pulse created by a nuclear explosion can create "color spots" in a fiber and interfere with the light's travel path.

A variety of connectors and contacts are currently available to interconnect fiber optic subsystems, preventing EMI as regards the cable assembly. One of the most innovative is a fiber optic contact which is a direct replacement for the contacts in the MIL-C-38999 Series I and III connectors. The contact gives immunity to EMI and RFI without requiring connector replacement or respecification. It fits into a size 16 cavity without modification, is moisture sealed to allow the use of electrical contacts in the same connector and features a precision jewel-ferrule alignment system which significantly reduces radial misalignment (the major source of signal loss in fiber optic interconnect).

Another fiber optic connector to examine is a series of environmental fiber optic connectors used in applications as varied as seismic exploration and military field communications. This series, named FOMC, offers a hermaphroditic, scoop-proof design which permits disassembly and field cleaning while protecting against fungus, humidity and salt spray, as well as a variety of corrosive elements, such as hydraulic fluids. Aside from the hostile environment resistance, the immunity from EMI or especially RF emission insures data security. Fiber optic connectors and systems are proof against eavesdropping or other sub-rosa line tapping.

In developing a fiber optic system for EMI control, one of the most important elements to consider is that not all vendors are as careful as you might wish. Your fiber optic system might be used with less than perfectly shielded or filtered hardware. Fiber optics neither radiate nor conduct, but the same might not be said of your hardware. Some form of filtration might be indicated.

Applying Fiber Optics to EMI/RFI Control

The United States Navy and the Marine Corps have been addressing the problems of EMI in specific problem areas. On board some aircraft carriers, the EMI is so bad that, when aircraft is sitting on the flight deck, the ailerons operate without anyone at the controls.

As a result, aircraft manufacturer McDonnell-Douglas developed aircraft that is wired with fiber optics. The major aircraft example is the AV8B Harrier II advanced V/STOL (vertical short takeoff and landing) light attack plane. The AV8B communications link is 43 feet long total in three segments. The system only requires a 125 kbps rate, but the original experiments tested a 40Mbps configuration. McDonnell-Douglas developed its own test instruments for measuring lab and field losses, running extensive tests and selecting fiber-optic connectors for the sake of quality and durability. Being non-electric, the fiber optic cable does not react to exterior EMI, and the ailerons make no mysterious moves.

The pilots of the AV8B won't notice any difference with the inclusion of the fiber optic system, but a special training course was developed for personnel involved in the maintenance, installation and assembly. While the EMI-proof link is very straightforward to install, maintenance is a more careful consideration. This is due to the fact that the fiber optic faces must be kept clean while unmating the connector.

Another area where fiber optics plays an important role in EMI control is in the field of tactical field communications. The United States Air Force now uses a field radio set which employs a fiber optic

Tactical field radio uses fiber-optic cable/connectors for high bandwidth and lightweight mobility.

Eight-channel FOMC connector from ITT Cannon is field cleanable and is designed for military communications systems.

cable/connector assembly to remove a ground observor from the radio set. It would be possible, though difficult, to use field wire for this purpose, but fiber optics, being proof against EMI, hold a special advantage. Historically, field wire had been used to remote the spotter, but field wire held too many disadvantages. The Air Force specified fiber-optics, not only for EMI resistance, but for the fundamental advantages of lighter weight and higher bandwidth.

The tactical field radio is one case in which the manufacturer had full design control from the beginning of the project. It provides probably the most secure communications in field support technology.

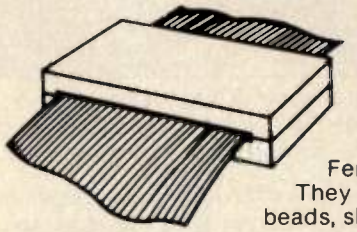
Security in an optical cable is almost unconditional at this time. Fiber optic cables do not radiate at all, and thus cannot be detected in operation or tapped by induction or other non-invasive means. In addition, the light weight and high bandwidth of fiber optics offers exciting possibilities for a new generation of wire-guided missiles and torpedoes — without the limitations imposed by the narrow bandwidth of copper wires as presently used, the smart part of the missile can stay back at the launch site, making the weapon smaller, more powerful and more intelligent.

Conclusion

The use of fiber optics is becoming more flexible every year, and it is used in a variety of EMI sensitive applications, from the military to data communications. But it should be pointed out that the shielding of existing hardware is essential to a full program of EMI control. Imperfectly shielded hardware will still emit. Cases like the tactical field radio, in which all hardware was built from the ground up, are still the exception, rather than the rule. This only points up the necessity to consider fiber optic interconnect at the beginning of the design process rather than making cables and connectors a design afterthought. A careful combination of the right connector elements, planned and developed early in the design stages of a potentially EMI-emitting system, will result in a significant degree of control in the finished product.

STOP EMI

Before It Stops Your Product



FCC Parts 15 and 18 severely limit EMI/RFI for most electronic and electric devices. Even more stringent standards are enforced in Europe.

Fair-Rite, the leader in ferrite cores for shielding, can help you solve EMI/RFI problems. Appliances, communications radios, EDP equipment, switching power supplies, and robots all must be clean to the FCC and other authorities.

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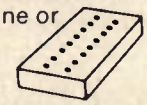

Fair-Rite also makes beads-on-leads, available taped and reeled per EIA RS296D, for use with automatic insertion equipment.

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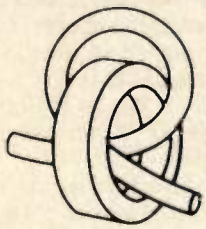

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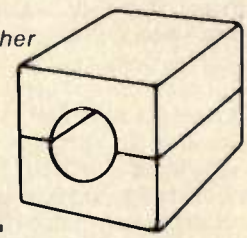

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EMC/EMI Suppliers Product Matrix

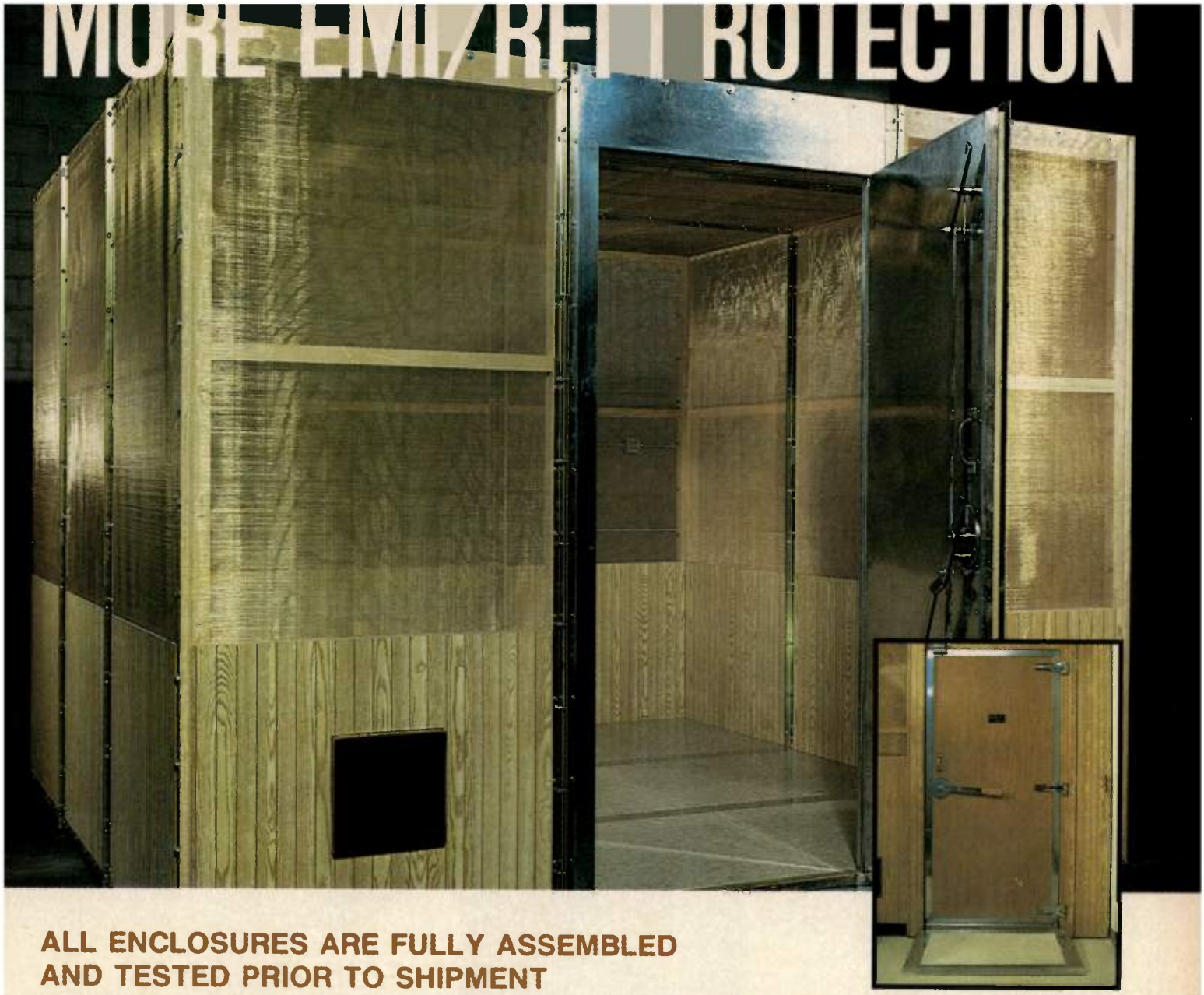
Categories

Absorbers (Broadband, Microwave, RF, Tuned)
Adhesives/Adhesive Films (Copper-filled, Silver-filled, Conductive, Epoxy, Insulating, Silicone, Specialty)
Air Filters (Lossy, Shielded)
Anechoic Materials (Pyramids)
Cable, Shielded (Shielded, Magnetically Sheilded, HV Impulse, Braid)
Chambers/Shielded Rooms (Anechoic, Environmental, Shielded, TEM-cells
Coatings (Antistatic, Anti-EMI, Anti-reflection, Anti-fog, Conductive, Conformal, Epoxy, Masking, Metal Spray, Rust Inhibitors, Shielding, Thin-film, Water Displacing)
Contact Strips (Fingers, Cleaning Solvent)
Elastomers (Absorbive, Conductive, Polyurethane, Sheet Stock, Shielding Silicone, Synthetic Rubber)
Equipment Enclosures, Shielded
Epoxy (Conductive, Thermally Conductive, Potting & Encapsulating)
Filters (Custom, EMI, Kits EMI, Crystal)
Foils (Magnetic Shielding, Shielded Tape, Solder, Wallpaper/Ultra Thin
Gaskets (Environmental, Rubber, Shielding, Solder)
Lubricants (Conductive, General Purpose greaseless non-silicone silicone, Synthetic Rubber)
Networks (Impedance Stabilization [LISN], Rejection)
Shielding Materials (Cable Jackets, Conductive Epoxies, Conductive Filler, Conductive Fiber, Yarn & Fabric, Custom Fabricated, CRT, Ferrite Components, Microwave Absorbing, Transformer, Paint, Raw Materials, Sheets, Foils, Windows, Wire Mesh)

The following matrix presents a tabulation of suppliers serving the EMC/EMI market. It is intended to serve as a guide to locating vendors for EMC/EMI products and services.

	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable, Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
AC Transformer Corp.	1A																•					
Ad-Vance Magnetics, Inc.	2A												•				•	•				
AEMC Corporation	3A																			•		
AMP Incorporated	4A											•										
Abbeon Cal, Inc.	5A		•								•											
Ablestik Laboratories	6A		•								•											
Acheson Colloids Co.	7A							•														
Acme Chemicals & Insulation Co.	8A		•					•		•	•											
Adams-Russell Co., Inc.						•																
Antenna & Microwave Division	9A																					
Advanced Electromagnetics, Inc.	10A	•			•		•										•					
Aerovox Incorporated	11A											•										
Agamice	12A	•			•			•	•									•				•
Allen Avionics, Inc.	226A											•										
Altoflex	13A		•	•				•		•	•		•	•	•		•					
American Cyanamid	14A																•					
American Electronic Laboratories	15A																			•		
American HV Test Systems, Inc.	16A																			•	•	
Amplifier Research	17A						•												•	•		
Amuneal Manufacturing Corp.	18A																•	•				•
Andrew Corporation	19A	•				•																
R.B. Annis Co.	20A																			•		
Applied Controls Co., Inc.	21A											•										
Aptron Laboratories, Inc.	22A																			•		
Arconium Corporation	23A												•	•								
Aremio Products, Inc.	24A		•					•			•				•							

MORE EMI/RFI PROTECTION



ALL ENCLOSURES ARE FULLY ASSEMBLED AND TESTED PRIOR TO SHIPMENT

Only Lindgren combines the proven superior performance of double-electrically-isolated (DEI) shielding with the benefits of modular room construction. Independent tests demonstrate that Lindgren's DEI design gives highest shielding efficiency in both low-frequency magnetic and high-frequency microwave fields.

Lindgren offers a complete line of modular enclosures, equipment cabinets, and custom RF rooms. Lindgren enclosures are offered in virtually all shielding materials, in all typical shielding thicknesses, in solid-sheet or screen, to cover all shielding requirements. Each enclosure is fully assembled at our plant before shipment, tested to verify RF integrity, and guaranteed to meet its attenuation specifications.

Patented overlapping pressure joints allow Lindgren enclosures to be easily assembled, rearranged, moved, expanded, partitioned, and reassembled again and again with no need for specially trained personnel.

To coordinate with your specific environment, Lindgren can also provide special interior/exterior finishing . . . soundproofing . . . suspended ceilings . . . recessed lighting . . . raised computer floors.

A wide range of options lets you custom-design your enclosure with windows, access panels, manual or automatic sliding doors, wave guide feedthru, lights. RF connectors, fiber-optics, filters for power, signal and communication lines, emergency (panic bars) doors, permanent in place threshold ramps, and more.

The diversity of Lindgren enclosures has satisfied the needs of more than 5000 customers we've served over the last 30 years.

Next time you need a specialized shielded enclosure, make sure you get the superior performance of double-electrically-isolated design plus all the other Lindgren advantages.

Write or call today for full information or applications assistance.

FOR MORE INFORMATION, WRITE 22 ON READER INQUIRY CARD

LINDGREN RF ENCLOSURES

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(312) 628-9100

INFO/CARD 21

Shielded Enclosure Services

From Design to Completion. . .

- Consulting
- Relocation
- Modification
- Repairs
- Assembly
- Test and Certification
- Resale

Established 1962

FREE: ***Booklet on maintenance, modification, repair, testing and simplified shielding theory. Available upon request.***

ECS-I

ELECTRONIC CONSTRUCTION SERVICE

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INFO CARD 22

EMC/EMI Suppliers Product Matrix

	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable, Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
Argo Electronics, Inc.	25A					•																
Ralph Aronson & Associates	26A																			•		
Asheville-Schoonmaker Mica Co.	27A													•				•				•
Atlas Engineering Co., Inc.	28A			•																		
Atomergic Chemetals Corp.	29A												•									
BIW Cable Systems, Inc.	30A					•																
Bacon Industries, Inc of CA.	31A		•							•	•			•								
Balzers Optical Group	32A																•					
Baron Wire & Cable Corp.	33A					•																
Behlman Engineering Corp.	34A																				•	
Belden Electronic Wire & Cable	35A					•																
Bendix	36A											•										
Bi-Tronics	102A					•																
Bird Electronic Corp.	37A											•										
A.R. Blanck Co.	38A																			•		
Blue M., A Unit of Gen'l. Signal	39A						•															
Brand-Rex Co., Electronic & Industrial Cable Division	40A					•																
Breeze-Illinois, Inc.	41A					•																
Brim Electronics, Inc.	42A					•																•
C & M Corporation	43A					•																
Cal Crystal Lab, Inc.	44A											•										
Caig Laboratories, Inc.	45A							•	•						•							
Calmont Engineering & Electronics	46A					•																
Capcon	93A	•	•			•		•		•		•	•	•		•	•					•
Captor Corporation	47A											•				•						
The Carborundum Co.	48A							•														
Caroline Steel & Wire Co.	49A					•																
Carol Cable Co./Columbia Elec.	50A					•																
Chabin Corporation	51A					•																
Chemfab Chemical Fabrics Corp.	52A		•																			
Chomerics, Inc.	53A	•	•					•		•	•		•	•	•		•	•				•
Coaxial Dynamics Inc.	54A											•										
Compac	55A											•		•								
Comsearch, Inc.	56A						•															
Conap, Inc.	57A		•							•	•											
Cool-Amp Conducto-Lube	230A							•							•							
Core-Tronics, Inc.	58A	•															•					
Cornell Dubilier	59A											•										
Chritchley Bros. Ltd.	60A																					•
Curtis Industries, Inc.	61A											•										
Daburn Electronics & Cable Corp.	62A					•																•
Dage Corporation	63A	•			•																	

Electromagnetic Compatibility Testing from 20 Hz to 18 GHz

Electro-Metrics CCS-750 computer-controlled system provides faster, more comprehensive EMC measurement and offers the flexibility to handle virtually any application. The system includes a desk-top computer system, a Digital Interface Unit and three EMI receivers to cover a frequency range of 20 Hz to 18 GHz (expandable to 40 GHz!).

The CCS-750 system displays signal strength vs. frequency directly, with automatic correction for antenna factors and RF attenuation. And all data can be stored for later use. An IEEE-488 Interface Bus controls signal sources as well as all other test parameters, and facilitates integration with other automated equipment.

CCS-750 Features

- ☐ 20 Hz to 18 GHz/40 GHz frequency coverage
- ☐ Automatic calibration for improved accuracy
- ☐ Automatic antenna selection
- ☐ Control of all test parameters
- ☐ Reduced data tabulation time
- ☐ EMI emissions and susceptibility tests per FCC/VDE/CISPR and Mil-Std 461/462 requirements

Automate your emissions and susceptibility testing with Electro-Metrics complete CCS-750 system. Call or write today for more information.

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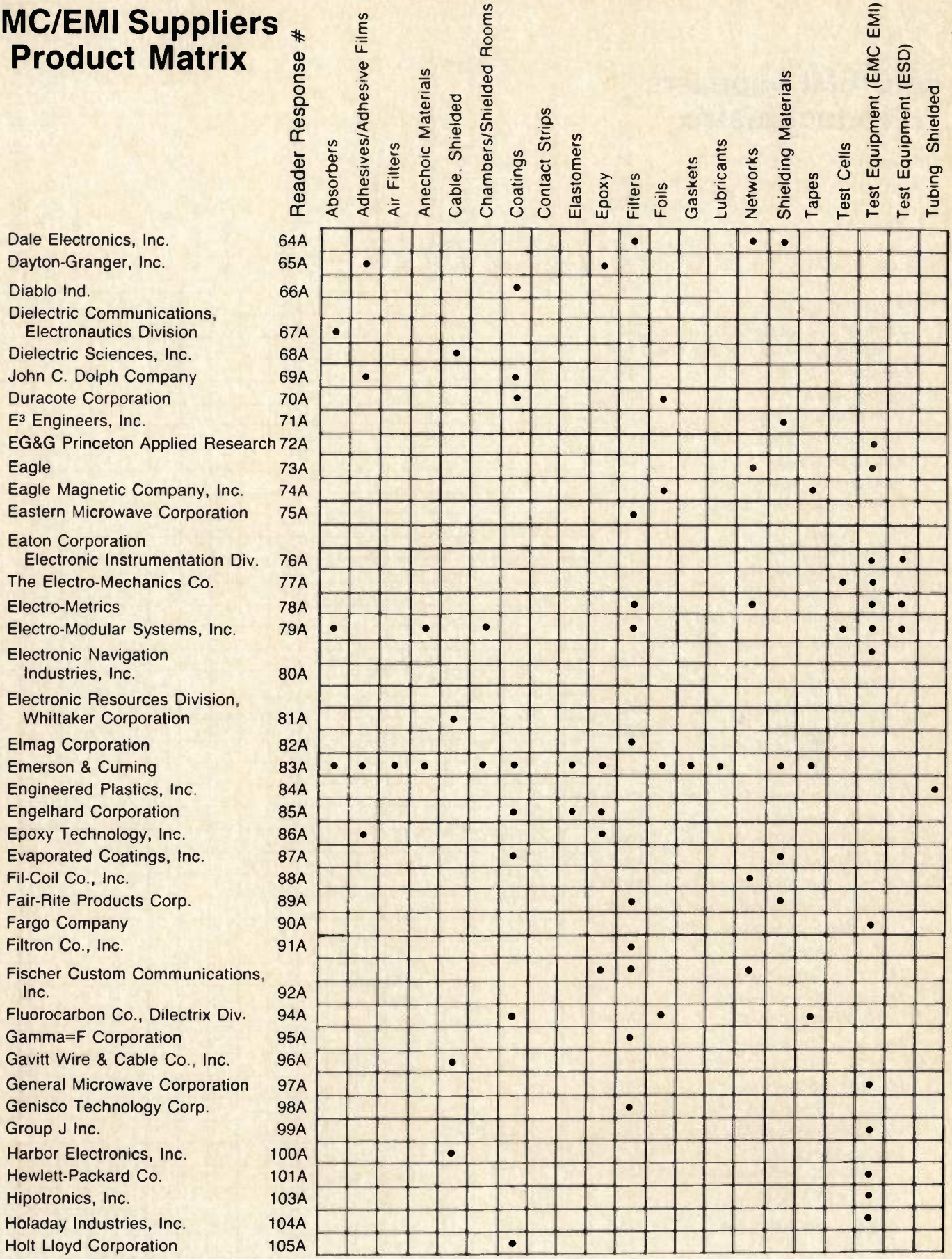
Amsterdam, New York 12010

ELECTRO-METRICS
A PENRIL COMPANY

Tel.: (518) 843-2600
TWX: 710-446-4798

INFOCARD 23

EMC/EMI Suppliers Product Matrix



	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable, Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
Dale Electronics, Inc.	64A											•				•	•					
Dayton-Granger, Inc.	65A		•								•											
Diablo Ind.	66A							•														
Dielectric Communications, Electronautics Division	67A	•																				
Dielectric Sciences, Inc.	68A					•																
John C. Dolph Company	69A		•					•														
Duracote Corporation	70A							•					•									
E³ Engineers, Inc.	71A																•					
EG&G Princeton Applied Research	72A																			•		
Eagle	73A															•				•		
Eagle Magnetic Company, Inc.	74A												•					•				
Eastern Microwave Corporation	75A											•										
Eaton Corporation Electronic Instrumentation Div.	76A																			•	•	
The Electro-Mechanics Co.	77A																		•	•		
Electro-Metrics	78A											•				•				•	•	
Electro-Modular Systems, Inc.	79A	•			•		•					•							•	•	•	
Electronic Navigation Industries, Inc.	80A																			•		
Electronic Resources Division, Whittaker Corporation	81A					•																
Elmag Corporation	82A											•										
Emerson & Cuming	83A	•	•	•	•		•	•		•	•		•	•	•		•	•				
Engineered Plastics, Inc.	84A																					•
Engelhard Corporation	85A							•		•	•											
Epoxy Technology, Inc.	86A		•								•											
Evaporated Coatings, Inc.	87A							•									•					
Fil-Coil Co., Inc.	88A															•						
Fair-Rite Products Corp.	89A											•					•					
Fargo Company	90A																			•		
Filtron Co., Inc.	91A											•										
Fischer Custom Communications, Inc.	92A										•	•				•						
Fluorocarbon Co., Dilectrix Div.	94A							•					•					•				
Gamma=F Corporation	95A											•										
Gavitt Wire & Cable Co., Inc.	96A					•																
General Microwave Corporation	97A																			•		
Genisco Technology Corp.	98A											•										
Group J Inc.	99A																			•		
Harbor Electronics, Inc.	100A					•																
Hewlett-Packard Co.	101A																			•		
Hipotronics, Inc.	103A																			•		
Holaday Industries, Inc.	104A																			•		
Holt Lloyd Corporation	105A							•														

EMC/EMI Suppliers Product Matrix

	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable, Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
Hopkins Engineering Co.	106A											•										
ICAR SPA — Industria Condensatori Applicazioni Elettroelettroniche	107A											•										
Inductive Products, Inc.	108A											•					•					
Injectorall Electronics	109A							•														
Instruments for Industry, Inc.	110A						•												•	•		
Instrument Specialties Co., Inc.	111A						•		•								•			•		•
Integra Microwave	112A																			•		
Integrated Microwave Corp.	113A											•										
The Inter-Technical Group, Inc.	114A																•					
JMK, Inc.	115A											•				•				•		
Joaquin Mfg. Corp.	116A						•					•										
K & L Microwave, Inc.	117A											•										
Kalglo Electronics Co., Inc.	118A											•										
The Kannard Company, Inc.	119A							•														
Keene Corp., Advanced Absorber Div.	120A	•		•	•		•	•	•	•	•	•		•			•					
Keene Ray Proof	121A	•			•		•					•				•	•					
Key Polymer Corporation	122A		•					•			•				•		•					
Kirkhill Rubber Co.	123A									•				•			•					•
Kyocera International, Inc.	124A											•										
LDJ, Inc.	125A																			•		
LDV Electro Science Ind., Inc.	126A	•																				
Lambda Electronics	127A											•										
Lancer Chemical, Inc.	128A		•					•														
Lebow Company	129A							•					•									
Lindgren R.F. Enclosures, Inc.	130A			•			•										•					
Lindsay Shielding Int'l. Steel Co.	131A						•															
Lorch Electronics Co.	132A											•										
Lu-Sol Products	133A		•					•		•	•				•							
MIC Technology Corporation	134A							•														
Magnetic Shield Division Perfection Mica Co.	135A					•							•					•				
Magnetics, Division of Spang & Co.	136A																	•				
Maxwell Laboratories, Inc.	137A																			•		
McLean Engineering	225A			•																		
Mercury Wire Products, Inc.	138A					•																
Mereco Division Metachem Resins Corp.	139A							•		•	•						•					
Merix Chemical Co.	140A										•				•							
Merrimac Industries, Inc.	141A											•				•						
Metco, Inc.	142A							•														

How to avoid Capitol Punishment.

Now there's a code of silence in Washington. It's called FCC Docket 20780. And the Cannon® Shielded/Shrouded D Series of subminiature connectors helps manufacturers meet all its stringent EMI/RFI requirements.

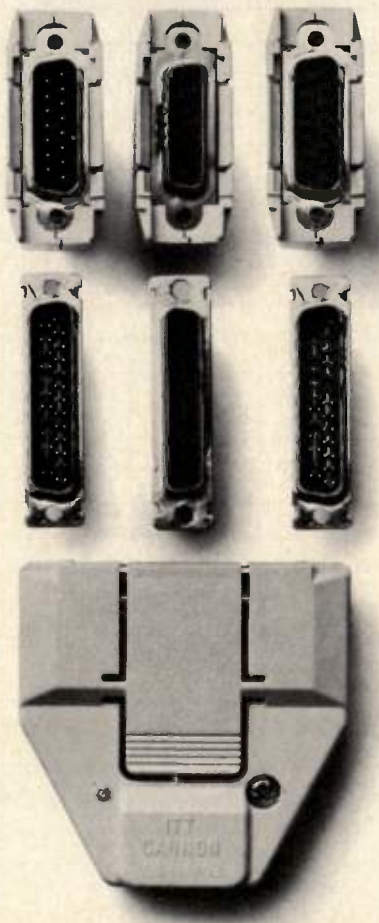
Our shield is crimped to the cable to maximize shielding effectiveness and provide a low-impedance path to the ground.

The shroud/plastic backshell protects the equipment from ESD (Electro Static Discharge) and isolates the user from ground potentials. Plastic strain-relief members are provided. The center-latched version is available in configurations of 15, 25 and 37 contacts.

Cannon's quality D Subminiature Transverse Monolith Filter connectors reduce EMI/RFI noise.

The addition of the transverse monolith filter expands the overall shielding versatility of the D Subminiature without adding to the overall dimensions of the connectors. These Cannon connectors are available in up to 37 positions, with a wide range of capacitances and cutoff frequencies.

Silence FCC Docket 20780 with D Series subminiature connectors.



The Shielded/Shrouded D and Transverse Monolith Filter Series connectors from ITT Cannon. The best way to give FCC Docket 20780 the silent treatment.

So call Cannon. You'll get more than great connectors. You'll benefit from our expanded R&D program — **Response and Delivery.**

For more information on Transverse Monolith Filter Connectors, contact Phoenix Division, ITT Cannon, 2801 Air Lane, Phoenix, AZ 85034. Telephone: (602) 275-4792. Or for more information on the D Subminiature Shielded/Shrouded D Series, contact Commercial Interconnect Products, ITT Cannon, a Division of ITT Corporation, 10550 Talbert Avenue, Fountain Valley, CA 92708. Telephone: (714) 964-7400. For the local sales office nearest you, call toll-free: (800) 845-7000.

CANNON ITT
The Global Connection

INFO/CARD 24

EMC/EMI Suppliers Product Matrix

	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable, Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
Micro-Circuits Co., Inc.	143A		•					•		•	•			•	•		•					
Micro-Now Instrument Co., Inc.	144A																			•		
Microlab/FXR	145A											•										
Microwave Filter Co., Inc.	146A	•																				
Microwave Systems, Inc.	147A																			•		
Midisco	148A					•																
Minor Rubber Co., Inc.	149A									•				•								•
Motorola Inc. Components Div.	150A											•										
Multi-Flex Seals, Inc.	151A													•								
Murata Erie North America, Inc.	152A											•				•						
NWL Transformers	153A																•					
National Magnetics Group	154A																•					
Netcom, Inc.	155A											•										
Neutrik Products, Inc.	156A					•																
Omega Engineering, Inc.	157A					•					•				•							
Oneida Electronic Mfg. Co., Inc.	158A		•																			•
Optical & Conductive Coatings	159A							•														
Optical Coating Lab., Inc./OCLI	160A							•														
Oxley Developments Co. Ltd.	161A											•										
OY Euramecano AB	162A						•															
Pelforma Industries, Inc.	163A		•			•	•		•				•	•			•	•				
Penn Microwave Devices	164A	•																				
Permabond International	227A		•																			
Piconics, Inc.	165A											•										
Picosecond Pulse Labs, Inc.	166A																			•		
Pioneer Components Corp.	167A										•											
Plessey Microwave Materials	168A	•								•												
Polard Electronics, Inc.	169A															•				•		
The Polymer Corp.	170A																•	•				
Polyphase Instrument Co.	171A											•				•						
Polysciences, Inc.	172A		•								•											
Power Dynamics Inc.	173A											•										
Powercube Corp.	174A											•										
Precision Paper Tube Co.	175A																					•
RF Products	176A					•						•										
RF Products, Inc.	177A																					
RFI Corporation	178A											•				•						
RLC Electronics, Inc.	179A											•										
Racal-Dana Instruments, Inc.	180A																			•		
Rantec Division, Emerson Ele. Co.	181A	•			•		•															
Rayshield Ltd.	182A						•															

One Antenna Kit with everything, to go please.

A complete line of kits with upper limits to 18GHz that satisfy FCC, VDE, and MIL-STD 461 specifications, and more.

Antenna kits that meet your specifications of high quality and frequency response, and that are also responsive to your demands of portability and easy use. A.H. Systems offers nine different kits that fill the bill. Each comes in a single, lightweight case. Just one kit can contain all the antennas, probes and cables to perform E-Field 1KHz-18GHz, H-Field 20Hz-50KHz and conducted 20Hz-100MHz testing. Antenna factor calibrations are provided with each antenna.

So order one to go, with everything, or one of our other tantalizing specials.

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/510	300 - 1800 MHz	Log Periodic
SAS-200/511	1000 - 12000 MHz	Log Periodic
SAS-200/512	200 - 1800 MHz	Log Periodic
SAS-200/518	1000 - 18000 MHz	Log Periodic
SAS-200/530	150 - 550 MHz	Broadband Dipole
SAS-200/540	20 - 300 MHz	Biconical
SAS-200/541	20 - 300 MHz	Bicon'l Collapsible

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/542	20 - 300 MHz	Biconical, Folding
SAS-200/550	001 - 60 MHz	Active Monopole
SAS-200/560	per MIL-STD-461	Loop - Emission
SAS-200/561	per MIL-STD-461	Loop - Radiating
BCP-200/510	20 Hz - 1 MHz	LF Current Probe
BCP-200/511	100 KHz-100 MHz	HF/VHF Crnt. Probe

INFO/CARD 25

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A.H. SYSTEMS

EMC/EMI Suppliers Product Matrix

	Reader Response #	Absorbers	Adhesives/Adhesive Films	Air Filters	Anechoic Materials	Cable. Shielded	Chambers/Shielded Rooms	Coatings	Contact Strips	Elastomers	Epoxy	Filters	Foils	Gaskets	Lubricants	Networks	Shielding Materials	Tapes	Test Cells	Test Equipment (EMC EMI)	Test Equipment (ESD)	Tubing Shielded
Remee Products Corp.	183A					•																
Republic Packaging Corp.	184A							•														
Research Products Corp.	185A			•								•										
Reynolds Ind., Inc.	186A					•																
Ribbon Cable Co.	187A					•																
Richey/Western Electronics, Inc.	188A					•																
Rilsan Corporation	228A		•																			
Rogers Corporation														•								
Microwave Materials Division	189A																					
The Milton Ross Company	190A																			•		
Rutherford Research	191A																			•		
SAE Power Devices	192A											•										
Sanders Associates, Inc.	193A											•										
Saxton Products, Inc.	194A					•																
Schaffner EMC, Inc.	195A											•				•				•	•	
Scientific-Atlanta, Inc.	196A																			•		
Seiscor Technologies, Inc.	197A																			•		
Shogyo International Corp.	198A					•																
Shokai Far East Ltd.	199A					•																
Shurite Meters, Inc.	200A																			•		
The Simco Co., Inc.	201A								•													
Sinclair & Rush, Inc.	202A																					•
Skyway Magnetics	203A																			•		
Sloan Technology Corporation	204A																			•		
Solar Electronics Company	205A											•										
Soundcoat Company, Inc.	206A									•												
Southwall Technologies	207A	•																				
Spaulding Fiber Co., Inc.	208A																•					
3M/Electro-Products Division	209A		•										•					•				
Tafa Incorporated	210A							•									•					
Tech Comm, Inc.	211A																			•		
Tech-Etch, Inc.	212A								•					•								
Tecknit	213A		•	•				•		•	•		•	•	•		•	•				
Tektronix, Inc.	214A																			•		
Tensor, Inc.	215A																			•		
Test Equipment Corp.	229A																			•		
Transmet Corp.	216A									•	•								•	•		
Trompeter Electronics, Inc.	217A					•																
U.S Microtek Components Corp.	218A											•										
Watkins-Johnson Co., SP Div.	219A																			•		
Waveline, Inc.	221A	•																				
Whitmore Wire & Cable Corp.	222A					•																
World Business Corporation	223A					•																
The Zipper Tubing Co.	224A																•					•

Take the guess out of rfi testing.

You've decided not to take chances with rfi susceptibility. Then why mix and match the tools you'll use to test for it?

Instead, you can equip your entire test loop with instruments from Amplifier Research that have been thoroughly tested and work well with our high-performance broadband rf amplifiers.

From 1W to 10kW, 10 kHz to 1,000 MHz, in 32 standard models, AR amplifiers give you optimum power, bandwidth, and versatility for your cw, sweep, and pulse requirements. Each model provides instantly available bandwidth without bandswitching or tuning, is completely immune to load mismatch, and won't shut itself down when you may need it most.

But a high-quality test presumes high-quality test equipment throughout. So we also supply specialized antennas, leveling preamplifiers, field sensor systems, fiber-optic telemetry links, TEM cells, matching transformers, and directional couplers.

With this full-system approach, equipment variables are less likely to show up in your test results. It'll pay you to talk with us about *all* your rfi test requirements.

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INFO/CARD 26

7977

DIGITAL ATTENUATORS

63.5 dB
30-500 MHz

7 Bits: 0.5 dB least significant

internal driver
TTL or CMOS compatible

Specification	TTL	CMOS
Part Number	DA0295	DA0285
Control	7 line TTL	7 line CMOS
D.C. Power	+5 VDC at 50 mA	+5 to +15 VDC 25 mA
Frequency	30 to 500 MHz	
Range	63.5 dB Above Insertion Loss	
Sections	0.5, 1, 2, 4, 8, 16, 32 dB	
Switching Speed	5 Microseconds Nominal	
R.F. Power	+13 dBM CW Maximum	
Insertion Loss	6 dB Maximum	
VSWR	1.35 Maximum	
Impedance	50 Ohms	

Industry Leader in Microwave Integrated Circuit & Connectorized Switches, Step Attenuators, Voltage Control Attenuators

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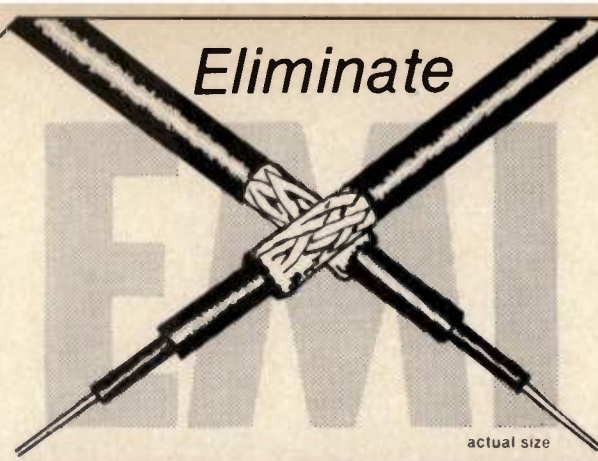
2351 East Del Amo Blvd., Compton, Calif. 90220
Telephone: (213) 631-1143 · TWX 910-346-6741

mp8408

INFO/CARD 27

Eliminate EMI



actual size

CAPCON LOSSYLINE™ Flexible Filter absorbs and dissipates unwanted or spurious electrical energy such as RFI/EMI, harmonics or other "noise." Inexpensive and easy to use. LOSSYLINE™ requires no grounding, connectors or housing. All types of connectors may be used as required.

- 10 MHz to 100 GHz
- 10 to 100,000 Volts
- 100 dB attenuation
- − 67° to + 250°C
- 1 mA to 50 A
- 0.5" Minimum bend radius

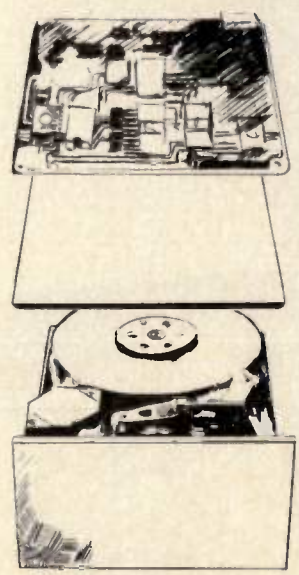
CAPCON, INC.

147-149 W. 25th Street
New York, N.Y. 10001
212-243-6275

SEND NOW FOR TECHNICAL LITERATURE

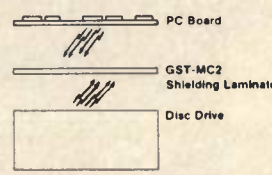
INFO/CARD 28

GST-MC2 Shielding Laminates



When it comes to direct shielding of printed circuit boards, Glasteel Industrial Laminates will help keep you covered with GST-MC2 shielding laminates.

Applications include die cut forms to reduce RFI in disc drives, card cage PC board radiated interference, or aesthetic coverings for walls to effect shielding to E fields of greater than 120 dB at 1 MHz to 70 dB at 500 MHz.



Features:

Excellent fabricating qualities

May be die-cut to almost any size and shape

Inquire for your special requirements

Glasteel Industrial Laminates

A DIVISION OF THE ALPHA CORPORATION
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(213) 357-3321

INFO/CARD 29

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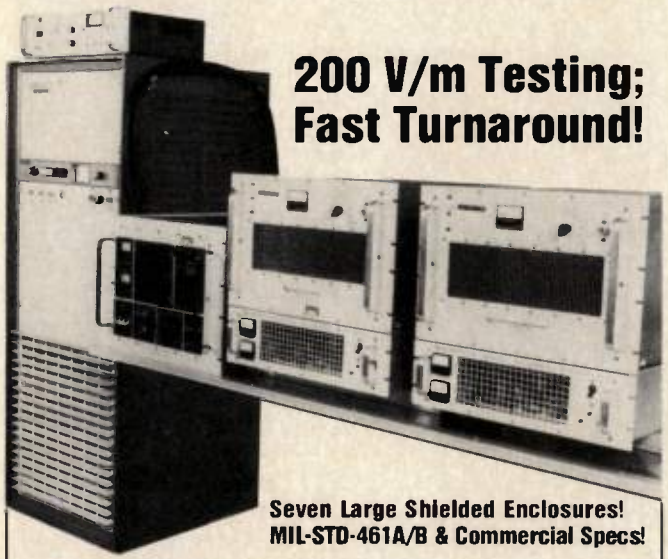

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LMI LectroMagnetics, Inc.

INFO/CARD 33

Automatic MIL-STD and Commercial EMI Measurements

COMPLETE MIL-STD 461A/B TESTING

The new HP 85864A EMI Software gives HP 8566A/B and 8568A/B spectrum analyzer based systems complete, automatic MIL-STD measurement capability to 22 GHz and above.

COMMERCIAL TEST CAPABILITY

Adding the HP 85650A Quasi-Peak Adapter to the HP 8566A/B or HP 8568A/B spectrum analyzers provides quasi-peak detection for FCC and VDE measurements.

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The new HP 85864A EMI Software not only performs MIL-STD and commercial compliance tests, but also permits the rapid analysis of emissions with diagnostic features such as:

- "TUNE & LISTEN" for easy identification of ambient signals.
- "ZOOM LOCAL" to select and evaluate emissions.
- "PRE-VIEW" to confirm test set-up.

The HP 85864A EMI Software is priced at $3020 (U.S.A. list price only).

For more information about HP's automatic EMI measurement solutions, call your local HP sales office listed in the White Pages. Or write to the following address: Hewlett-Packard, Dept. 5222, 1424 Fountain Grove Parkway, Santa Rosa, CA 95401.

HEWLETT PACKARD

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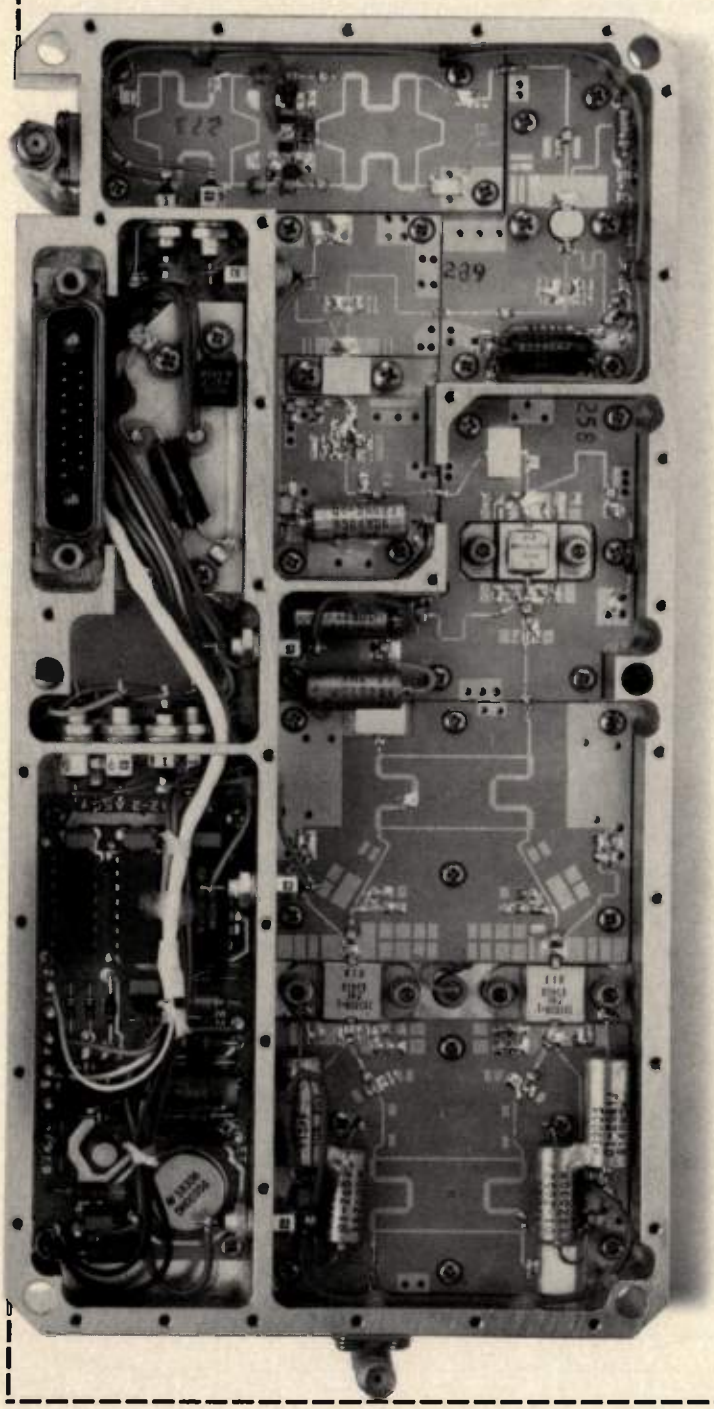
INFO/CARD 34

LOOK AT ALL THE SPACE YOU SAVE WITH RT/DUROID 6010.



The large, empty space on the left is brought to you by RT/duroid® 6010—the new soft substrate from Rogers that can shrink a circuit by 30%. And let you design in higher quality and reliability to boot.

MAKE CIRCUITS 30% SMALLER. AND INFINITELY BETTER.

RT/duroid 6010 has a dielectric constant as high as many ceramic substrates—yet it's soft, durable and easy to work with. It lets you position components much more compactly, without resorting to touchy ceramics. And components—with their interconnecting traces—can be etched on a single board, virtually eliminating wirebonding. That means faster assembly. Superior reliability. And cost savings, across the board.

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INFO/CARD 35

A Prompting HP-67 Calculates h_{fe} and f_T From S-Parameters

By Ed Oxner
Siliconix Inc.

Here's a program especially suited for users of the Hewlett Packard HP-67 programmable calculator that *prompts* the user to enter data (And you thought only the HP-41 could prompt)!

This program calculates f_T — the gain-bandwidth product — of transistors using S-parameter data available from network analyzers which are generally offered in power coordinates (dB and phase). Simultaneous with offering both h_{fe} and f_T the program stores S-parameter data in rectangular coordinates in Registers 0 through 7 for easy access should the user wish to use the S-parameters in subsequent programs.

Should the user wish to input S-parameters already in rectangular coordinates, simply omit the four 'f GSB D' commands (lines 8, 22, 46 & 56) and the final subroutine beginning on line 93 (f LBL D).

To run the program first enter the frequency at which the S-parameters were measured by keying A. the calculator prompts by reading 22.00, which means you enter S22 magnitude data (dB) by means of the ENTER key and the angle by keying the R/S. After following the prompts the first readout will be h_{fe} followed by f_T. Access to the rectangular coordinates of the S-parameters is available at the conclusion of the program by recalling (RCL) any Register, 0 through 7.

0	M11	4	M12
1	A11	5	A12
2	M21	6	M22
3	A21	7	A22

Step	Instructions	Input Data/Unit	Keys	Output Data/Units	
1	Load Program			0.00	
2	Input Frequency of Measured S-param.	MHz	A	22.0	
3	Input Magnitude of S_{22}	dB	↑	MAG22	
4	Input Angle of S_{22}	degrees	R/S	11.00	
5	Input Magnitude of S_{11}	dB	↑	MAG11	
6	Input Angle of S_{11}	degrees	R/S	12.00	
7	Input Magnitude of S_{12}	dB	↑	MAG12	
8	Input Angle of S_{12}	degrees	R/S	21.00	
9	Input Magnitude of S_{21}	dB	↑	MAG21	
10	Input Angle of S_{21}	degrees	R/S	hfe	
				f_T	
	All S-parameters in rectangular				
	coordinates (Magnitude & Angle)				
	are stored in Registers 0 thru 7				
	S REGIST.				
	M11 0				
	A11 1				
	M21 2				
	A21 3				
	M12 4				
	A12 5				
	M22 6				
	A22 7				
	Data stored in these Registers				
	are available for subsequently				
	loaded programs				

USER INSTRUCTIONS

h_{fe} & f_T R = 0 thru 7
o Asks for S-parameters (dB/phase)

Step	Key Entry	Key Code
01	f LBL A Freq (MHz)	31 25 11
02	STO A	33 11
03	2	02
04	2 Prompts for S22	02
05	R/S Input S_{22}	84
06	STO 7	33 07
	h x ≷ y M_{22} =x; A_{22} = y	35 52
08	f GSB D	31 22 14
09	STO 6	33 06
010	f P → R	31 72
011	1	01
012	+	61
013	g R → P Polar storage of $(1 + S_{22})$	32 72
014	STO 8	33 08
015	h R↓	35 53
016	STO 9	33 09
017	1	01
018	1 Prompts for A11	01
019	R/S Input A_{11}	84
020	STO 1	33 01
021	h x ≷ y M_{11} = x; A_{11} = y	35 52
022	f GSB D	31 22 14
023	STO 0	33 00
024	f P → R	31 72
025	1	01
026	h x ≷ y	35 52
027	–	51
028	h x ≷ y	35 52
029	CHS	42
030	h x ≷ y	35 52
031	g R → P	32 72
032	STOX8 $(1 - S_{11})$ $(1 + S_{22})$	33 71 08
033	h R↓	35 53
034	STO + 9	33 61 09
035	RCL 9	34 09
036	RCL 8	34 08
037	f P → R	31 72
038	STO 8	33 08
039	h R↓	35 53
040	STO 9	33 09
041	1	01
042	2	02
043	Prompts for A12 R/S Input A_{12}	84
044	STO 5	33 05
045	h x ≷ y M_{12} = x; A_{12} = y	35 52
046	f GSB D	31 22 14
047	STO 4	33 04
048	STO B	33 12

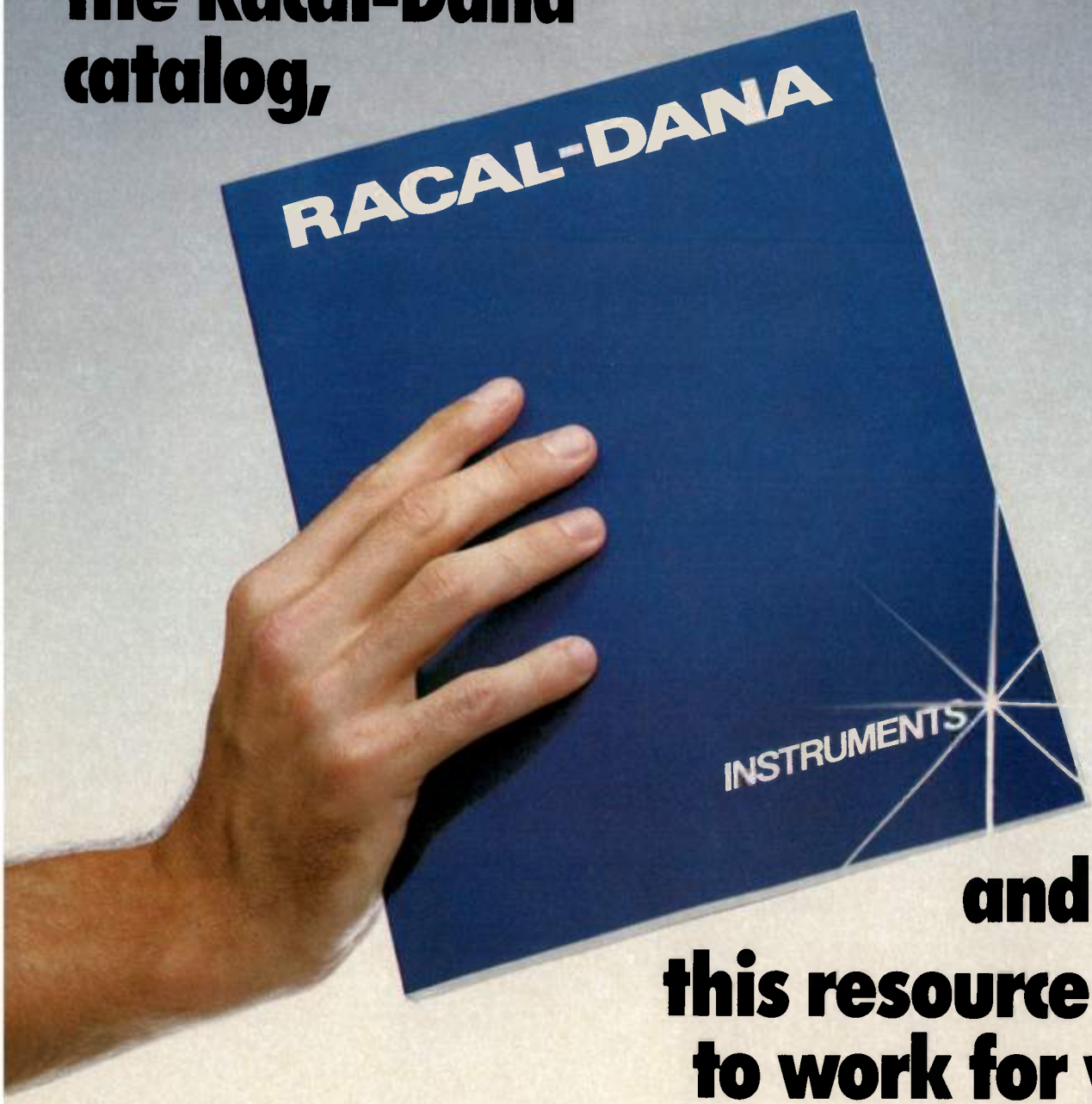
r.f. design

Step	Key Entry	Key Code
049	h R↓	35 53
050	STO C	33 13
051	2	02
052	1 Prompts for A21	01
053	R/S Input A_{21}	84
054	STO 3	33 03
055	h x ≷ y	35 52

Step	Key Entry	Key Code
	$M_{21} = x$; $A_{21} = y$	
056	f GSB D	31 22 14
057	STO 2	33 02
058	STO D	33 14
059	h R↓	35 53
	STO E	33 15
	A_{21}	
061	RCL C	34 13
	A_{12}	

Step	Key Entry	Key Code
062	+ $A_{21} + A_{12}$	61
063	RCL B M_{12}	34 12
064	RCL D M_{21}	34 14
065	X $M_{12} \times M_{21}$	71
066	f P → R	31 72
067	STO + 8 $(S_{12})(S_{21})$ +	33 61 08
068	h R↓ $(1 - S_{11})(1 + S_{22})$	35 53
069	STO + 9	33 61 09
070	RCL 9	34 09
071	RCL 8	34 08
072	g R → P	32 72
073	STO 8	33 08
074	h R↓	35 53
075	STO 9	33 09
076	RCL B	34 12
077	RCL D	34 14
078	2	02
079	CHS −2	42
080	X	71
081	RCL 8 Denominator	34 08
082	÷	81
083	h x ≷ y	35 52
084	RCL 9	34 09
085	−	51
086	h x ≷ y	35 52
087	f P > R	31 72
088	g R > P	32 72
089	f − x − h_{fe}	31 84
090	RCL A	34 11
091	X h_{fe} x Freq.	71
092	h RTN f_T readout	35 22
093	f LBL D	31 25 14
094	2	02
095	0	00
096	÷	81
097	g 10^x	32 53
098	h RTN Returns Rect. coordinates	35 22
099	R/S	84

Get your hands on the Racal-Dana catalog,



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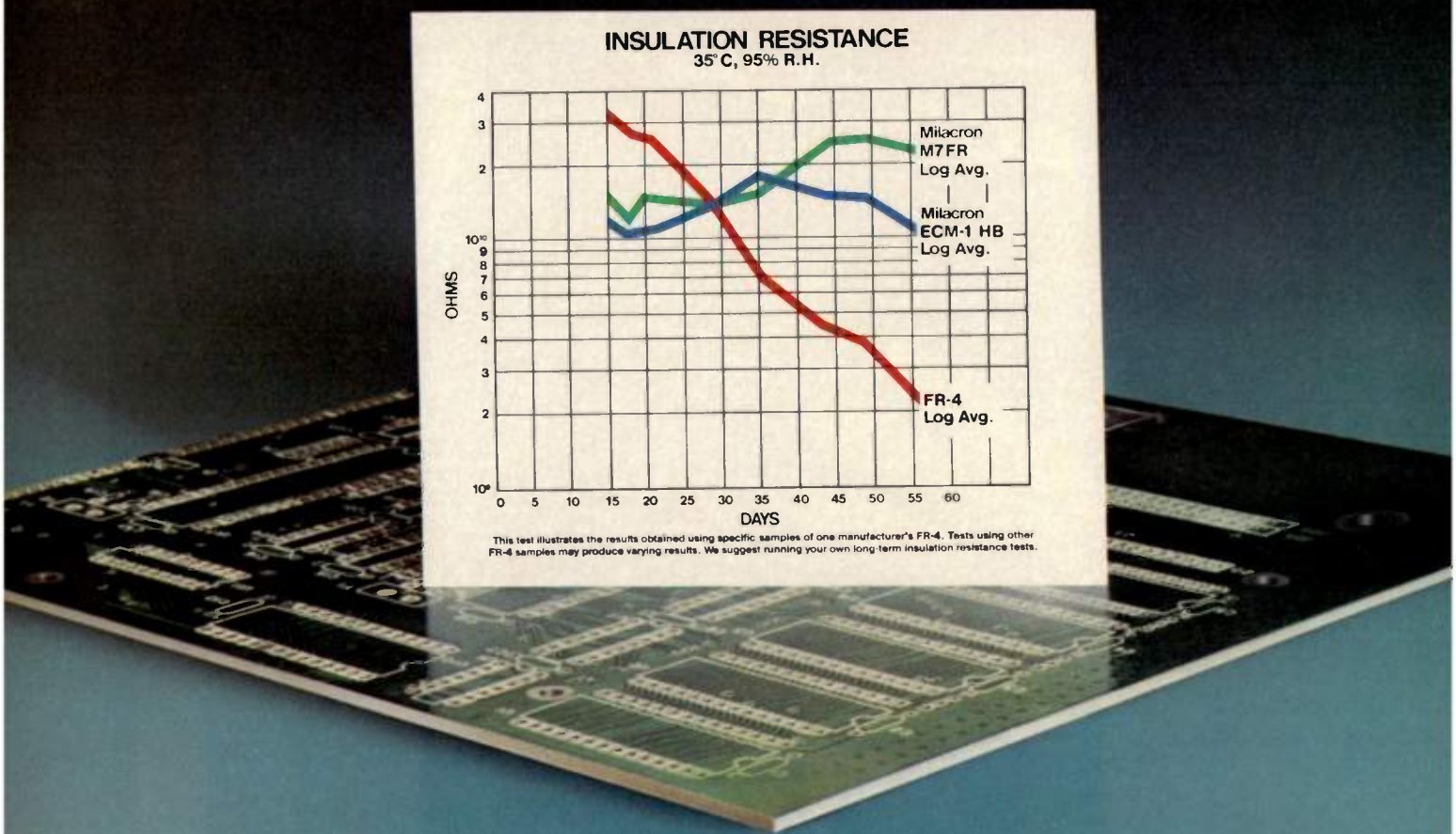
INFO/CARD 38

What Good Are Good Electricals If They Don't Stay That Way?



Milacron all-glass laminates.

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As a designer, you know that one of the most important functions of a PWB laminate is to provide good insulation resistance. So you want to be sure you specify a laminate that performs well in this crucial area. That's where Milacron laminates excel.

As illustrated in the test results above, Milacron laminates maintain stable insulation resistance over time, even in conditions of high temperature and humidity. *More stable than the FR-4.*

That's right — over the several weeks of the test period, the FR-4 lost a considerable amount of its insulation resistance, while Milacron laminates remained steady throughout the test period.

Take them into the harsh environments of high temperature, high humidity, and high voltage (50V or more), and Milacron laminates give you an added advantage: they provide *10 times* more resistance to conductive anodic filaments (CAF) than typical FR-4 laminates!

Our conclusion: Milacron laminates — single- and double-sided — perform exceptionally well in these difficult environmental applications.

And that's not all. Take a look — over high and low frequencies — at our stable dielectric constant and dissipation factor. Our excellent dimensional stability and processing performance. And our cost-effectiveness: one customer, for example, reports a 25% savings in cleaning and touch-up costs, due to the superior solderability of Milacron laminate. *Milacron laminates save you money, both upfront and in use.*

Milacron laminates. The reliable choice.

But don't take our word for it. Contact the Cincinnati Milacron Marketing Company, P.O. Box 246, Blanchester, Ohio 45107 for samples that best fit your applications. Or call toll-free 1-800-221-7084; in Ohio call 513-783-2464.

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CINCINNATI MILACRON

Electronic Circuit Materials Division

INFO/CARD 89

The new Model 5155A synthesizer is ideal wherever a very pure, high-frequency signal source is needed at a reasonable price in the laboratory and in production for communications or radar.

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Phase noise is exceptionally low, particularly close to the carriers where low phase noise is most important for signal multiplication or closely spaced communication channel testing. Typical performance is: −100 dBc/Hz at 10 Hz offset (500 MHz), and −90 dBc/Hz at 1 Hz offset.

Priced at less than $15,000, the Model 5155A cost thousands less than you'd have to pay for this high-level performance elsewhere, So get more details before you spend too much and get too little for your money.

Call or write Wavetek San Diego, Inc., 9045 Balboa Ave., P.O. Box 85265, San Diego, CA 92138. Tel: (619) 279-2200; TWX 910-335-2007.

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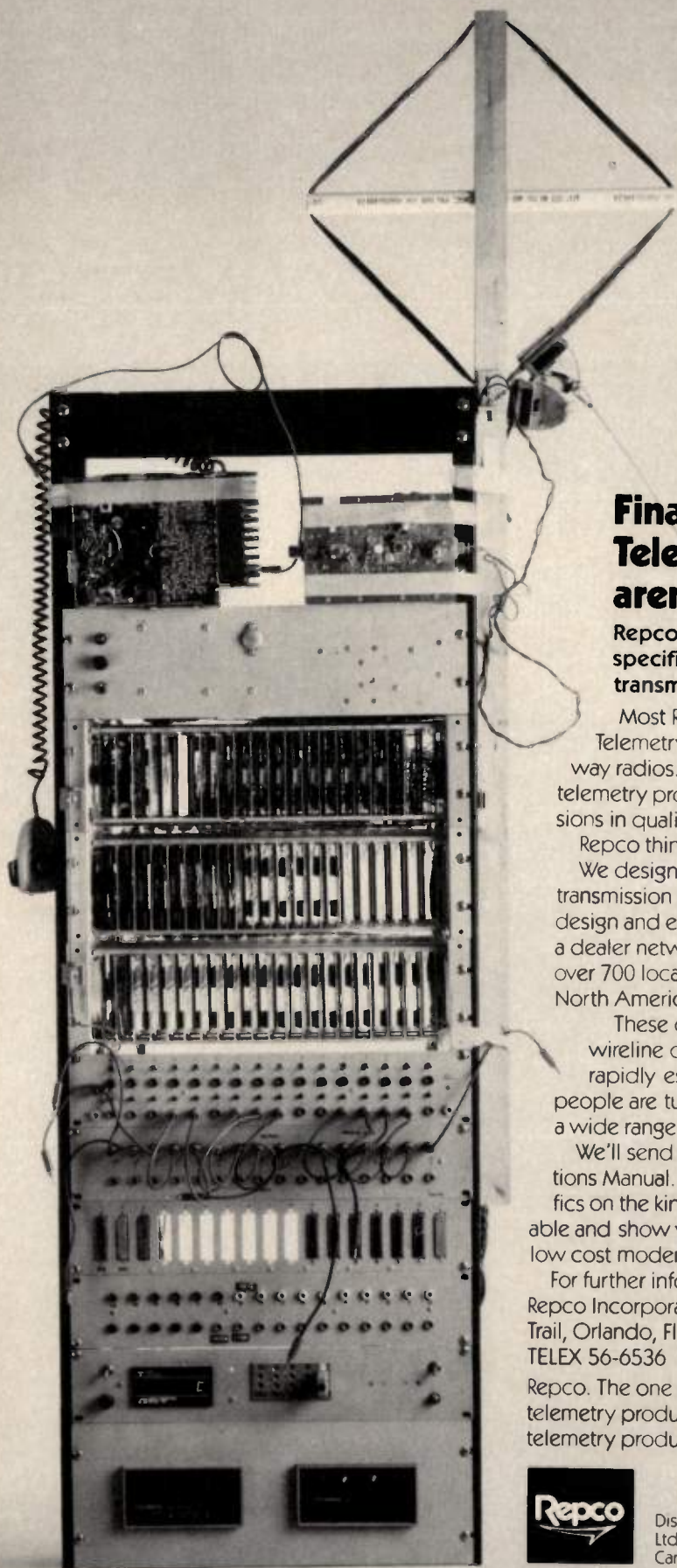
DEMONSTRATION INFO/CARD 42
LITERATURE INFO/CARD 86



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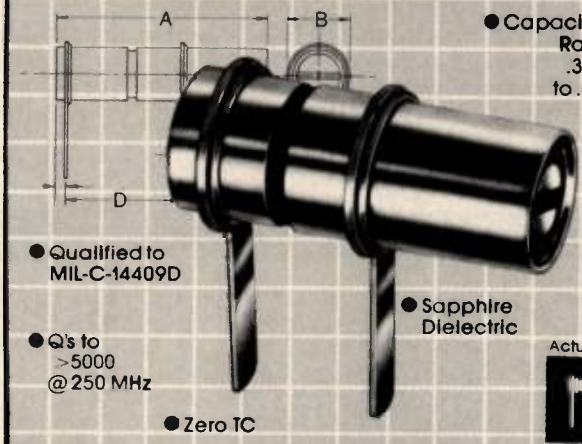

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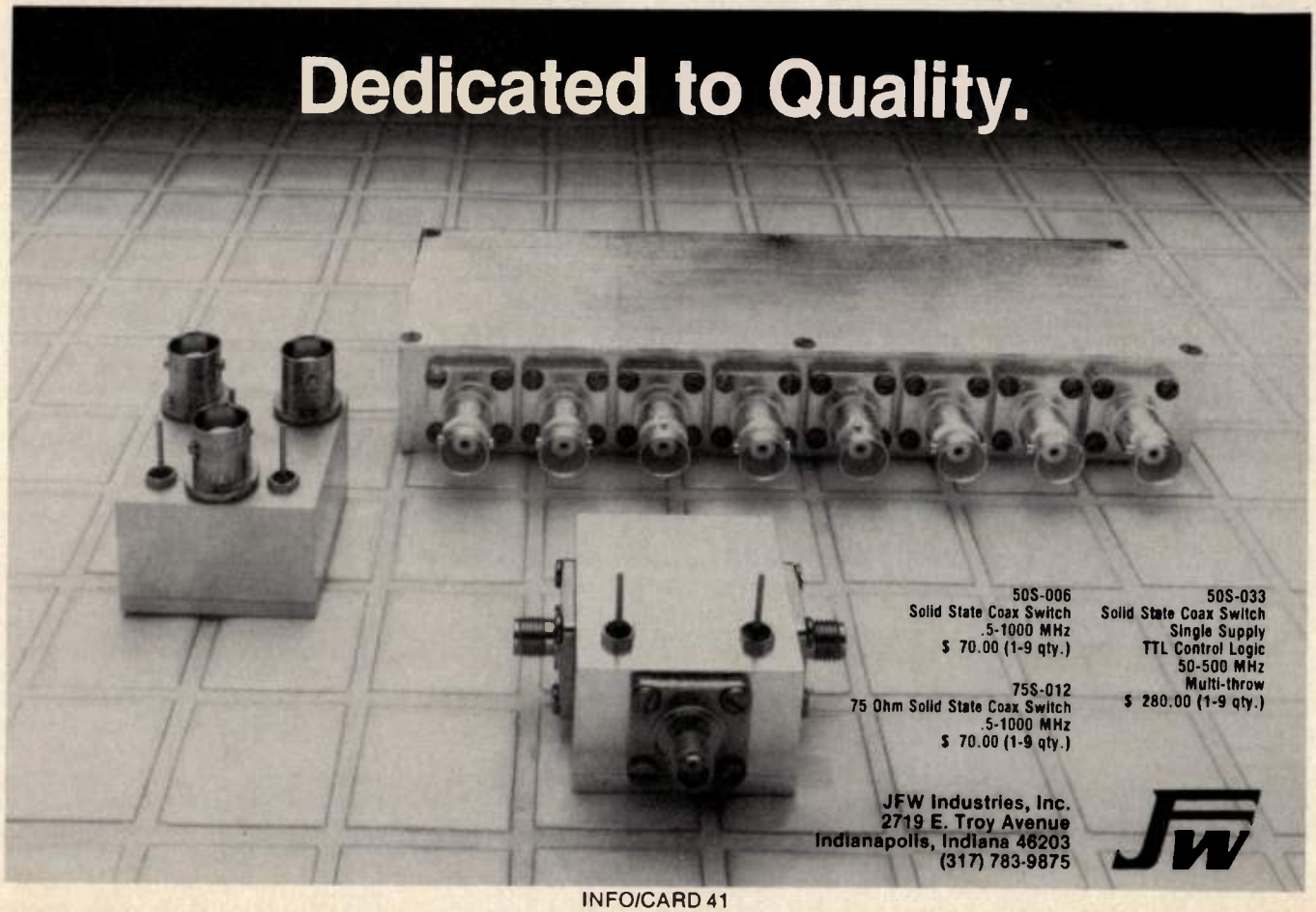

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JFW

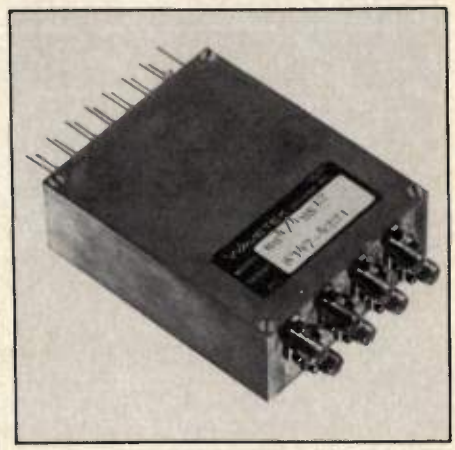
INFO/CARD 41

100 Watt Transistor

Thomson Semiconductor announced availability of the TCC 0105-100, an operationally-balanced 100 watt transistor with internal inductive-capacitance (LC) matching networks, operating in the 100 to 500 MHz frequency range, with 7.5 dB gain at 28 volts, under CW conditions. TCC 0105-100 is designed for extremely wideband amplifier applications in UHF military and industrial communications. It directly replaces the Acrian 0105-100. It is available in a balanced package or flangeless ceramic package. Balanced prices start at $165 for 1-24 pieces, $161.20 for 25-99 pieces, $141.85 for 100 pieces, with delivery between six to eight weeks. **Thomson Semiconductor, RF Marketing Group, Montgomery, PA 18936, INFO/CARD #135.**

Programmable 4x4 Matrix Switch

The Wavetek RF & Microwaves Components Business Unit, located in Beech Grove, Ind., are introducing a unique new Programmable 4 x 4 Matrix Switch which has a frequency range of DC-1000 MHz at an impedance of 50 ohms. Specifications of the programmable 4 x 4 matrix switch includes and insertion loss < 2.0



dB at 1000 MHz and a VSWR of < 1.5:1 at 1000 MHz. The isolation on this model is > 30 dB at 1000 MHz. Configuration of the Programmable includes four inputs and four outputs. Any input may be connected to any output individually. All unused ports are 50 ohm terminated. The operating voltage is a standard 12 volt but is also available in 5, 6, 9, 18 and 26 volts. Power handling is 1 watt CW with a switching speed of < 6 MSEC at an operating temperature range of –55°C to +71°C. Dimensions of the case (excluding connectors) are L = 3 in., W = 2.5 in., H = 1.0 in., with a weight of 5 oz. The connectors for this unit are SMA Female for RF in/out and solder terminals for control. Price: $695.00. Delivery: 8 weeks ARO. **Wavetek Indiana, Inc., RF and Microwave Components, Beech Grove, Indiana 46107, INFO/CARD #134.**

RFI Shielded Packages

The Modpak system of shielded packaging has specially designed RF connectors that typically provide VSWR of 1.2 or less up to 1.5 GHz when a 50-microstrip p.c. board is installed in the case. Twenty-seven standard packages are available from stock for shipment in less than 24 hours. Using 13 standard extrusions, custom models can be supplied to customer specifications in three weeks. Fabricated models can be made from customer drawings of sketches in four weeks. The Modpak mounting clip and connector locking system permit p.c.

boards to be positioned and retained quickly. Direct access to circuits and choice of connectors are other important features. **Adams-Russell, Modpak Division, Burlington, MA, please circle INFO/CARD #133.**

Professional Microphone

Crown International's new 12 SP model microphone offers studio quality in recording, sound reinforcement, broadcasting and electronic news gathering for the experienced professional. The 12 SP is phanton powered by a supply providing 18 to 48 volts. It features a transformer balanced, low-impedance output available at an integral 3-pin connector; wide, smooth frequency response with high-frequency emphasis for brilliance; low noise and high overload level (150 dB-SPL); a hemispherical pickup pattern; high sensitivity and excellent reach for clear pickup of distant sounds. A windscreen is included for outdoor or closeup use. In operation, the ruggedly constructed 12 SP can be placed on a surface such as a floor, table, or lectern; used as a hand-held microphone; or affixed to a surface near a sound source such as the underside of a raised grand piano lid. Suggested retail price is $249.00. **Crown International, Elkhart, IN 46517, INFO/CARD #132.**

TC MLC Capacitors

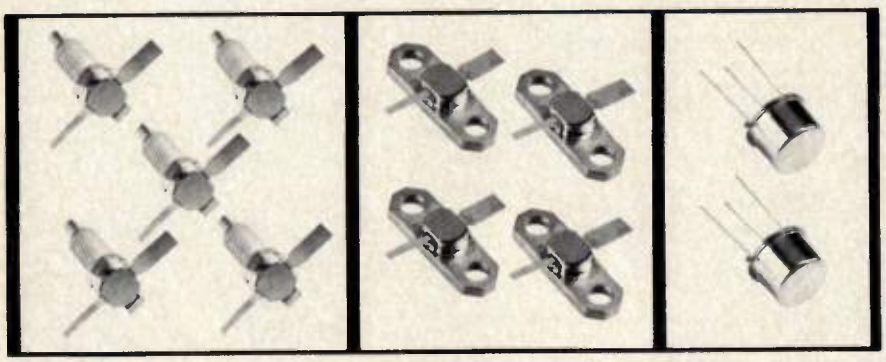
A new series of temperature compensating MLC capacitors has been introduced by the San Fernando Electric Division of SFE Technologies. These negative temperature compensation characteristics are available in N080 and N150. The company believes that these units are some of the first negative TC MLC products on the market. Providing high volumetric efficiency, packaging is available in chip form and as axial or radial leaded devices. All specifications, including environmental, electrical and packaging, are identical to the standard San Fernando Electric Division NP0 series of MLCs, with the exception of the temperature coefficient N080/N150. Superior performance over film type capacitors is achieved due to greater stability and tighter tolerances. The negative TC MLC units can effectively withstand hostile environments created by high production soldering methods without degradation or changes in value. Chip capacitors and axial or radial leaded devices, including a 2 pin DIP configuration, are available in bulk or tape-and-reel for automatic assembly. Evaluation samples in chips and 2 pin DIP configurations are available upon request. **SFE Technologies, San Fernando Electric Division, San Fernando, CA, INFO/CARD #131.**

BNC Bulkhead Connectors

Marshall Electronics Inc. is introducing a new series of BNC bulkhead connectors for computer, data and video installations. The connectors have been designed to meet the latest requirements of the commercial market which includes ease of installation, adaptability to different panel materials, cost effective design and mil-type performance. The connectors are available in female to female and direct cable to female. Isolation "D" washers are available for each type when it is necessary to isolate the connectors from metal panel installations.

New TX Microwave/CRT Transistors for MIL-S-19500 applications

Choose from 11 TRW RF devices processed to the equivalent of JANTX, with full documentation available.*



When the RF performance level you want isn't readily available on the MIL-S-19500 Qualified Products List (QPL), try the TRW list of Standard REL Processed Devices. You'll find 11 microwave linear and CRT Z-Axis drivers REL processed to an integrity level equivalent to JANTX—and we supply all the documents you need for military use qualification. This means large savings to you because you eliminate masses of expensive drawings and possibly months of testing. All you do is fill out a one-page form—and we can even help you with that! It's that simple to get these parts qualified.

TRW STANDARD REL PROCESSED DEVICES

STANDARD PART NUMBER	STANDARD REL EQUIVALENT PART NUMBER		DESCRIPTION
LT1001A	TX1033	3.0GHz TO-39	Low Noise
LT1814	TX1814	High Voltage CRT	Z-Axis Driver GP-14 Stud
LT1839	TX1839	High Voltage CRT	Z-Axis Driver TO-39
TRW52501	TX52501	1.5W 2GHz GP-14	Common Emitter, Isolated Stud
TRW52502	TX52502	3.0W 2GHz GP-14	Common Emitter, Isolated Stud
TRW52601	TX52601	1.5W 2GHz HLP-8	Common Emitter, Grounded Flange
TRW52602	TX52602	3.0W 2GHz HLP-8	Common Emitter, Gounded Flange
TRW53501	TX53501	0.8W 3GHz GP-14	Common Emitter, Isolated Stud
TRW53601	TX53601	1.6W 3GHz HLP-8	Common Emitter, Gounded Flange
TRW54501	TX54501	0.5W 4GHz GP-14	Common Emitter, Isolated Stud
TRW54601	TX54601	0.5W 4GHz HLP-8	Common Emitter, Grounded Flange

You'll recognize TRW Standard REL Processed Devices by the "TX" prefix to their part numbers. And in small quantities (1-24) their U.S. price is in the $50 to $80 range.

The list of TRW TX devices includes two CRT drivers for ultra-high resolution featuring gain bandwidth of 1.2GHz and 130V breakdown and eight MIL-packaged microwave linear parts in studded or flanged versions with common emitter configurations offering f_T to 4GHz and powers to 3W. These units are processed according to MIL-S-19500 JANTX level and come with a Certificate of Compliance. Standard part pricing and off-the-shelf delivery through authorized TRW distributors.

For application note, which explains how easy it is to use and qualify these parts, contact RF Devices Division, TRW Electronic Components Group, 14520 Aviation Blvd., Lawndale, California 90260, phone 213.536.0888.

*Available now through your local TRW distributor.

TRW

RF Devices Division
TRW Electronic Components Group

INFO/CARD 46

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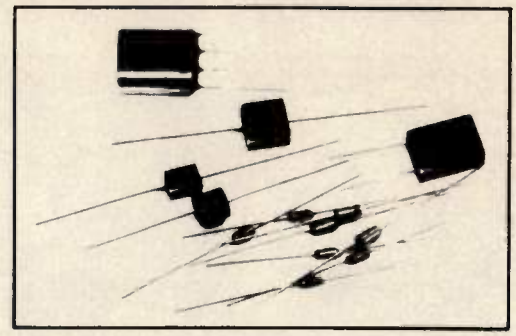
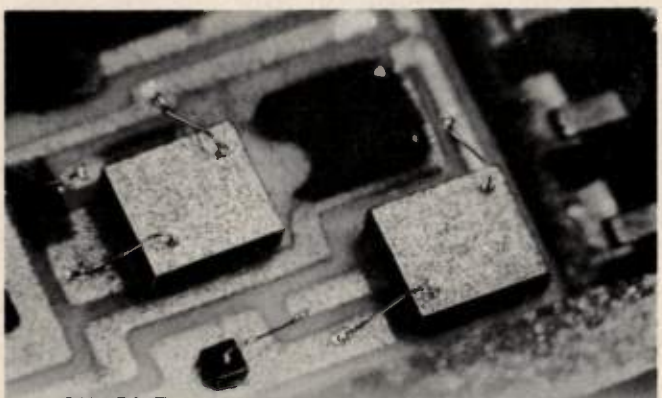
Varactor Tuning Diodes



Crystalonics offers the broadest line of varactor tuning diodes in the industry with capacitance from 6.8pf to 1,320pf & Q as high as 600. High Q JAN/JANTX 1N5139 series, very high Q JAN/JANTX 1N5461 series, & high capacitance (330pf to 1,320pf) VA521 series highlight the line. All manufactured with Crystalonics' passivated ultra-high reliability processing. Send for our free catalog.

TELEDYNE CRYSTALONICS
147 Sherman St. Cambridge, MA 02140
Tel. (617) 491-1670 • TWX: 710-320-1196

INFO/CARD 50



SINGLE LAYER PARALLEL PLATE CERAMIC CAPACITOR CHIPS

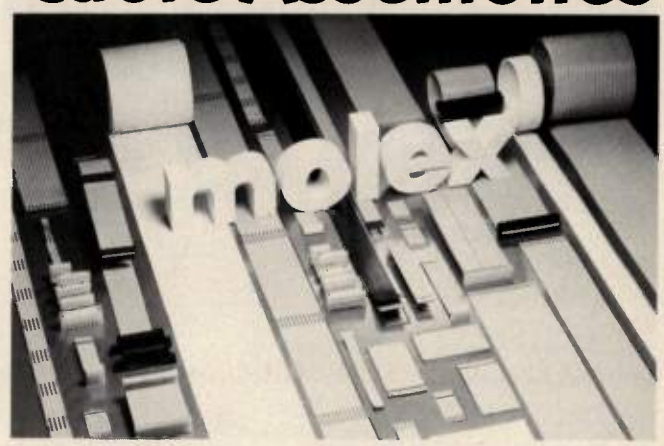
Featuring a single layer dielectric construction with associated low series inductance, this family of capacitor chips are ideal for applications ranging from DC to microwave frequencies.

Available in capacitance ranges from 0.25 pf to 15,000pf voltage ratings to 15KV, their high dielectric strength makes them resistant to damage from static discharge. Precious metal terminations are compatible with epoxy, solder or wire bonding assembly techniques.

JOHANSON DIELECTRICS

2220 SCREENLAND DRIVE, BURBANK, CALIFORNIA 91505
(213) 848-4465 TWX 910-489-2735
INFO/CARD 51

Cable Assemblies



Molex makes more than 20 different types of planar cable on four separate center spacings for a wide range of circuit configurations ... from our standard .156" single-conductor flat cable to our latest .050" foil shielded cable with stranded tinned signal wires, with wire options for 18 to 30 AWG.

Molex also offers you the added service of custom assemblies, using Molex's own compatible interconnection devices, to create a total IDT® system that meets all your exact specifications and lowers your total applied costs.

molex®

Molex Incorporated, 2222 Wellington Ct., Lisle, IL 60532
Phone: (312) 969-4550

INFO/CARD 52

Flame-Retardant Polypropylene Capacitors

The new KP8OS flame-retardant capacitors available from STK Electronics, Inc., are completely encapsulated in molded valox with epoxy end seals to prevent moisture penetration. These axial lead capacitors offer very low dissipation factors, high insulation resistance, exceptional capacitance stability and low dielectric absorption. Each unit is 100% leak tested to assure moisture resistance, making STK KP8OS Series capacitors suitable for wash systems, wave soldering and applications in humid environments. Because each is of uniform configuration, the encapsulated polypropylene capacitors are also ideally suited for automated assembly operations. Capacitance ranges from 100 pf up to 0.5 MFD. Standard or nonstandard capacitors are available with tolerances of ±0.5%, ±1%, ±2%, ±2.5% or ±5% for operating temperatures from −40°C to +105°C. Accurate control of film foil lengths, compact winding and thorough post-curing make the STK KP8OS Series one of the most compact polypropylene capacitors available. Suitable for a wide variety of telecommunications and data communications applications and precision timing circuits, the STK KP8OS Series capacitors are interchangeable with other manufacturers' polystyrene and polypropylene capacitors. **STK Electronics Inc., Cazenovia, NY 13035, INFO/CARD #129.**

Field-Installable Single Channel Fiber Optic Connector

In response to the increasing demand for low-loss single channel fiber optic connectors, a new field-installable fiber optic connector product line has been introduced by Automatic Connector, Inc. The connector is designed with a longitudinal hole precisely along the axis of the conical plug body. The diameter of the hole is 3 to 5 microns larger than the diameter of the fiber being terminated. The connectors achieve less than 1.0 dB coupling loss and are totally field-installable. They feature an epoxy/polish type of termination. The cable strength fibers are captured by the ferrule and crimped to the body using standard hex M22520 dies. Application of the shrink tubing completes the termination procedure and ensures positive cable retention. Two connector styles are available; both styles have threaded coupling. The plug connectors are mated using an adapter that contains a biconical sleeve. This alignment sleeve is precisely molded and has an internal conical configuration which matches the external taper of the molded plug. The separation and axial alignment of the fiber ends are held to demanding tolerance in order to

achieve superior coupling loss characteristics. Three cable to cable mounting adapters are available. One adapter style is totally interchangeable with the type manufactured by AT&T; another style is "D" hole mounted so as to minimize the overall size. A source/detector receptacle is also available. A unique conical sleeve alignment is used to provide precise fiber to device alignment. The source/detector is contained in one half of the conical sleeve; the cable connector mates with the other half of the sleeve. The precision tapers in the sleeve and the mating plug provide accurate positioning while preventing damage to the fiber or the device. Typical pricing for production quantities: $6.50 for connectors; $14.00 for adapters. Availability 12-14 weeks. **Automatic Connector, Inc., Commack, NY 11725, please circle INFO/CARD #128.**

Wideband Current Amplifier

MEL TEC, Division of EPSCO Incorporated, announced the release of its Wideband Current Amplifier, Model EH0002. Manufactured using Hybrid Microelectronics Technology, the EH0002 is available in an 8-lead TO-99 hermetically sealed package. The EH0002 provides operational amplifier output buffering and increased load current capability up to 400mA (pulse) for

high current and cable drivers. Typical quiescent supply current is ±6mA and current gain is typically 40A per mA. The EH0002 may be used in feedback loops without added system compensation, has low output impedance of typically 10 ohms or less, and a typical rise time less than 7 nanoseconds. The EH0002 is available in 0° to 70°C and −55° to +125°C operational temperature ranges. Availability of the EH0002H is stock to six

weeks. Price in quantities of 100 is $14.00 each. **MEL TEC, Division of EPSCO Incorporated, Westwood, MA 02090, INFO/CARD #127.**

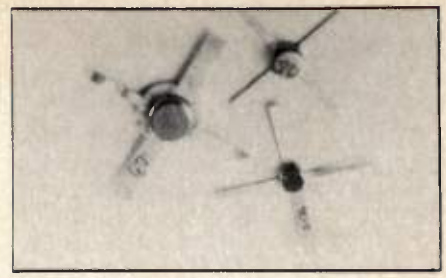
Sweep Generator Offers 10 MHz to 40 GHz Sweep

The new WILTRON 6669A Programmable Sweep Generator provides an internally levelled 10 MHz to 40 GHz sweep from a single coaxial connector. With an output power of greater than +6 dBm to 26.5 GHz and 0 dBm on up to 40 GHz, this lightweight (< 34 pounds) sweep generator sets new standards for reliability and ease-of-use in microwave measurements. The 6669A is fully IEEE-488 (GPIB) programmable, has a frequency accuracy of ±20 MHz, and attenuates spurious signals to greater than 40 dBc below 2 GHz and 60 dBc above 2 GHz. The remarkable sweep and output power performance of the 6669A is made possible through the development

of a 10 MHz to 40 GHz PIN switch, a 2 GHz to 40 GHz leveling coupler, and a 2.92 mm connector that offers glitch-free performance to 46 GHz. The engineering breakthrough that made the K Connector™ possible also spawned development of several other 40 GHz components (also available from WILTRON). They include 0.118-inch OD semirigid coaxial cable; in-line, male and female K connectors for use with the cable; and, for adapting to the user's device, microstrip-to-K male and female sparkplug-launcher connectors and microstrip-to-K male and female flange-mount-launcher connectors. In addition to the 6669A, WILTRON offers three other 40 GHz models: 6662A, 6663A, and 6668A. The 6663A offers the same performance as the 6669A, only from 2 GHz to 40 GHz. The 6668A and 6662A offer the similar performance from 10 MHz to 40 GHz and from 2 GHz to 40 GHz repectively using two output connectors: a WSMA coaxial output to 26.5 GHz and a UG-599/U waveguide output from 26.5 to 40 GHz. Delivery: 90 days. **WILTRON Company, Mountain View, CA 94042-7290, INFO/CARD #126.**

High Power Silicon Microwave MMICs

Avantek Inc. has released three new MODAMP™ silicon microwave monlithic integrated circuits with greater output



power than previous releases in this series. Designated the MSA-0420, MSA-0435 and MSA-0470, these versions offer typical output powers of +19, +13 and +13 dBm respectively at 1 dB gain compression with exceptional gain flatness of ±0.25 dB from 0.05-2.0 GHz and associated minimum gain of 8.5 dB typically. Each unit features typical noise figure of 6 dB, and a maximum usable frequency of 3.0 GHz. The MSA-0420 is housed in the Avantek 200 Mil Stripline package, the MSA-0435 in the standard micro-X package and the MSA-0470 in the industry standard 70 mil stripline package. All versions use nitride self-alignment, ion-implantation for precise control of doping and nitride passivation for high reliability and are hermetically sealed with an inert atmostphere. The -0420 and -0470 models have gold plated leads. Available from stock, domestic U.S. prices range from $7.15 and up in 100 piece quantities. These MODAMP™ silicon MMICs will be available through Avantek's network of stocking distributors and factory authorized representatives. **Avantek Semiconductor Sales, Santa Clara, CA 95051, INFO/CARD #125.**

Directional Couplers

A new series of bi-directional couplers for monitoring incident and reflected power or to sample directional power flow for measurement, test and alignment purposes has been announced by Alan Industries, Inc. These precision devices, designated the DC Series, have three external SMA female connector ports and a fourth port which is terminated internally. The fourth port will withstand open or short conditions occurring on the main arm at 5 watts input. Coupling values (dB) and frequency range (MHz) for the three models in the series are: 10 dB, 10-1000 MHz; 15 dB, 5-1000 MHz and 20 dB, 10-1000 MHz. Coupling tolerance for the

10 dB model is ±0.5 dB and ±1.0 dB for the other models. All have a 50 Ohm impedance. Size including the two hole mounting flange is: L=2.000"; W=1.000" and H=0.560". Prices for the DC Series range from $95 to $115 and all models are available for immediate delivery. **Alan Industries, Inc., Columbus, Indiana, 47202, please circle INFO/CARD #124.**

Connectors and Adapters

Gilbert Engineering announces its line of SMA, Type N and TNC connectors and adapters (between-series and in-series). These products are designed and manufactured to meet the performance specifications of MIL-C-39012, MIL-C-83517 and MIL-A-55339. Gilbert Engineering has qualified Microwave Engineers on staff to assist with your application requirements, and provide precise electrical data. **Gilbert Engineering Company, Inc., Glendale, Arizona 85301, INFO/CARD #123.**

Surge Network

KeyTek Instrument Corp. has introduced a new Surge Network, the P21, to simulate lightning and switching transients in telecommunications equipment, as required by international standard CCITT Rec. K.17. Surge Network P21, when used with a KeyTek 711 Series

Mainframe, produces the 10 x 700 μs voltage impulses to 6kV as required by CCITT. In addition, the new network produces a higher speed, 0.5 x 700 μs impulse. The desired wave is selected via a front panel, high voltage switch. The CCITT-specified output damping resistances of 0, 2.5, and 25 ohms are included internally, and are also selectable from the unit front panel. Complete systems for testing to CCITT Rec. K.17 are available from about $18,000.00. Additional Surge Networks are available for the same 711 Mainframe, for testing to various other national and international standards, including IEEE Std. 587-1980. Standard options are available for complete surge voltage and surge current monitoring using remote differential, high-voltage probes. **KeyTek Instrument Corp., Burlington, MA 01803, INFO/CARD #122.**

Ceramic Capacitors

A new line of CLA Series parallel plate single layer ceramic capacitors for microwave equipment applications is now available from Murata Erie North America, Inc. These new CLA Series parallel plate single layer capacitors with their simple electrode construction and ceramic dielectric are designed for operation over 20 GHz while providing ultra reliable performance and dielectric strength under high temperature and moisture conditions. A 50 micro-inch minimum gold plated electrode provides superior adhesion for die binding (eutectic) and thermo compression binding (wire and ribbon). In addition, multi-plate designes (binary segmented capacitance values on one chip) provide a variety of capacitance values for fine tuning, by connecting single or multiple plate combinations in parallel. **Murata Erie North America, Inc., SE, Marietta, GA 30067, INFO/CARD #121.**

Microwave Counter

Marconi Instruments announces a new Microwave Frequency Counter, Model 2440. With a frequency range of 10 Hz to 20 GHz and a resolution of 0.1 Hz, the 2440 is ideal for production testing and maintenance work on all types of communications equipment. The instrument

is supplied complete with integral GPIB facility, and can acquire and indicate frequency in a fast 200msec, reducing test time in ATE systems. The display rate can be set independently of resolution, so that optimum measurements of 1 Hz resolution in 1 sec can be achieved. In its rack mount form, Model 2440 occupies only half a rack width and 3½ inches of rack height. The microwave channel covers 600 MHz-20 GHz, with high sensitivity between –25 and –15 dBm, dependent on frequency range, To reduce repair costs, the overload damage level has been raised to +27 dBm at all frequencies. The wide tolerance to FM and AM allows direct measurements on microwave radio links. This counter features automatic amplitude discrimination, so that only the largest signal is displayed, and all others ignored. An added benefit in maintenance application is the unit's small size and weight. This

microprocessor controlled instrument accepts the keyboard entry of offset frequencies to 0.1 Hz resolution to simplify measurement of frequency drift or error. Servicing is enhanced with self-check and internal diagnostics. Model 2440 is priced at $5920, including integral GPIB and oven stabilized reference oscillator, and is available in 60-90 days. **Marconi Instruments, Northvale, NJ 07647, INFO/CARD #120.**

Multiple Channel Crystal Source

Model MM309 is designed to operate over any 7% bandwidth in the frequency range of 350 MHz to 500 MHz. The unit provides up to 7 BCD selectable channels holding a stability of ±.005% over a temperature range of −55°C to +85°C. The oscillators deliver a minimum of 10 mW into 50 Ohms with harmonics and sub-harmonics of −26 dBc. The package size is 3.88" x 2.25" x 1.1" and the unit is designed to be customized for most military environmental requirements. Oscillator gating for fast turn-on and turn-off can also be provided. **Techtrol Cyclonetics, Inc., New Cumberland, PA 17070, INFO/CARD #119.**

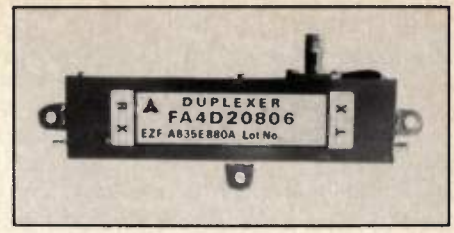
Glass Precision Trimmer Capacitors

Voltronics Corporation is now in production of its "H" line of high range glass embedded band precision trimmer capacitors. The capacitance is nearly double the standard maximum ranges. Typically, in a horizontal P.C. unit where MIL-C-14409D offers 16 pF in .734" length (21.9 pF/in) and Voltronics' standard SP offers 20 pF in .44" length (45 pF/in), the new HSP34 offers 34 pF in .44" length (77 pF/in). This line is the result of Voltronics' development of a new

and unique technique for making uniform thinner walls of the inner glass tube. Ranges of up to 250 pF are offered in 20 different standard units. All have Voltronics' non-rotating piston design which provides linear tubing with no reversals. All are "O" ring sealed to withstand 40 p.s.i. pressure tests. Extended plastic or metal shafts are available as are insulated bushings and different leads or pins. Many of these capacitors can be made as non-magnetic parts for NMR and magnetometer applications. **Voltronics Corporation, East Hanover, NJ 07936, INFO/CARD #118.**

Microwave Dielectric Duplexers and Filters

Miniaturized microwave dielectric duplexers are now available from the Electronic Components Division of Panasonic Industrial Company. Designated as Series "EZE-H," the duplexers are intended for applications in the 800 MHz band. These include land mobile radio telephone systems, microwave communication radar and telemetry, corresponding test and measurement equipment. Designed around a ceramic coaxial resonator, the duplexers offer low insertion loss (1.3 to 2.5 dB); small size and light weight; excellent temperature stability; and high



resistance to shock and vibration, per MIL-STD-202. Other specifications include: center frequency 835 to 880 MHz; 20-MHz bandwidth; VSWR of 1.5; attenuation around 25 dB at f_O±35 MHz; CW power rating of 10 W; and 50-ohm nominal impedance. Units meeting custom specifications can be ordered. Deliveries are 12-14 weeks. In production quantities, prices range between $40 and $60, depending on the duplexer type. **Panasonic, Secaucus, NJ 07094, INFO/CARD #117.**

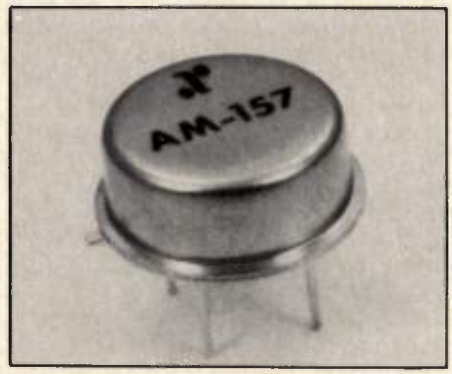
40 Meter Hy-Gain Antenna

Telex/Hy-Gain introduced a new 40-meter antenna series named DISCOVERER. The company stated the antennas were developed for high performance operation on 40 meters, because declining sunspot activity is impacting the efficiency of the 10-20 meter bands. The new series consists of several configurations. The Discoverer 7-1 is a 45-foot

(13.7m) rotatable dipole which can be added to many existing beam antenna installations. The dipole can be tuned to either 30 or 40 meters. Another version is the Discoverer 7-2, a two-element beam with a wind load of only 6 square feet (.56m²) and requiring only a 25-foot (7.6m) turning radius. In addition to high forward gain and front-to-back ratio, the Discoverer 7-2 maintains a broadband width in excess of 190 kHz below 2:1 SWR. The Discoverer 7-2 can be further enhanced with the addition of a Director Kit, thereby creating a three-element beam. This almost doubles the front-to-back ratio and forward gain which almost doubles the E.R.P. over the two-element version. All this fits on a boom of only 35 feet (10.7m). The relatively compact array does not require a heavy-duty tower, but can be safely installed on a less expensive medium-duty tower such as the Hy-Gain HG52SS. The manufacturer states that a low voltage feedpoint eliminates insulator failure and assures that the antenna can be safely handle twice the new legal power limit. SWR is 1.5:1 or less at resonance. The rugged, maintenance-free antenna is easily assembled from taper swaged aluminum tubing, preformed stainless steel compression clamps and hardware. The suggested list price for the Discoverer 7-1 is $195.00. The Discoverer 7-2 and the Director Kit are listed at $435.00 and $272.00 respectively. **Telex Communications, Inc., Minneapolis, MN 55420, please circle INFO/CARD #116.**

Isolation Amplifier

The Anzac Division of Adams-Russell Company announces a new high performance 20-500 MHz Isolation Amplifier. Model AM-157 provides 12.5 dB gain over its full frequency range. Superior performance characteristics exhibited by the AM-157 include an extremely flat typical third order intercept point of +42 dBm, high reverse isolation of 35 dB (typical), low VSWR of 1.2:1, low noise figure performance of 2.5 dB and a high 1 dB com-



pression point of +24 dBm. Further, these amplifiers are hermetically sealed, screenable to MIL-STD-883B and operate over the full MIL Spec temperature range of –55°C to +85°C. Prices start at $110.00 each in 1-5 quantities and delivery is stock. **Anzac Division of Adams-Russell, Burlington, MA 01803, INFO/CARD #115.**

Connector Pin Filters and Capacitors

EMI/RFI filters and capacitors for connector pins are most effective in suppressing high frequency interference in the 30 MHz to 10 GHz range. A unique, proprietary technology results in either a multi-layer or imbedded inner electrode

ceramic construction that is impervious to moisture and contamination. These true monolithic structures have dimensional constancy and excellent reliability and feature a light weight with high mechanical and dielectric strength. These tubular products have complete design versatility in voltage, capacitance and size. **Spectrum Control, Inc., Erie, PA, INFO/CARD #140.**

EMI Absorber

Chromerics Shielding Technology announces the availability of CHO-SORB™ EMI absorbers. CHO-SORBs reduce radiated EMI for compliance with FCC

and VDE emission limits, while reducing susceptibility to ESD. Unlike cable shields, CHO-SORBS do not require grounding and will not affect the data being transmitted as filters or filter pin connectors often do. This development in EMI absorbers is made of a sleeve of specially formulated ceramic material providing a minimum of 8 dB of EMI attenuation on data and power cables in the 15-500 MHz frequency range. CHO-SORBs are available in two standard sizes, one for cables up to ¼" in diameter, and one for cable diameters up to ½". Additional attenuation can be obtained by passing the cables through the CHO-SORB twice, or by adding a second absorber. **Chomerics Shielding Technology, Inc., Woburn, MA 01888, INFO/CARD #139.**

EMI/RFI Shields For D Subminiature Connectors

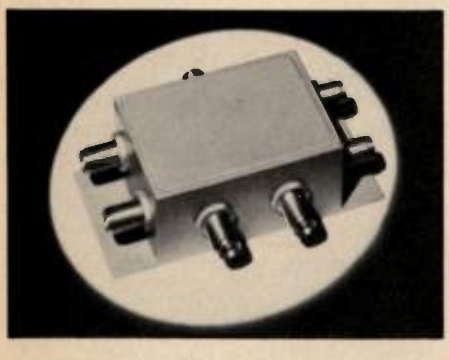
Eldon Group America has announced a new line of plated steel shields for D subminiature connectors that provide effective EMI/RFI shielding and high mechanical strength at low cost. Top and side entry versions are available to fit all sizes from 9 to 50 pins. The two-piece shields are fast and easy to assemble, and can be opened for field service without disturbing the cable braid. The cable braid is terminated by crimping to provide mechanical strain relief and continuous, unbroken shielding without solder or pigtails. Air operated tooling is

available for production, and hand tooling is available for prototypes and field service. Custom ferrule diameters can be supplied to precisely match the user's cable diameter. Decorative molded plas-

tic shells in black are available from stock, and can be supplied in custom colors. Delivery is stock to two weeks for standard products, six weeks for custom products. Price of a top entry 25 pin shield, part number DTK 25, is $1.10 each in 1000 quantities. **Eldon Group America Inc., Elmsford, NY 10523, please circle INFO/CARD #137.**

Six-Way Power Dividers/Combiners

Engelmann Division has introduced two new six-way Power Dividers/Combiners. The PSK-612 operates between 1 MHz and 100 MHz and features an Amplitude Balance of ±0.1 dB with a Phase Balance of ±2° maximum. Insertion loss is held to 0.6 dB maximum. Isolation of 30 dB minimum and VSWR is 1.3:1 maximum. The PSK-613 operates between 10 MHz and 500 MHz with an Amplitude Balance of ±0.3 dB and Phase Balance of ±5° maximum. Isolation is at least 24 dB, VSWR is no greater than 1.4:1 and the Insertion Loss is 1.7 dB maximum. These products are available with either SMA, TNC, and BNC connectors. **KDI Electronics, Inc., Whippany, NJ 07981, INFO/CARD #114.**

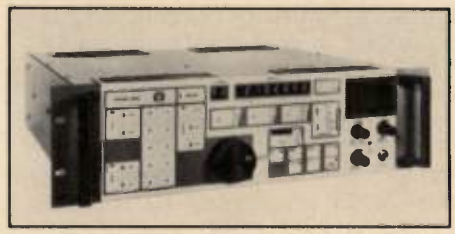


EMP Simulation and RFI Materials Testing

Two new product lines for EMP simulation and RFI materials testing have been added by Amplifier Research, Souderton, PA. The new products are the result of a recent sales agreement between Amplifier Research and Elgal Electronics, an arm of the Israeli ministry of Defense. The agreement makes Amplifier Research exclusive USA distributor of Elgal products. Elgal simulators are unique because they are designed for EMP-testing of compact electronic equipment such as radios, telephones, portions of larger systems, and equipment often carried by personnel. These test items are much smaller than the units usually associated with EMP testing with large $2-4 million systems, units such as aircraft, tanks, and similar large military equipment. Because of smaller test-item size, voltage generation requirements are lower, as is the cost of Elgal equipment relative to that of the larger systems. Also available from Amplifier Research is an Elgal chamber designed to test the screening capability of shielding and other materials when exposed to high-intensity RF fields. **Amplifier Research, Souderton, PA 18964-9990, INFO/CARD #113.**

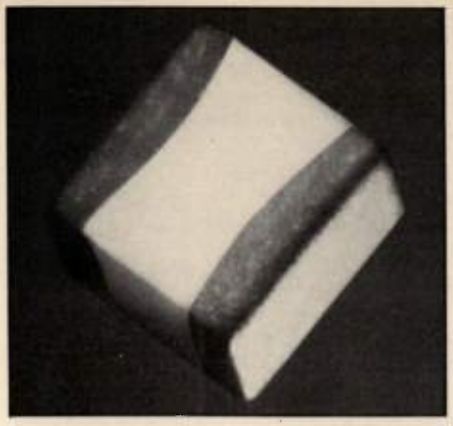
HF/MF Receiver

Marconi Instruments announces the Eddystone Radio's 1650 Receiver, which provides the professional user with an equipment which is sophisticated, simple to operate and reasonably priced. Its many operational features, made possible by a built-in microcomputer, can be called up by a single keying action. It covers the frequency range 10 kHz to 30 MHz in synthesized, 5 kHz steps, and is suitable for AMSSB and CW operation, though other modes can also be accommodated. On each receiver, seven different bandwidths can be made available, of which one can be for marine use. The store can handle up to 100 frequencies and their associated control settings in numbered channels. These settings can be made without interrupting reception. Stored channels can be scanned or two adjacent channels can be set at adjustable rates. Remote control is possible, and the store can be programmed by sources such as bar-code readers or mimic receiver control units. Model 1650 priced at $6,500. Available within 45 days. **Marconi Instruments, Northvale, NJ 07647, INFO/CARD #112.**



Microwave Chips for Military Market

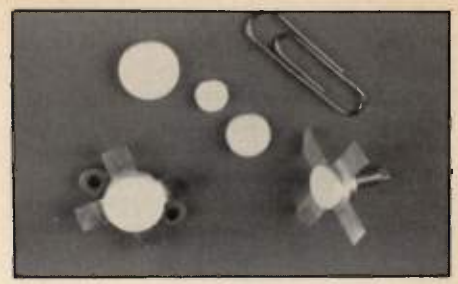
AVX Corporation has entered the microwave chip market with a new line of single-layer ceramic (SLC) and multilayer ceramic (MLC) capacitor chips suited to military and telecommunications applications. The two types of capacitors — the SLC Pathguard™ and the various MLC chips — are designed for the demanding military environments experienced in RF microwave circuitry. "AVX has long been the world leader in military MLCs, with a commitment to excellence in supporting defense programs. The current market entry underscores their dedication to providing the highest quality SLCs for these markets as well," said John Tinkler, product manager for the new chips. "The new products have applications in low-noise amplifiers, GaAs FET amplifiers, voltage-controlled oscillators, and other



electronic warfare/electronic countermeasures devices and components." The Pathguard SLC chip uses sputtered electrodes with gold metallizations and a leach-proof intermediate layer. The dielectric is fine-grained high-density ceramic with a choice of NPO, PO9O, X7R, or X7V temperature characteristics. Depending on the SLC capacitance required, varying Pathguard sizes are available, ranging from nominal measurements of 0.015" x 0.015" x 0.006" to 0.090" x 0.090" x 0.010". Capacitance ranges from 0.5 pF to 2700 pF, with tolerances of ±0.1 pF to ±20 percent. The working voltage rating is a minimum of 50WVdc. Delivery time on the Pathguard chips ranges from four to six weeks. The new MLC chips use a fine grained, high density porcelain dielectric impervious to moisture, with heavy internal palladium electrodes. End terminations may be palladium/silver, an intermediate barrier layer with Sn62, or pure gold over an intermediate barrier layer. NPO and PO9O temperature configuartions are available. Capacitance ranges from 0.3 pF to 1000pF, and the chips come in several sizes. Tolerance is ±0.1 pF to ±20 percent. Operating temperatures range from -55°C to +125°C. Delivery time on the microwave MLC chips is eight to ten weeks. The Pathguard and the new MLC are the first major microwave chips of their type offered by AVX to the military and telecommunications markets, and are expected to be widely used in these demanding applications. **AVX Corporation, Myrtle Beach, SC 29577, INFO/CARD #111.**

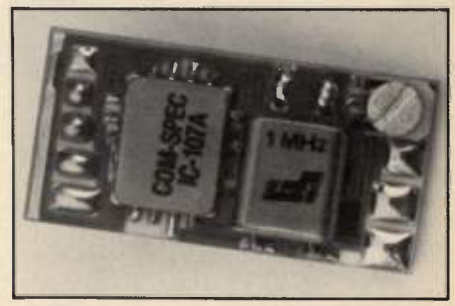
Low Temperature Sealant for RF and MW Packages

Kyocera International Inc. introduces a new low temperature sealant (LTS) designed specifically for RF and microwave packages. This sealant is supplied precoated to ceramic lids and eliminates the need to handle separate preforms. The material, NCO-125RF, can be sealed in 15 minutes using a clamp at 175°C and has a shelf life of one year when stored at 0°C. Cup-shaped standard lid sizes are tooled for .280 in., .380 in., and .500 in. diameter packages. Custom sizes are also available. Kyocera offers four other LTS materials — the NCO-150, NCO-150S, NCO-200 and NCO-200S. These are used in hybrid packages, chip carriers and other IC packages. **Kyocera International, Inc., Substrates Division, San Diego, CA 92123, INFO/CARD #109.**



Small Encoder

Communications Specialists of Orange, California recently announced what is now the industry's smallest CTCSS encoder. The SS-32HB measure only .5 x 1.0 x .15 inches and will fit into any portable requiring send only CTCSS.



The unit may be programmed to any of the 32 standard sub-audible tone frequencies by bridging solder pads on the board. Price is $29.95. **Communications Specialists, Inc., Orange, CA 92665, INFO/CARD #110.**

DC to 1 GHz Toggle Switch Attenuator

The TX Series of miniature toggle switch attenuators has been introduced by Alan Industries, Inc. These precision products have 100,000 life cycle silver contact switches for long life and reliability. Their size and light weight are ideal for panel mounting or in-line applications. Three TX attenuation ranges are available; 0-42 dB, 0-82.5 dB and 0-102 dB. The physical size of the 0-42 dB model is 1.062" x 1.062" x 4.249" while the higher attenuation models measure 1.062" x 1.062" x 6.249". All operate over the full frequency range of DC to 1 GHz. VSWR is 1.2 at DC-500 MHz and 1.4 at 500 MHz to 1 GHz. Impedance is 50 Ohms and power average is 1 watt.

BNC, N, SMA or TNC connectors may be selected. The TX Series is priced from $200 to $245. **Alan Industries, Inc., Columbus, Indiana 47202, please circle INFO/CARD #108.**

Amplifier Modules

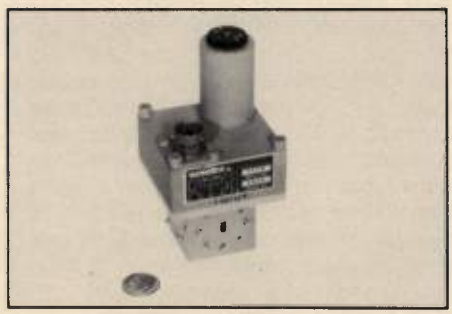
A new series of low noise and linear amplifier modules has just been introduced by WI-COMM Electronics Inc. These wideband amplifiers cover the MF/HF marine, VHF/UHF mobile and cellular radio bands. They can be used to improve the system sensitivity at sites with low ambient noise level, are suitable for intermodulation and noise figure test set ups or can be purchased together with a WI-COMM power divider to make up own receiver multicoupler. The noise figure ranges from a low of 3.5 dB for low noise units to 7 dB for feedforward amplifiers. The output is typically 60 dBm. The modules are supllied with BNC female connectors and a DC terminal for powering from a 12.5VDC or 28 VDC source. **WI-COMM Electronics Inc., Ottawa, Ontario KIG 3H8, INFO/CARD #107.**

Log Amplifier

The model CLA3-200/50A log amplifier and the CLA series of log amplifiers incorporate a discrete hybrid technique to provide a low priced, small packaged amplifier. Input dynamic range is selectable at the factory from 30 to 80 dB. The CLA series covers the frequency range from 30 MHz to 1.2 GHz. **Log Tech, Inc., Newbury Park, CA 91320, please circle INFO/CARD #105.**

Waveguide Switch

Model 1176, single pole, double throw, WR-22 latching type switch is one of a series of catalog MILSTAR waveguide components spanning 43.4 to 45.6 GHz. Because of the low VSWR (1.2:1 maximum all thru ports, 1.2:1 maximum during switching) the lightweight rugged switches continually operate while switching without removal of RF power. Normally the RF power has to be removed while switching, because of the danger of signal reflections causing damage or burnout to the power source. This unique



feature is not normally found in off-the-shelf catalog units. Insertion loss is 0.2 dB maximum and isolation is 25 dB minimum. The switch handles up to 350 watts CW. For low insertion loss the housing is made of precision machined copper and the switching element is mounted on ball bearings ensuring rapid reliable switching action and long life. Driver voltage is 28 VDC and acutating current is 2.5 amps maximum. Switching time is 50ms maximum with an operating temperature of 0°C to +65°C. Availability is stock to 20 weeks. **Waveline Inc., West Caldwell, NJ 07006, INFO/CARD #104.**

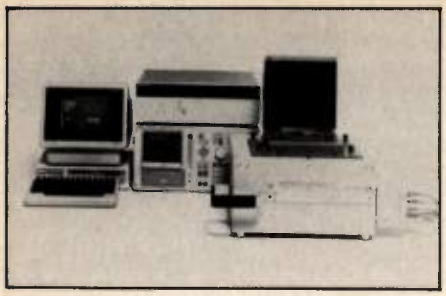
X-Band Synthesized Signal Generator

Polarad's new model 308 Synthesized Signal Generator has been developed for radar, satellite and microwave link test and measurement applications. Dedicated for operation from 7 to 12.4 GHz with 1 kHz resolution, >85 dBc phase noise, >45 dBc harmonics, >60 dBc spurious, built-in AM/FM modulation facilities and continuous, uninterrupted calibrated solid state output level control from +10 to −127 dBm makes the 308 ideal for intermodulation, sensitivity and other receiver measurements. Built-in high speed pulse capability with <10 nsec. transition times and >80 dB on/off

ratio enhances radar systems measurements. Sweepable too! Enables quick broadband characterization of systems and components. All this and more controlled conveniently by the front panel or IEEE-488 bus. **Polorad Electronics, Lake Success, NY 11042, please circle INFO/CARD #103.**

Switching Matrix Provides Semiconductor Testing

The new HP 4085M switching matrix from Hewlett-Packard Company is a dedicated subsystem created for use with the HP 4145A semiconductor-parameter analyzer. Designed to minimize noise and current leakage, this new switching matrix can make high-sensitivity measurements of 1 picoampere and 1 millivolt at each of up to 48 pins of a DUT (device under test) in wafer or packaged



form. This high-sensitivity measurement capability is critical in the semiconductor industry, especially in high-density VLSI products. The HP 4085M switching matrix is $34,109, with eight weeks estimated delivery ARO. The HP 4145A semiconductor-paramter analyzer is $17,500, and delivery is aproximately nine weeks ARO. **Hewlett-Packard Company, Palo Alto, CA 94393, INFO/CARD #101.**

Rackmount 1 GHz Oscilloscope

Tektronix, Inc.'s Instruments Group announced a rackmount version of its popular 7104 1-GHz real-time oscilloscope. Designated the R7103, this compact new unit offers the high-performance capabilities of the 7104 into application areas that place a premium on instruments rack space. The R7103 is a seven-inch-high rackmount version of the 7104. The only performance difference is three, rather than four, plug-in compartments. Delayed sweep capability is provided with the Tektronix 7B92A Dual Time Base, and full Electro Magnetic Compatibility capability (an option on the 7104) is standard. The R7103 is priced at $22,250 (without plug-ins). Product availability is September, 1984. **Tektronix, Inc., Beaverton, Oregon 97077, please circle INFO/CARD #102.**

Mobile Amplifier/Charger

Trilectic Inc. announces an additional model of its third generation of Mobile Amplifier/Charger (MAC III) for use with the ICOM Portable Radios. The MAC III mounts in a vehicle and provides ICOM Portable with the capabilities of a mobile and the convenience of a portable with a self-contained package which includes

a 5 watt audio amplifier w/speaker, an automatic fast/trickle battery charger and a RF power amplifier. The ICOM MAC III model comes with either a 45 watt VHF or 20 watt UHF RF power amplifier. A charger model is also available. **Trilectric Incorporated, Las Vegas, NV 89109, INFO/CARD #100.**

Low EMI/RFI AC Power Source

The Behlman KB Series AC power source is designed to help the RF engineer contend with EMI/RFI problems from the AC power source. This is possible by the use of advanced linear power amplifier designs which inherently do not generate EMI/RFI. The KB Series meets a variety of RF applications requiring

stand-alone or computer controlled AC power. Each model features a microcomputer control and measurement system that provides independent verification of operating output voltage, frequencies, currents and phase relationships, rather than just programmed values. On command the measurements are reported on a front panel flourescent display and/or a variety of host interfaces such as IEEE 488, RS232 and others. Programming is accomplished by the front panel keyboard or a host computer. Power configurations range from 100VA to 54KVA with less than 1% total harmonic distortion in single and multi-phase models. Frequency configurations range from 45 to 10,000 Hz with .01% accuracy. All KB Series AC power sources are designed for 19" rack mounts, have tight line and load regulation, and generate virtually no EMI and RFI emmissions. **Behlman Engineering Corp., Carpinteria, CA 93013, INFO/CARD #99.**

1% Tolerance Thick Film Chip Resistor

Dale Electronics has expanded the usefulness of its Series CRC Thick Film Chip Resistors by adding a 1% tolerance for precision applications. The Series CRC is available in the internationally standardized size of .126" x .063" [3.20 x 1.60] and is compatible with automatic placement equipment. Rated at 1/8 watt (70°C) the CRC is available in a resistance range from 10Ω to 2.2 megohms in tolerances of 1%, 2%, and 5% with a TC of ±200 PPM/°C. The new 1% model is available with a TC of 100 PPM/°C from 20Ω to 300Ω. In addition,

a zero ohm jumper (0.05Ω max) is also available. Series CRC chip resistors are provided with wraparound terminations and can be flow soldered. **Dale Electronics, Inc., Norfolk, NE 68701, INFO/CARD #98.**

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New Literature

Product and Capabilities Catalog

Rantec Anechoic/EMI Systems division of Emerson Electric Co., has announced the availability of a new 28-page product catalog that includes facilities and capabilities information on RF Anechoic and EMI/RFI shielded enclosure systems. Capabilities depicted include Anechoic chamber, shielded rooms, modular RF/EMI structures for high security data processing rooms and controlled testing environments. Products include a complete line of Anechoic chamber absorbant material and accessories that include microwave absorbers, telescoping fire sprinkler assemblies, RF shielded doors, penetrations for piping, cabling, waveguides, waveguide vents, shielded downlight fixtures and fire-retardant RF absorbing material. **Rantec Anechoic/EMI Systems, Canoga Park, CA 91304, Please circle INFO/CARD #97.**

Filter Connectors Suppress EMI/RFI Emissions

A four-page folder from Souriau Inc. describes the company's new line of D*J D-subminiature filter connectors. They are designed to suppress spurious radiated and/or conducted EMI/RFI emissions. The D*J line is derived from MIL-C-24308 and is interchangeable and intermateable with all connectors based on this specification. The brochure presents performance curves for Pi- and C-type filter networks, electrical characteristics, attenuation levels over the range 0.3 MHz to 1 GHz plus full ordering information. **Souriau Inc., Valencia, CA 91355, please circle INFO/CARD #96.**

Custom EMI Filters Data Sheet

Captor Corporation has published a new data sheet — Bulletin 2843 — detailing ten customer-designed EMI filters which are typical of those recently produced by the firm. Each filter is shown and described as to application, dimensions and circuitry. Captor's capability to produce and test such complex filter designs is also covered. **Captor Corporation, Tipp City, OH 45371, INFO/CARD #95.**

Shielding Effectiveness Test Report

Existing and prospective users of shielded cable assemblies and interconnect systems will be very interested in an 8-page report on shielding effectiveness being offered for the first time by Cable Systems & Assembly Co., Inc. (CSA). Entitled "Test Report On Shielding Effectiveness/Shielded Cable" the documented report cites the test objective as measuring shielding effectiveness of braided cable and copper foil applied from braid to the backshell of a connector assembly. Included in the report are Test Procedures, Results, and Conclusions supported by a test diagram and five (5) sets of curves indicating 25-30 dB of shielding effectiveness between the frequencies of 20-200 MHz. **Cable Systems & Assembly Co., Inc., Everett, MA 02149, INFO/CARD #94.**

Microwave Signal Generators Data Sheet

A new 6-page data sheet describes the Wavetek Model 950 Micro Source series of low-cost microwave signal generators covering the 1 to 18 GHz range. This data sheet also provides

complete specifications and some measured performance curves for each of the four models. It also describes numerous applications for these small, stand-alone instruments. Examples of applications include Mixer Testing, Electromagnetic Environment Simulation, Receiver Sensitivity Testing and Basic Microwave Measurements. The Model 950 Series includes the following four models: 952 (1-4 GHz), 954 (3.7-7.6 GHz), 955 (7.5-12.4 GHz) and 957 (12-18 GHz). Each small source generates a tunable low noise CW signal with square wave AM, FM and sweep —either internally or from an external signal. Typical power exceeds +13 dBm for the 952 and +10 dBm over most of the band for each of the other three models. RF output power is adjustable over a 25 dB or greater range, and external leveling is provided through standard lab components. Price: 950 $5500, 954 $4600, 955 $4600, 957 $4950, Delivery: 30-60 days. **Wavetek, San Diego, CA 92123, INFO/CARD #92.**

Hermetically Sealed Temperature Probes Design Catalog

Midwest Components, Inc. new TUFF SENSOR™ Catalog outlines standard probes available, as well as the technical information necessary for designing a probe to fit your own needs. Encapsulated in plastic, these sensors are hermetically sealed to protect against moisture and harsh environments. An easy-to-read table outlines the available plastics and their characteristics. The sensing element may be an NTC or PTC thermistor for a resistance vs. temperature change or a thermal switch for single set-point sensing. **Midwest Components, Inc., Muskegon, MI 49443, INFO/CARD #93.**

Ham Catalog

A new amateur radio products catalog has been issued by Telex/Hy-Gain. The 24-page color catalog gives detailed specifications, SWR curves and ordering information for antennas, towers, rotators, as well as headsets and microphones. Where applicable, metric information is also given. **Telex Communications, Inc., Minneapolis, MN 55420, INFO/CARD #91.**

Cable/Wire Rope & Fittings Catalog

Bergen Cable Technologies, Inc. is now offering a new 20-page, full-line catalog. The catalog introduction contains useful information on cable construction, materials and applications, as well as assembly design parameters. The balance of the catalog is divided into six sections covering: miniature stainless steel cable and assemblies; Mil Spec cable and assemblies; commercial cable/strand; Mil Spec terminals; commercial fittings; push/pull controls. As required, each section provides product descriptions, photographs or illustrations, engineering drawings and charts. General chart information includes part numbers, construction, diameter, material and breaking strength. **Bergen Cable Technologies, Inc., Lodi, NJ 07644, INFO/CARD #90.**

5 MHz OCXO Brochure

Thomson's C.E.P.E. Division announces new high stability (0.2 ppm) over –40 to +70°C OCXO's in a 1 cubic inch package. Brochure describing three basic models: PMTU-515A for 2 x 10^{-8} maximum stability over 0 to 50°C; PMTU-515B for 8 x 10^{-8} maximum stability over –20°C to +70°C; PMTU-515C for 2 x 10^{-7} maximum stability over –40°C to +70°C. **Thomson Components Corp. C.E.P.E. Division, Rutherford, NJ 07070, please circle INFO/CARD #88.**

Full Line Catalog

Tucker Electronics Company announces the availability of its annual Full Line catalog. This comprehensive guide contains over 250 pages of descriptions, specifications and prices on more than 4,000 new and expertly reconditioned electronic test instruments. All equipment listed in this catalog is for sale, and most items are also available for short-term rental. These reconditioned instruments were manufactured by such major equipment suppliers as: Hewlett-Packard, Tektronix, General Radio, Narda Microwave, Fluke and Weinschel. For new instruments, Tucker Electronics represents Beckman, Keithley, Leader, EMCO and Soltec. In addition to equipment sales and rentals, Tucker also has extensive repair and calibration facilities. These laboratory operations are described in this new catalog, showing their capabilities, service charges and instructions on obtaining R & C estimates. **Tucker Electronics Company, Garland, TX 75046, INFO/CARD #89.**

"Advanced Lithium Battery Technology" Booklet

Altus Corporation has made available a free booklet illustrating the advanced technology of their Lithium Thionyl Chloride batteries in applications ranging from flashlights to microprocessors and missiles. Comparisons are given on various lithium batteries, as well as standard carbon/zinc, alkaline and mercury cells, in commercial, military and electronic markets. In addition to photographs, charts and graphs, the publication provides detailed information on such features as cell-construction, the high open-circuit voltage of 3.6 VDC, 10 year-plus shelf life, safety and ability to operate in harsh environments that make Altus' lithium power cells the highest energy density batteries commercially available. Data is also given on Altus' unique design alternatives in flat-profile, cylindrical, or custom-built models that meet the most stringent requirements of all four military services. Altus lithium batteries are found in commercial applications such as medical, memory backup, industrial controls, communications, aviation, and military projects from lasers to missiles — anywhere where safe, dependable, and portable, high-current energy output is required. **Altus Corporation, San Jose, CA 95112, please circle INFO/CARD #87.**

Group Delay Measurement Application Note

This 9-page Application Note describes how to simply and economically measure the group delay in the transmit and receive chains of the Intelsat V traffic terminals. This measurement system is unique because it does not require any up- or down-converters. Although specifically written for the Intelsat V application, the measurement techniques described in this Application Note can be easily employed for precision group delay (time delay) measurements of other types of active and passive RF and microwave devices. **RANTEC Division, Emerson Electric Co., Calabasas, CA 91302, INFO/CARD #86.**

Delay Line Catalog

The availability of its comprehensive, new 24-page catalog of precision-quality delay lines, catalog Number 710, has been announced by Bel Fuse, Inc. A major reference source for the design engineer, the new 2-color catalog contains the most complete and current delay line data in the industry. In addition to drawings and detailed specifications for the firm's Digital Delay Modules and SIP Delay Lines, the new catalog contains several other sections which will be useful to the specifying engineer. **Bel Fuse, Inc., Jersey City, NJ 07302, INFO/CARD #85.**

Flexible Connector Brochure

A new four-page brochure highlights Air-O-Tronics FLEXCON flexible test connectors for continuity, signal and voltage testing of telecommunications, computer, aviation and military equipment. With induction soldered joints, these durable NASA-approved connectors are reusable for up to 50 bends, and are suitable for testing in even the tightest spaces without damaging pins. Three hook-up options are illustrated: permanent hook-up by capturing the wire down the barrel; in side, capturing the wire with a set screw in the barrel to permit stacking; or in the barrel itself through an interchangeable connector on a banana plug that allows the user to change sizes quickly and easily. Diagrams illustrating both pin and socket type flexible connectors are supplemented by specifications and current pricing information on 14 standard pin and socket models. **Air-O-Tronics, a division of The Trush Group, Cazenovia, N.Y. 13035, please circle INFO/CARD #83.**

Square-Cut Connectors Catalog

A new 25-page illustrated catalog detailing Amphenol SQUARE-CUT™ SMA, BNC and TNC coaxial connectors is now available from Amphenol Products. Detailed in the catalog is the full line of SMA, BNC and TNC connectors, cable plugs and jacks and mating receptacles. **Amphenol Products, Oak Brook, IL 60521, INFO/CARD #84.**

Supplies Catalog

The Supply Division of CAD CAM, Inc., distributor and manufacturer of supplies for computer-aided design, announces its 1984 Computer Graphics Supplies Catalog/Guide. This 32-page, full-color catalog presents detailed descriptions of a full range of supply items, which includes: computer supplies, plotter supplies and plotter media, including genuine electrographic media from Versatec. The CAD CAM Catalog/Guide explains performance data, features/benefits, product characteristics and care and handling information for all products listed. The CAD CAM Supply Division will ship same-day from Regional Supply Centers located strategically throughout the United States. **CAD CAM, Inc., Dayton, OH 45439, INFO/CARD #81.**

Technical Brochure

Magnecraft's new article "Compatibility of Electro-Mechanical Relays with Electronic Circuits" describes the problems that the circuit designer must be concerned with in applying electro-mechanical relays with electronic circuits. Compatibility must address both the electrically controlled input and the effects of the output to the circuits which are controlled by the relay. Effects of "back emf" and RFI generator, speed of operation, contact switching including "bounce" and "contact noise," are described to help the circuit designer show how they may affect his circuit performance and make both the relay and electronic compatible. **Magnecraft Electric Company, Chicago, IL 60630, INFO/CARD #82.**

Technical House Journal

Number 104 of the technical house journal "News from Rohde & Schwartz" presents the following new developments: VHF-UHF Doppler Direction Finder PA 055 handling RF signals in the range from 20 to 1000 MHz and delivering the bearing information in digital and analog form in an exceptionally short time; Radiocode Test Set SCUD for selective-calling and data transmission devices; Scanner UVZ, a universal test point selec-

tor; and TV-channel Antennas HF 305 to 312. Also new are the Active VHF-UHF Receiving Dipoles HE 202 and HE 302 with optimized gain, the Oscilloscopes BOP and BOL for laboratory, service and production, and the VHF-UHF Coaxial Dipole HK 014 for shipboard environments. Other contributions describe the adaptation of subassemblies of the Tornado avionics to DATE (PUGB) stations, the software development for radio-monitoring/radiolocation systems, and the new models for Signal Generator SMS 2 and Process Controller PUC, which now offer even more measuring comfort. The test hint presents a method for the fast Q measurement of RF capacitors and the application note deals with the measurement of amplitude and group-delay responses of VTR machines. **Rohde & Schwarz GmbH & Co., KG. Pressestelle. Muhldorfstr. 15 Postfach 801469, D-8000 Munchen 80, INFO/CARD #80.**

Amplifiers Literature

New literature detailing Varian Associates line of low- and medium-power traveling wave tube amplifiers (LPA/MPA) is available from the company's Microwave Equipment Division. Designed specifically for application in ground transmitters of commercial satellite communications systems, these power amplifiers operate between 5.925 and 6.425 GHz. The four-page brochures describe the modular, easily maintained amplifiers, specifically: Model VZC-6962D6, a 125 watt LPA; Model VZC-6965D8, a 400 watt MPA; VZC-6965E4, a 600 watt MPA, and VZ-6965E6, a 700 watt MPA. General features: electrical, mechanical, and environmental specifications, block diagrams, and outline drawings are provided for each amplifier. **Varian Microwave Equipment Division, Santa Clara, CA 95050, Please circle INFO/CARD #79.**

Low EMI/RFI UPS Brochure

A new brochure from Behlman Engineering describes the benefits of ultra low EMI/RFI Uninterruptible Power Systems (UPS). The brochure details the use of linear designs which virtually eliminates EMI/RFI noise and acts as a complete line condition. Behlman Engineering is the only manufacturer using linear technology in UPSs which are well suited for RF applications. A complete price list and battery guide accompanies the brochure. **Behlman Engineering Corporation, Carpinteria, CA 93013, INFO/CARD #78.**

Catalog/Engineering Manual

Ad-Vance Magnetics' new Procurement Catalog/Engineering Manual No. 90 offers to all magnetic shielding users the major useful technical guideline data needed to design or choose the optimum magnetic shielding solution for a given application. The three Engineering Sections include 30 pages of technical/engineering article reprints written by Ad-Vance Magnetics' engineering staff to help fill the gap between many users and the EMC Specialists. Also, there are technical articles on Basic Relations Between E and H Vectors for a Plane Wave, and Enhanced Skin Effect. For additional help to those with magnetic shielding problems, 13 pages are devoted to 25 case histories of solutions to such problems. For recent engineering graduates, there is an informative article on The Need For Magnetic Shielding. Other useful data includes the principal Electrical and Magnetic Units, various tables, graphs and trigraphs, two Engineering Reports on Sheilding Effectiveness, and 1½ pages of Helmholtz coil testing. **Ad-Vance Magnetics, Inc., Rochester, IN 46975, INFO/CARD #77.** □

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Design, analysis and documentation (HADD) of nuclear hardened weapon systems in support of vendor specifications. Translate free field EMP environments to avionics component design requirements, pin injection voltages as a function of cable configuration, component surface currents, resultant internal fields and effects on circuits. Document circuit analysis to determine upset/burnout design margins required. Requires knowleage of component and circuit level effects due to neutron and gamma irradiation.

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Engineers

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nteractive Systems/3M, located in Ann Arbor, Michigan as been a supplier of broadband network hardware ince 1972. A key to the continued leadership position of M in this arena is the strength of its RF design, digital lesign and software engineering groups. As a member f one of these groups you will have the opportunity to ork on state-of-the-art data communication products.

you have the background and interest in this unique echnology, one of the following positions may be the hance for excellence you have been looking for:

RF Engineers:

MSEE with 2 years or BSEE/CE with 5 years experience modulation systems, communication theory and RF ircuit design. Will have responsibility for improving xisting products, engineering additions to these roducts and design of new RF modems. Position will ffer the opportunity to work with state-of-the-art odulation techniques, digital transversal filtering, urface acoustic wave devices and the latest in emiconductor technology.

Digital Engineers:

SEE/CE/CS with 3 to 5 years experience in the design f digital hardware. The position will offer the opportunity work with programmable logic arrays, state machines, icroprogrammable hardware and design of gate arrays nd semi custom logic.

Software Engineers:

SEE/CS with a minimum of 3 years experience in the esign and implementation of software for data ommunication systems. Will be responsible for the evelopment of modular real-time software under multi- sking executives for local area networks using ommunication protocols of ISO, DOD and IEEE.

terested persons should send their resumes in omplete confidence to Linda Sachs.

teractive Systems/3M
920 Varsity Drive
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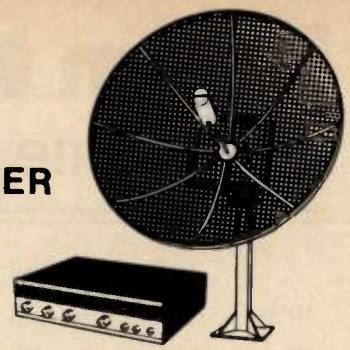
Equal Opportunity Employer M/F/H/V

3M

RF ENGINEER
Colorado



Manufacturer of RF products for TV broadcast, CATV and satellite TVRO needs EE's to design new products. Experience in RF/microwave circuit design required.

Based in Burlington, Iowa and recognized as an industry leader for 30 years, Winegard Company develops new products at its engineering and research division located in a scenic Colorado mountain community within commuting distance of Denver.

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Join GE NMR in our new advanced facility in Fremont, California, across San Francisco Bay from Silicon Valley.

Send your resume, including salary history or phone (415) 490-8310 (collect) to Mr. R. Watkins, Manager, Employee Relations, GE NMR Instruments, 255 Fourier Ave., Fremont, CA 94539.

The future is working at General Electric.

An equal opportunity employer m/f.

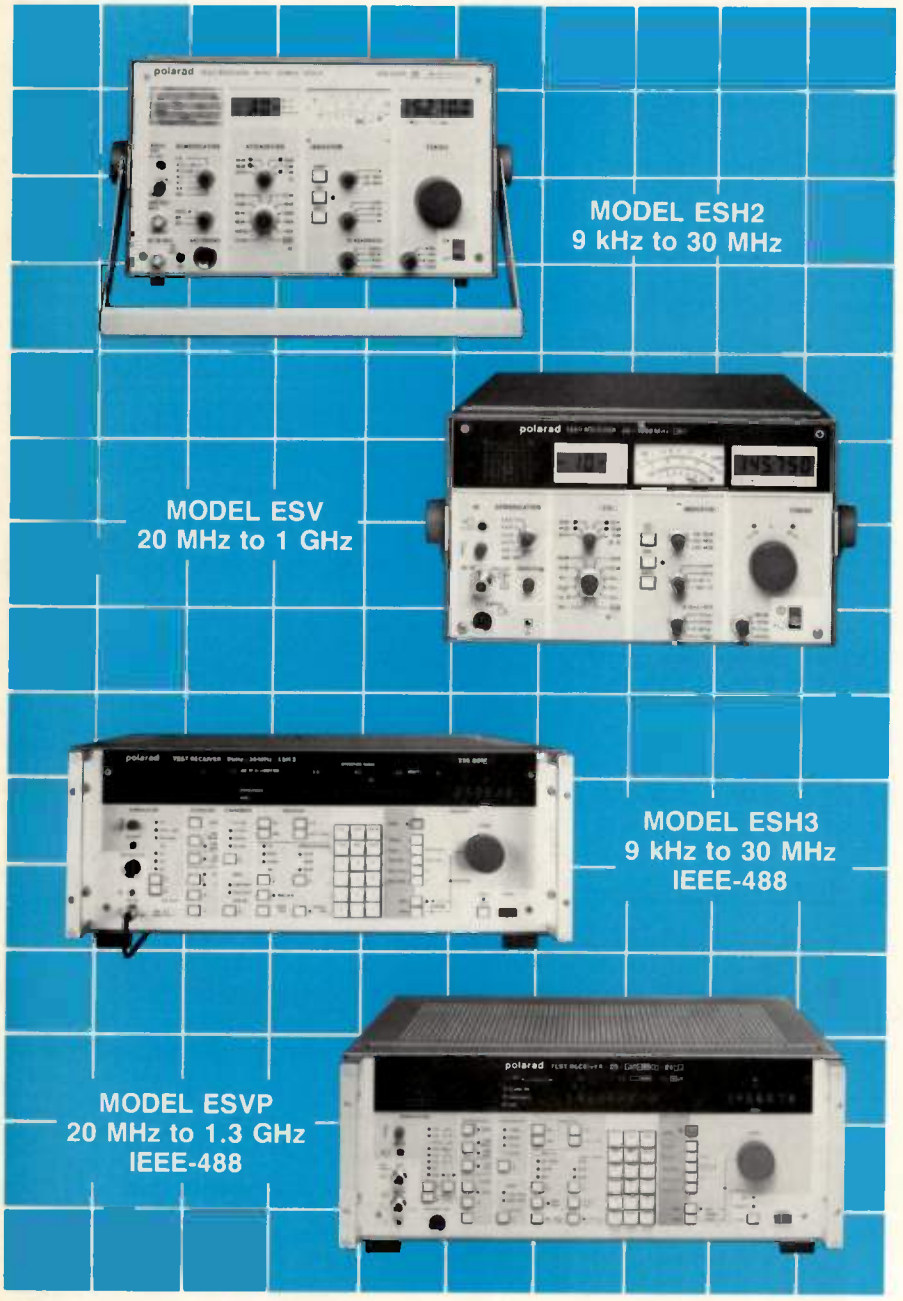
Advertiser Index

Correction

In the May/June 1984 issue of r.f. design we inadvertently referred to the advertisement of Piezo Technology, Inc. on page 90 as Piezo Systems in our advertiser index. This has lead to some confusion to customers since it might have referred to Piezo Systems which is an affiliate of Piezo Crystal Company. We apologize for this error on our part.

4 WAYS TO BETTER AND FASTER EMI MEASUREMENTS

Portable or Programmable Test Receivers for interference measurements in accordance with CISPR, MIL, VDE, VG and FCC specifications.



PORTABLE test receivers, ESH2 and ESV, feature automatic preselection and a digital frequency display with 100 Hz or 1 kHz resolution, respectively. Synthesized local oscillators provide crystal controlled frequency accuracy and stability. Built-in automatic amplitude calibration insures highly accurate selective voltmeter measurements. With Polarad antennas, read-out is directly in dBμV/meter.

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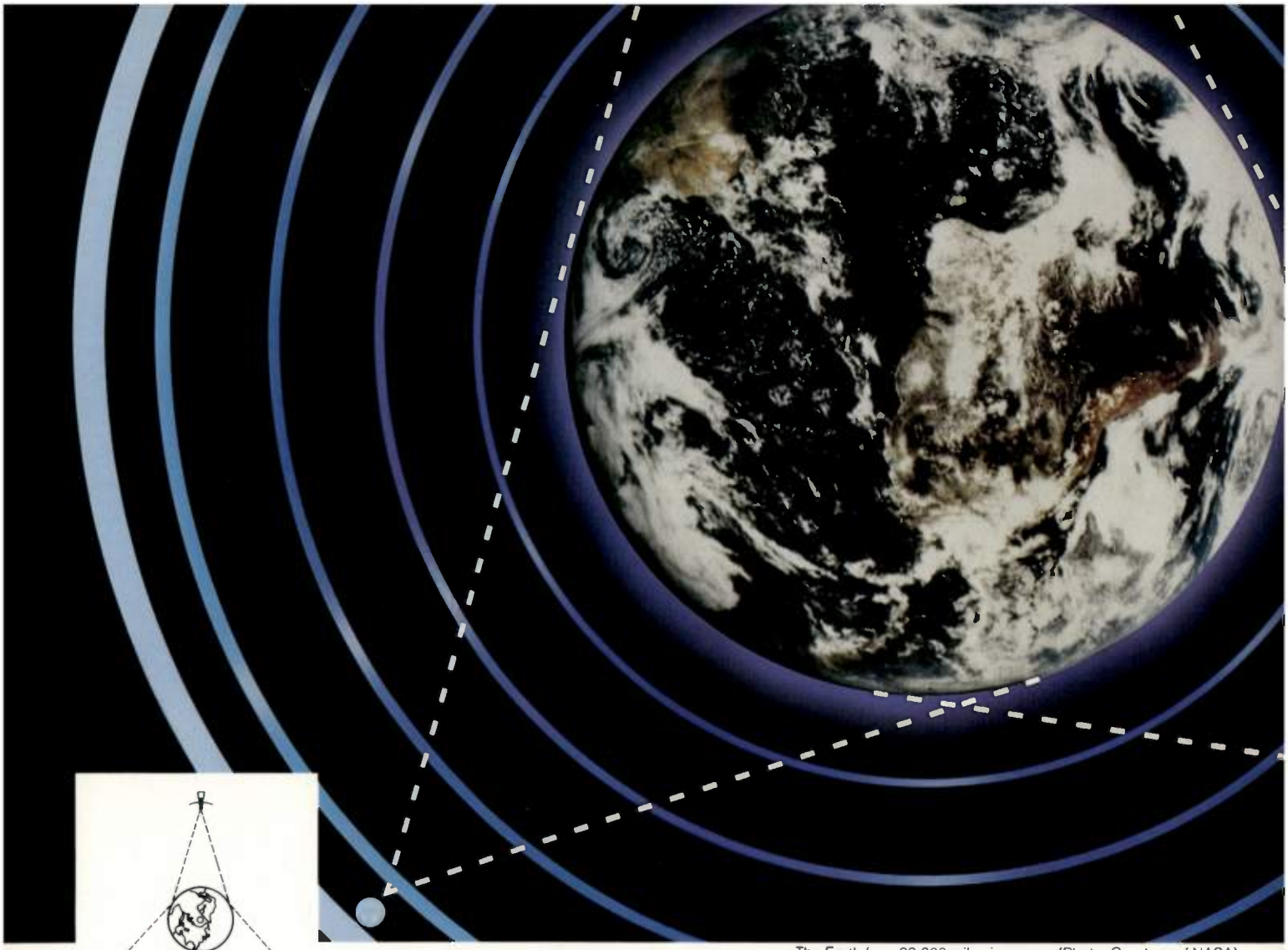

The Earth from 22,300 miles in space. (Photo: Courtesy of NASA)

Clarke's proposed
3-satellite system.

FINDING NEW WAYS...

In 1945, Arthur C. Clarke—a British mathematician, wireless operator and creative science fiction writer found a better way to beam communications signals around the world. He theorized that an artificial satellite, carried by a rocket to an orbit 22,300 miles above the earth's equator and traveling at 6879 mph (the speed at which the earth rotates on its axis), would appear motionless to an observer on earth. From that height, Clarke reasoned, a radio relay station could cover one-third of the earth's surface; three such satellites, placed in geosynchronous orbit around the equator could provide worldwide communications. In 20 years, advances in electronics, miniaturization and rocketry made Clarke's dream a reality and gave the world improved communications capability.

Likewise, in 1969, Mini-Circuits made its total commitment to serve the emerging communications market . . . by replacing expensive, custom RF signal-processing components with low-cost, catalog units with unparalleled reliability.

Our dream, like Clarke's, has come true. Over 1,000 catalog items available with such Mini-Circuits innovations as our exclusive HTRB burn-in testing, the world's only 3-year guaranteed mixers, computer-automated performance data (CAPD) to eliminate design guesswork . . . just to name a few.

Mini-Circuits' products have become the industry standard. We are actively dedicated to the pursuit of further improvements in product cost/performance, quality and reliability for more effective worldwide communications.

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