Automation of Data Gathering and Analysis for the Fourth-Harmonic Analyzer

Y. L. Grigsby
R. F. Systems Development Section

The Fourth-Harmonic Analyzer is used to measure the magnitude of the fourth harmonic of the S-band transmitter in waveguide for any mode or combination of modes to develop operational techniques in measuring harmonics. The gathering and analyzing of data have been automated to reduce the number of man-hours needed to perform this task by hand.

I. Introduction

An analyzer called the Fourth-Harmonic Analyzer has been developed (Fig. 1) to measure the magnitude of the fourth harmonic of the S-band transmitter in waveguide for any mode or combination of modes and to develop operational techniques to establish measurement accuracy in measuring harmonics. (Refer to Ref. 1 for technical information on the analyzer.) Previously it took two people two hours to gather the data. An additional two days were needed to analyze the data. With the use of a PDP-11/20 computer along with its real-time programming and operating system, RT-11, and a general microwave digital power meter, the time required for gathering and analyzing data is drastically reduced.

II. Summary

A PDP-11/20 with RT-11 program was used to analyze data of the Fourth-Harmonic Analyzer. A program was written to (1) read the voltage standing wave ratio (VSWR) values from a file stored on Digital Equipment Corporation (DEC) tape, (2) read the power-level data typed in at the teletype (TTY), (3) save the power-level data on paper tape, (4) analyze the data, (5) compute the total power, and (6) provide the option of listing only the total power or the total power, all data, and calculated values. The preliminary results were within ±1.8 dB of the measured harmonic input. The time required to gather and analyze data was reduced from two days to three hours.

The automation of data gathering and analyzing is the first step in establishing measurement techniques and instrument precision. With automation many tests can be run to achieve maximum accuracy in a laboratory environment prior to inserting the analyzer into the high-power microwave system and making the actual power measurements. The time required for gathering and analyzing data is drastically reduced.

III. Previous Analyzing Techniques

The power level at each port was read by a power meter and recorded on a work sheet. In the laboratory only the test procedure requires placing objects, such as metal, in the waveguide to obtain various combinations of modes. The data gathering process took two people two hours. One person alone took an additional two days to analyze the information and calculate the total power. The calculation involved 960 pieces of data.

The analyzer has a total of 240 ports. The ports are divided into nine groups labeled A through I. Each group contains 30 ports with the exception that there are no ports for C16 through C30 and G16 through G30. For programming purposes the ports become a 9×30 matrix.

Using the measured VSWR of each port, the measured power levels were corrected for all ports. The corrected values were then summed and multiplied by the insertion loss to obtain the total power. For each port, a total of four data values were used (two given data values and two computed values), giving a grand total of 960 values.

IV. Automation Techniques

To automate the procedure of gathering and analyzing data, the following equipment was used:

(1) PDP-11/20 computer with RT-11 operating system.

(2) Teletype or cathode-ray tube (CRT) terminal.

(3) Fourth-Harmonic Analyzer.

(4) General microwave digital power meter with test probe.

Figure 2 shows how the equipment is set up.

A program was written to analyze the data and compute the total power. The program also has the option of listing only the total power or the total power, all data, and calculated values. The flowcharts (Figs. 3–8) describe in more detail how the program works. The measurements are typed in at the TTY or CRT from the recorded data. Each data value typed in is saved by the high-speed paper-tape punch. The VSWR values are stored and read from a file maintained on DECtape. This is possible because one advantage of RT-11 Basic is the ability to read and write data files while running a basic program. All measurements are analyzed in the computer and the process of analyzing data which took two days was reduced to three hours.

If a listing of the analysis (all data and calculated values) is required at a later date, the data on paper tape are fed through the high-speed paper-tape reader. A second program was written for the sole purpose of reading the data (measured power levels) off of paper tape, reading the VSWR values off of a file on DECtape, analyzing all data, and reproducing a complete listing of the analysis. The paper tape saved time because it eliminated the need of typing in the data at the TTY again.

V. PDP-11/20 and RT-11

One outstanding feature of RT-11 is its ability to link an assembly language routine with a basic program. This feature makes it possible to insert the test probe into a port of the analyzer, read the power level, and transmit the data to the assembly language routine in the computer. The basic program then calls on the assembly language routine for the data. The linkage of an assembly language routine to a basic program works on the same principle as fortran and its subroutine. This linkage will completely eliminate the need of typing in data at the TTY in the future.

VI. Future Plans

In the near future the gathering and analyzing of the data for the Fourth-Harmonic Analyzer will be fully automated. Data will no longer have to be recorded on a data sheet and typed in at the TTY. There will be a direct connection between the digital power meter and the computer. As the power levels are displayed and read by the meter, they will automatically be stored in the computer by way of the "data line" (see Fig. 2). The entire task will require only one person instead of the two people required to perform the present automation techniques.

Reference

1. Smith, R. H., "Fourth Harmonic Analyzer," in *The Deep Space Network Progress Report 42-20*, pp. 121–123, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1974.

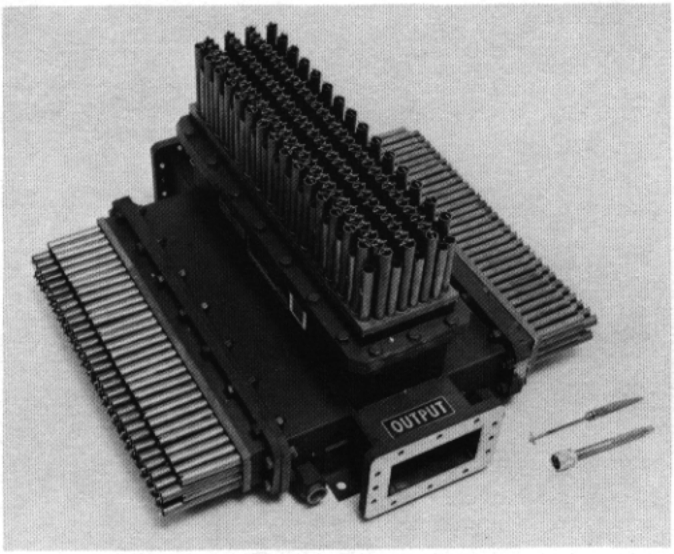

Fig. 1. Fourth-Harmonic Analyzer

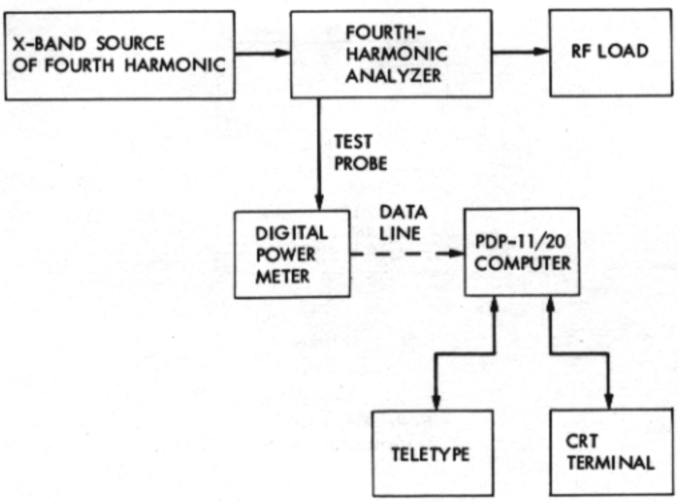

Fig. 2. Laboratory equipment setup for automation of harmonic analysis

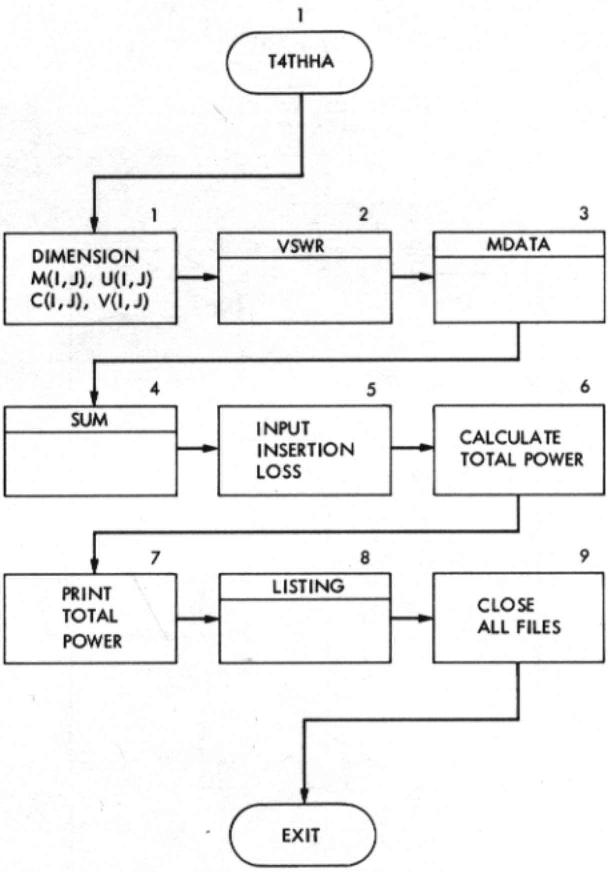

Fig. 3. General flowchart data analysis

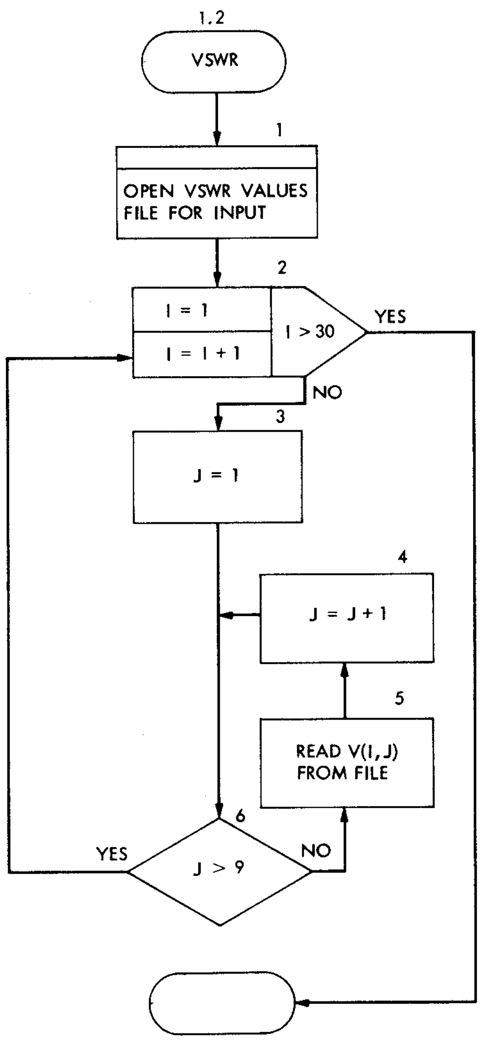

Fig. 4. Read VSWR data from DECtape

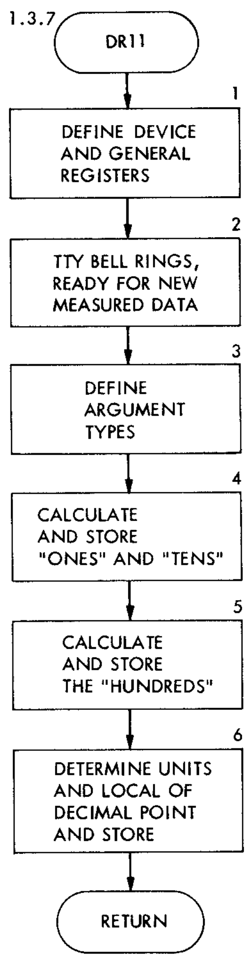

Fig. 5. Measured data input and save

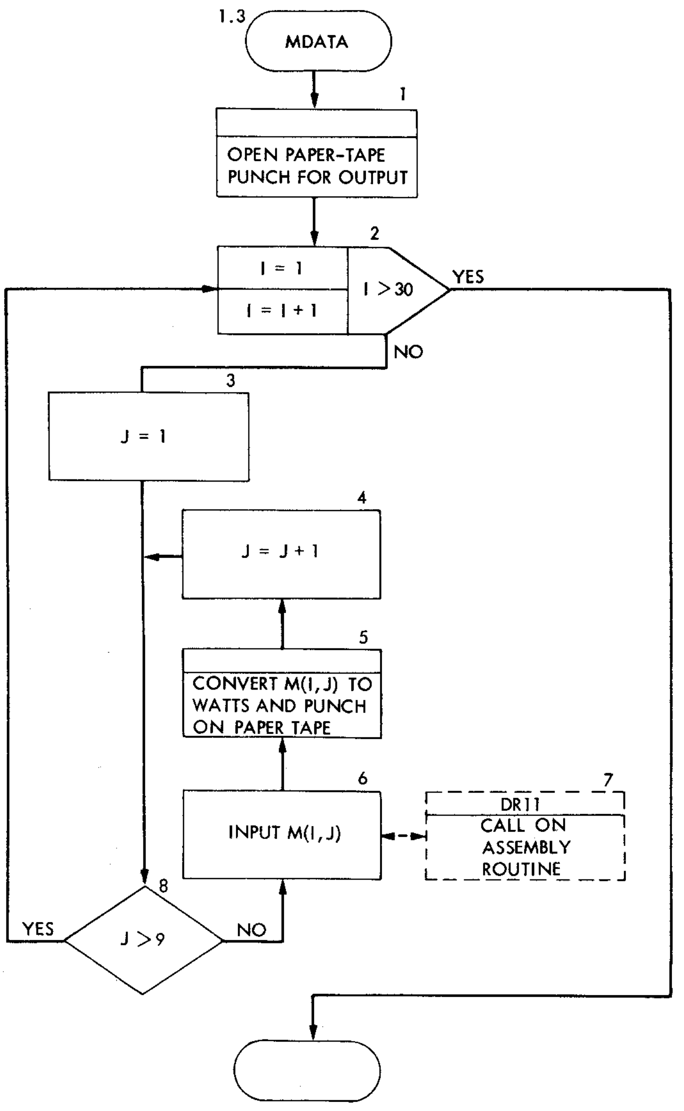

Fig. 6. Assembly language routine

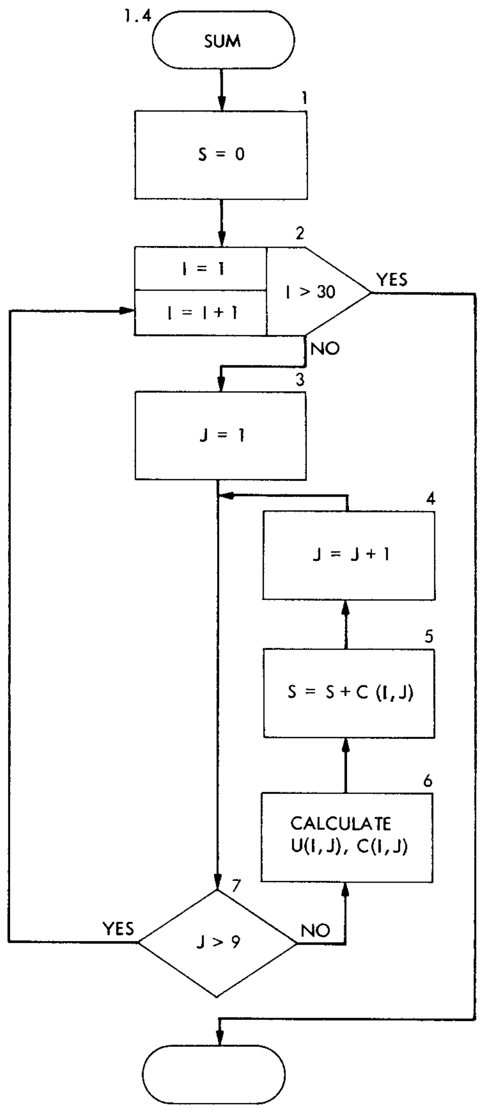

Fig. 7. Correct measured data

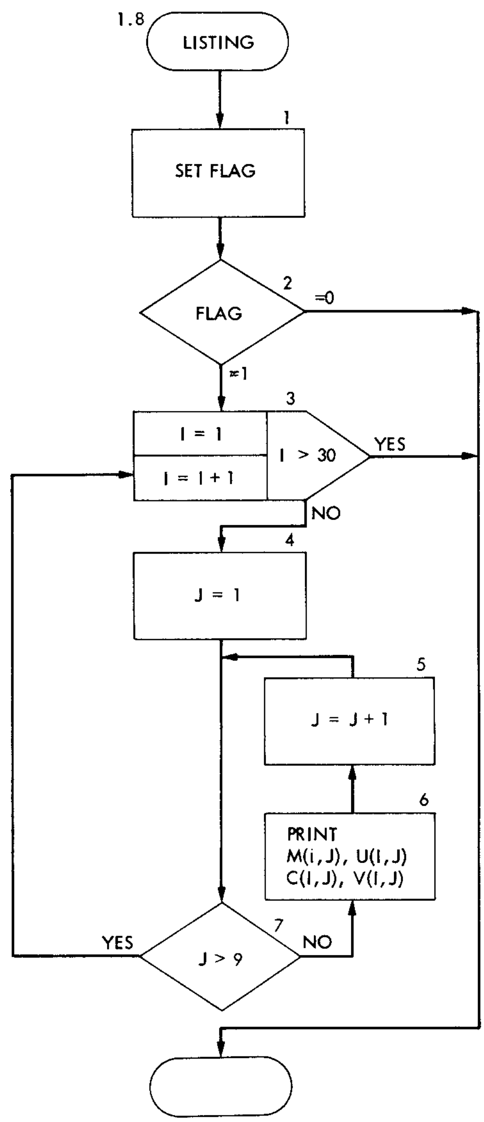

Fig. 8. List all data and results