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Computer control of GPIB/GPIB measuring instruments with the program MESSZEIT

Note from the editor: MESSZEIT is only available in German. Hans has encouraged me to translate his article because he thinks that MESSZEIT will be useful to radio amateurs. He will provide help, by email, to anyone who want to use his program.

Where the German word will help the understanding of the program when it is in use I have put the English translation in square brackets. Andy

It is possible to control many measuring instruments with a GPIB/HPIB interface from a PC using the program MESSZEIT or to just pick up data. The actions of a measuring position are defined on the computer by registering standardised measuring instructions in tables therefore programming knowledge is not necessary. The program also offers routines for evaluation, conversion and producing diagrams from measurement data.

1.0

Introduction

Radio amateurs, in particular those who want to build equipment for the higher frequency ranges, are frequently dependent on high-quality measuring instru-

ments such as signal generators, RF power meters, spectrum analysers and network analysers. Fortunately these devices are quite inexpensive on the surplus market from well-known manufacturers such as HP/Agilent, Rohde & Schwartz, Tektronix, Wiltron/Anritsu and others. These measuring instruments are used throughout industry and have many features e.g. the possibility of control and reading by computer. This is only interesting for devices e.g. oscilloscopes, spectrum or network analysers that digitally store a complete result of a measurement. This result can be picked up as a file by the computer, converted and be represented or printed out for documentation in many different formats. This is better than the display of the screen contents on an HPIB plotter or printer.

Simpler devices such as signal generators and wattmeters can be controlled by a computer to take measurements that are not possible by hand such as reflection measurements e.g. error corrected, normalised transfer function measurements, see Fig 1.

For thirty years these measuring instruments have been equipped with a standard interface for computer control that was called HPIB (Hewlett-Packard Interface Bus) by its inventor. In the today's language it is usually GPIB (General Purpose Interface Bus) or IEC-bus (IEC-



Fig 1: A typical measurement setup using GPIB devices.

625) shown in Figs 2 and 3. It has an 8-bit parallel bus system with additional handshaking lines that permit addressing up to 30 devices by a control computer. Because of bus loading, a maximum of 16 devices can be operated at the same time when interfaced to a computer. The cable length between two devices should be a maximum of 2m (in exceptional cases up to 4m).

The devices are interconnected and connected to the computer over a shielded multi-way GPIB cable with piggyback plug connectors having 24 pins, see Figs

4 and 5. Both the hardware (24 pin connectors) the TTL levels and transmission protocol are an international standard (IEEE-488.1 and IEC-625). Newer devices also use a uniform syntax for the control instructions (IEEE-488.2).

A so-called bus Extender using coaxial cables, fibre-optic cables or Ethernet can be used to connect to remote devices. Interface cards for the GPIB are available for most types of computers; naturally they are available for the PC (Figs 6 and 7).

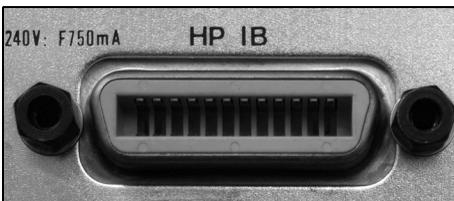


Fig 2: A GPIB (HPIB) bus socket.

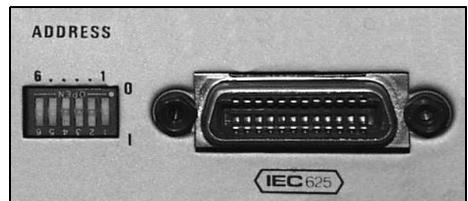


Fig 3: A GPIB (HPIB) bus socket showing address setup switches.

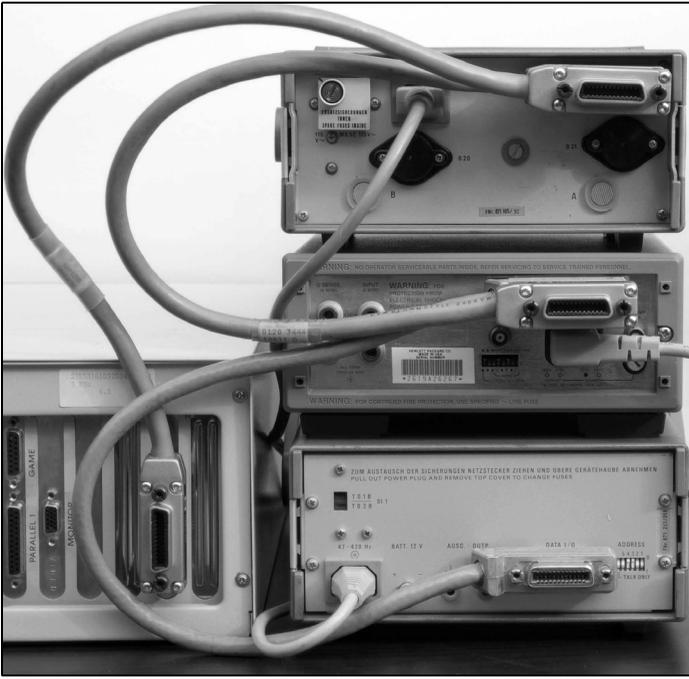


Fig 4: Picture showing several devices connected with GPIB bus cables.

Radio amateurs hardly ever use the interface for control and data capture except to connect them to GPIB plotters or GPIB printers, which nowadays are no longer available. The reason for the lack

of use is probably that no ham versions of programs are available for computer control and reading of these measuring instruments.

At the start of this technology the programs necessary were usually written in the laboratories of companies and research establishments (typically in the programming language HP BASIC). This generally led to special programs for

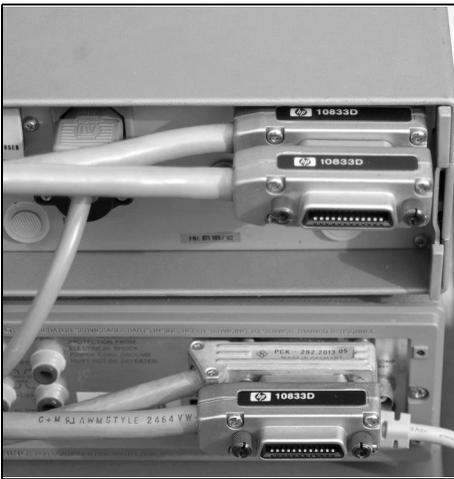


Fig 5: Piggy back GPIB bus cables.

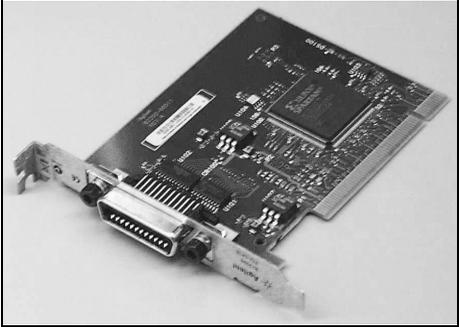


Fig 6: A GPIB PCI interface card for a PC (Agilent 82350).



Fig 7: A USB GPIB adaptor (Agilent 82357B).

dedicated devices and special applications. Later measuring instrument manufacturers offered programs for certain measurements (e.g. EMV measurement by R&S) these were frequently only for certain individual measuring instruments. The prices for the programs were frequently of the same order as the devices themselves.

In the last few years programming languages have become available for graphic programming of GPIB systems such as HP/Agilent VEE and National Instruments Lab-View. It must be noted that these products are not user programs but are programming languages like HP BASIC to produce measuring programs.

For interested radio amateurs it is possible to get results by self-programming with these languages or the classical programming languages or the use of manufacturer user programs that are available to the amateur market.

An example of a universally usable and freely available program is the program, MESSZEIT presented here. It does not conform to the latest standards of Windows programs but it fulfils all the main requirements required for measuring tasks.

2.0

The origins of MESSZEIT

The origins of the program MESSZEIT go back to around 1980. At that time the job of the author involved computer controlled measuring techniques with HPIB/GPIB devices. After a large number of special programs were developed for certain tasks and devices it was decided that a standard program should be developed to cover the majority of measuring tasks. It should be device independent in order to be able to merge both existing as well as later measuring instruments. The program should fulfil the following requirements:

- Time-dependent measurements with several devices at the same time, e.g. change of RF or DC voltages over time, incremental frequency shift of oscillators, etc.
- Measurements with several devices as a function of setup of the first device (parameter measurements), e.g. RF gain at several measuring points as a function of the frequency of a signal generator (transfer functions), power output of amplifiers as a function of the input power from a signal generator (compression measurements), return loss measurements with directional couplers or measuring bridges as a function of the frequency, antenna patterns (antenna output voltage as a function of the angular position of a turntable or a rotor).
- Direct data read out of spectrum and network analysers, oscilloscopes and similar devices with digital memory that send a whole file on instruction.
- Operation of all existing GPIB devices using appropriate device drivers and the ability to merge new device drivers into the program.
- Operation of most devices with a set of standardised instruction words that are accepted by all device drivers.



- Configuration of the measurement setup and the measuring instructions using input tables in order to avoid programming work by the end user.

The control computer (at that time extremely expensive) was an HP 9000 Workstation (the PC had not been invented yet!), these were equipped as standard with HPIB interfaces and the programming environment HP BASIC giving an ideal way of programming measuring instrument in a high-level language. HP BASIC contains a large number of instructions for easy operation the HPIB/GPIB so that the programmer does not have to worry about the details of the bus. The servers used the HP-UX operating system with HP BASIC as a programming language.

The HP 900 computer family (series 200 and 300) as well as HP BASIC were maintained and developed up to the end of HP as a measuring instrument manufacturer in 2000, many measuring systems in industry use these computers up to now.

In order to be able to re-use the substantial software investments in the company laboratory the standard programming language/programming environment was made available as HP BASIC on PCs by the company Transera since the end of the 1990s and today HT BASIC on a PC practically emulates the HP BASIC environment of the HP 9000 and user programs like MESSZEIT run within this environment.

The company Tams converted HP BASIC to run on a PC under the LINUX operating system in the same way. At the authors company new measuring systems used HT BASIC and older ones were changed over. The software was extended in such that it worked without change on all systems.

3.0

Characteristics of MESSZEIT

3.1. Basic functions of MESSZEIT

The MESSZEIT program consists of a nucleus program for execution of measurements, an evaluation part for diagrams and conversion of the measuring files (also HPGRAFIK is individually executable), a large number of device drivers (at present over 100 types), an equipment list file and various support and configuration files.

After the program starts the following actions are implemented or offered as options:

- Up to 16 devices can be selected from the equipment list to be used for measurements. The sequence of the selection determines the order used by the computer to responding to the devices.
- The devices are examined for their initial setup.
- Manual adjustments can be made to any selected devices that are switched on using a standard computer menu (frequently easier than the front panel controls and provides a standard approach).
- Sub menu mode for time-dependent measurements
- Sub menu mode for parameter measurements
- Sub menu for the interpretation program HPGRAFIK

3.2. Time-dependent measurements mode

The task of this mode is the execution of actions in several measuring instruments at regular intervals (measurement cycle). Examples are the measurement of the incremental frequency shift of an oscillator with a frequency counter, the monitoring of battery voltages with digital voltmeters, the fluctuations in level on an



RF transmitter etc.

1. A Time Table is set up:

- Table input of the total measurement time and the cycle, simple measurements only require a line:
e.g. 120, 5 (for a total interval of 120s measure every 5s)
- If several lines are entered then several sequential measuring intervals are defined that are processed successively. Different times can be used.
e.g. 120, 5 (for a total interval of 120s measure every 5s)
1000, 30 (for a total interval of 1000s measure every 30s);
60, 5 (for a total interval of 60s measure every 5s)
10, 11 (Only 1 measurement, the cycle time > interval time)

2. Set up a Command Table or Tables

- A table is completed for each connected and switched on device to describe the action to be implemented during the measuring period:
e.g. AUSLESEN [READ] (read the measured value from the device with unsolicited triggering)
or MESSEN [MEASURE] (unique triggering of the device and reading of the measured value)
- The number of lines in the command table for the device corresponds to the number of lines (measuring intervals) in the Time Table.

3. When measurements start in the Time Table the individual devices are addressed repeatedly and the selected results are stored by device (or by measuring channel for multi-channel devices) in their own file.

When the devices respond to the measuring instruction several measuring instrument classes must be differentiated:

- Normal measuring instruments (N)
These supply a measured value (e.g. digital voltmeter, frequency counter, wattmeter) with an action.
Devices with a source (e.g. signal

generators, voltage supplies) belong to this class. These are adjusted with an instruction such as FREQUENZ [FREQUENCY] or SPANNUNG [VOLTAGE], they send back the adjusted value as a measured value (e.g. frequency, voltage, power).

- T or Tr devices (T)
These devices have their own digital memory for measured values and usually a screen display for the contents, e.g. digital oscilloscopes, network spectrum analysers. They return a complete measured value file with a command (e.g. AUSLESEN [READ]).
- Devices with no data output e.g. relay switches
These devices are addressed via instructions such as SCHALTEN [SWITCH] but do not return a measured value.

Most measurement actions are relatively independent of the individual device. Therefore key words were defined by general measuring instructions that are understood by each device driver. Beyond that there are special measuring instructions that are only understood by a few devices. Typical measuring instructions for the individual device classes are:

Normal measuring instruments (N)

AUSLESEN [READ], Read an existing value

AUSLESEN,2,1,A.2.B [READ,2,1, A, 2, B], Read two measuring channels

MESSEN [MEASURE], 1x trigger and selection. The values read are written into the Y column of a matrix, the associated times into the X column. At end of the measurement this can be stored in a file.

Sources as N class devices

FREQUENZ,1,1,145MHZ [FREQUENCY,1,1,145MHZ], Adjust the frequency and value read



PEGEL,1,1,-60dBm
[LEVEL,1,1,-60dBm], Adjust the level and value read

SPANNUNG,1,1,2.75V
[VOLTAGE,1,1,2.75V], Adjust the voltage and value read

INCREMENT_F,1,1,1MHz
[INCREMENT_F,1,1,1MHz], Increase the frequency and value read

INCREMENT_P,1,1,1dBm
[INCREMENT_P,1,1,1dBm], Increase the level and value read

T or Tr devices (T)

AUSLESEN [READ], Read a complete data record into a file

AUSLESEN,2,1,A,2,B
[READ,2,1,A,2,B], Read two measuring channels in two files

MESSEN [MEASURE], 1x trigger, read data in file

Devices without data output

SCHALTEN,2,1,EIN,2,AUS
[SWITCH,2,1,OFF,2,ON], Turn switch on channel 1 on and switch on channel 2 off

3.3. Parameter measurements mode

The task of this mode is the execution of actions in several measuring instruments as a function of the settings of the first device, e.g. the measurement of the RF power with a wattmeter as a function of the frequency of a signal generator (transfer function).

A Source Table for the first measuring instrument must be set up using a menu. The information is:

- Initial value of the source (e.g. starting frequency)
- Final value of the source (e.g. stop frequency)
- Increment (e.g. step frequency)
- Dimension of the source value (e.g. MHz)

A Command Table is then required as in

3.1 for each other measuring device.

After the measuring starts the source is shifted up as indicated by the increment and the other devices are selected in sequence after each step. At the end of the measurement the results are written per device (or per measuring channel) into their own file.

3.4. Representation of measurement results

After completion of a measurement as described in 3.2. or 3.3. the final result for each channel or each device can be plotted, stored and printed out. The diagrams correspond to the appropriate part of the HPGRAFIK analysis program.

3.5. Immediate reading of screen contents for measuring devices

In the program menus for time-dependent and parameter measurements there is a menu option for “last measurement again”. The results for several device measurements from the last measurement session can be represented.

For T devices (e.g. spectrum/network analysers, oscilloscopes) the complete momentary measurement from the equipment is recalled and it can be displayed and stored on the computer (Fig 8). To pick out only the stored results of measurement for this type of device no table is required, i.e. after a program starts reading of the devices begins only this menu option is to be selected.

3.6. Evaluation of measurement results

The evaluation part of MESSZEIT (also separately by HPGRAFIK) has the following tasks:

- Diagrams from measurements already stored
- Expressions on measurement diagrams
- Manipulation of measurement files, Addition, Subtraction and Multiplication of files (e.g. to normalise a

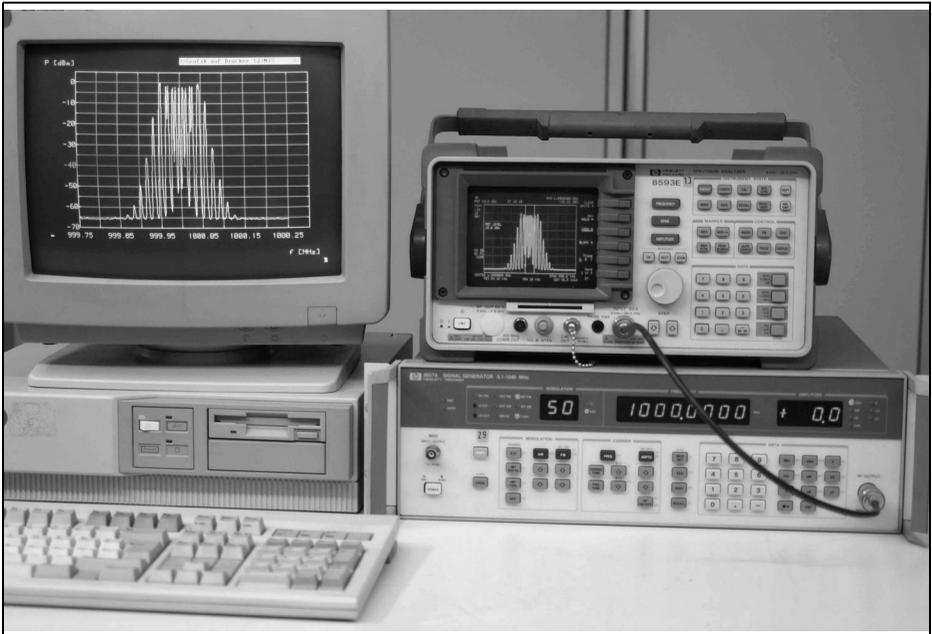


Fig 8: A display being picked up from a T class device and displayed on the PC as well as the device display screen.

transfer function measurement)

- Smoothing, curve fitting, integration, deviation,
- Conversions, e.g. dB to SWR, dBm to W
- Linking, cohering files
- Additional editing and re-entry of data

Diagrams can also be stored as HPGL files or in normal PC diagram formats and merged in text files. Some examples are shown in Figs 9 - 12

4.0

Using MESSZEIT on a PC with HTB

A PC that has High Tech Basic installed (HTB from Transera) can be used by radio amateurs to run MESSZEIT. HTB

operates like an HP 9000 system on a DOS or Windows PC. The DOS version is no longer available individually but is part of the Windows installation CD. The programs and the files produced are compatibly, so it can be quite useful to run MESSZEIT on a DOS computer (less expensive GPIB interface) and transfer the files over a network to a Windows computer and use HPGRAFIK for evaluation and diagrams.

System requirements for the DOS version (HTB-6):

- 386/486/Pentium PC with ISA-BUS,
- MSDOS 5 or 6, WIN 95 or WIN 98 (in the DOS mode)
- GPIB interface 8 Bit ISA (or some 16 Bit ISA),

HTB-6 or HTB-6 Demo Version

System requirements for the Windows version (HTB-7 or higher):

- Pentium PC with ISA or PCI bus
- NT-4, WIN 2000, XP (WIN 98 with

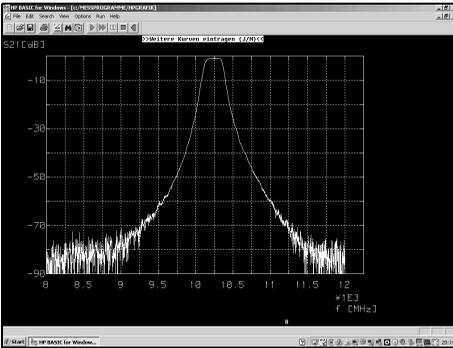


Fig 9: Display of a 10GHz transmission graph.

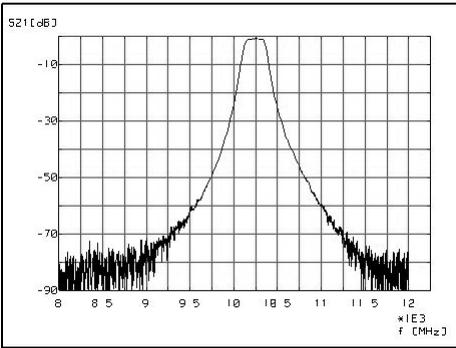


Fig 10: Printed version of a 10GHz transmission graph.

many restrictions)

- GPIB interface 16 Bit ISA, PCI, PCMCIA, USB, LAN
- HTB-7.x, HTB-8.x, HTB-9.x or the demo versions
- For all GPIB interfaces an NT device driver must be installed under Windows.

5.0

HTB versions

The latest Windows version of HTB is available from [1]. The older Windows and DOS versions are available on the installation CD from Transera. The HTB-

6 DOS programs on that CD can only be run under MS-DOS (5/6) and in the DOS mode of Windows 95 and Windows 98. The programs are compatible with the Windows versions; this does not apply to older DOS versions. A free demonstration version of HTB-6 exists, which exhibits the following restrictions: it runs for a half hour and is then terminates but can be started as often as required. Programs produced by the program editor cannot be stored. This restriction has no meaning for use with manufacturers programs such as MESSZEIT.

MESSZEIT can be used without restrictions with all Windows versions from version HTB-7. The latest full version is HTB-9.x from Transera, there is also an HTB-9.x-Run-time-Version that only permits execution of manufacturers pro-

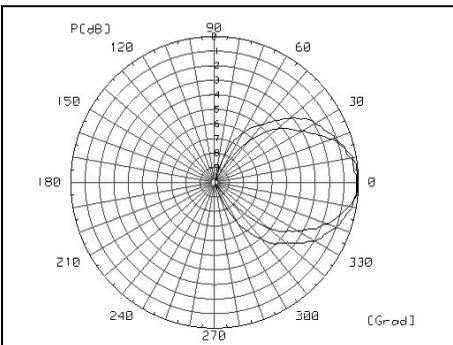


Fig 11: Printed polar diagram of a 6cm exciter.

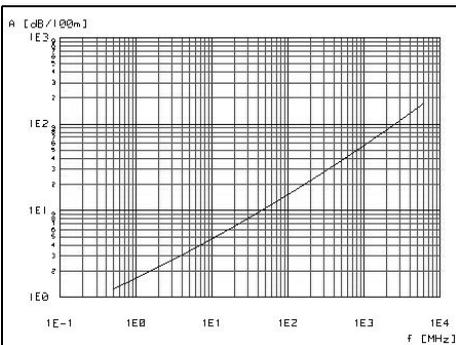


Fig 12: Printer transmission graph for RG 58 coax cable.



grams and contains no program editor. It is clearly less expensive. The HTB-7.1 version was available briefly before the end of Hewlett Packard (approximately 2000) under licence from Transera as HP BASIC for Windows. This was obviously as a replacement for the forthcoming HP-9000 offering. All HP customers with an HP basic service contract for this product were sent a copy free of charge at that time.

The demonstration version of the Windows HTB has the half hour running time and is prevented from using user memory. Demonstration CDs for versions HTB-7.1 and HTB-9.0 as well as HTB-9.0 Runtime are available on the Internet [1].

All full and demo versions are installed by an installation routine onto the computer hard disc. A manufacturer specific NT device driver for the GPIB interface must be installed and configured under Windows.

6.0

Availability of programs and prices

The latest version of HTB can be found from [1], they also supply free demonstration CDs. The programs MESSZEIT, HPGRAFIK, ZPVWOB (for Vector Network Analyser with R&S ZPV and a signal generator) are available free of charge from [2] plus further information, e.g. the supported measuring instruments and interface cards.

Unfortunately there is a cost to connect a GPIB device to a computer. A GPIB interface card must be purchased. The ex-factory prices lie between €300 and €600 [4], and used equipment companies can supply them in the range of €100 to €200. It should be possible to pick them up quite cheaply from a flea market or

Internet auction site. I have seen NI-AT interfaces for under €50. The GPIB cables are not cheap ex-factory however they are a few Euros from used equipment companies or flea markets.

The HTB demonstration versions are free but only run for half an hour. If this is a problem or you want to do your own program development the quite expensive full licensed versions is €800 - €900. Packages with five run time versions are offered that could be divided with colleagues for a more acceptable cost.

All photos taken by the author DJ6TA

7.0

References

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