HOMER Autotuner ISM 900 MHz, WR975 Waveguide

Contents

General Description

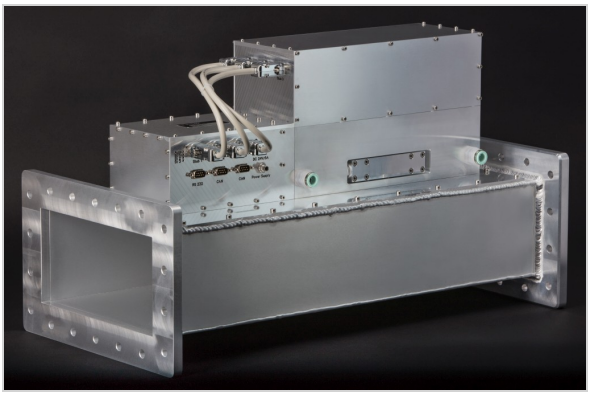

Fig. 1. STHT series STOLPA Autotuner.

The HOMER- Series STHT 900-MHz Autotuner (referred to as "**STOLPA**" in memory of Ing. Milivoj Štolpa, who greatly assisted in applications of six- port reflectometers in former Czechoslovakia) integrates the HOMER Analyzer (an automatic impedance and power measurement system) and the HOMER Mototuner (a three-stub motorized tuner) in one compact unit based on the WR975 (R9) waveguide.The system works under the full-power operating conditions of magnetron-based and solid- state microwave generators. The Analyzer measures both the magnitude and phase of the reflection coefficient as well as incident, reflected and absorbed power, and frequency. The Mototuner consists of three stepping-motor-driven tuning stubs spaced by nominally one quarter of guide wavelength. The Tuner uses data measured by the Analyzer for fast automatic impedance matching of time-varying loads in all industrial applications, including plasma. Matching for non-zero reflection coefficient magnitude (defined mismatch tuning) is also available. The system is designed forlow-ripple continuous wave (CW), high-ripple (Rectified) and Pulsed sampling modes. The peak working power is set at manufacture time as specified in the customer's order.

STHT can be:

- Used autonomously without an external controller.
- Controlled remotely from a personal computer or another controller via the following communication interfaces:
  - RS232 or RS422,
  - CAN (Controller Area Network),
  - EtherNet/IP.
- Integrated into a LabVIEW environment.

The system comes with its own firmware (Server) and documentation.

The Autotuner utilizes a water-based cooling system. The purpose of water cooling is not to enhance cooling efficiency but to isolate the HOMER interior from ambient air, enabling its operation in dusty or excessively hot environments. Air is forcibly circulated inside the HOMER electronics compartment, passing through the water-cooler, thus cooling the HOMER interior.

Note that the Autotuner's cooling is neither intended for nor capable of removing external heat that is conducted to HOMER's interior, for instance by the waveguide flanges. In the latter case, please use water-cooled external flanges.

Principle of Operation

The Analyzer part of STHT is based on the six-port reflectometer (SPR) principle. Reflectometers of this type are especially suitable for industrial applications where on-line monitoring and control under full working power is required. SPR is capable of measuring not only the complex reflection coefficient of the load but also the incident, reflected and absorbed powers. A frequency counter is also integrated with the system. The conceptual simplicity of SPR facilitates its stable and temperature-independent operation over long periods of time. The system parameters required for the computations are obtained in the process of factory-made calibration, in which a collection of impedance standards is connected in place of the load. It is recommended for the best performance that the recalibration be performed every two years.

The Mototuner part of STHT uses an accurate measurement-based equivalent circuit to find stub positions needed to match loads, characterized by a complex reflection coefficient delivered from the HOMER Analyzer. Thanks to the predictive algorithm employed, time-consuming trial-and-error optimization schemes are avoided, enabling fast and accurate matching of even grossly mismatched loads.

Modes of Sampling

HOMER supports three modes of microwave signal sampling, named *CW*, *Rectified*, and *Pulsed*.

- **CW mode** is applicable to unmodulated signals with output power ripple not exceeding 15% of the peak value.
- **Rectified mode** is designed for slowly pulsing signals (with repetition rates up to several kHz). Such signals are typical for magnetrons powered by economy power supplies which incorporate simple half-wave or full-wave rectifiers.
- **Pulsed mode** (optional) is intended primarily for sampling fast square pulse-modulated microwave signals with pulse widths down to 100 μs.

The *Rectified* and *Pulsed* modes provide both instantaneous and mean values of the reflection coefficient and powers. Impedance matching is based on the mean value of the load reflection coefficient.

HomSoft Windows Control, Visualization and Data Logging Software

Although HOMER can operate as a stand-alone system, the *HomSoft* control, visualization and data logging software (Fig. 2 on the next page) significantly expands its capabilities. Its basic features include:

- Microsoft Windows® environment.
- Accurate measurement of complex reflection coefficient and its display in various formats, such as
  - Magnitude
  - Phase
  - Return Loss
  - VSWR
  - Polar Display
  - Smith Charts (Z and Y)
  - Oven diagram (Rieke-type chart)
  - Frequency
- Measurement of incident, reflected, and absorbed powers and their display in various formats, such as watts, decibels, or percentage of incident power.
- Numerical readout of signal frequency, load reflection coefficient and power in various formats.
- Arbitrary shifting of the measurement plane.

- Saving measured data as tables (text files) or pictures (BMP, GIF, JPG).
- Periodic data logging of all measured quantities.
- Multiple windows enabling simultaneous observation of various quantities in different formats.
- Wide selection of appearances of displayed curves.
- Storage and retrieval of complete system settings tailored to particular tasks.
- Graphical interface for tuner control (manual stub movement, step-by-step/continuous autotuning).
- Prescribed scenario of tuning stub movements, enabling, for example, automated Rieke diagram measurement.
- DDE Server option, enabling other Windows applications to share measurement results.
- Extensive on-line help.

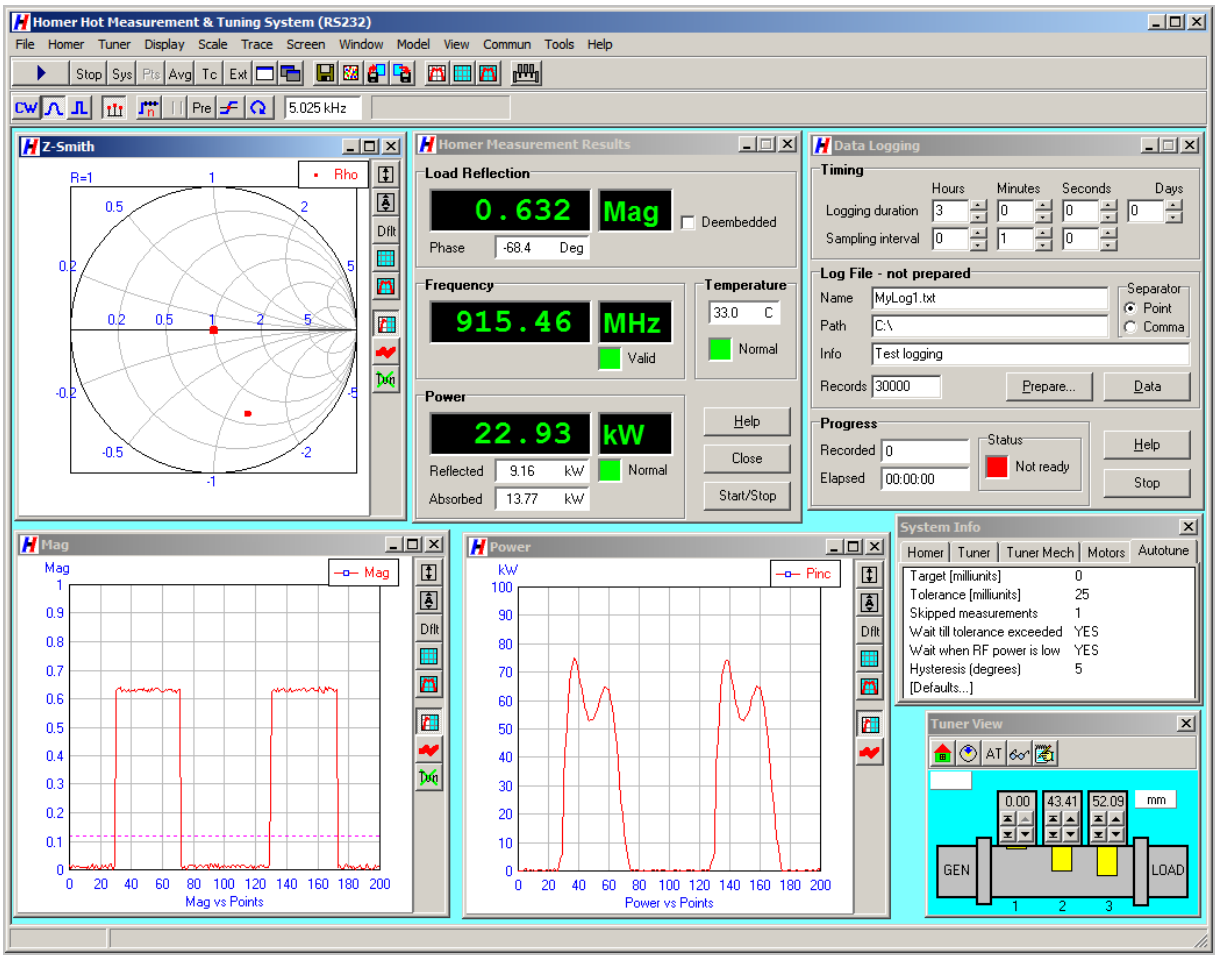

Fig. 2. An example of *HomSoft* graphical user interface.

Specifications

Electrical	
Waveguide type	R9 (WR975)
Flange type	IEC
Frequency range	890 – 930 MHz
Available maximum working power[1] [2] [3]	1 – 100 kW
Dynamic range of working power	20 dB
Reflection coefficient measurement error (uncertainty circle radius)	0.05
Incident power measurement error (matched load)	±5 %
Power supply voltage	24 V ±10% DC
Peak current consumption (all stubs moving)	5 A
Current consumption (stubs resting)	2 A
Interface	RS232, RS422, CAN, EtherNet/IP
Modes of signal sampling	CW, Rectified, Pulsed
Max acceptable ripple in CW mode	15 % of peak value
Max repetition rate of signal envelope in Rectified mode[4]	10 kHz
Min pulse width in Pulsed mode	100 μs
Tuner	
Max tuning stub travel	70 mm
Tuning range[5]	VSWR < 10:1
Tuning accuracy (reflected-to-incident power ratio)	1 %
Full stub insertion travel time	0.55 s
Time to achieve match[6]	Depends on load mismatch, initial stub positions and signal quality
Mechanical	
Mass	26.5 kg
Length	655.3 mm (25.8 in)
Width	336.6 mm (13.3 in)
Height	371.6 mm (14.6 in)
Surface finish	E-CLPS 4600

[1] The actual maximum working power is hardware-fixed according to customer's order (must be within the Specifications limits). Any changes to the peak working power require hardware modification and partial unit recalibration, and therefore must be done at the factory. The minimum working power is 20 dB (= dynamic range) below the actual maximum working power.

[2] The maximum working power is specified for ***retracted tuning stubs***.

[3] In Rectified and Pulsed modes, maximum power means ***peak*** power (not its mean value).

[4] Signal envelope repetition rate (ripple frequency) f_e is determined by power line frequency f_p and the rectification method. Examples: One-phase half-wave rectification $f_e=f_p$; one-phase full-wave rectification $f_e=2f_p$; three-phase half-wave rectification $f_e=3f_p$; three-phase full-wave rectification $f_e=6f_p$; three-phase Y+Δ half-wave rectification $f_e=6f_p$; three-phase Y+Δ full-wave rectification $f_e=12f_p$.

[5] Generally, the match will be improved for loads outside of the tuning range.

[6] For tuning speed details, see S-TEAM Application Note AN-0901.

Environmental	
Cooling water flow rate (minimum)	5 liters/minute
Cooling water temperature[7]	+15 to +25 °C
Pressure drop at min water flow rate	< 50 kPa
Maximum working pressure	500 kPa
Water inlet/outlet connector[8] [9]	SMC KPH12-03
Water hose	SMC TU 1208 Polyurethane
Operating temperature range	+5 to +55 °C
Storage temperature range	-10 to +70 °C
Optimal conditions for long term storage	+5 to +35 °C, humidity < 75%

[7] Increase the minimum cooling water temperature in situations where condensation can occur (e.g., when cooling while HOMER is switched off).

[8] The original water connectors are intentionally made of plastic material to prevent internal galvanic corrosion of cooler parts. If replacement with connectors made of metallic materials, such as brass, galvanized steel, or even stainless steel, is necessary, deionized cooling water with a conductivity of less than 1 µS/cm **must** be used.

[9] See, e.g., www.smc.eu

Configurations

Basic Configuration

- STHT Basic Unit
- Internal firmware (Server)
- Calibration in 890 – 930 MHz band
- RS232 or RS422 serial interface
- CW and Rectified modes of sampling
- Operating handbook (pdf)
- Communication protocol manual (pdf)
- A set of standard cables[10]

Options

1. *HomSoft* control
2. Pulsed mode of sampling
3. Defined mismatch tuning
4. CAN Bus communication interface (includes CAN Bus cable)
5. CAN-USB Adapter (to connect a PC to CAN Bus network)
6. LabVIEW HOMER Virtual Instruments Library
7. Dynamic Data Exchange (DDE) server in *HomSoft* Windows SW[11]
8. Technical support in hours
9. n/a
10. Digital input for selected HOMER commands
11. EtherNet/IP communication interface

For further details of some of these options, see section Option Descriptions.

Optional Power Supplies

- Traco Power TBL 150-124, 24V/6.25A, DIN rail mountable
- Electro-Automatik EA-PS-524-11T, 24V/10.5A, input 90-264 V, benchtop

[10] The set of standard cables includes DC power supply cable, RS232/RS422 cable, and (in case of CAN Bus) CAN Bus cable.

[11] *HomSoft* control option required.

Option Descriptions

***HomSoft* control.** *HomSoft* is a license-free software package designed for comprehensive monitoring and control of Autotuners thanks to its extensive graphical visualizations. However, *HomSoft* works only with Autotuners that have the "*HomSoft* control" option enabled within the unit. The *HomSoft* control option can be enabled at time of purchase of an Autotuner, or can be purchased later and activated at the customer's site without needing to return the unit to the manufacturer.

For units without the HomSoft control option enabled, the HomSoft installation package includes a limited-feature test software called TuTool. While TuTool provides basic functionality, it lacks graphical visualizations, displaying only numerical data.

Defined Mismatch Tuning. Some installations (notably some plasma applicators) may work better when the result of autotuning is not a zero reflection coefficient but a slight mismatch. Defined Mismatch Tuning option enables such tuning method, resulting in a reflection coefficient that has a user-specified, nonzero magnitude. The phase is uncontrolled.

CAN-USB Adapter. To connect your PC with a CAN Bus network (or with the STHT alone), either the Peak PCAN-USB Interface or Sontheim CAN USB Light Dongle adapter is needed. You can order it as an option. Another possibility is to buy the dongle yourself from the manufacturer (visit the links above).

LabVIEW HOMER Virtual Instruments Library enables HOMER monitoring and control from within the National Instruments' LabVIEW environment. The library consists of a collection of virtual instruments (Fig. 3 above) and includes several useful examples. The library enables users to integrate HOMER into their own applications with much less effort than trying to start from scratch by studying HOMER communication protocol and programming the complete communication.

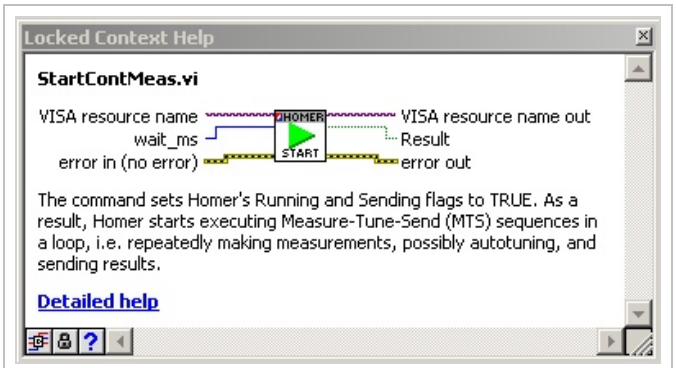

Fig. 3. An example of a LabVIEW virtual instrument block.

DDE Server. DDE Server is a functionality within the *HomSoft* Windows visualization and control SW, and hence it needs the *HomSoft*control option, too. The DDE Server enables another (customer's) Windows program, e.g., Microsoft Excel, to extract measurement results from running *HomSoft*.

Technical support. It often happens that new users, especially in the initial phase, need counsel about issues that are not directly a matter of HOMER itself but of their particular application, or about topics that are in fact described in the accompanying documentation. Four hours of such support are provided free of charge; additional support should be ordered.

Digital input for selected HOMER commands. This option enables selected HOMER commands to be remotely triggered by an external 24-V pulse. Currently, the commands include *Autotune ON/OFF*, *Single Autotuning Step*, and *All Motors Home* procedure.

Dimensional Drawing

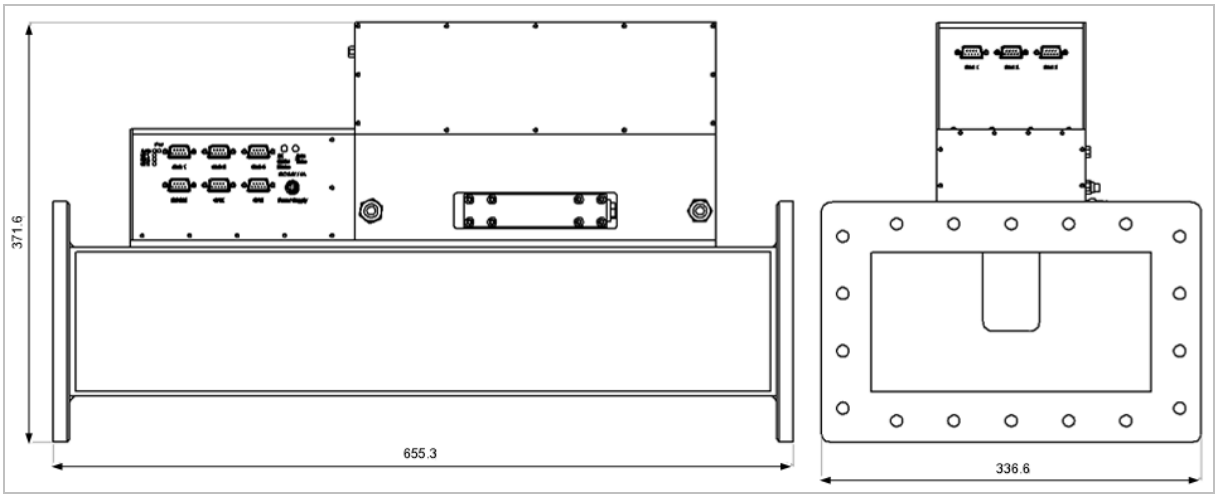

Fig. 4. Basic dimensions of STHT 2.3 in millimeters.