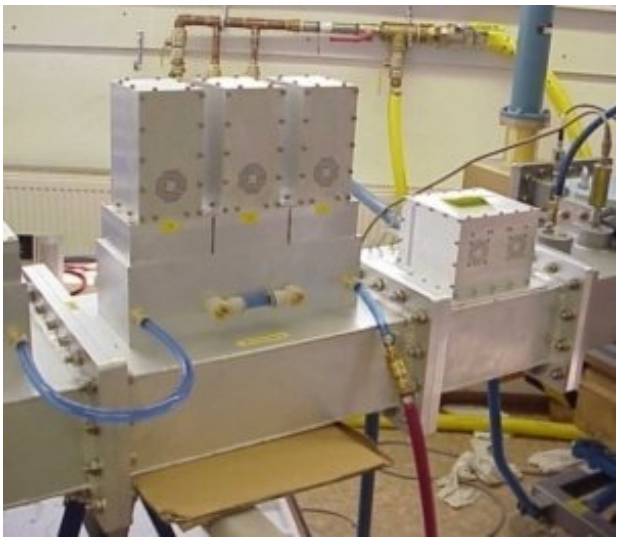
900-MHz Automatic Impedance Analyzer and Matching System

Basic Description

The 900-MHz Automatic Impedance Analyzer and Matching System consists of two separable parts: *HOMER*™ STHD impedance analyzer and a three-stub STT tuner. The unit, based on R-9 (WR-975) waveguide, works under the full-power operating conditions of magnetron-based microwave generators. *The HOMER* part measures both magnitude and phase of reflection coefficient as well as incident, reflected and absorbed power and frequency. The tuner part consists of three stepping-motor-driven tuning stubs spaced in mutual distances of nominally one quarter of guide wavelength. The tuner uses data measured by *HOMER* for fast automatic impedance matching of time-varying loads in all industrial applications, including plasma. The system is designed for CW, high-ripple ("Rectified") and pulsed operation modes. The system can

- work autonomously without any external controller;
- be controlled from a personal computer via RS232 or CAN interface;
- be integrated in a DeviceNet system.



Matching for non-zero reflection coefficient magnitude (mismatch tuning) is also available.

Principle of Operation

The *HOMER* part of the autotuner system is based on the six-port reflectometer (SPR) principle. SPR is cabable of measuring complex reflection coefficient of a load as well as 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. (It is recommended that a factory-made recalibration be performed once a year.) Reflectometers of this type are especially suitable for industrial applications where on-line monitoring and control under full working power is required.

The tuner uses an accurate measurement-based frequency-dependent equivalent circuit for finding stub positions needed for matching in terms of the complex reflection coefficient delivered from *HOMER*. Thanks to the predictive algorithm, time-consuming trial-and-error optimization schemes are avoided, enabling fast and accurate matching of even grossly mismatched loads.

Modes of Operation

STHT supports three modes of operation, named CW, Rectified, and Pulsed.

CW mode is applicable to unmodulated microwave signals with output power ripple not exceeding 15% of peak value.

Rectified mode is designed for slowly pulsing microwave signals (up to 400 Hz repetition rate). Such signals are typical for magnetrons powered by low-cost power supplies which incorporate simple half-wave or full-wave rectifiers.

Pulsed mode option is intended primarily for sampling fast pulse-modulated microwave signals with pulse widths down to 100 μs.

Rectified and Pulsed modes can provide both instantaneous and average values of reflection coefficient and power. Impedance matching is based on the average value of complex reflection coefficient.

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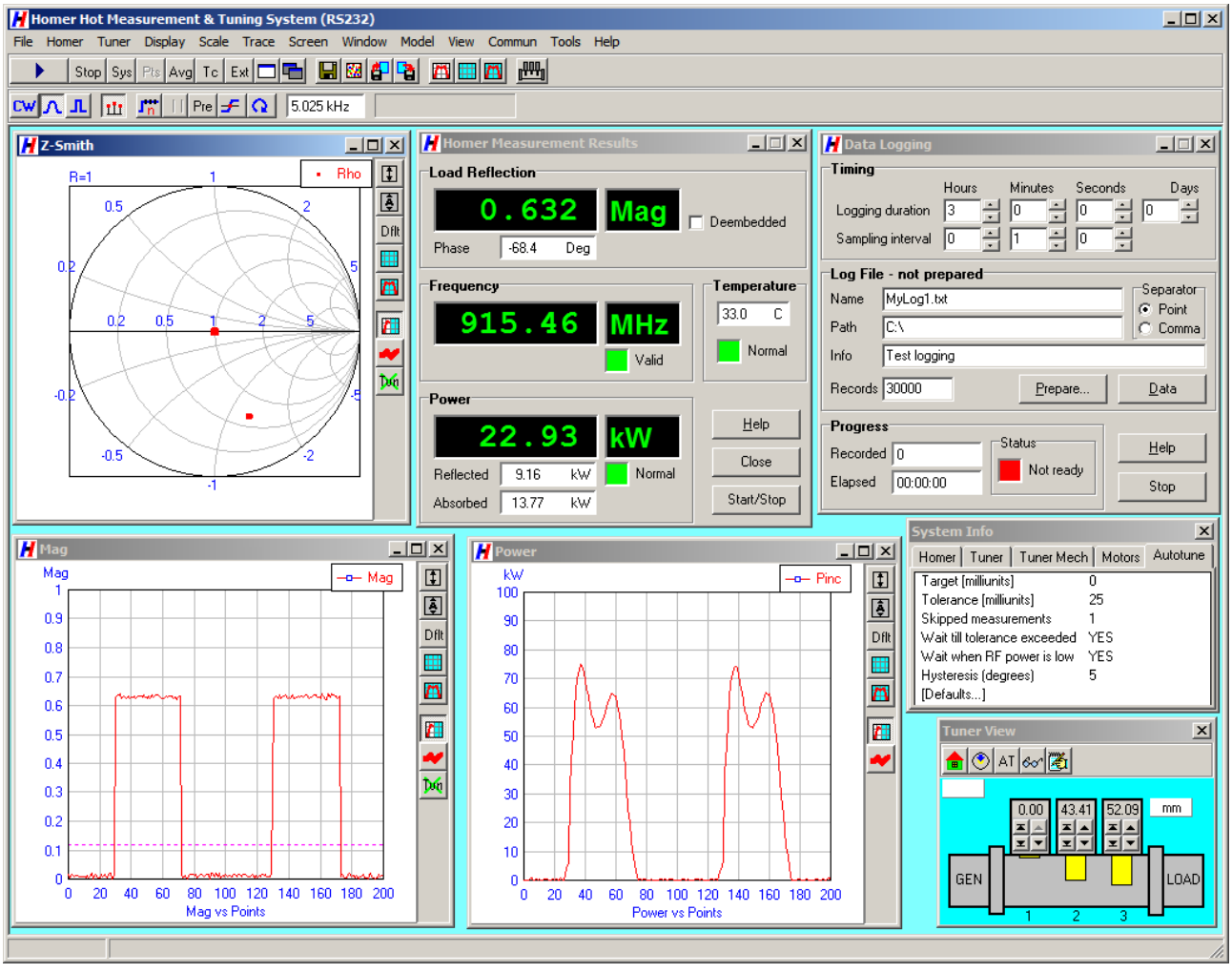
Windows Control, Visualization and Data Logging Software

Although designed as a stand-alone system, the control, visualization and data logging software significantly expands the the system capabilities. The basic features include:

- Microsoft Windows® environment
- Accurate measurement of complex reflection coefficient and its displaying in various formats, including
  - Magnitude
  - Phase
  - Return Loss
  - VSWR
  - Polar Display
  - Smith Charts (Z and Y)
  - Rieke-Type Chart
- Measurement of incident, reflected, and absorbed power and its displaying in various formats, including watts, decibels, 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 or some of the measured quantities
- Multiple windows enabling simultaneous observation of various quantities in different formats
- Wide selection of appearances of displayed curves
- Storing and retrieving of complete system settings tailored to particular tasks
- Graphical interface for tuner control (manual stub movement, step-by-step/continuous auto-tuning)
- Prescribed scenario of tuning stub movements
- Extensive on-line help



Specifications

Electrical	
Waveguide type	R-9 (WR-975)
Flange type	IEC
Frequency range[1)]	880 to 930 MHz
Maximum working power[2) 3)]	100 kW
Minimum working power	10 W
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
Power consumption (all stubs moving)	60 W
Power consumption (stubs resting)	40 W
Interface	RS232, CAN, DeviceNet
Modes of operation	CW, Rectified, Pulsed
Max ripple in CW mode	15 % of peak value
Max repetition rate of signal envelope in Rectified mode[4)]	400 Hz
Min pulse width in Pulsed mode	100 µs
Tuner	
Max tuning stub insertion depth	70 mm
Tuning range[5)]	VSWR < 10:1
Tuning accuracy (reflected-to-incident power ratio)	1 %
Full stub insertion travel time	12 s (standard) 2.4 s (high speed motors option)
Time to achieve match	Depends on load mismatch, initial stub positions and signal quality[6)]
Mechanical	
Mass	Homer 8.1 kg, Tuner 23.4 kg
Length	Homer 300 mm, Tuner 446 mm
Width	Homer 336.6 mm, Tuner 336.6 mm
Height	Homer 295 mm, Tuner 476 mm
Environmental	
Operating temperature range	+5 to +55 Celsius
Storage temperature range	-10 to +125 Celsius

1) The systems are optimized for the three ISM bands, centered at 896 MHz, 915 MHz, and 922 MHz.

2) Actual maximum working power is fixed according to customer's demand (must not exceed 100 kW). The actual minimum working power is 20 dB (=dynamic range) below the actual maximum operating power or 10 W, whichever is greater.

   Maximum working power is specified for ***matched load*** conditions. For loads with high reflection coefficient magnitude (>0.9), the maximum power is derated to avoid arcing with deeply inserted tuning stubs. Please contact the manufacturer for details.

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

4) Signal envelope repetition rate f_e is determined by power line frequency f_p and the rectification method. Examples: Half-wave-rectified signal $f_e=f_p$; full-wave-rectified signal $f_e=2f_p$; 3-phase ripple period $f_e=3f_p$ (half-wave rectification), $f_e=6f_p$ (full-wave rectification).

5) Generally, the match will be improved for loads outside of the tuning range (e.g. VSWR=30 drops below 5).

6) For tuning speed details see S-TEAM Application Note AN-0901.

Configurations

Basic Configuration
STHD+STT+Firmware
RS232 interface
CW and Rectified modes of operation
Operating handbook

Options
Windows software
Pulsed mode of operation
High-speed motors
Additional interface – CAN Bus
Additional interface – DeviceNet
CAN-USB Adapter
Water cooling
Mismatch tuning
Set of cables

Basic Dimensions