WR975 E-H Auto Tuner

Part Number: AT-EH-975-XXX

Microwave TECHNIQUES LLC

June 2025

WR975 E-H AUTO TUNER

MICROWAVE TECHNIQUES P/N: AT-EH-975-XXX

Contents

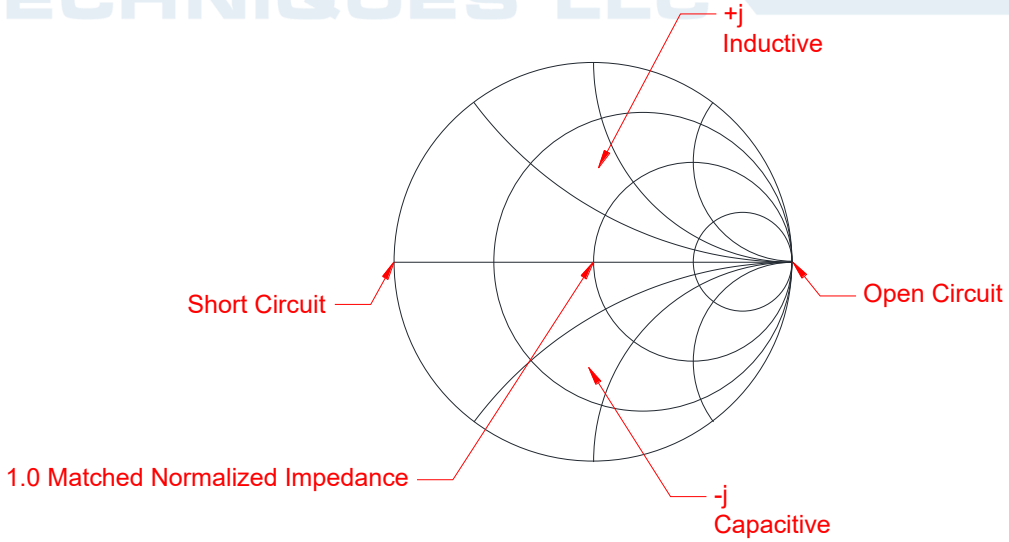
Introduction

Overview

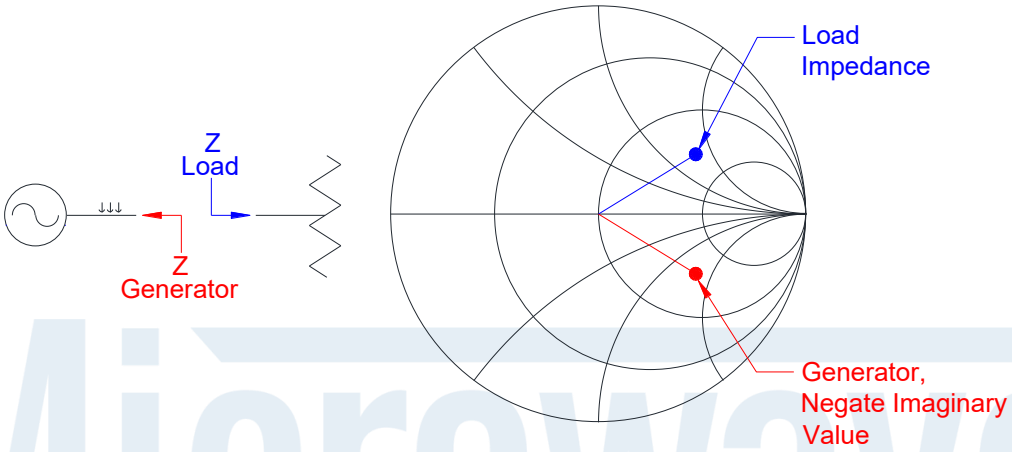
Optimal power transfer in an RF system requires matched impedances between the generator, transmission line, and the termination (or load). Deviation from the nominal system impedance of any of these components results in power reflections and voltage standing waves within the system. This power reflection results in a decrease in system efficiency in addition to providing unnecessary stress on devices within the system. For many RF applications, the terminating impedance of the load may vary making it difficult to optimize to the nominal system impedance. RF tuners can be used to help optimize the load impedance and improve system efficiency. Tuners can be motor driven, and with the aid of a control system can be remotely adjusted to the user's desired positions or automatically through programmed algorithms. There are many different physical approaches for RF tuning, this manual will cover the Microwave Techniques AT-EH-975-XXX series of waveguide E-H tuners and their operation.

Theory of Operation

A Smith Chart is a standard graphical tool used for RF impedance matching. Impedance is defined using complex numbers and contains real and imaginary components. A Smith Chart is a transformation of the Cartesian complex plane to a normalized polar plot.



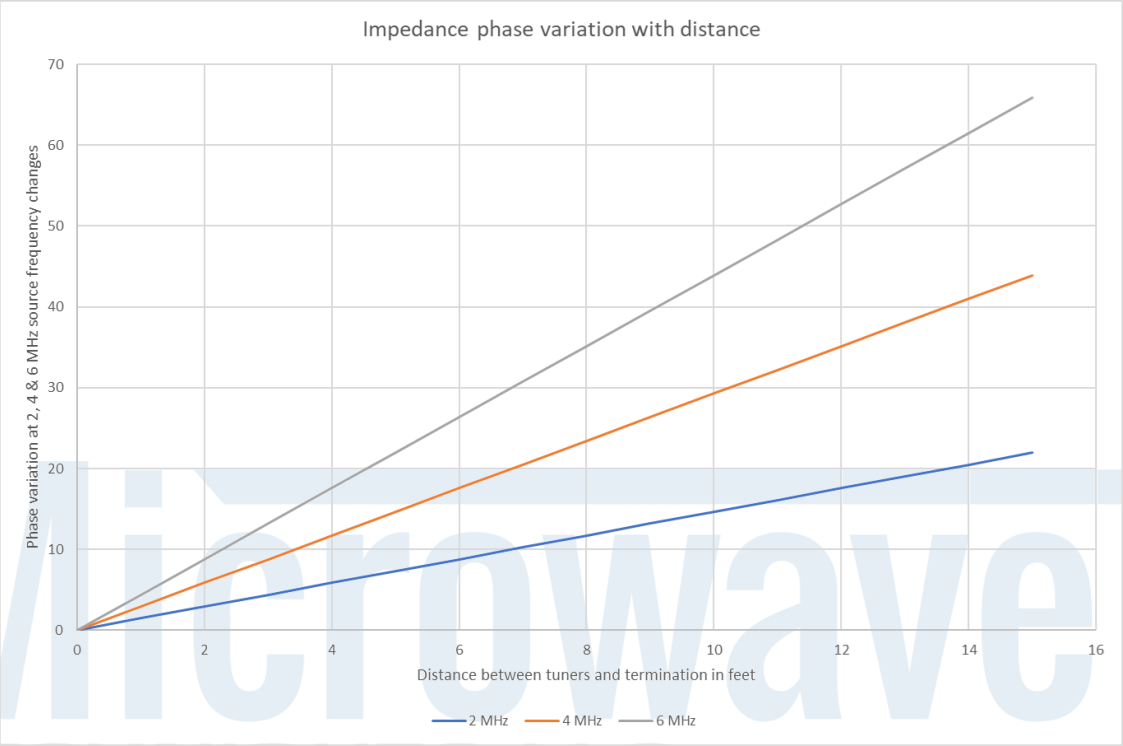
A Smith Chart provides a visual representation of the impedance. The horizontal axis represents the "real" axis whereas the left most position represents zero impedance while the right most position represents an infinite resistance. An impedance above this axis indicates an inductive reactance, below the axis shows a capacitive reactance. The center of the chart is a perfectly matched device to the normalized impedance. If the terminating load in a system does not match the system impedance, conjugate impedance matching can be used to improve the power transfer between the generator and load.



Conjugate matching is achieved by changing the impedance seen looking back towards the generator to have the same real component and opposite or negated imaginary component of the impedance of the load. An RF tuner is used to change the generator's impedance. Impedance values can also be expressed in a polar format as opposed to the real and imaginary complex number pairs. An impedance mismatch in polar terms is referred to as the reflection coefficient and will have a magnitude that varies from 0 to 1 and a phase angle that varies from 0 to ±180 degrees.

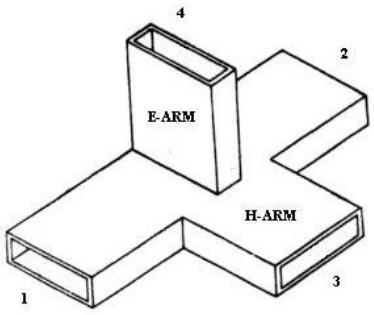
The example above is for a single, fixed RF frequency. If a band of frequencies or an RF generator is being used that is not completely frequency stable, the load impedance will change. Phase variations in the load impedance due to frequency variations will increase proportionally as the distance from the load is increased. To effectively calculate and apply a conjugate match, it is important that the system tuner is located as close to the device that is generating the mismatch as possible.

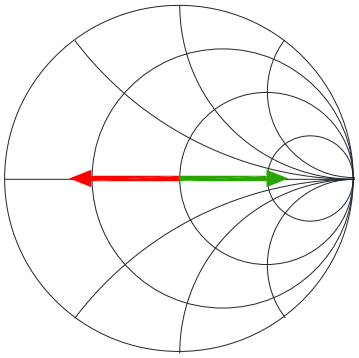
The plot below indicates the amount of phase variation that can be expected as the distance between the offending mismatch and the tuner is increased. Maintaining a stable load impedance will improve tuner performance greatly. It is not realistic to expect a motorized tuner to maintain an accurate conjugate match that needs to vary greatly due to generator frequency instabilities.

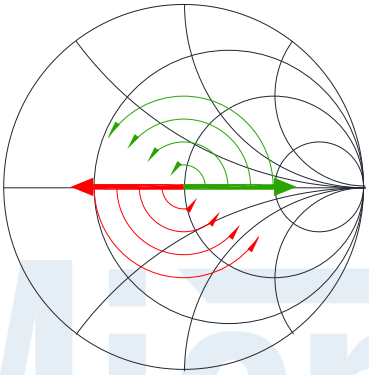


Phase Variation Vs. Distance Between Tuner and Termination

The tuner is referred to as an E-H tuner due to the construction and method used to generate mismatch. The body of the tuner is a 180° hybrid or more commonly referred to as a "Magic Tee". A Magic Tee has unique properties that allow it to split or combine RF energy with specific phase characteristics. When it is used as a combiner, the two input ports, 1 and 2, can direct the combined RF energy out to an E-Port or H-Port based on the phase difference between the signals. For use as a tuner, the Magic Tee is configured differently. One input port is used to inject RF energy into the device while variable length short circuits are installed on the E and H output ports. By varying the phase of the short circuits, the amount of power reflected, and the phase angle of that power can be controlled. The remaining RF energy will pass through to what would typically be used as the other Magic Tee input (Port 2). The AT-EH-975-XXX series of tuners "folds" the H-Port to reduce the physical size of the device.







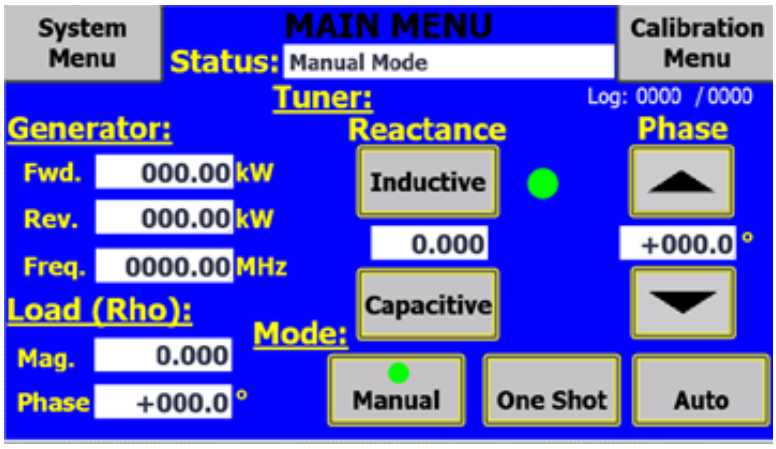
The tuner will initially “Home” during power up to a nominal tuning position where the device will not introduce any conjugate matching. This position is defined as having zero reactance.

While in Manual Mode, the user can add inductive or capacitive reactance to the conjugate mismatch the tuner is generating. Starting from the home position, inductive reactance will move the conjugate matching along the 0° axis, capacitive reactance will move it in the opposite direction following the ±180° axis. The display will read out the magnitude of the reactance providing a value between 0.000 and 1.000. A green LED will indicate inductive reactance and a red LED will indicate capacitive reactance. The Phase control will move the reactance in the counterclockwise direction when it is increased, and clockwise when it is decreased. This allows the inductive reactance to cover any point on the upper half of the Smith chart and the capacitive reactance to cover any point on the lower half of the Smith chart. The horizontal axis is a crossover region for the tuner. Introducing an inductive reactance is intended for conjugate matching above this axis however, the phase control will allow you to move the inductive reactance below this axis by forcing the phase to go below 0° or above 180°. This does not cause a problem and the display will continue to register the phase value. Likewise, the capacitive reactance can be forced above the axis if the phase control is used to increase the phase above 0° or below -180°. The excursions across the axis can continue until the physical motor drive limits are reached.

To accurately generate the conjugate match for the terminating load, the magnitude and phase of the load impedance is required. A differential detector is used between the E-H tuner and the load to make these measurements. This is a real-time measurement of the impedance seen at that point in the system. The detector also has an integral frequency counter to aid in the calculations made by the control system.

Key Features

Real Time Control and Monitoring



Microwave Techniques AT-EH-975-XXX series Auto-Tuner provides real time control and monitoring all within the main operating display. The user may control the tuner by first selecting their desired operation mode. Once a control mode is selected, available control features will be presented for user input. At all times, the main operating display will present selected operating mode, current short positions represented in Reactance Magnitude and Phase, generator properties such as Input Power, Reflected Power and Frequency, and load properties such as Impedance Magnitude and Phase.

Operating Modes

The AT-EH-975-XXX series Auto-Tuner is equipped with three modes of operation: Manual, One Shot and Auto. These mode options are displayed on the main operating display. A green indicator above the text will be present to signify the current operating mode.

Manual mode allows the operator full manual control of the short position represented in Reactance Magnitude and Phase. From the main operating display, the user can easily adjust short positioning using the provided buttons.

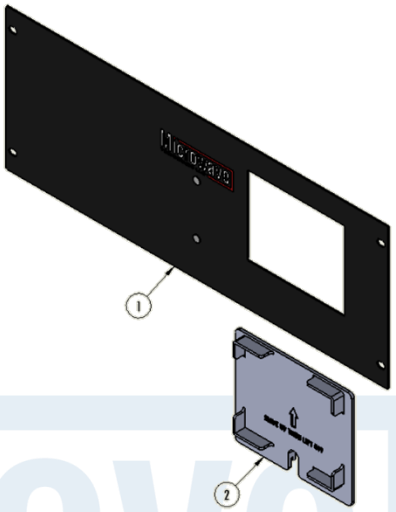
One-Shot mode applies a single calculated amount of correction based on the measured load impedance at the time the mode is selected. This mode is ideal for correcting gross mismatches within a system.

Auto mode is full, automatic operation. This mode will apply calculated correction based on the measured load impedance in addition to making fine corrections to the impedance based on the measured reflected power prior to the tuner. The tuner will continue to make improvements alternating between magnitude and phase adjustments until a user defined return loss has been met. Users can set system specific return loss goals and thresholds to personalize auto-tuning performance to meet specialized system requirements.

Remote Operation

Microwave Techniques has multiple remote operation options available for the AT-EH-975-XXX series. Not all options are available within the standard Auto Tuner design and some options require additional hardware both within the Auto Tuner assembly and for user interface. Should you be interested in remote operation for an AT-EH-975-XXX Auto Tuner, contact a Microwave Techniques sales representative for more information.

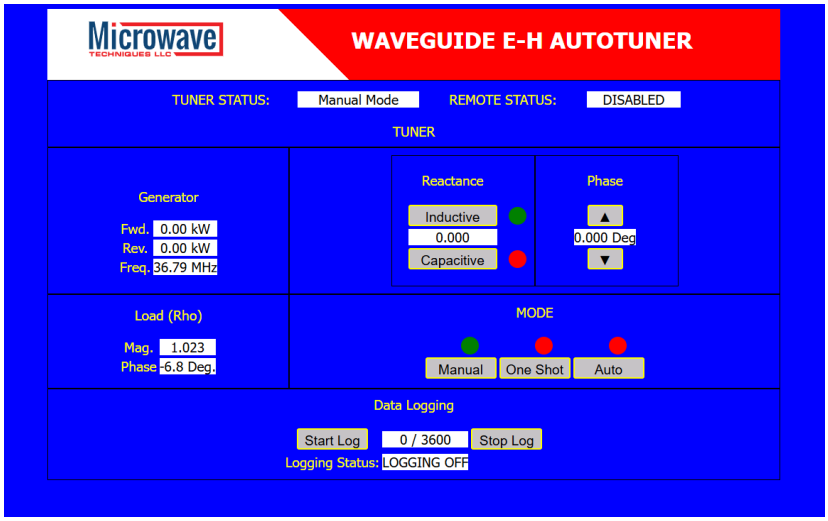
Remote Screen Kit



Microwave Techniques offers both single and dual Remote Screen Kit for the E-H Auto Tuner. Each kit includes a 19" rack mount display panel, power supply, filler panel for the E-H tuner body and installation instructions. This rack mount display panel allows for the touch screen for each tuner to be easily relocated to a convenient location away from the tuner body. Interconnect between the touch screen and the body is made using standard CAT-5 ethernet cables. Since this is just a relocation of the primary interface, it is still considered to be the "local" interface, and the system contains all the features, readouts and calibration settings readily available. This Remote Screen Kit is an addon feature to your AT-EH-975-XXX Auto Tuner. Please contact a Microwave Techniques sales representative for more information, cost and ordering information about this feature.

Remote Webpage Access

Each AT-EH-975-XXX series Auto Tuner is supplied with access to Remote Webpage Access. This portal can be found by accessing the server through the PLC system. Detailed instructions on accessing the PLC system can be found in the AT-EH-975-XXX Instruction Manual.



Discrete Remote Control

Discrete Remote Control is another method of providing simple, but limited, remote control of the Auto Tuner. Using Discrete Remote Control, tuning mode control and status, in addition to data logging control and status are available on the 15-pin D-Sub Remote Control connector located on the back of the Auto Tuner Electrical Control Box. Contact closures are used to initiate a control change and +24VDC output signals provide status outputs. The pin designations for the connector are provided for each tuner within the Instruction Manual. Like the webpage, the status signals from the remote connector will always provide the current operational status. Discrete Remote Control commands may also be utilized by Microwave Techniques MTX-100 generator control system to allow basic tuner control. Please contact a Microwave Techniques sales representative for more information about this feature.

PLC Bridge

Although less common, Microwave Techniques AT-EH-975-XXX series Auto Tuners may be supplied to provide a "bridge" addon. This add-on allows system control variables provided Microwave Techniques Auto Tuner to be supplied to an alternate control system. Please contact a Microwave Techniques sales representative for more information, cost and ordering information about this feature.

Variable Input Power Supply

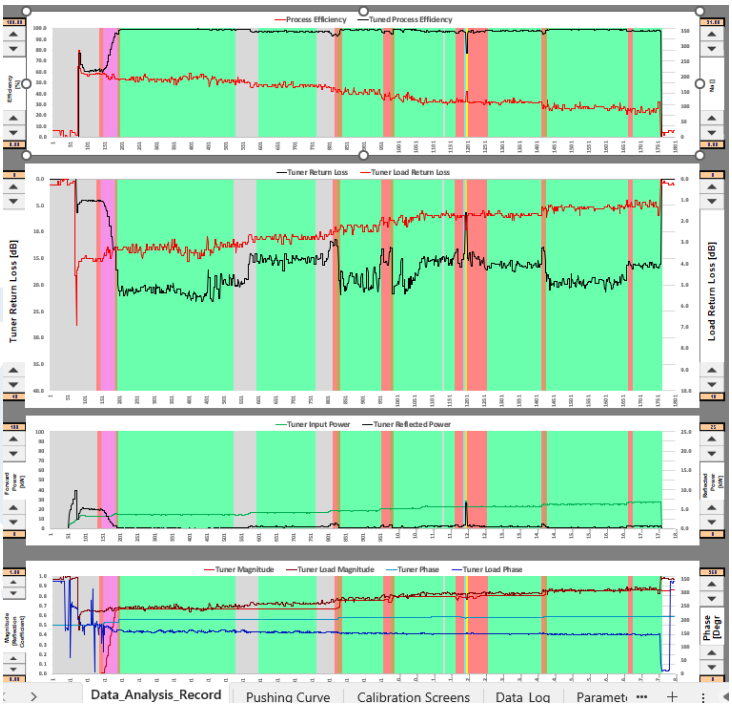
Microwave Techniques AT-EH-975-XXX series Auto Tuner utilizes a variable input, 48VDC output power supply housed within the Auto Tuner Electrical Control Case. This power supply allows both 115VAC and 230VAC supplied AC power and can be accessed through a fused IEC320-C14 receptacle. See below the Voltage and Current specifications of the installed power supply.

VOLTAGE RANGE Note.5	85 ~ 264VAC 120 ~ 370VDC							
FREQUENCY RANGE	47 ~ 63Hz							
POWER FACTOR (Typ.)	PF>0.95/230VAC PF>0.99/115VAC at full load							
EFFICIENCY (Typ.)	80%	84%	86%	88%	88%	88%	89%	89%
AC CURRENT (Typ.)	2.1A/115VAC 1.1A/230VAC							
INRUSH CURRENT (Typ.)	35A/115VAC 70A/230VAC							

Data Logging

The System Menu also provides access to the Data Logging feature equipped on all AT-EH-975-XXX series Auto Tuners. This feature allows the user to initiate a second-by-second capture of the performance and fine-tuning parameters being used by the Auto Tuner control system. Logged data is available and can be accessed using the PLC web pages. Data is provided in a CSV file format and can be viewed in your preferred spreadsheet program such as Microsoft Excel.

Data Log Analysis



To assist with analyzing the data logging files, a spreadsheet is available from Microwave Techniques. This file provides plotted data with a color-coded background to visually show the current operating mode of the tuner. Available plots within this spreadsheet include tuned vs untuned efficiency, pre and post tuner return loss, forward and reverse power (kW), tuner and load impedance in rectangular and polar formats and frequency of the generator. Each of these plots may be able to assist in selecting tuning parameters. In addition, the plots have also been found to be extremely helpful in system troubleshooting, gaining a greater insight into individual system processes and how processes may change over time. Further instructions on the use of the EH analysis spreadsheet are included with the software. If you are interested in this software, please contact a Microwave Techniques sales representative for more information about this feature.

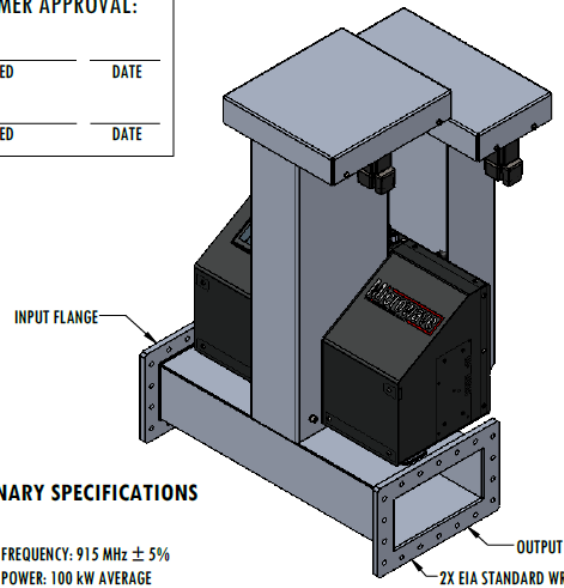
Outline Drawing: AT-EH-975-701

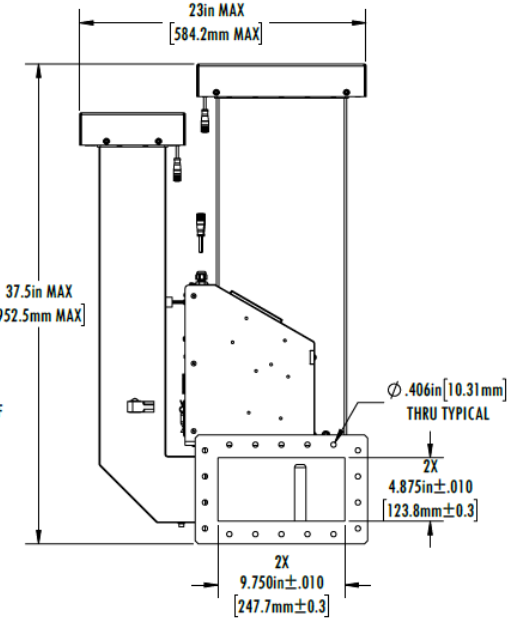
CUSTOMER APPROVAL:

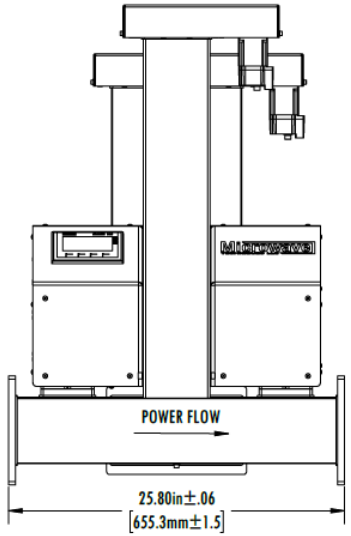
SIGNED DATE

SIGNED DATE

REV	ECN	DESCRIPTION	DATE	BY	APPROVED
A	-	INITIAL RELEASE	9/7/2023	TMM	DGB
B	M23685	UPDATE TO SHOW NEW ENCLOSED CONTROL BOX. OVERALL DEPTH INCREASE FROM 22in MAX TO 23in MAX. ADD SHEET 2 TO SHOW KEY COMPONENTS. REMOVE COUPLING AND DIRECTIVITY SPECIFICATION. COUPLERS FOR INTERNAL USE ONLY.	4/18/2024	TMM	DGB
C	M23906	ADD INPUT, OUTPUT AND POWER FLOW ANNOTATIONS	8/2/2024	TMM	MM
D	M24793	UPDATE PAINT COLOR FROM GREY TO BLACK; ADD START UP AND OPERATION SPECIFICATIONS	6/25/2025	TMM	DGB







PRELIMINARY SPECIFICATIONS

ELECTRICAL:
- FREQUENCY: 915 MHz ± 5%
- POWER: 100 kW AVERAGE
- VSWR: 10:1 MISMATCH OVER BANDWIDTH
- PHASE SHIFT: 360°

MECHANICAL:
- BODY MATERIAL: ALUMINUM 6061-T6
- INTERFACE: 2X WR975 EIA CPRF
- SHORT CONSTRUCTION: 2X SINGLE NON-CONTACTING BUCKET
- PRESSURE: N/A - NOT HERMETIC
- APPROXIMATE WEIGHT: 110 lbs [50 kg]

START UP AND OPERATION:
- AC INPUT: 115 VAC, 60 Hz, 2.1A / 230 VAC, 50 Hz, 1.1A
- OPERATING MODES: MANUAL, ONE-SHOT, AUTOMATIC
- CONTROL & MONITORING OPTIONS (STANDARD): LOCAL,WEB-PAGE, DISCRETE

FINISH: MIL-DTL-5541 TYPE II, CLASS III (ALUMINUM ONLY)
PAINT (WAVEGUIDE BODY): MICROWAVE TECHNIQUES BLACK
MARKING: STANDARD LOGO AND PRODUCT INFORMATION INCLUDING PART NUMBER AND SERIAL NUMBER
ADDT'L MARKING: LABEL OR STENCIL "INPUT" AND "OUTPUT" ON RESPECTIVE FLANGES AS INDICATED.

CONTACT SALES@MICROWAVETECHNIQUES.COM FOR MORE INFORMATION

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28 Sanford Drive : Gorham, ME 04038 : (207) 854-1700

DRAFTED BY: T. Mathieu DATE: 9/7/2023
CHECKED BY: S.Jipson DATE: 9/7/2023

DESCRIPTION: WR975 CONDENSED E-H AUTO TUNER ASSEMBLY

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UNLESS SPECIFIED: UNITS: INCHES X.XXX± .005 X.XX± .02 X.X± .05 ∠ ± 30' 63

3rd ANGLE PROJECTION

INTERPRET PER ASME Y14.5-2009 REV: D DRAWING #: AT-EH-975-701_OTL B

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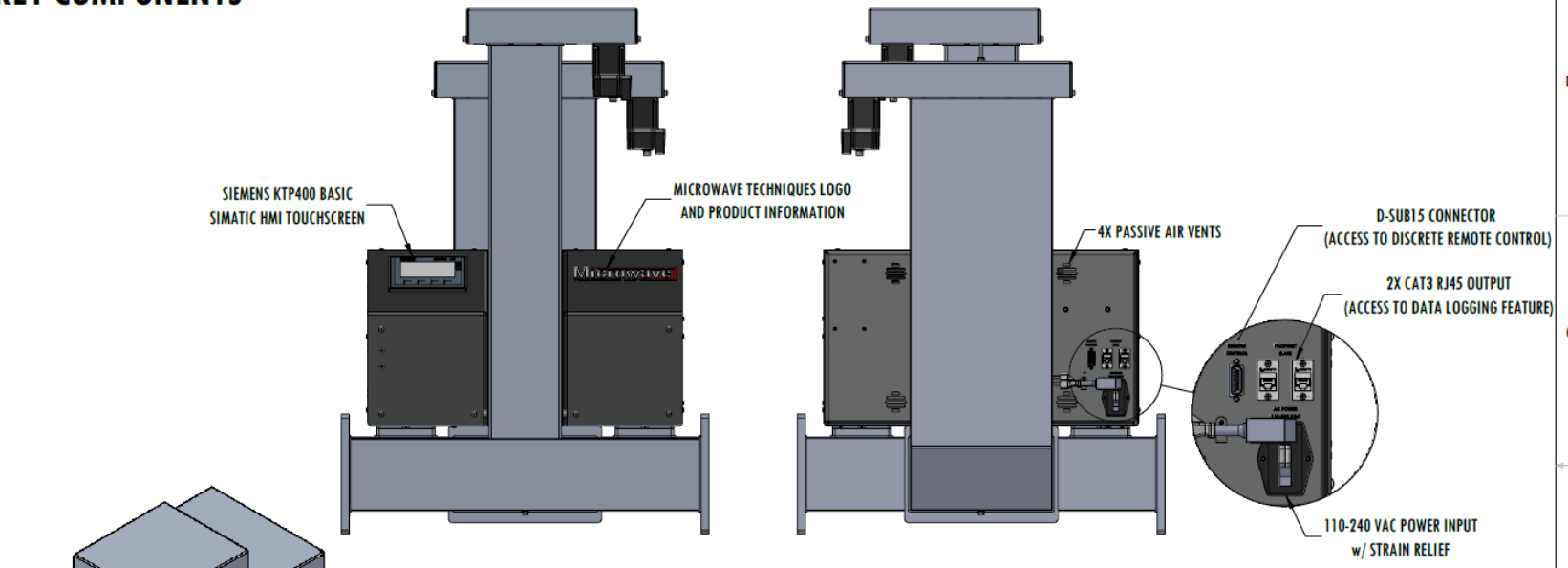
CAGE CODE: 0G9Y7 SCALE: NA SHEET: 1 OF 2

KEY COMPONENTS



CONTACT SALES@MICROWAVETECHNIQUES.COM FOR MORE INFORMATION

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3rd ANGLE PROJECTION	63	THIS DOCUMENT IS NOT INTENDED FOR MANUFACTURING PURPOSES	
		CAGE CODE: 0G9Y7	SCALE: NA SHEET: 2 OF 2

Have Questions or
Need More Information?

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