LXI™ High-Gamma Automated Tuners (HGT™) And LXI™ High-Power Automated Tuners

DATA SHEET / 4T-050G01

MODELS:
MT981HL13 MT981BL10
MT981HL14 MT981BL18
MT981HL15 MT981WL40
MT981AL14 MT981VL10
MT981BL15 MT981EL10
What is load pull?

Load Pull is the act of presenting a set of controlled impedances to a device under test (DUT) and measuring a set of parameters at each point. By varying the impedance, it is possible to fully characterize the performance of a DUT and use the data to:

> Verify simulation results of a transistor model (model validation)

> Gather characterization data for model extraction (behavioral model extraction)

> Design amplifier matching networks for optimum performance (amplifier design)

> Ensure a microwave circuit’s ability to perform after being exposed to high mismatch conditions (ruggedness test)

> Confirm the stability or performance of a microwave circuit or consumer product under non-ideal VSWR conditions (stability/performance/conformance/antenna test)

Example of load pull measurements with Output Power (Pout) contours plotted on a Smith Chart.

 Iso Pout Contours
 Measured @ 1.85 GHz

 Iso Pout Contours
 Simulated @ 1.85 GHz
**Slide-Screw Impedance Tuner**

One tool available to vary the impedances presented to a DUT is the slide-screw impedance tuner. The slide-screw tuner is based on a 50Ω slabline and a reflective probe, sometimes referred to as a slug. Ideally, when the probe is fully retracted, the tuner presents a near-50Ω impedance represented by the center of a normalized Smith Chart. As the probe is lowered into the slabline (Y-direction) it interrupts the electric field that exists between the center conductor and walls of the slabline, reflects some of the energy back towards the DUT, creates a capacitance and increases the magnitude of reflection (represented by the red curve on the Smith Chart at right). As the probe travels along the slabline (X-direction), the distance between the probe and the DUT is altered, thereby rotating the phase of the reflection (represented by the blue curve on the Smith Chart). It is therefore possible to recreate nearly any arbitrary impedance without the need of discrete components (lumped elements or transmission lines).

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The probes used in slide-screw tuners are wideband in nature, and have similar reflective properties over a wide range of frequencies. In order to increase the overall useful bandwidth of the tuner, two probes of varying dimensions are independently used within a tuner; one for low frequencies and one for high frequencies. In this manner, it is common for slide-screw tuners to achieve an overall frequency range of several octaves to over a decade.

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**VSWR versus Frequency of a two-probe slide-screw tuner.**
Pre-Calibration (Pre-Characterization)

Slide-screw tuners are available in both manual and automated varieties. While they both work on the same slabline and capacitive probe technique, automated tuners have the ability to be pre-calibrated. Pre-calibration involves recording the s-parameters of each probe at varying X and Y positions for the frequencies of interest using a calibrated vector network analyzer. In general, X and Y positions are selected such that an even distribution of impedances are recorded over the Smith Chart. Once the calibration data is stored in a lookup table, the VNA is no longer required to use the tuner; the tuner ‘knows’ how to present impedances accurately without VNA verification.

Tuner Repeatability

Tuner repeatability is defined as the vector difference between the pre-calibrated s-parameter data and subsequent s-parameter measurements after movement, when returning the probe to a given X and Y position. Since the impedances presented to the DUT are reliant on the tuner’s ability to accurately return to pre-calibrated states, repeatability is a critical tuner characteristic that affects the reliability of measurement data. In order to guarantee a high level of repeatability, precision mechanics and motors within the tuner are used to return the probe to its pre-calibrated positions with s-parameter vector differences of –40 to –50dB or better (see specific tuner model pages 6 through 14 for typical repeatability graphs).

Tuning Accuracy and Interpolation

During pre-calibration, the tuner’s s-parameters are recorded at a user-definable number (normally between 300-3000) of X and Y positions giving an even distribution over the Smith Chart. However, an arbitrary load impedance that falls between pre-calibrated states might be required. To achieve a high level of accuracy, a two-dimensional algorithm is used to interpolate between the closest pre-calibrated impedances in order to determine the new physical X and Y positions of the desired interpolated impedance. Interpolation increases the number of tunable impedances well beyond the initial pre-calibration range.

Given a sufficiently dense pre-calibration look-up table, a tuner’s repeatability (ability to return to pre-calibrated states) and accuracy (ability to interpolate between pre-calibrated states) offer similar performances.
Patented LXI™-Certified Embedded Tuner Controller

(U.S. Patent No. 8,823,392)

All Maury slide-screw automated impedance tuners are equipped with a patented embedded LXI™-certified controller (U.S. Patent No. 8,823,392) with onboard microprocessor and memory. After pre-calibration, the lookup table is copied onto the tuner’s embedded flash memory storage, as are any s-parameter files of passive components that will be used with the tuner (adapters, cables, fixtures, probes, attenuators...). The tuner’s onboard microprocessor will use the lookup table and component s-parameter blocks to calculate the probe positions required to present an arbitrary load impedance taking into account (de-embedding) all adapter/fixture losses between the tuner and DUT, and all back-side losses between the tuner and the measurement instrument, as well as possible non-50Ω terminations.

An integrated web interface allows for easy point-and-click tuning. Simply open Internet Explorer, Firefox, Chrome or any web browser in any operating system, and begin tuning. Capabilities include a graphic interface for de-embedded tuning at the DUT reference.

Direct ASCII commands can be sent through raw TCP/IP interface over Ethernet or USB and used with any socket programming language or through any Telnet client program in any operating system. Commands include direct impedance tuning, reference-plane shifting, VSWR testing and more.
## Available Models — MT981( )L Series

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency Range (GHz)</th>
<th>Matching Range</th>
<th>Power Capability</th>
<th>Vector Repeatability</th>
<th>Insertion Loss (Probes Fully Retracted)</th>
<th>Mating Surface Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT981HL13</td>
<td>0.80 – 6.5</td>
<td>100:1</td>
<td>200:1</td>
<td>–40 dB</td>
<td>250 W CW 2.5 kW PEP</td>
<td>17.46” [44.35 cm]</td>
</tr>
<tr>
<td></td>
<td>6.5 – 8.0</td>
<td>60:1</td>
<td>60:1</td>
<td></td>
<td></td>
<td>13.42” [34.07 cm]</td>
</tr>
<tr>
<td>MT981HL14</td>
<td>1.8 – 8.0</td>
<td>100:1</td>
<td>200:1</td>
<td>–50 dB</td>
<td></td>
<td>24.91” [63.28 cm]</td>
</tr>
<tr>
<td>MT981HL15</td>
<td>0.65 – 6.0</td>
<td>15:1</td>
<td>25:1</td>
<td></td>
<td></td>
<td>36.16” [91.85 cm]</td>
</tr>
<tr>
<td>MT981AL14</td>
<td>0.227 – 4.0</td>
<td>30:1</td>
<td>45:1</td>
<td></td>
<td></td>
<td>24.91” [63.28 cm]</td>
</tr>
<tr>
<td>MT981BL15</td>
<td>0.40 – 2.5</td>
<td>15:1</td>
<td>25:1</td>
<td></td>
<td></td>
<td>19.0” [48.26 cm]</td>
</tr>
<tr>
<td>MT981BL18</td>
<td>0.40 – 8.0</td>
<td>10:1</td>
<td>25:1</td>
<td></td>
<td></td>
<td>17.46” [44.35 cm]</td>
</tr>
<tr>
<td>MT981WL40</td>
<td>0.60 – 3.0</td>
<td>40:1</td>
<td>50:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.0 – 6.0</td>
<td>30:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MT981VL10</td>
<td>0.65 – 3.0</td>
<td>40:1</td>
<td>50:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.0 – 6.0</td>
<td>30:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MT981EL10</td>
<td>0.80 – 8.0</td>
<td>15:1</td>
<td>30:1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Defined as the minimum VSWR over 70% of the frequency range.
2 Power rated at maximum VSWR.

### Accessories Provided

Each MT981( )L series tuner is provided with one (1) MT1020F power supply, one (1) USB cable, one (1) Ethernet cable, one (1) USB to Ethernet adapter, and one (1) operating manual.

### Recommended Accessories

**2698C2 Torque Wrench**
Recommended for tightening 7mm precision connectors to the proper in. lbs without over-torquing the connection.

**A028D 7mm Connector Gage Kit**
Recommended for checking the critical interface dimensions of precision 7mm connectors. Dial indicator style. Thread-on connector.

**8022S/8022T Precision 7mm/3.5mm (Female & Male) Adapters**
Maury metrology-grade precision 7mm/3.5mm (female) and 7mm/3.5mm (male) adapters.
Exemplary Performance Data for Model MT981HL13 High-Gamma™ Automated Tuners

VSWR versus Frequency for MT981HL13 automated tuners.

Repeatability for MT981HL13 automated tuners.

Specifications

Frequency Range -- 0.8 to 8.0 GHz
VSWR Matching Range
  Minimum (0.8-6.5 GHz) -- 100:1
  Minimum (6.5-8.0 GHz) -- 60:1
  Typical (0.8-6.5 GHz) -- 200:1
  Typical (6.5-8.0 GHz) -- 60:1

Step Size (Probes) -- 62.5 microinches
Step Size (Carriage) -- 786 microinches
Connectors -- Precision 7mm
Power Capability -- 250 W CW; 2.5 kW PEP
Vector Repeatability (Min.) -- –40 dB
Insertion Loss (probes fully retracted) -- 0.3 dB

1 Minimum VSWR over 70% of the frequency range.
2 Based on 1/2 stepping the drive motors.
3 Precision 7mm per Maury data sheet 5E-060.
4 Power rated at maximum VSWR.

MT981
HL13
Exemplary Performance Data for Model MT981HL14 High-Gamma™ Automated Tuners

VSWR versus Frequency for MT981HL14 automated tuners.

Repeatability for MT981HL14 automated tuners.

**Specifications**

- **Frequency Range:** 1.8 to 8.0 GHz
- **VSWR Matching Range**
  - Minimum (1.8-8.0 GHz) -- 100:1
  - Typical (1.8-8.0 GHz) -- 200:1
- **Step Size (Probes):** 62.5 microinches
- **Step Size (Carriage):** 786 microinches
- **Connectors:** Precision 7mm
- **Power Capability:** 250 W CW; 2.5 kW PEP
- **Vector Repeatability (Min.):** –40 dB
- **Insertion Loss (probes fully retracted):** 0.3 dB

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1. Minimum VSWR over 70% of the frequency range.
2. Based on 1/2 stepping the drive motors.
3. Precision 7mm per Maury data sheet 5E-060.
4. Power rated at maximum VSWR.
Exemplary Performance Data for Model
MT981HL15 High-Gamma™ Automated Tuners

VSWR versus Frequency for MT981HL15 automated tuners.

Repeatability for MT981HL15 automated tuners.

MT981
HL15

U.S. Patent No. 8,823,392
International Patents Pending
LXI™ High-Gamma™ Automated Tuner

Specifications

Frequency Range -- 0.65 to 6.0 GHz
VSWR Matching Range
Minimum (0.65-6.0 GHz) -- 100:1
Typical (0.65-6.0 GHz) -- 200:1\(^1\)

Step Size (Probes) -- 62.5 microinches \(^2\)
Step Size (Carriage) -- 786 microinches \(^2\)
Connectors -- Precision 7mm \(^3\)
Power Capability -- 250 W CW; 2.5 kW PEP \(^4\)
Vector Repeatability (Min.) -- –40 dB
Insertion Loss (probes fully retracted) -- 0.3 dB

\(^1\) Minimum VSWR over 70% of the frequency range.
\(^2\) Based on 1/2 stepping the drive motors.
\(^3\) Precision 7mm per Maury data sheet 5E-060.
\(^4\) Power rated at maximum VSWR.
Exemplary Performance Data for Model MT981AL14 High-Power Automated Tuners

**Specifications**

- **Frequency Range**: 0.227 to 4.0 GHz
- **VSWR Matching Range**
  - Minimum: 15:1
  - Typical: 25:1
- **Step Size (Probes)**: 62.5 microinches
- **Step Size (Carriage)**: 786 microinches
- **Connectors**: Precision 7mm
- **Power Capability**: 250 W CW; 2.5 kW PEP
- **Vector Repeatability (Min.)**: $-50$ dB
- **Insertion Loss (probes fully retracted)**: 0.3 dB

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1 Defined as the minimum VSWR over 70% of the frequency range.
2 Based on 1/2 stepping the drive motors.
3 Precision 7mm per Maury data sheet 5E-060.
4 Power rated at maximum VSWR.
Exemplary Performance Data for Model MT981BL10 High-Power Automated Tuners

VSWR versus Frequency for MT981BL10 automated tuners.

Repeatability for MT981BL10 automated tuners.

MT981BL10

Specifications

Frequency Range -- 0.4 to 4.0 GHz
VSWR Matching Range
  Minimum -- 15:1
  Typical -- 25:1

Step Size (Probes) -- 62.5 microinches
Step Size (Carriage) -- 786 microinches
Connectors -- Precision 7mm

Power Capability -- 250 W CW, 2.5 kW PEP
Vector Repeatability (Min.) -- –50 dB
Insertion Loss (probes fully retracted) -- 0.3 dB

1 Defined as the minimum VSWR over 70% of the frequency range.
2 Based on 1/2 stepping the drive motors.
3 Precision 7mm per Maury data sheet SE-060.
4 Power rated at maximum VSWR.

U.S. Patent No. 8,823,392
International Patents Pending
Exemplary Performance Data for Model MT981BL15 High-Power Automated Tuners

![Graph showing VSWR versus Frequency for MT981BL15 automated tuners.](image1)

![Graph showing Repeatability for MT981BL15 automated tuners.](image2)

**Specifications**

- **Frequency Range**: 0.4 to 2.5 GHz
- **VSWR Matching Range**
  - Minimum: 30:1
  - Typical: 45:1
- **Step Size (Probes)**: 62.5 microinches
- **Step Size (Carriage)**: 786 microinches
- **Connectors**: Precision 7mm
- **Power Capability**: 250 W CW, 2.5 kW PEP
- **Vector Repeatability (Min.)**: –50 dB
- **Insertion Loss (probes fully retracted)**: 0.3 dB

**Notes**:
1. Defined as the minimum VSWR over 70% of the frequency range.
2. Based on 1/2 stepping the drive motors.
3. Precision 7mm per Maury data sheet SE-060.
4. Power rated at maximum VSWR.
Exemplary Performance Data for Model MT981BL18 High-Power Automated Tuners

VSWR versus Frequency for MT981BL18 automated tuners.

Repeatability for MT981BL18 automated tuners.

MT981BL18

Specifications
Frequency Range -- 0.4 to 8.0 GHz
VSWR Matching Range
  Minimum -- 10:1
  Typical -- 25:1¹
Step Size (Probes) -- 62.5 microinches²
Step Size (Carriage) -- 786 microinches²
Connectors -- Precision 7mm³
Power Capability -- 250 W CW, 2.5 kW PEP⁴
Vector Repeatability (Min.) -- --40 dB
Insertion Loss (probes fully retracted) -- 0.3 dB

¹ Defined as the minimum VSWR over 70% of the frequency range.
² Based on 1/2 stepping the drive motors.
³ Precision 7mm per Maury data sheet 5E-060.
⁴ Power rated at maximum VSWR.
Exemplary Performance Data for Model MT981WL40 High-Power Automated Tuners

Specifications
Frequency Range -- 0.60 to 6.0 GHz
VSWR Matching Range
- Minimum -- (0.60-3.0 GHz) 40:1
- Minimum -- (3.0-6.0 GHz) 30:1
- Typical -- (0.60-6.0 GHz) 50:1 1
Step Size (Probes) -- 62.5 microinches 2
Step Size (Carriage) -- 786 microinches 2
Connectors -- Precision 7mm 3

Power Capability -- 250 W CW, 2.5 kW PEP 4
Vector Repeatability (Min.) -- -50 dB
Insertion Loss (probes fully retracted) -- 0.3 dB

1 Defined as the minimum VSWR over 70% of the frequency range.
2 Based on 1/2 stepping the drive motors.
3 Precision 7mm per Maury data sheet 5E-060.
4 Power rated at maximum VSWR.
Exemplary Performance Data for Model MT981VL10 High-Power Automated Tuners

VSWR versus Frequency for MT981VL10 automated tuners.

Repeatability for MT981VL10 automated tuners.

**Specifications**

Frequency Range -- 0.65 to 6.0 GHz

VSWR Matching Range
- Minimum (0.65-3.0 GHz) -- 40:1
- Minimum (3.0-6.0 GHz) -- 30:1
- Typical (0.65-6.0 GHz) -- 50:1

Step Size (Probes) -- 62.5 microinches

Step Size (Carriage) -- 786 microinches

Connectors -- Precision 7mm

Power Capability -- 250 W CW; 2.5 kW PEP

Vector Repeatability (Min.) -- –50 dB

Insertion Loss (probes fully retracted) -- 0.3 dB

1 Defined as the minimum VSWR over 70% of the frequency range.

2 Based on 1/2 stepping the drive motors.

3 Precision 7mm per Maury data sheet 5E-060.

4 Power rated at maximum VSWR.

U.S. Patent No. 8,823,392
International Patents Pending
Exemplary Performance Data for Model MT981EL10 High-Power Automated Tuners

VSWR versus Frequency for MT981EL10 automated tuners.

Repeatability for MT981EL10 automated tuners.

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>0.8 to 8.0 GHz</td>
</tr>
<tr>
<td>VSWR Matching Range</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>15:1</td>
</tr>
<tr>
<td>Typical</td>
<td>30:1</td>
</tr>
<tr>
<td>Step Size (Probes)</td>
<td>62.5 microinches</td>
</tr>
<tr>
<td>Step Size (Carriage)</td>
<td>786 microinches</td>
</tr>
<tr>
<td>Connectors</td>
<td>Precision 7mm</td>
</tr>
<tr>
<td>Power Capability</td>
<td>250 W CW; 2.5 kW PEP</td>
</tr>
<tr>
<td>Vector Repeatability (Min.)</td>
<td>-50 dB</td>
</tr>
<tr>
<td>Insertion Loss (probes fully retracted)</td>
<td>0.3 dB</td>
</tr>
</tbody>
</table>

1 Defined as the minimum VSWR over 70% of the frequency range.
2 Based on 1/2 stepping the drive motors.
3 Precision 7mm per Maury data sheet SE-060.
4 Power rated at maximum VSWR.
**MT981HL13/MT981EL10**  
Dimensions in Inches [cm]

**MT981HL14**  
Dimensions in Inches [cm]

**MT981AL14**  
Dimensions in Inches [cm]