



# Nano Series 1mm Automated Tuners

## DATASHEET / 1mm Automated Tuners

### MODELS:

- » NT-24G-110G-1C
- » NT-24G-110G-1C-C
- » NT-24G-110G-2C
- » NT-24G-110G-2C-C
- » NT-24G-110G-3C
- » NT-24G-110G-3C-C

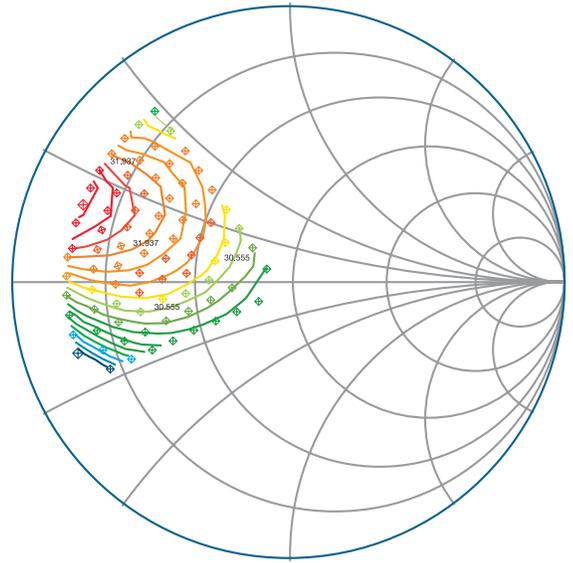


## What is load pull?

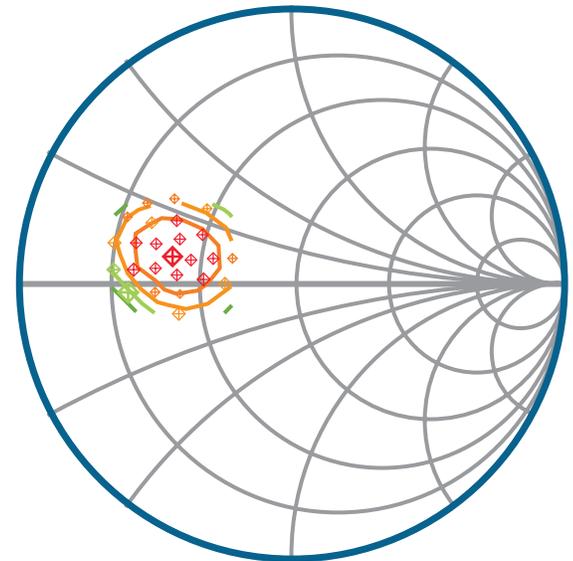
Load Pull is the act of presenting a set of controlled impedances to a device under test (DUT) and measuring a set of parameters at each point. By varying the impedance, it is possible to fully characterize the performance of a DUT and use the data to:

- > 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)

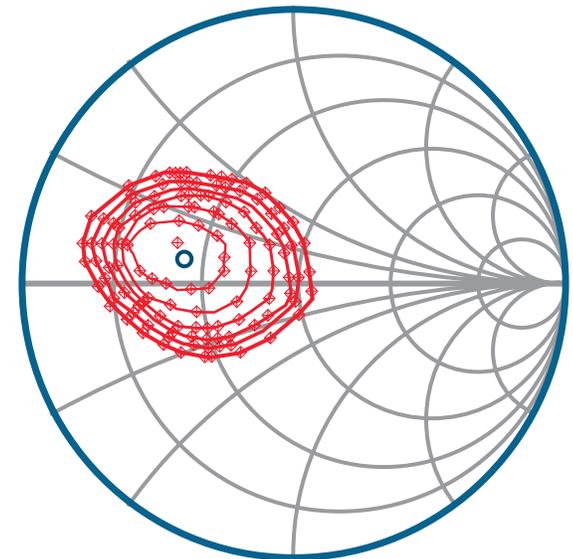
Example of load pull measurements with Output Power ( $P_{out}$ ) contours plotted on a Smith Chart.



Iso Pout Contours  
Measured @ 28 GHz



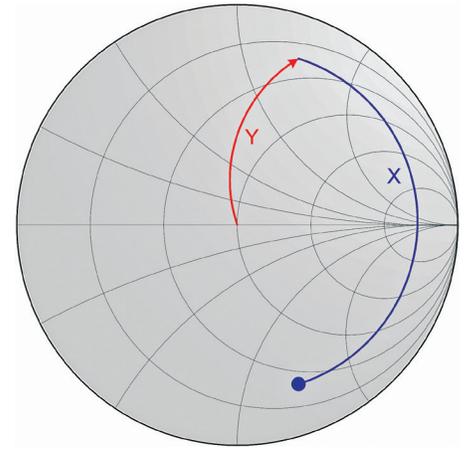
Iso Pout Contours  
Simulated @ 28 GHz



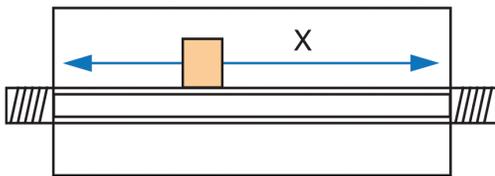
# Slide-Screw Impedance Tuner

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

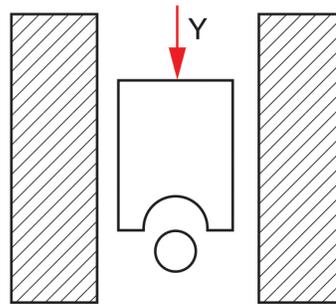
the center conductor and walls of the slabline, reflects some of the energy back towards the DUT, creates a capacitance and increases the magnitude of reflection (represented by the red curve on the Smith Chart at right). As the probe travels along the slabline (X-direction), the distance between the 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).



## Simplified representation of a slide-screw tuner.



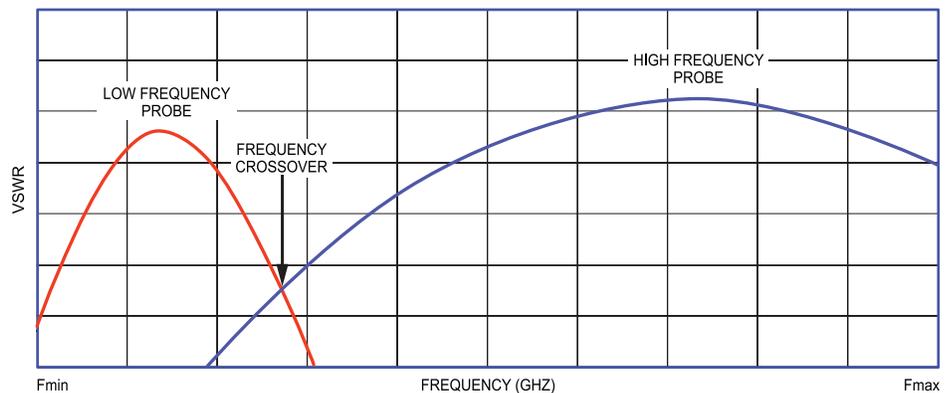
(Side View)



(End View)

The probes used in slide-screw tuners are wideband in nature and have similar reflective properties over a wide range of frequencies. Each tuner employs at least one probe, and many models utilize two probes of varying dimensions to increase the overall useful bandwidth of the tuner.

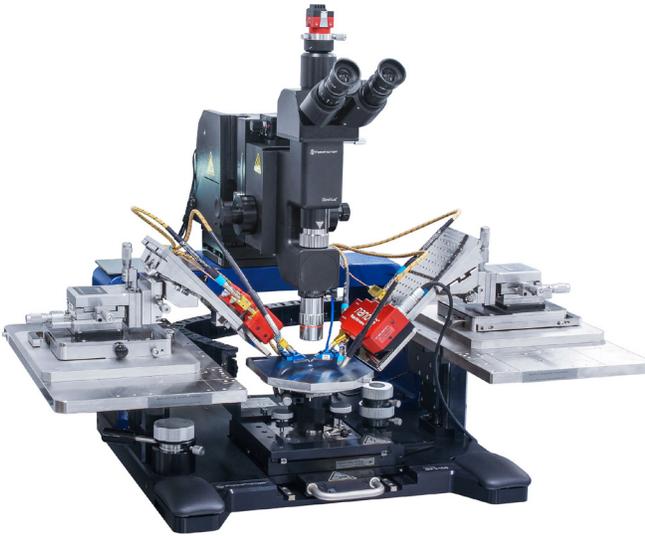
In this manner, it is common for slide-screw tuners to achieve an overall frequency range of several octaves to over a decade.



VSWR versus Frequency of a two-probe slide-screw tuner.

## Optimized for on-wafer integration

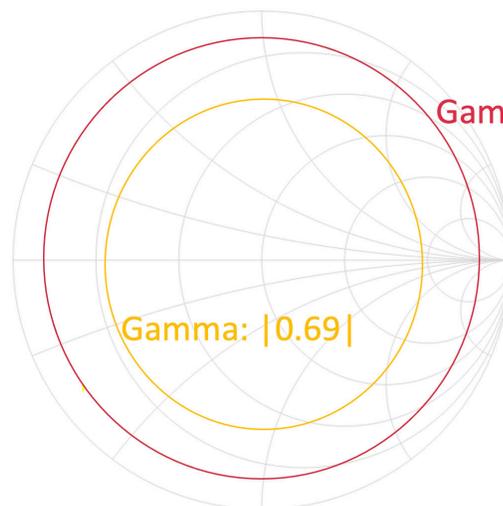
Nano-series automated impedance tuners have been optimized for on-wafer integration. At 1/10 the volume and 1/10 the weight\* of MT984 series, Nano-series tuners have been designed to directly connect to wafer probes thereby eliminating the need for short integration cables or probe mounts. The direct connection offers two advantages: maximizing VSWR at the DUT reference plane and minimizing phase skew at the DUT reference plane.



## Maximizing VSWR at DUT reference plane

The tuning range achievable at the DUT reference plane is determined by the tuning range of the tuner and the insertion losses of all components between the tuner and the DUT. The formula to calculate the net tuning range, shown as return loss (RL), is  $RL_{DUT} = RL_{tuner} + RL_{components}$ . Minimizing the insertion loss of the components between the tuner and the DUT reduces the return loss impact and maximizes the tuning range at the DUT. The Smith Charts below show two scenarios:

- > The yellow circle on the Smith Charts shows the net tuning range of a tuner with minimum VSWR of 16:1 at 28 GHz, probe mount and coupler insertion loss of 0.6 dB and wafer probe insertion loss of 0.4 dB.
- > The red circle on the Smith Chart shows the net tuning range of Nano5G with minimum VSWR of 40:1 at 28 GHz, probe insertion loss of 0.4 dB, but no probe mount.



**Gamma: |0.87|**

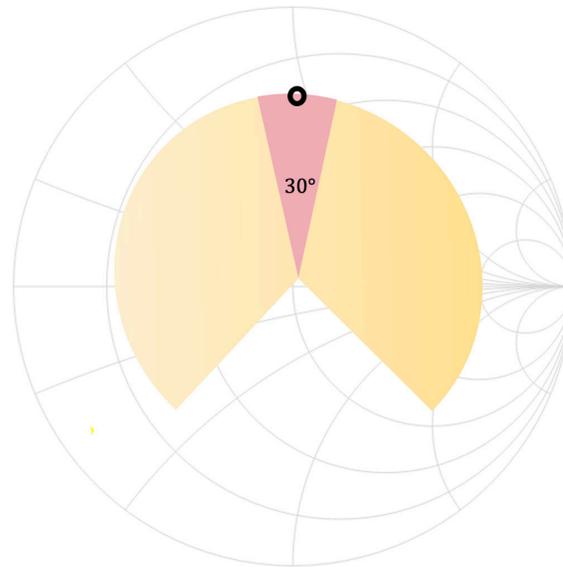
### Tuning range:

- > MT984AL01 + coupler + cable + probe
- > Nano5G + probe

## Minimizing phase skew at the DUT reference plane

The phase shift, or phase delay, or phase skew of the impedance presented at the DUT reference plane is determined by the length of transmission line between the tuning element (probe inside of tuner) and the DUT. The larger the length, the greater the phase skew; the shorter the length, the smaller the phase skew. Minimizing the transmission line by removing integration cables or probe mounts helps reduce the phase skew of the impedance presented to the DUT. The Smith Chart below shows two scenarios: the first shows the phase skew of a tuner connected to a 6" integration cable and a wafer probe (yellow); the second shows the phase skew of the same tuner and probe, but no integration cable (red). Nano-series automated impedance tuners minimize the phase skew at the DUT reference plane!

● target



Phase skew:

Tuner Impedance phase variation over a 100 MHz input signal with left and right adjacent channels:

- >  $\Delta\theta_{(MT984+cable+probe)} = 300^\circ$
- >  $\Delta\theta_{(Nano5G+probe)} = 30^\circ$

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## Integrated coupler

Modern vector-receiver load pull systems use a coupler between the tuner and DUT to directly measure the incident and reflected waves (a- and b-waves) at the DUT reference plane in real-time. Doing so eliminates the need for de-embedding tuner/fixture losses or relying on pre-characterized tuner positioning to determine the tuned impedance. These benefits usually come with a tuning range reduction as the coupler adds insertion loss between the tuner and DUT. Nano-series automated impedance tuners are offered with an optional nearly-lossless integrated coupler that empowers vector-receiver load pull while maintaining the highest tuning range at the DUT reference plane.

# Nano-Series™ 1mm Automated Tuner

## Available Models

Model	Frequency Range (GHZ)		Integrated coupler <sup>1</sup>	Matching Range Single Frequency		Matching Range Harmonic Frequency	Power capability (W)	Vector repeatability (dB)	IL (dB)	Connector type	Weight (lbs)
	Tuner	Impedance control		Minimum	Typical	Typical					
NT-24G-110G-1C	DC to 110	24 to 110	no	8:1	12:1	n/a	1 CW, 5W PEP	-40	1.2	1mm	2
NT-24G-110G-1C-C			yes						1.35		
NT-24G-110G-2C			no	6:1	20:1	6:1 to 30:1			2		3
NT-24G-110G-2C-C			yes						2.2		
NT-24G-110G-3C			no						2.8		
NT-24G-110G-3C-C			yes						3		

<sup>1</sup> 40 dB coupling factor

## Accessories Provided

Each tuner is provided with:

- > Power Supply
- > USB cable and TCPIP cable
- > USB to ethernet adapter
- > NT-1C Tuner controller
- > Operating Manual





**DATASHEET / 1mm Automated Tuners / 2026.03**

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