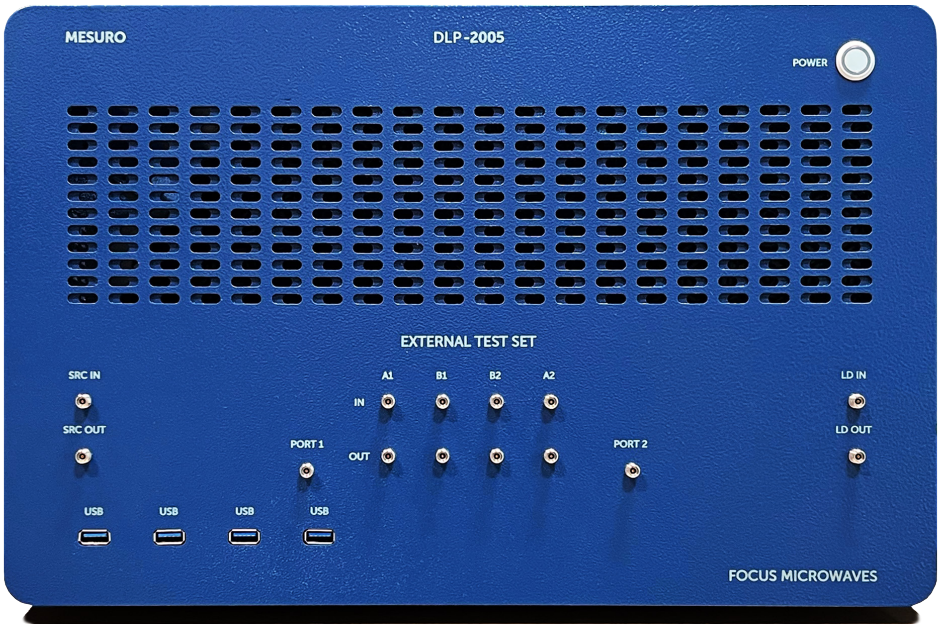
FOCUS MICROWAVES

DLP - Dynamic Load Pull

Active Load Pull for CW and Pulsed Signal Application



mesuro

Summary | DLP

Focus Microwaves' DLP (Dynamic Load Pull) is an active load pull platform designed for flexibility and optimized for measurement accuracy, speed, and reliability. With the capability to characterize devices at test frequencies up to 40GHz and beyond, the DLP provides a powerful, extendable, and flexible platform for advanced device characterization. The one-box solution provides a fast load pull platform for both fundamental and harmonic frequencies, CW or pulsed signal load pull and S-parameter measurements. It also offers the options for time domain measurements (when using a phase reference) and generating PHD based behavioral models using Cardiff modelling suite. There are also additional options for integrated Auriga functionality such as DC IV and pulsed IV measurements that can be tied up with RF frequencies for pulsed load pull or pulsed S-parameter measurements. This all-in-one system opens up the possibility of using this system in all parts of the design cycle, from initial device characterization, to MMIC or PA design, design verification** and ultimately to product testing in the factory.

** US patents and patents pending

Introduction | DLP

Active load pull systems are used in load pull labs around the world and offer the user the ability to provide a controlled impedance for various applications. The DLP is a fully Vector receiver-based Load Pull system for up to 3 harmonics on the load and two on the source side. In this measurement setup, the forward (a1, b1) and reverse (a2, b2) travelling signal waves are measured using two dual directional couplers connected at the input and output of the DUT and the custom receivers. Measuring "a" and "b" waveforms allow Vector Load Pull to calculate the actual load impedance presented to the DUT in real time using the fully calibrated receivers. The DLP uses industry standard calibration techniques to generate the necessary error correction models for the system and make accurate absolute and vector-based measurements.

The DLP active load pull system has been optimized for ease of use and speed. Using our unique load pull algorithm, the time in conducting sweeps has been vastly reduced due to lower number of iterations in achieving the target load while maintaining high level of load pull impedance accuracy. In addition, the hardware configuration has been optimized for simultaneous DC and RF measurements in CW and pulsed modes of operation. The intuitive user experience provided by our software allows users of all levels to quickly set up and conducting high quality measurements day in day out.

Key Features | DLP

- Single-tone CW and pulsed signals
- Fundamental and harmonic tuning
  - With pulsed DC capability
- Load and source pull tuning configurations
- Large dynamic range for device characterization
  - Supports devices from 0dBm to >50dBm peak power.
- Time domain measurements
  - For advanced waveform engineering
  - Advanced Cardiff Model generation
- S-parameter measurements
- Pulsed S-parameters (Pulsed DC & Pulsed RF)
- Flexible and versatile API with an expanding feature set
- Hybrid load pull and source pull capability
- This system can be used in all parts of the design cycle
  - Initial device characterization
  - MMIC or PA design
  - Design verification
  - Product testing in the factory
  - Compact model verification and optimization

DLP allows the user to optimize not only the fundamental impedance, but also the harmonic impedances and both source and load side to enabling complete characterization and optimization of key parameters like power added efficiency and linearity

Key Measurements Available | DLP

- Input / Output Power
  – Peak and Average
- Input Power Delivered (Pin_Del)
- Delivered Output Power (Pout_Del)
- Power Gain (Pout_Del – Pin_Del)
- Gamma In DUT (Γin)
- Power Added Efficiency (PAE)
- AM/PM
- Time Domain Waveforms (Requires Mesuro Phase Reference)

US patent 9,625,556

S-Parameters | DLP

DLP has many additional key features and capabilities. S-Parameter measurements being one of them. This one-box system requires a two-port calibration which can then be used to measure both active and passive devices. DLP supports multiple calibration techniques such as TRL, SOLT, TRM and fixture de-embedding. The system also supports pulsed S-parameters down to a 200ns pulse width. An absolute calibration can be done if absolute power measurements are required. The S-parameter plot of a bandpass filter represented below exhibits the dynamic range of DLP vectors receivers. It also illustrates an excellent agreement with PNA-x based S-parameter measurements. Integration of the Focus/Auriga Pulsed IV system functionality with the DLP system enables the ability to capture pulsed S-parameters under pulsed DC and pulsed RF conditions which can be used for isothermal compact modelling activities.

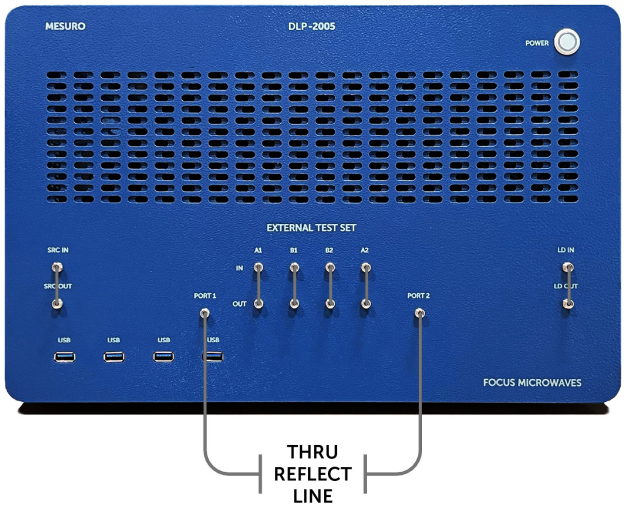


Figure 1: 8 - Term TRL Calibration

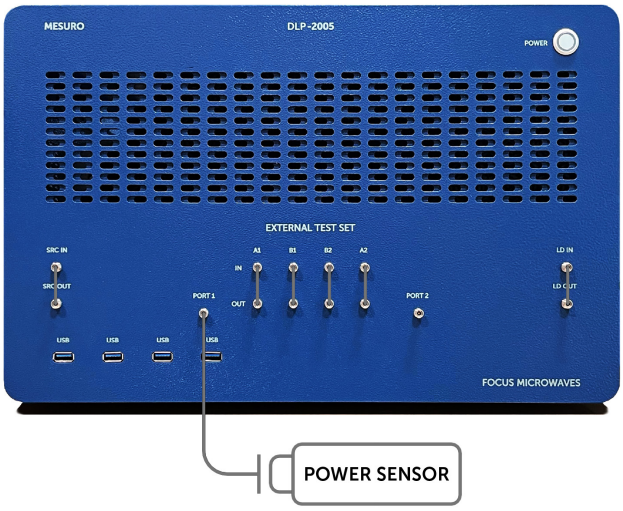


Figure 2: Absolute Power Calibration

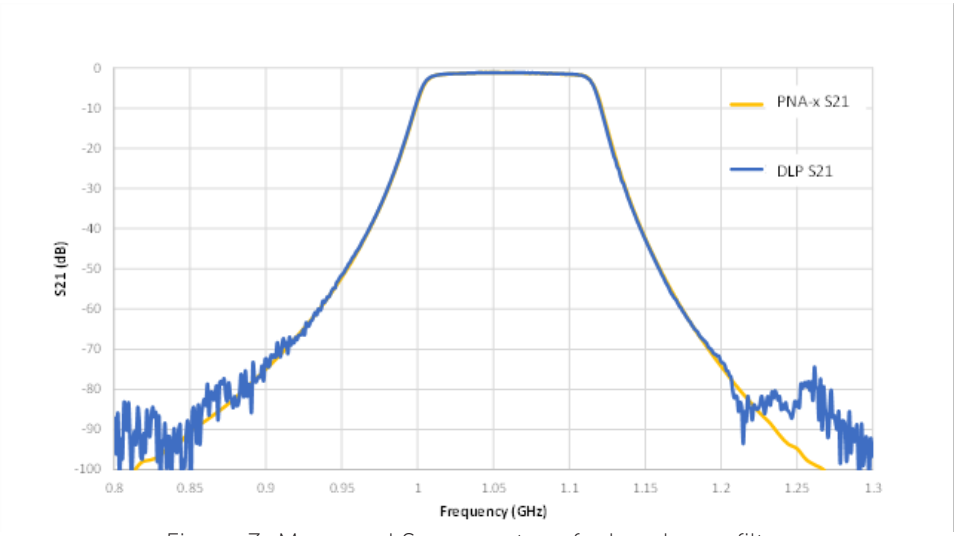


Figure 3: Measured S-parameter of a band pass filter

Basic Configuration | DLP

The basic configuration of the DLP is a single mainframe unit capable of conducting fundamental load pull using fully synchronized internal signal sources as shown below. The internal test set can support up to 30dBm peak power, but is versatile enough to accurately characterize devices below -30dBm with high accuracy and repeatability in CW and pulsed conditions. DLP also offers integrated DC measurement capabilities as standard option in all systems while pulsed DC generation and measurement hardware can be added as additional options.

For load pull and pulsed applications all timing synchronization is handled internally by the DLP system.

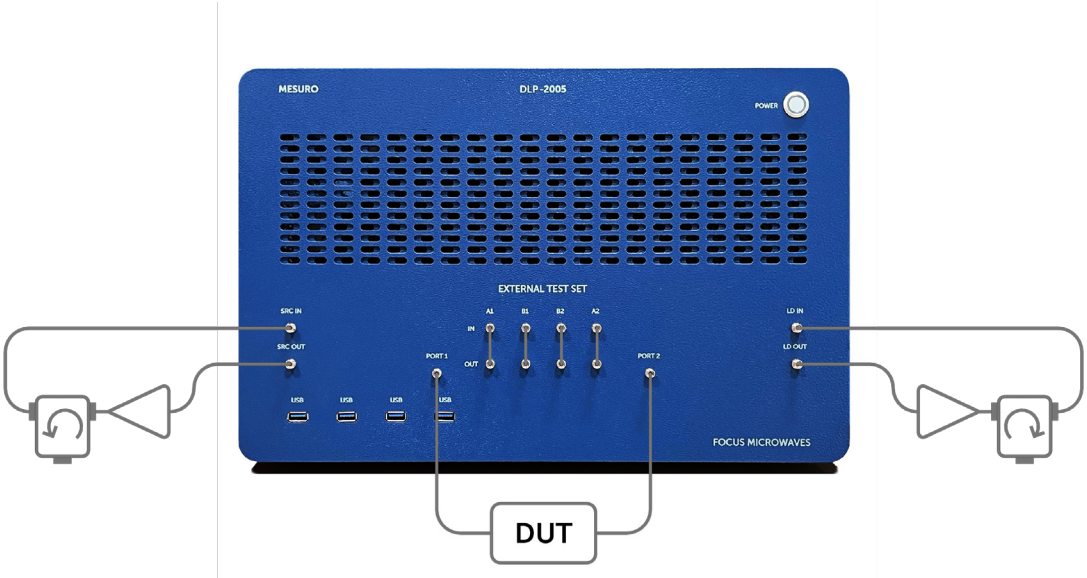


Figure 4: Fundamental only loap pull setup

Modular Architecture | DLP

The DLP mainframe unit is fully capable of doing harmonic vector measurements. Its modular architecture allows for simple modifications, yielding harmonic capabilities by addition of loop amplifiers to tune the desired frequencies. In addition to the traditional 2 loop fundamental system, DLP allows 3-loop to 6-loop configurations. For each additional load or source pull loop, extra sources are required which can be easily added to the DLP system. The DLP system is designed to have multi-channel phase coherent sources, fully synchronized with the main frame for load or source pull operation. The additional signal sources can be flexibly assigned to do source pull or load pull at any of the harmonic frequencies. For example, with two additional sources, it is possible to configure the DLP active load pull system for three harmonic load pull or for two harmonic source and load pull. This gives the user full capability to characterize the device in a variety of ways without the need for extra hardware.

If the DUT has very high input or output gamma requirements, it is also possible to integrate passive tuners to do hybrid load pull and source pull. This can vastly reduce the size of the load pull amplifier and ease the requirements of the setup in terms of power capability. Thus, avoiding the need for very high-power bias tees and saving considerable amounts of capital on the purchase of broadband high-power amplifiers.

Supported Configurations | DLP

2 loop fundamental (20/40GHz)
3-6 loop harmonic

Example: 6 loop 3f0

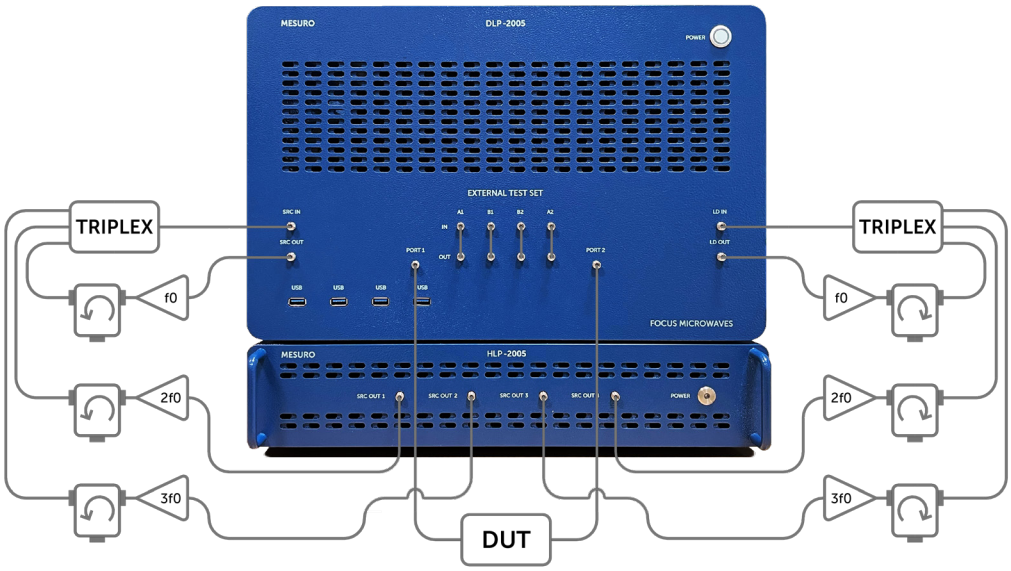


Figure 5: f0/2f0/3f0 input, f0/2f0/3f0 output

Example: 3 loop 2f0

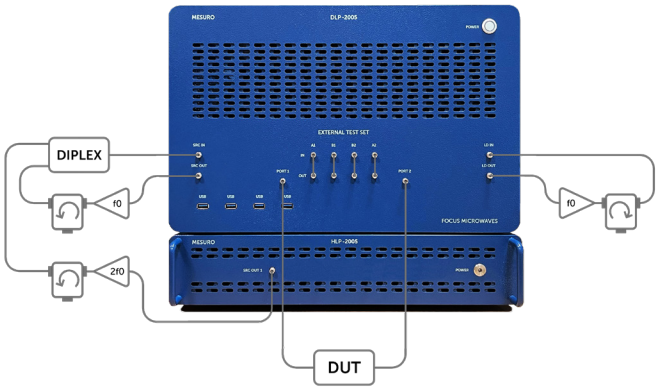


Figure 6: f0/2f0 input, f0 output

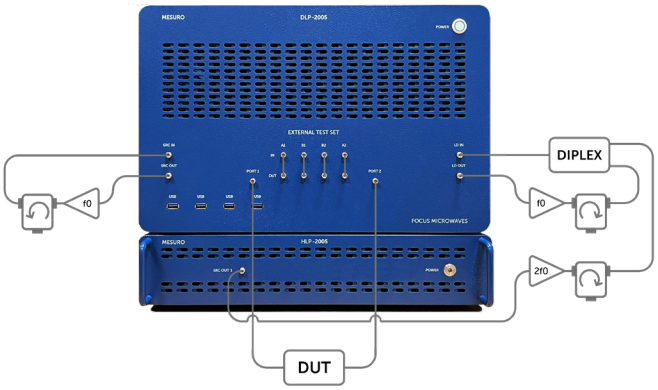


Figure 7: f0 input, f0/2f0 output

Example: 4 loop 2f0 / 3f0

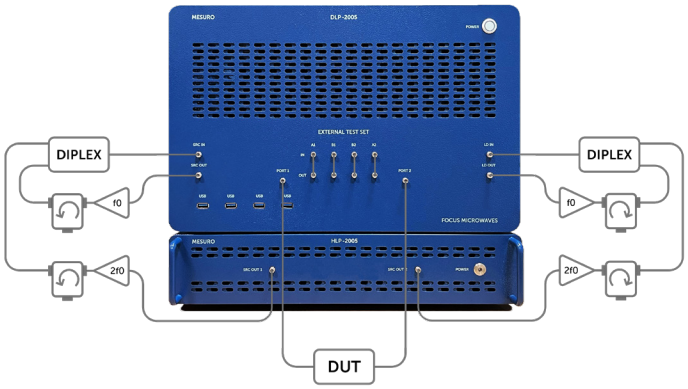


Figure 8: f0/2f0 input, f0/2f0 output

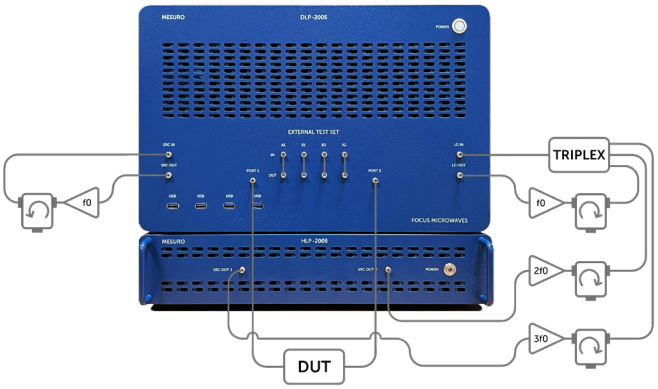


Figure 9: f0 input, f0/2f0/3f0 output

High-Power Configuration | DLP

For high power applications, the direct access to the internal receivers of the DLP system offers the capability to perform load pull for high power devices. This option is enabled by using a high-power test set, and using appropriate load pull amplifiers. To extend the dynamic range and to stay within the internal test set specification, when testing high power signals, it is recommended to use external couplers to separate a1, b1, a2, and b2. Similar modular configurations for harmonic tuning are used when high power multiple harmonics are involved.

Hybrid Load-Pull | DLP

The DLP system can also be adapted for Hybrid loadpull system. A hybrid load pull system includes both an active loop as well as the passive tuners. The hybrid system has all the advantages of speed and tuning range of an active system as well as the power handling of a passive system. Using an MPT tuner in a hybrid system allows for simultaneously pre-matching the fundamental second and third harmonics closer to the DUT. This option brings down the amplifier power requirements at both the input and output and offers a more cost-effective solution particularly at higher frequencies.

Hybrid Load-Pull using harmonic passive tuner | DLP

f0 input, f0/2f0/3f0 output with an MPT tuner

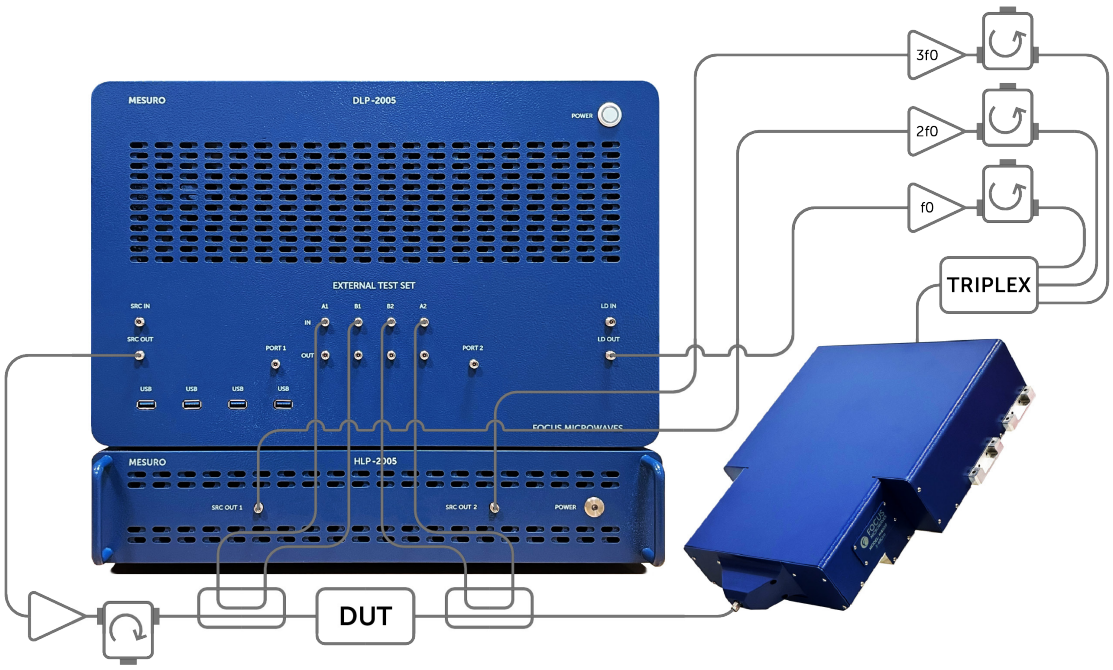


Figure 10: High power hybrid load pull with three, f0/2f0/3f0 loops and passive harmonic tuner

S-Parameter Performance Summary (Typical)** | DLP

		CW		Pulse		
Model	Frequency Range [GHz]	Dynamic Range [dB]	Average Power [dBm]	Min. Width [ns]	Dynamic range [dB]	Peak Power [dBm]
D2005	0.5 - 8	70	30	200	70	30
	8 - 20	65			65	
D4005	0.5 - 8	70			70	
	8 - 20	65			65	
	20 - 40	60			60	

Load Pull Performance Summary (Typical)** | DLP

		CW		Pulse		
Model	Frequency Range [GHz]	Dynamic Range [dB]	Average Power [dBm]	Min. Width [ns]	Dynamic range [dB]	Peak Power [dBm]
D2005	0.5 - 20	>60	30	200	>60	30
D4005	0.5 - 40					

**These specifications are with regards to DLP Load pull systems performance only and at +23°C +/-2°C
The power ratings are those of the internal test set. External couplers enable higher power capabilities.

Accessories | DLP

Model	Fmin [GHz]	Fmax [GHz]	Part Number	Option Description
PM-1806D	0.5	18	U2052XA	Keysight diode power sensor
PM-4006D	0.5	40	U2064XA	
PM-1806T	0.5	18	U8481A	Keysight diode power sensor
PM-4006T	0.5	40	U8487A	
D500-1805BT	0.5	18		Integrated bias tees at input and output ports. 50V and 1A rating
D500-4005BT	0.5	40		
DPU-DC				Conditioning box for Pulsed DC applications
DPHD220-2				Pulse DC drain side with 220V and 2A
DPHD220-10				Pulse DC drain side with 220V and 10A
DPHG20				Pulse DC Gate side with ±20V and 0.1A

Software Options | DLP

Model	Description	Software Dependecy
DMCS	Mesuro Cal software, S-Parameter and CW source/load pull, fundamental only	DMCS
D2H	Second Harmonic extension (applicable with all options)	
D3H	Third Harmonic extension (applicable with all options)	
DPU-LP	Pulse load pull for all purchased control loops	
DSP	Source pull extension (applicable with all options)	
DPU-DC	Pulsed DC generation and Pulsed IV measurement	
DLP-HYB	Hybrid Loadpull option	
DLP-PR	Phase reference calibration for dynamic loadline and time domain measurements	
DAPI	API command access and FDCS operation for tuner integration	

Other customized configurations are available upon request.