Keysight Technologies
RF Payload Test System

Technical Overview
The Keysight Technologies RF Payload Test System provides reliability, consistency, ease-of-use, flexibility and support.

Use of high-quality instrumentation and uncompromising development standards provide a test system, which accurately reports results to the test operators and are repeatable over time.

Keysight’s extensive experience in test system software yields systems that have efficient control flow and intuitive user interfaces. Test automation provided by application software minimizes potential manual errors when running tests.

The RF Payload Test System’s (PTS) modular construction maximizes flexibility and ease of upgrade. Expansion space is provided in the rack for additional switching, a digital oscilloscope and other equipment.

System calibration and verification methods use the best available technology for PNA-X based solutions yielding highly automated methods, improved confidence in measured data, and a unique automatic calibration method using the Auto Calibration Module (ACM) simplifies the calibration in remote locations such as Thermal Vacuum Chambers.

The PTS provides the most flexibility in RF Switching with industry-leading technology to automate system calibration.
The Keysight Technologies RF Payload Test System Provides Reliability, Consistency, Ease-of-Use, Flexibility and Support.

System description
Keysight's Payload Test System Platform uses state of the art measurement capability to provide a base configuration for Uplink and Downlink testing between UHF and Q band. The system contains instrumentation, RF switching and signal conditioning with an optional inline calibration verification capability.

System capability
The Keysight PNA-X provides complete measurement capability for:
- Gain Transfer/Gain Compression/Pin vs. Pout/Gain Steps
- Ability to measure Normal Operating Points (NOP) using various methods - stores values to a database enabling subsequent measurements to be run relative to NOP
- Frequency Response/Group Delay/Phase vs. Drive/Output power and frequency accuracy (technique supports embedded LO's)
- TOI/IP3/IMD (with built-in second source and combiner)
- Noise Figure (cold source)/Carrier to Noise
- Path Check
- Gain and Frequency Monitoring with sequential or continuous stimulus
- Absolute Phase (non-converted)
- Functional interfaces to set and uplink signal, monitor downlink signals, or set a RF path

Other measurements are made using the PSG and PXA:
- TT and C (TCR)
- Bit Error Rate
- Passive Intermodulation
- Repeater Isolation
- Ranging Delay
- Phase Noise
- Spurious search and spur investigation with an innovative algorithm to compute resolution bandwidth settings automatically
- Noise Power Ratio
- Noise Pedestal
- Modulation Index
- Error Vector Magnitude
- Telemetry vs Power/AGC Threshold
- AM to PM transfer/AM to PM conversion

Calibration verification capability provides in situ verification of RF paths between the test system and the UUT to ensure measurement accuracy over time and temperature variations.
Core configurations

Three core configurations service a variety of military and commercial customer applications across a broad range of test capabilities and frequency options.

Economy Payload Test System
Based on Payload Test System – instruments and connectivity are configured as required.

Basic Payload Test System
Payload Test System (PTS) – connectivity, simple switch matrix assembly and CalPods.

Advanced Payload Test System
RF Test Equipment (RFTE) – connectivity, complex core switch matrix assembly and CalPod assemblies

Economy Payload Test System

Major features/capability

- PNA-X based Payload Test System – connections to the PSA/PXA and connection from the PSG are made through the PNA-X test set
- System can be configured with only a PNA
- Reduced number of calibrations
  - Wideband calibration only required at the front of the PNA-X, eliminating numerous narrow bandwidth specific mixer calibrations
  - All test parameters including spectrum and power
- Calibration is only performed once – station can be moved without recalibrating
- Connectivity options are limited to lower complexity test configurations, for example with CalPod Assemblies
- CodeOne™ CalTool application software controls the test system configuration and calibration
- Supports:
  - Reference Plane Extension (RPE) embedding
  - Frequency Shift Alignment

Semi-automated/customizable measurements

- Frequency – UHF Band to Ka Band
- Gain Frequency Group Delay (GFGD)
- Gain Transfer (Nominal Operation Point or IP Power Saturation)
- Output power and frequency accuracy
- Gain adjustment
- Gain adjustment gain mode
- Near and far out of band
- Spurious
- Spurious - SA
- Spurious - SMD
- Phase Noise
- Path Check
- Gain Monitoring
Basic Payload Test System

**Major features/capability**

- PNA-X based Payload Test System – connections to the PSA/PXA and connection from the PSG are made through the PNA-X test set
- Rubidium reference source
- Reduced number of calibrations
  - Wideband calibration only required at the front of the PNA-X, eliminating numerous narrow bandwidth specific mixer calibrations
  - All test parameters including spectrum and power
- Calibration is only performed once – station can be moved without recalibrating
- Switch matrix UL=1x30, DL=1x30, upgrading to 1x60
  - Uplink Switch Matrix includes couplers on each port for simultaneous carrier injection
- CodeOne™ application software controls the PTS rack – Payload Test Conductor controls CodeOne™
  - CodeOne™ manages the Switch control, Calibration and Measurements/Results
  - Results can be output in multiple formats for analysis
- Supports:
  - Reference Plane Extension (RPE) embedding
  - Diagnostic mode (single step)
  - Frequency Shift Alignment

**Semi-automated/customizable measurements**

- Frequency – UHF Band to Ka Band
- Gain Frequency Group Delay (GFGD)
- Gain Transfer (Nominal Operation Point or IP Power Saturation)
- Output power and frequency accuracy
- Gain adjustment – ALC mode
- Gain adjustment – fixed gain mode
- Spurious
- Spurious - SA
- Spurious - SMD
- Phase Noise
- Path Check
- Gain Monitoring
Advanced Payload Test System RF Test Equipment (RFTE)

Major features/capability

- Expanded from the Basic Payload Test System and is customizable through addition of extra chassis
- Integrates the Function Test System via the Core Switch Matrix to the Payload Test System
- Added Function type tests to CodeOne™
- CalPod Assemblies provide dual test paths to DUT for parametric testing and functional testing (modem connections)
- Functional paths are calibrated via the Payload Test System and CalPod Assemblies
- Six CalPod Assembly models, provide the capability to expand up to 6 ports in one unit
- Characterized over temperature and TVAC compatible
- Includes couplers to couple in and out Functional signal

Automated/customizable measurements

- Frequency – UHF to Ka Band
- Gain Frequency Group Delay (GFGD)
- Gain Transfer (Nominal Operation Point)
- Output power and frequency accuracy
- Gain adjustment – ALC mode
- Gain adjustment – fixed gain mode
- Spurious
- Spurious - SA
- Spurious - SMD
- Phase Noise
- Path Check
- Gain Monitoring
- Noise Pedestal
- NPR
- EVM
- BER
System Benefits:

The payload test solution brings together the benefits of a platform using state of the art measurement equipment, innovative calibration and calibration verification technology and strong software solutions.

- PNA-X based RF test solutions provide tremendous speed improvements over legacy satellite test methods
- Minutes of time for a PTE measurement reduced to seconds
- Cal and verification methods can be improved reducing setup time and improving confidence in measured data
- Days of PTE setup time reduced to a few hours
- Fully automated calibration and calibration refresh (T-VAC compatible)
- Greatly reduced occurrences of test data anomalies
- Test system development and support costs are reduced through use of modern instruments and built-in measurements and calibrations
- Most of the custom system software replaced by COTS firmware applications
- Standardized reliability, reduced complexity, low support cost

Built-in Calibration Methods

User guided calibrations for all measurement types

- Vector de-embedding to extend calibrations to the test interface
- Apply calibration for measurements made with external source/PXA
- Perform calibration verifications whenever desired without disconnecting
- Remote automatic calibration reduces overall calibration time
- Base reference calibration is performed wideband using the Auto Calibration Module

CalPod Module In Situ Calibration Verification Concept

The CalPods are initialized during calibration close to the PNA-X, the Calibration Plane is generated at the CalPod output port. The characterization calibration set, temperature, and relevant standard information is stored to a CodeOne™ calibration file. At measurement time the Calibration Plane is refreshed thus returning the calibration accuracy very close to the initialization.
System Software

The system comes with standard Keysight instrument drivers, measurement firmware, depending on instrument options selected, and Windows 7 Professional operating system.

Software and calibration modules are provided by CodeOne™ application software. CodeOne™ software provides the CalPod management and a test conductor interface customized to the customer environment. Once established, the interface allows usage of RF measurements science layer, equipment drivers and measurement facilities from the user friendly API/GUI. A list of measurements, calibrations and analysis capabilities are shown in the table on the following page.

CodeOne™ Software Overview

User guided calibrations for all measurement types
- 20+ Engineering Years of software development
- Payload-centric suite of 39 measurements
- Full measurement level regression suite
- Dedicated development rack
  - Multi-channel RF payload simulator
  - Fully automated software regressions for each measurement
- Extensive documentation
  - Installation, self-test, configuration, calibration, measurement, analysis, customization, remote interface
- Calibration collection, generation and tracking
- Remote controlled measurement gathering in satellite test environments
- Data analysis and reporting
**CodeOne™ Measurements:**

- Path Check
- Gain Transfer, Normal Operating Point, and Phase vs Drive
- ALC Power Sweep
- Gain, Frequency, and Group Delay
- Fixed Gain State Sweep
- ALC State Sweep
- Noise Figure (PNA-X Opt 29 is recommended)
- Phase Noise
- Radiated Susceptibility
- Radiated Emissions
- Spurious Modulation Distortion
- Return Loss
- Out of Band Response
- Carrier to Noise
- Noise Figure Y-Factor
- Noise Pedestal
- Noise Power Ratio
- Error Vector Magnitude
- Modulation Index
- Ranging Delay
- Set Uplink Signal
- Set Downlink Signal
- Set Path
- AM to PM Conversion
- Transmit Power and Frequency Accuracy
- Bit Error Rate
- Transmit Frequency Spectrum
- Passive Intermodulation
- Spurious Search and Spur Investigation
- AM to PM Transfer
- Intermodulation Distortion
- Absolute Phase
- Repeater Isolation
- Gain Monitoring
- Telemetry vs Power Sweep (AGC Calibration)

**Where applicable the above measurements support:**

- Normal Operating Point (NOP) – as part of above suite, for automatic testing or TWTAs at nominal operation levels
- Reference Plan Extension (RPE) compensation (embedding)
- Diagnostic mode (single step)
- Automatic compensation for LO frequency error
- TT&C related measurement support using external modems for stimulus and downlink - a TTC chassis is optionally available to enable this connectivity
CodeOne™ Calibrations:
- CALPOD calibration
- Inline re-correction
- Calibration transfer (PNA-X front panel to DUT ports)
- Standard mode calibration
- SMC plus Phase calibration (without need for calibration mixers)
- Noise Figure calibration (without need for calibration mixers)
- Noise Figure calibration (NF and NFX)
- PXA, PSG and PSA calibration (single tone and combined)
- Intermodulation calibration (IMDX)
- Modem downlink calibration

Where applicable the above measurements support:
- Calibration upload/calibration transfer facility for diagnostic purposes
- A calibration tracking and validation facility

CodeOne™ Analysis Algorithms:
- Real time comparison to
  - Specification limits
  - Prediction data
- Flexible analysis definition system
  - Pre-defined, easy-to-use templates for all aspects of above measurements
  - Tabular output for most measurements
- Quick look plotting facilities
  - Superposition by phase or state
  - Limit lines
- Extensive library or plug-in analysis for
  - Slope
  - Smoothing and Curve Fitting
  - Ripple
- Export to various formats
  - XML
  - Excel
  - CITI

Typical Keysight System Hardware:
Available in 26.5 GHz or 40 GHz configurations
- N5244A - 43.5 GHz PNA-X with options 200, 219, 224, 080, 083, 084, 087, 029
- N9030A - 44 GHz PXA with options 2FP, 1FP, LNP, B71, P44
- 89601A - VSA Software with option 200, 300
- E8267D - 44 GHz PSG, (31.8 GHz options 532), 602, 1EH, UNT, UNX, 016
- N4693A E-Cal
- CalPod modules and controller
- 40 GHz Automatic Calibration Module (advanced only)
- L4491A based RF switching and signal conditioning unit (Custom or off the shelf design)
  - optional and configurable based on customer requirements
- System rack (EMI option available), cabling, and industrial PC
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