Keysight
Microwave Transceiver

N7081A 100 kHz to 5 GHz

Data Sheet and
Technical Overview

KEYSIGHT
TECHNOLOGIES

Documentation Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

U.S. Government Rights

U.S. Government Rights. The Software is “commercial computer software,” as defined by Federal Acquisition Regulation (“FAR”) 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement (“DFARS”) 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Contents

Overview

The N7081A Microwave Transceiver is a compact vector network analyzer (VNA) that uses a novel broadband, multi-tone source and broadband receivers to capture the instantaneous S-parameters at multiple tones simultaneously. Measurements can be made up to the full frequency range of the N7081A and orders of magnitude faster than traditional swept frequency VNAs.

With the ability to measure instantaneous S-parameters, fast measurement speed, small size and low cost, the N7081A Microwave Transceiver is the ideal measurement subsystem for Microwave Sensing and Imaging (MSI) solutions, high volume test solutions and built-in test in operational equipment.

Key Features

- Captures the instantaneous S-parameters over the entire frequency range of interest simultaneously, critical for measuring S-parameters of anything that changes in time.
- Fast measurement speed: Captures ~ 200 frequency points in less than 40 µsec
- Compact size: 3.9 cm (h) x 10.5 cm (w) x 17 cm (l)
- Broad frequency operation: 100 kHz to 5 GHz (unspecified operation from 25 kHz to 100 kHz and 5 GHz to 6 GHz)
- Full 2-port VNA: Enables measurement of all four S-parameters
- Measurement accuracy similar to other Keysight VNA products
- The broadband source minimizes interference with other electronic or communication equipment, an important feature in EMI sensitive environments such as hospitals or for built-in test applications.
- Controlled by an external PC via USB or LAN using a simple and easy to implement API

New Approach to RF/Microwave Measurements

The N7081A Microwave Transceiver applies a novel “digital” architecture to RF/microwave vector network analysis. A repetitive binary pattern generator within the N7081A provides a broadband, multi-tone RF/microwave stimulus. The repetitive nature of the binary digital pattern creates a comb function with harmonics at multiples of the repetition frequency.

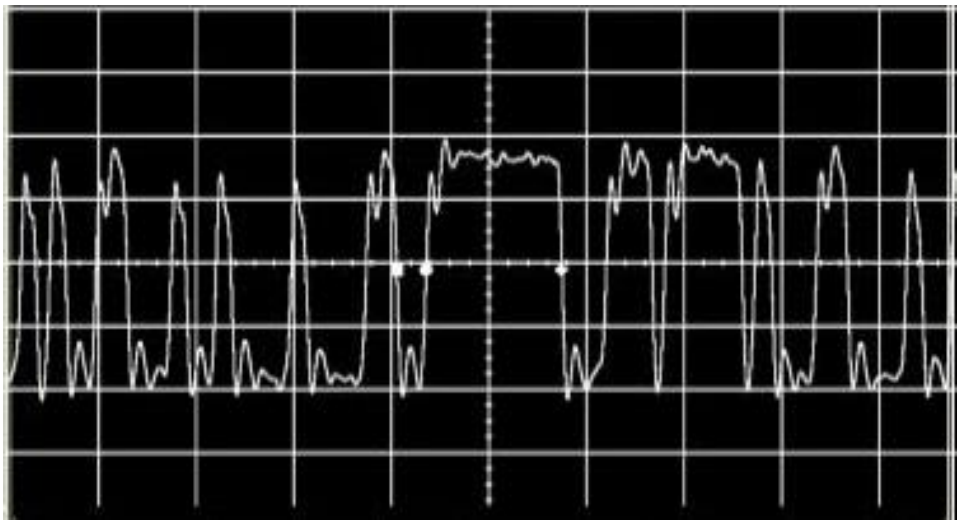


Figure 1. An example of the stimulus output as measured by an oscilloscope.

In the frequency domain, the same signal can be shown to be broadband. Figure 2 shows a spectrum analyzer measurement of a typical broadband stimulus. Figure 3 shows a narrower span of the same stimulus in order to reveal the frequency comb more clearly. This method for creating the broadband stimulus does not, however, provide equal amplitude stimulus at all frequencies, given the sinc function power roll-off vs. frequency of an arbitrary bit sequence.

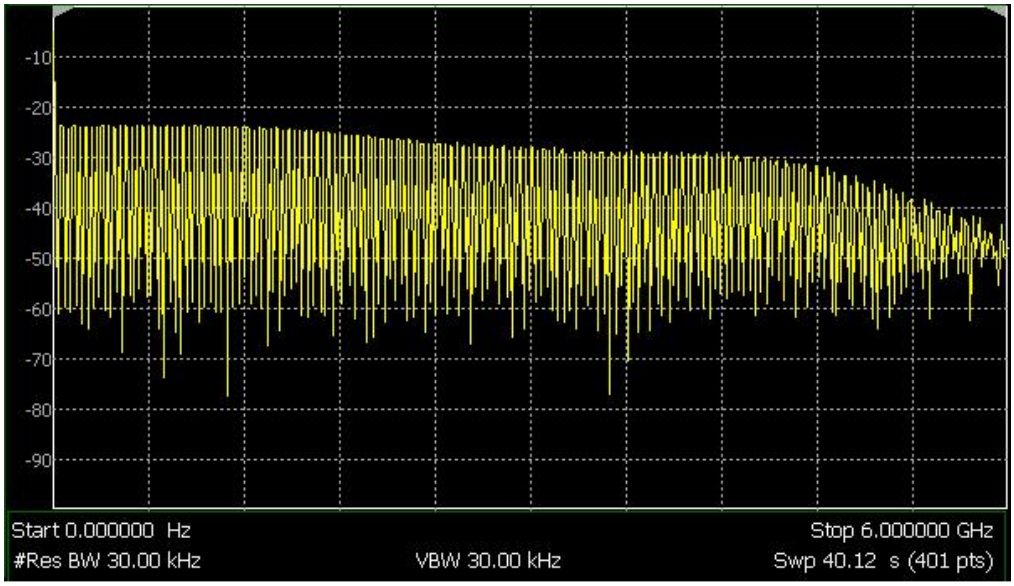


Figure 2. Spectrum analyzer display of a typical stimulus output.

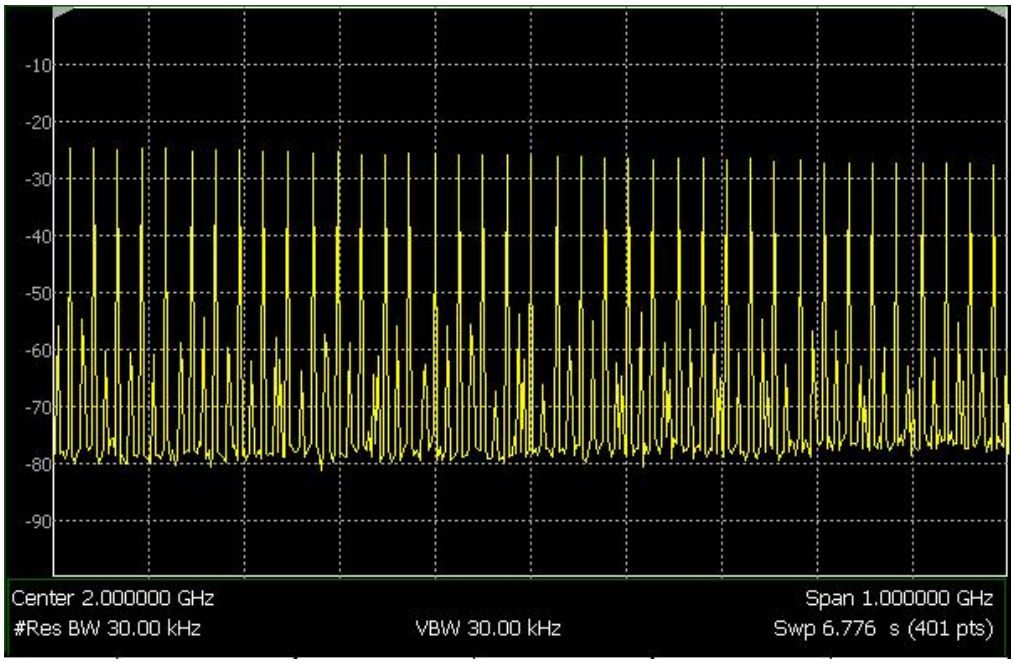


Figure 3. A narrower span in order to reveal the frequency comb more clearly.

The S-parameters are determined by simultaneous measurement of these tones upon reflection from or transmission through the device under test (DUT) using the proprietary broadband receivers incorporated in the N7081A.

Broadband stimulus and broadband receivers enable the N7081A to make ultra-fast measurements, as all the tones can be measured simultaneously and without delays induced by sweep and settling times as in conventional vector network analyzers. No tunable swept oscillators are used in the N7081A.

Instantaneous S-parameters

The N7081A Microwave Transceiver introduces a new paradigm as it is the only VNA that can measure instantaneous S-parameters over the entire frequency range of interest simultaneously. This is critical to accurately measure the reflection/transmission characteristics of RF and microwave devices, components, systems or materials that vary in time. A device's time variation may be due to thermal effects, memory effects, bias transients, switching transients, chemical reaction, micro-phonics or physical movement. Often these changes are unpredictable in nature, hence the need for characterization. All VNAs currently on the market sweep a CW stimulus over the frequency range of interest while synchronized receivers measure the S-parameters at each frequency point. The process of setting the source and acquiring the data over multiple frequencies gathers the measurement data at different times. If the S-parameters of the DUT have changed during that time the measurement results will be invalid. This is particularly critical if the data will be used in an inverse FFT.

Faster Measurements than Swept Frequency VNA

For applications requiring the ultimate in measurement speed, the N7081A Microwave Transceiver provides the fastest measurements and highest throughput without sacrificing measurement accuracy. The measurement time depends on the frequency span and resolution but the N7081A can measure ~ 200 frequency points over the full frequency span of the instrument in 40 µS. Measurements with fewer frequency points, and/or lower resolution, will be even faster.

Table 1. Measurement speed vs. E5071C

Measurement: 0 to 4 GHz, 200 points		
	E5071C	N7081A
Meas. Time	~11 ms.	~40 µs*
Update Rate	~10 fps	~450 fps
Dynamic Range	~90 dB	~50 dB
* Corresponds to 200 ns/pt. fps = frames per second.		

Small Size

The small size (3.9 cm (h) x 10.5 cm (w) x 17 cm (l)) and fully enclosed package of the N7081A Microwave Transceiver make it easy to integrate into test or OEM solutions.

Measurement Accuracy on Par With Keysight Swept Frequency VNAs

Despite using a new broadband measurement technique, the basic measurement principles used in the N7081A are the same as in conventional VNAs. All measurements are based on ratios of signals being reflected from or transmitted through a DUT then detected by the reference receivers and test receivers. Measurements of calibration standards are used to correct for imperfections in the N7081A and associated hardware, the same as is done in conventional VNAs. In this way, calibrated (error-corrected) measurements are obtained for the DUT with accuracy similar to conventional swept frequency VNAs.

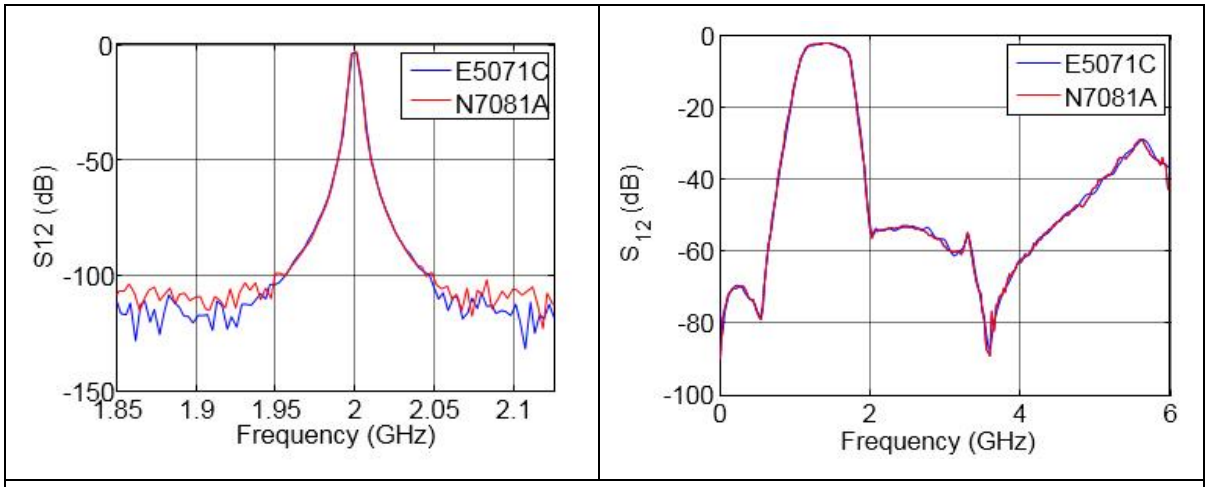


Figure 4. Measurement accuracy vs E5071C

Remote Control Capability

The N7081A Microwave Transceiver can be controlled from an external PC via USB 2.0 or LAN using one of the easy to implement APIs supplied by Keysight. Example programs are provided to demonstrate how to use the API within your programming environment. Table 1 below illustrates the operating systems and programming languages supported with the N7081A.

Operating Systems & Programming Languages Supported				
	C++	C#	VB.net	VB6
Windows 7	✓	✓	✓	✓
Wndows 8	✓	✓	✓	✓
Linux	✓	–	–	–

The API is supported on both 32-bit and 64-bit Windows platforms, and 32-bit ARM-based Linux platforms. The Linux API currently is compiled with the “arm-linux-gnueabi” GNU compiler tool chain and has been fully tested on the Utilite HW platform running Ubuntu version 3.0.35-cm-fx6-5.5. Contact Keysight if other Linux platforms are needed.

VNA Application Graphical User Interface

A simple VNA Application Graphical User Interface (GUI) supplied with the N7081A provides some of the basic features and capabilities required to measure and display S-parameters with the N7081A. While not intended to be a full featured network analyzer application, this GUI can still be a useful tool to help understand the operation or to evaluate the performance of the N7081A. The GUI can also be useful in developing or troubleshooting solutions based on the N7081A.

Two versions of the GUI are available:

1. A version written in MATLAB for 32 bit operating systems
2. A version written in MATLAB for 64 bit operating systems.

Target Applications[1]

The N7081A is the only solution for any application that requires the measurement of RF and microwave devices, components, systems or materials that vary quickly over time. Some example applications are:

- Measurement of materials that are moving in time or space (material/food processing or materials going through a chemical reaction).
- Measurement of changes in RF/microwave "components" due to thermal effects, biasing, etc...
- Measurement of switching times, settling times or transients of RF/microwave amplifiers, switches and modulators
- Measurement of RF/microwave antennas in a reverb chamber
- Imaging of moving people or luggage for security

Measurement applications requiring high throughput or ultra-fast measurement speed:

- High volume manufacturing test of hand set components
- RF imaging where it is difficult for the subject to remain still for long periods

Applications requiring a small compact solution:

- Portable or field applications
- Any built-in test or OEM application where small size matters

The N7081A Microwave Transceiver is the ideal measurement subsystem for high volume manufacturing test, Microwave Sensing and Imaging (MSI) solutions or as an integrated, built-in test solution in operational equipment.

[1] The manufacturer integrating this subsystem into the final product is responsible for all applicable compliance regulations.

N7081A Specifications

Definitions

Specification (spec.)

Warranted performance. All specifications and characteristics apply over the temperature range from 42° C to 48° C as indicated by the internal thermal sensor (unless otherwise stated). The instrument must be stabilized, and must remain at a stable surrounding environment temperature during operation.

Typical (typ.)

Expected performance of an average unit operating at a stable temperature between 42° C to 48° C, as indicated by the internal thermal sensor. It is not covered by the product warranty.

Nominal (nom.)

A general, descriptive term or design parameter. It is not tested, and not covered by the product warranty.

Calibration

The process of measuring known standards to characterize an instrument's systematic (repeatable) errors.

Corrected (residual)

Indicates performance after error correction (calibration). It is determined by the quality of calibration standards and how well "known" they are, plus system repeatability, stability, and noise.

Description	Specification	Supplemental Information
Frequency range		
N7081A	100 kHz to 5 GHz	User range specified by start frequency, stop frequency and number of points. Operates down to 25 kHz and up to 6 GHz but performance is unspecified.
Maximum Frequency Resolution (comb spacing)	25 kHz for frequency spans < 500 MHz. 794 kHz at full span	n=number of points. Resolution = 6.5 GHz / n n is determined by N7081A and depends on start and stop frequencies of the measurement.
Frequency reference		
Accuracy	±5 ppm	
Aging rate	±1 ppm/yr	
Temperature stability	±1.5 ppm over 0 to 70 °C	
System impedance		
	50Ω (nominal)	

Uncorrected Module Performance

Uncorrected Error Terms (dB)

Frequency	Directivity	Source Match	Load Match	Transmission Tracking	Reflection Tracking
100 kHz to < 2.5 GHz	10	15	14		
2.5 GHz to < 3.1 GHz	10	10	14		
3.1 GHz to < 3.3 GHz	5	10	14		
3.3 GHz to < 4.5 GHz	5	10	14		
4.5 GHz to 5 GHz	5	10	12		

Dynamic Range

Frequency	Effective Dynamic Range (Specification)	Effective Dynamic Range [2] (Typical)	System Dynamic Range [3] (Characteristic)
100 kHz to < 800 MHz	90		110
800 MHz to < 3 GHz	70		105
3 GHz to < 4 GHz	70		100
4 GHz to < 5 GHz	66		90
5 GHz to < 6 GHz	---	---	60

Test Port Output

Description	Specification	Supplemental Information
Test Port Power		
Max	-2 dBm (Typical)	Total Integrated Power. (See Measurement Concepts in Help system for definition)
Range	20 dB (Nominal)	

[2] Effective dynamic range is when the crosstalk is greater than the noise floor, and thus crosstalk limits the dynamic range. Crosstalk only limits the dynamic range when more than 1024 averages are used (5 kHz equivalent IF Bandwidth)

[3] System dynamic range = source maximum output power minus the receiver noise floor at 1024 hardware averages and 500 software averages (10 Hz equivalent IF Bandwidth). After crosstalk calibration and error correction.

Test Port Input

Description	Specification	Supplemental Information
Receiver compression level at 0.1 dB compression		
100 kHz to 5 GHz	> +4 dBm (Nominal)	
Input damage level		
100 kHz to 5 GHz	+25 dBm	

Trace Noise (1 kHz equivalent IF bandwidth, nominal power)	
Frequency	Magnitude dB rms (Typical)[1]
100 kHz to < 3 GHz	0.01
3 GHz to < 4 GHz	0.02
4 GHz to 5 GHz	0.05

Temperature Stability	
Frequency	Stability dB / °C (Typical)
100 kHz to < 4 GHz	±0.025
4 GHz to 5 GHz	±0.04

[1] When N7081A is configured for high speed measurements (software API DRFlag = 0), typical performance will degrade at frequencies below 25.5 MHz. When instrument is configured for improved signal isolation and dynamic range measurements (software API DRFlag = 1), typical performance will degrade at frequencies between 3.17 GHz to 3.23 GHz.

General Information

Description	Specification	Supplemental Information
Measurement speed		
Data Acquisition	40 µs/sweep (Typical) Full-span measurement of ~ 200 points	
Port Switching Speed for Paired Measurement (S11/S21 → S22/S12)	263 µs (nom.)	When AllChannelsOn configuration selected in API
	Increases with frequency resolution: 120 ms (Typical) for 12-MHz resolution 950 ms (Typical) for 800 kHz resolution	Standard channels operation (AllChannelsOn not selected)
Instrument Calibration cycle		
	Periodic instrument calibration not required	
Environmental		
	Samples of this product have been type tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of Storage, Transportation and End-use; those stresses include, but are not limited to, temperature, humidity, shock, vibration, altitude, and power line conditions. Test Methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.	
Altitude – Operating	4,600 m (15,000 ft)	
Altitude – Non-Operating	4,600 m (15,000 ft)	
Intrusion protection	IP 20 IEC/EN 60529	
Temperature range		
Operating	0 to 70C	Temperature of the module as determined by the internal thermal sensor.
Storage	–40 to 70C	Surrounding environment temperature

Description	Specification	Supplemental Information
EMC		
	▪ IEC/EN 61326-1 ▪ CISPR Pub 11 Group 1, class A ▪ AS/NZS CISPR 11 ▪ ICES/NMB–001 This ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada.	Complies with the essential requirements of the European EMC Directive as well as current editions of these standards (dates and editions are cited in the Declaration of Conformity).
Safety		
	▪ CSA C22.2 No. 61010-1-12 ▪ C22.2 No. 213-15 ▪ UL 61010-1 3rd edition ▪ ANSI/ISA 12.12.01-2015	Compliant with these standards when used only in or with complete equipment where the acceptability is determined by UL LLC.
Power		
Power supply	6 V DC	Can operate from 6 to 18 V but higher voltages may increase power consumption and module temperature.
Power consumption		S11 & S21: 19 W (typical) All Receivers ON: 24 W (typical) PowerDown (RF off): 5.3 W (typical)
Connector		DC Power Jack: 2 mm center pin, 6.5 mm outer diameter
Weight		
	0.5 kg 0.8 kg	Without heat sink With heat sink
Dimensions (H x W x D)		
	2.5 (h) x 10.5 (w) x 17 (l) cm 3.9 (h) x 10.5 (w) x 17 (l) cm	Without heat sink With heat sink
Test ports		
RF Port 1 or Port 2		
Connector	SMA female	
Impedance	50 Ω (nominal)	
Damage Level	> +25 dBm, > ±8 VDC	

Description	Specification	Supplemental Information
Safety Controls		
Over Temperature Shut Off	Automatically turns module OFF when maximum temperature is exceeded. The ability to read module temperature is provided.	
Programming		

	Operating Systems & Programming Languages Supported			
	C++	C#	VB.net	VB6
Windows 7	✓	✓	✓	✓
Wndows 8	✓	✓	✓	✓
Linux	✓	–	–	–

Connectivity		
	USB2.0 (mini-B Type connector) LAN: 1000 Base-T	Can control over slower networks, but requires use of 1000 Base-T switch between N7081A and network
External PC System Requirements		
	OS: Windows 7, 8, Linux, USB 2.0 (or 3.0) or LAN ports	
External Frequency Reference		
Connector	MCX	
Frequency Reference Input		
Input Frequency	10 MHz	
Input Amplitude Range	-5 to +10 dBm	
Impedance		50 Ω (nominal)
Lock Range	± 10 ppm	
Frequency Reference Output		
Output Frequency	10 MHz ± 2.5 ppm	
Output Amplitude	7 dBm ± 3 dB	
Impedance		50 Ω (nominal)
Hardware Triggering		
Connector	HDMI Type-C	
External Trigger	Pin 17 (HDMI Reserved)	3V logic (transition at 1.5V) Do not exceed 6V
Trigger Ready	Trigger Ready: Pin 15 (HDMI SCL)	

GUI Measurement Capabilities

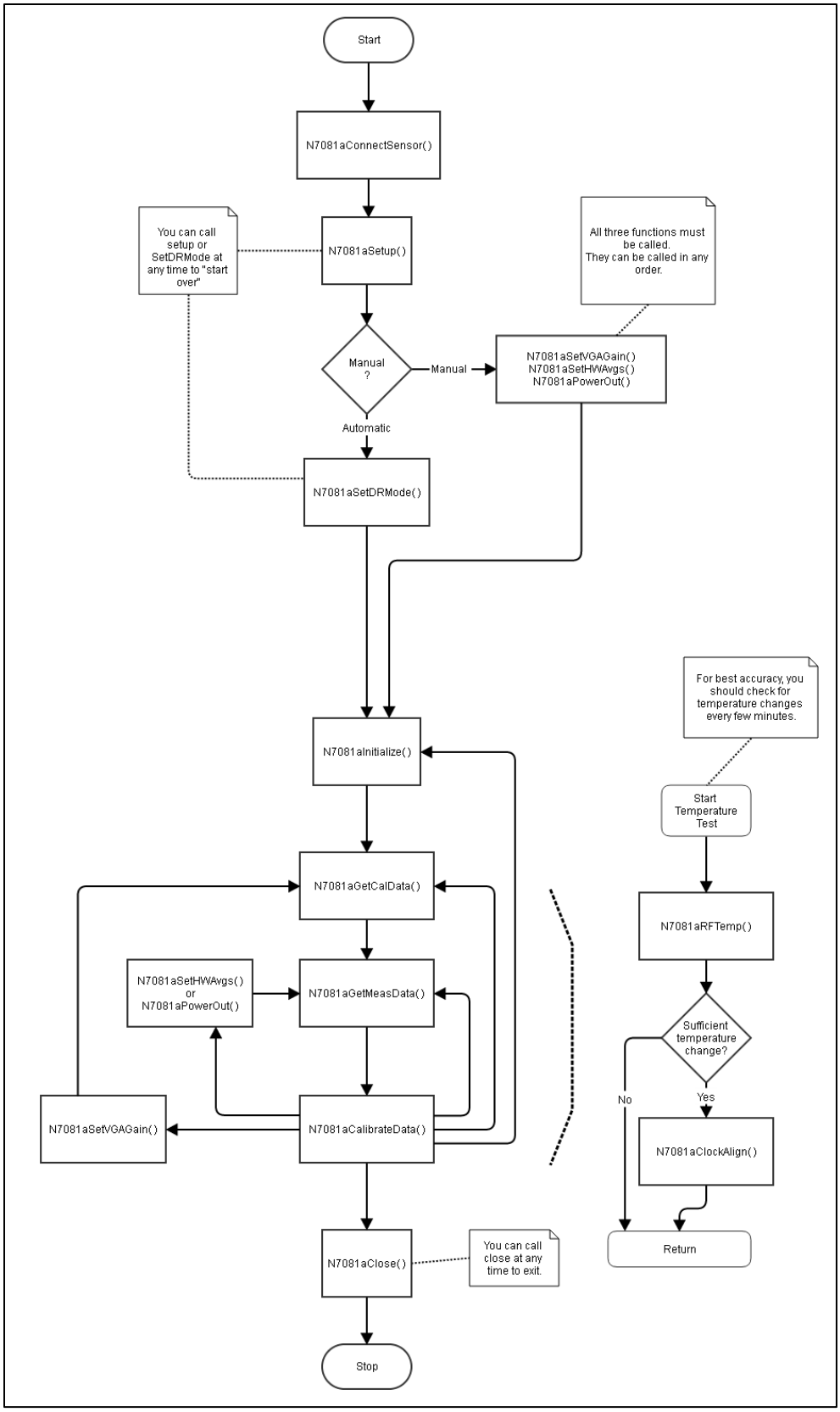
Description	Information
Measurements	
Standard Measurements	S11, S21, S12 and S22 magnitude and phase
Paired Measurements	S11 and S21 or S22 and S12 magnitude and phase
All Receivers ON	This mode improves measurement speed, reduces thermal drift, but increases power consumption.
Formats	
Data Display Formats	Log magnitude, phase
Averaging	
Hardware Averaging	2 to 1024 – DSP averages (internal to the unit)
Software Averaging	2 to 999 – GUI averages (Averages in the GUI)
Traces	
Number of traces	Two traces simultaneously for paired measurements
Sweep	
Sweep type	Linear frequency sweep, sweep range defined by start, stop and number of points
Display	
Scale	Scale Min and Max Autoscale: Automatically selects scale resolution and reference value to center the trace.
User/Measurement Calibration Types	
Frequency response	Simultaneous magnitude and phase correction of frequency response errors for either reflection or transmission measurements.
2-port 1-path (enhanced response)	Today, this automatically happens when the user selects paired measurements. This is not available for single S-parameter measurements. Corrects for frequency response and source match for transmission measurements, and provides one-port calibration for reflection measurements.
1-port calibration	Corrects for directivity, frequency response, and source match errors.
2-port calibration	Not enabled at this time.
Isolation calibration	Performed for any 2 port calibrations. Removes crosstalk errors.
Calibration Kits	Supports any SOLT calibration kit but assumes the calibration standards are perfect.
Calibration Save/Recall	Enables saving or recalling user calibrations.
Calibration Refresh	Enables the current calibration to be refreshed by re-measuring any of the calibration standards.
Calibration Display	The results of the calibration standard are displayed during the measurement.
Source Data Patterns	
Custom Data Patterns	Enable saving and recalling custom data patterns

API Capabilities

Description	Information
Module Connection	
QueryNumberSensors	Identifies all N7081A modules on LAN or connected via USB
ConnectSensor	Connects for session with a particular N7081A module
Set / Get IP Address	Sets or returns the instrument IP address
Get MAC Address	Returns an instruments MAC address
Set / Get Sensor Alias	Sets or returns the N7081A user-defined “alias”
AddLANSensor	Using the IP address, this command adds a remote unit (on a different LAN subnet) to the list of modules that can be connected
Measurement Configuration	
Frequency Span	Entered as Start and Stop Frequency
Number of points	Number of points to be measured in the desired span.
Number of Averages	The N7081A can average successive acquisitions with no time lost to signal processing or data transfer. This is the preferred method of averaging up to 1024 averages. This is mathematically equivalent to adjusting the IF bandwidth in a conventional VNA.
Measurement Type	Defines measurement type (S11, S21, S22, S12, S11&S21, or S22&S12).
Trigger Modes	External HW triggers: (Number of groups (continuous or individually triggered), Single) SW triggers: Number of groups (continuous), Single
RF Output Power Level	Use to set the level of the RF output power
Set VGA level	Used to set the gain of the IF amplifiers in the reference and test receivers
Enable/Disable 10 MHz	Enables user to turn the 10 MHz Reference Out ON or OFF
Download Custom Pattern	Enables user to download custom patterns.
Set Dynamic Range	Automatically configures instrument based on user-specified preference for trade-off between speed and dynamic range
Initialize	Executes configuration and enables measurements
Power Down	Turns OFF RF output, putting unit in low-power standby mode
Spur Interpolation	Enables or disables spur interpolation

Description	Information
Acquire Data	
Standard Acquire Data	Acquires data and sends to USB/LAN (includes 1 ms time stamp)
Acquire to Memory	This is implemented as a SW trigger mode. One or more data acquisitions written to memory.
Read Data from Memory	Data acquired from memory for one or multiple acquisitions.
Acquisition Time	Returns time required for single data acquisition
Triggered Acquisition	Acquires measurement data according to the trigger-mode specified during measurement configuration
Clock Align	Performs an internal clock alignment
Calibration	
Read Error Terms	Returns calibration error terms (equivalent to the uncorrected performance)
Get Calibration Data	Returns ratioed non-corrected measurement of the calibration standard
Instrument Status (or System Monitor)	
System Monitor	Queries instrument supply voltages
Temperature	Returns the temperature as measured by an IC on the RF board. This can be used to determine when the instrument has reached thermal equilibrium or when the Clock Align function should be called
Instrument State	
Save State	Saves instrument state (Measurement parameters, start and stop frequencies, number of points, dynamic range mode (1 – 6), VGA gain, output buffer setting, number of HW averages, interpolation points if interpolation ON)
Recall State	Restores instrument state (Measurement parameters, start and stop frequencies, number of points, dynamic range mode (1 – 6), VGA gain, output buffer setting, number of HW averages, interpolation points if interpolation ON)
FPGA bitfile	
Check version	Returns the version number and date-code for the existing FPGA bitfile
Update FPGA bitfile	Enables uploading a new FPGA bitfile
Module Serial Number	
Read Serial Number	Reads module serial number from module flash
RF Power Output	
RF Output ON/OFF	Turns RF on or off.
Check RF Power On/Off	Used to check if the RF power is On or Off. Critical feature if Inactivity Standby is enabled

Typical API Measurement Flow



Edition 5 Print Date: April 2, 2019
Printed in USA/Malaysia
Supersedes: November 30, 2018
N7081-90002
www.keysight.com