Keysight Technologies
E4727A Advanced Low-Frequency Noise Analyzer

Data Sheet

KEYSIGHT TECHNOLOGIES

Introduction

The Keysight E4727A Advanced Low-Frequency Noise Analyzer is the next-generation system for characterization and analysis of 1/f (flicker) noise and random telegraph signal noise (RTN). Designed for both on-wafer and discrete device/circuit measurement, it uniquely allows for versatile noise measurement under diverse conditions, including: ultra-low frequency, ultra-low current, high current, high voltage, or high power.

The E4727A's industry leading specifications make it the ideal system for low-frequency noise characterization in nano-technologies, bioelectrical applications, green energy technologies, and advanced analog/RF/SOC designs. The E4727A adopts an innovative modular architecture to minimize system noise level. It also minimizes the footprint and improves mobility of the system.

The E4727A is equipped with resident GUI-based instrument/prober control and measurement automation software for high throughput. It enables automated multi-bias, multi-device, and wafer mapping DC and noise measurement. Its multiple measurement modes make it possible to select the most desired tradeoff between measurement speed and accuracy. The software also provides a rich set of built-in biasing schemes that efficiently deliver noise characteristics of the DUT under real circuit operation conditions.

Basic Features

Measurement capabilities

DC measurement

– Accurate and precise DC measurement when used with suported parameter analyzers: up to 0.1 A and 200 V
– Supports BJTs, FETs, diodes, and resistors

1/f (flicker) noise measurement

– Supports BJTs, FETs, diodes, and resistors
– Supports circuits (Op-Amps, comparators)
– Maximum frequency range of 0.03 Hz to 40 MHz
– Measures noise down to 0.67 $\dfrac{nV}{\sqrt{Hz}}$ @ 10 KHz
– Current/voltage/power range of up to 0.1 A/200 V/10 W, respectively

Random telegraph signal noise (RTS a.k.a. RTN) measurement

– Supports FETs
– 2.5 nsec minimum time step
– 8M-point maximum sampling size
– Continuous sampling
– Provides time domain results and histograms of current and voltage

Specification conditions

– Temperature: 23 °C ± 5 °C
– Humidity: 30% ~ 80% RH
– Warming up time: Minimum 40 minutes
– Calibration period: 1 year

E4727A Specifications

Main modules

The E4727A adopts an innovative modular architecture to minimize system noise.

Module Name	Key Features
PXIe unit	Provides central control of E4727A
M9018A PXIe mainframe	18-slot chassis
M9036A embedded PC	Windows 7 64-bit (in English)
E4727A(K01) interface module	Controls input module, output module, and LCD display
Digitizer	A/D converter (digitizer)
E4727A(K02) Input module	Connects to DUT input port
E4727A(K03) Output module	Connects to DUT output port
E4727A(K04) Substrate module	Connects to DUT substrate/backgate
E4727A(K05) Test fixture	Fixture for packaged devices

E4727A(K01) specifications

Input module control section	
Logic circuit output voltage	4.5 V
Relay circuit output voltage	6.7 V, 6.0 V
Signal generator circuit output voltage	4.5 V
Connector type	36-pin miniature delta ribbon (f)
Output module control section	
Logic circuit output voltage	4.5 V
Relay circuit output voltage	6.7 V, 6.0 V
LNA circuit output voltage	11.6 V, 9.7 V, -9.0 V
Connector type	26-pin miniature delta ribbon (f)

E4727A(K02) specifications

LPF		
Number of LPFs	2	
	LPF1	LPF2
Cut-off frequency	0.03 Hz	0.53 Hz
Series resistance	5 KΩ	300 Ω
Maximum voltage	±50 VDC	±50 VDC
Maximum current	±0.1 A	±0.1 A
Input resistances		
Resistor values	0 to 100 MΩ (25 selections)	
Accuracy	±0.5%	
Signal generator circuit		
Output signal	Sine wave	
Frequency range	0.01 Hz to 40 MHz	
Frequency resolution	233 μHz ($f_{out} \leq$ 30 Hz); 29.1 mHz (f_{out} > 30 Hz)	
Output amplitude	-50 dBm ±5 dB; -60 dBm ±5 dB; -70 dBm ±5 dB	
Output impedance	50 Ω	
Connector		
Gate/base terminal (SG output)	SMA(f)	
DC source monitor	Tri-axial(f) X2	
Interface module	36-pin miniature delta ribbon (f)	

E4727A(K03) specifications

LPF		
Number of LPFs	2	
	LPF1	LPF2
Cut-off frequency	0.03 Hz	0.53 Hz
Series resistance	5 KΩ	300 Ω
Maximum voltage	±200 VDC	±200 VDC
Maximum current	±0.1 A	±0.1 A
Output resistances		
Resistor values	0 to 100 MΩ (25 selections)	
Accuracy	±0.5%	

LNAs				
Number of LNAs	4			
	LNA1	LNA2	LNA3	LNA4
LNA type	Voltage	Voltage	Voltage	Current
Frequency range	0.03 Hz to 1 MHz	1 Hz to 1 MHz	1 Hz to 40 MHz	0.03 Hz to 100 KHz
Input voltage noise density	$0.67\,\frac{nV}{\sqrt{Hz}}$ @ 10 KHz	$0.67\,\frac{nV}{\sqrt{Hz}}$ @ 10 KHz	$1.5\,\frac{nV}{\sqrt{Hz}}$ @ 1 MHz	-
Input current noise density	$<100\,\frac{fA}{\sqrt{Hz}}$ @ 10 KHz	$<100\,\frac{fA}{\sqrt{Hz}}$ @ 10 KHz	$<100\,\frac{fA}{\sqrt{Hz}}$ @ 10 KHz	$<1\,\frac{pA}{\sqrt{Hz}}$ @ 1 KHz
Corner frequency	20 Hz	200 Hz	200 Hz	200 Hz
Maximum input voltage	±200 VDC	±200 VDC	±200 VDC	±5 VDC
Maximum input current	-	-	-	±30 mA
Output impedance	220 Ω	220 Ω	220 Ω	220 Ω

E4727A(K03) specifications, continued

Connector	
Drain/collector/ anode/resistor+	SMA(f)
Source/emitter/cathode/resistor-	SMA(f)
DC source monitor	Tri-axial(f) X2
Interface module	26-pin miniature delta ribbon (f)

E4727A(K04) specifications

LPF	
Cut-off frequency	0.08 Hz
Series resistance	2 KΩ
Maximum voltage	±50 VDC
Maximum current	±0.1 A
Connector	
Substrate terminal	SMA(f)
DC source monitor	Tri-axial(f) X2

E4727A(K05) specifications

IC socket	
Type	DIP (300 mil and 600 mil)
Lead pitch	2.54 mm (100 mil)
Number of leads	28
Connector	
Drain/collector/ anode/resistor+	SMA(f)
Source/emitter/cathode/resistor-	SMA(f)
Gate/base terminal	SMA(f)
Substrate terminal	SMA(f)

E4727A Software

The E4727A is equipped with resident GUI-based software running on the embedded 64-bit Windows 7 platform, which can be accessed through included keyboard and mouse. The software provides instrument control of commonly used parameter analyzers and probe stations to enable repeatable and high-throughput automated on-wafer DC and noise measurement. It provides data analysis, sanity check, visualization, and reporting. The software saves DC and flicker noise measurement conditions and data that can be directly used in Keysight device model extraction and qualification solutions (IC-CAP, MBP, and MQA). It also guides you through periodic system calibration by step-by-step onscreen interactive instructions.

Key features

– External instrument control
– Wafer-mapping DC and noise measurement
– Multiple measurement modes for flexible throughput-accuracy tradeoffs
– Multiple built-in biasing schemes for flicker noise characterization
– Measurement data ready for use in Keysight device model extraction and qualification solutions
– Guided system calibration procedures

– Measurement project and data management

Measurement modes and functions

Measurement modes

– Auto Fast Mode: it uses internal algorithms to set Rin and Rload values and delivers the highest measurement speed
– Auto High Accuracy Mode: it users internal algorithms to set Rin and Rload values and delivers higher accuracy in measurement results than the auto fast mode
– Expert Fast Mode: it allows expert user to optimize Rin and Rout values and delivers high measurement speed
– Expert High Accuracy Mode: it allows expert user to optimize Rin and Rload values and delivers the most accurate measurement results

Built-in biasing schemes

Device type	Biasing scheme	Description
FET	SetVg	Defines V_{gs}, V_{ds}, & V_{bs} as bias conditions
	SetIds	Defines I_{ds}, V_{ds}, & V_{bs} as bias conditions. V_{gs} is determined automatically
	SetVth	Defines constant-current or gm_max threshold voltage (V_{th}) & an offset voltage. V_{gs} will be automatically set at the offset value to V_{th}
FET	SetVbVc	Defines V_{be} and V_{ce} as bias conditions
	SetIcVc	Defines I_c and V_c as bias conditions. V_{be} is determined automatically
Diode	SetVd	Defines V_d and V_{sub} as bias conditions
	SetId	Defines I_d and V_{sub} as bias conditions
Resistor	SetVr	Defines V_r and V_{sub} as bias conditions
	SetIr	Defines I_r and V_{sub} as bias conditions

External instrument control

Supported parameter analyzers

– Keysight 4142B (41420A HPSMU, 41421B MPSMU)
– Keysight 4155B/C (MPSMU)
– Keysight 4156B/C (HRSMU)
– Keysight B1500A (B1510A HPSMU, B1511A/B MPSMU, B1517A HRSMU)

Supported probe stations

– Cascade Summit 12K
– Cascade S300
– Cascade Elite300
– Cascade PA300

Program and interface capabilities

Data storage

– Hard disk drive

Interfaces

Interface	Description
LAN	LAN connector for embedded PC (2)
USB	UCB port for embedded PC (front 4)
GP-IB	GP-IB interface for embedded PC
VGA video output	External display connector to embedded PC
Interlock	Keysight 4142B, 4155B/C, 4156B/C, and B1500A

General specifications

Temperature range

– Operating: 10 °C to 40 °C
– Storage: -30 °C to 70 °C

Humidity range

– Operating: 20% to 70% RH, no condensation
– Storage: 20% to 90% RH, no condensation

Dimensions and weight

Part	Dimensions W X H X D (mm) (excluding protruding object)	Weight (Kg)
PXIe unit	444.4 x 177.8 X 466	17.1
E4727A(K02) input module	65.0 X 125.0 X 180.0	2.3
E4727A(K03) output module	65.0 X 125.0 X 180.0	2.4
E4727A(K04) substrate module	65.0 X 98.0 X 99.4	1.5
E4727A(K05) test fixture	100.0 X 85.0 X 120.0	0.8
E4727A(K06,07) oscillation block filter (type 1, 2)	50.0 X 20.0 X 30.0	0.04

Keysight IC-CAP
Device Modeling Software
www.keysight.com/find/eesof-iccap

Keysight MBP
Turn-key Device Model Extraction
Solutions
www.keysight.com/find/eesof-mbp

Keysight MQA
Device Model Validation Software
www.keysight.com/find/eesof-mqa

Keysight WaferPro Express
On-wafer Measurement Program
www.keysight.com/find/eesof-waferpro-express

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