ANALOG DEVICES

LF–2.7 GHz RF/IF Gain and Phase Detector

AD8302

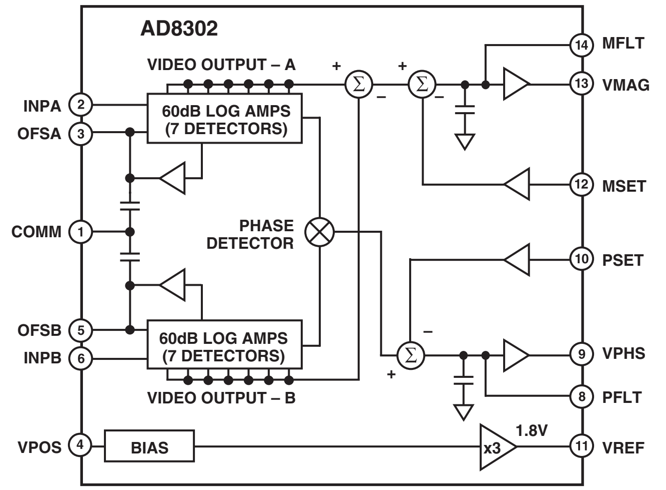
FEATURES

Measures Gain/Loss and Phase up to 2.7 GHz
Dual Demodulating Log Amps and Phase Detector
Input Range –60 dBm to 0 dBm in a 50 Ω System
Accurate Gain Measurement Scaling (30 mV/dB)
Typical Nonlinearity < 0.5 dB
Accurate Phase Measurement Scaling (10 mV/Degree)
Typical Nonlinearity < 1 Degree
Measurement/Controller/Level Comparator Modes
Operates from Supply Voltages of 2.7 V–5.5 V
Stable 1.8 V Reference Voltage Output
Small Signal Envelope Bandwidth from DC to 30 MHz

APPLICATIONS

RF/IF PA Linearization
Precise RF Power Control
Remote System Monitoring and Diagnostics
Return Loss/VSWR Measurements
Log Ratio Function for AC Signals

FUNCTIONAL BLOCK DIAGRAM



PRODUCT DESCRIPTION

The AD8302 is a fully integrated system for measuring gain/loss and phase in numerous receive, transmit, and instrumentation applications. It requires few external components and a single supply of 2.7 V–5.5 V. The ac-coupled input signals can range from –60 dBm to 0 dBm in a 50 Ω system, from low frequencies up to 2.7 GHz. The outputs provide an accurate measurement of either gain or loss over a ±30 dB range scaled to 30 mV/dB, and of phase over a 0°–180° range scaled to 10 mV/degree. Both subsystems have an output bandwidth of 30 MHz, which may optionally be reduced by the addition of external filter capacitors. The AD8302 can be used in controller mode to force the gain and phase of a signal chain toward predetermined setpoints.

The AD8302 comprises a closely matched pair of demodulating logarithmic amplifiers, each having a 60 dB measurement range. By taking the difference of their outputs, a measurement of the magnitude ratio or gain between the two input signals is available. These signals may even be at different frequencies, allowing the measurement of conversion gain or loss. The AD8302 may be used to determine absolute signal level by applying the unknown signal to one input and a calibrated ac reference signal to the other. With the output stage feedback connection disabled, a comparator may be realized, using the setpoint pins MSET and PSET to program the thresholds.

The signal inputs are single-ended, allowing them to be matched and connected directly to a directional coupler. Their input impedance is nominally 3 kΩ at low frequencies.

The AD8302 includes a phase detector of the multiplier type, but with precise phase balance driven by the fully limited signals appearing at the outputs of the two logarithmic amplifiers. Thus, the phase accuracy measurement is independent of signal level over a wide range.

The phase and gain output voltages are simultaneously available at loadable ground referenced outputs over the standard output range of 0 V to 1.8 V. The output drivers can source or sink up to 8 mA. A loadable, stable reference voltage of 1.8 V is available for precise repositioning of the output range by the user.

In controller applications, the connection between the gain output pin VMAG and the setpoint control pin MSET is broken. The desired setpoint is presented to MSET and the VMAG control signal drives an appropriate external variable gain device. Likewise, the feedback path between the phase output pin VPHS and its setpoint control pin PSET may be broken to allow operation as a phase controller.

The AD8302 is fabricated on Analog Devices' proprietary, high performance 25 GHz SOI complementary bipolar IC process. It is available in a 14-lead TSSOP package and operates over a –40°C to +85°C temperature range. An evaluation board is available.

REV. A

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AD8302–SPECIFICATIONS (T_A = 25°C, V_S = 5 V, VMAG shorted to MSET, VPHS shorted to PSET, 52.3 Ω shunt resistors connected to INPA and INPB, for Phase measurement $P_{INPA} = P_{INPB}$, unless otherwise noted.)

Parameter	Conditions	Min	Typ	Max	Unit
OVERALL FUNCTION					
Input Frequency Range		>0		2700	MHz
Gain Measurement Range	P_{IN} at INPA, P_{IN} at INPB = –30 dBm		±30		dB
Phase Measurement Range	ϕ_{IN} at INPA > ϕ_{IN} at INPB		±90		Degree
Reference Voltage Output	Pin VREF, –40°C ≤ T_A ≤ +85°C	1.72	1.8	1.88	V
INPUT INTERFACE	Pins INPA and INPB				
Input Simplified Equivalent Circuit	To AC Ground, f ≤ 500 MHz		3‖2		kΩ‖pF
Input Voltage Range	AC-Coupled (0 dBV = 1 V rms)	–73		–13	dBV
	re: 50 Ω	–60		0	dBm
Center of Input Dynamic Range			–43		dBV
			–30		dBm
MAGNITUDE OUTPUT	Pin VMAG				
Output Voltage Minimum	20 × Log (V_{INPA}/V_{INPB}) = –30 dB		30		mV
Output Voltage Maximum	20 × Log (V_{INPA}/V_{INPB}) = +30 dB		1.8		V
Center Point of Output (MCP)	$V_{INPA} = V_{INPB}$		900		mV
Output Current	Source/Sink		8		mA
Small Signal Envelope Bandwidth	Pin MFLT Open		30		MHz
Slew Rate	40 dB Change, Load 20 pF‖10 kΩ		25		V/µs
Response Time					
Rise Time	Any 20 dB Change, 10%–90%		50		ns
Fall Time	Any 20 dB Change, 90%–10%		60		ns
Settling Time	Full-Scale 60 dB Change, to 1% Settling		300		ns
PHASE OUTPUT	Pin VPHS				
Output Voltage Minimum	Phase Difference 180 Degrees		30		mV
Output Voltage Maximum	Phase Difference 0 Degrees		1.8		V
Phase Center Point	When $\phi_{INPA} = \phi_{INPB} \pm 90°$		900		mV
Output Current Drive	Source/Sink		8		mA
Slew Rate			25		V/µs
Small Signal Envelope Bandwidth			30		MHz
Response Time	Any 15 Degree Change, 10%–90%		40		ns
	120 Degree Change C_{FILT} = 1 pF, to 1% Settling		500		ns
100 MHz	MAGNITUDE OUTPUT				
Dynamic Range	±1 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		58		dB
	±0.5 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		55		dB
	±0.2 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		42		dB
Slope	From Linear Regression		29		mV/dB
Deviation vs. Temperature	Deviation from Output at 25°C				
	–40°C ≤ T_A ≤ +85°C, $P_{INPA} = P_{INPB}$ = –30 dBm		0.25		dB
	Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = ±25 dB, P_{INPB} = –30 dBm		0.25		dB
Gain Measurement Balance	$P_{INPA} = P_{INPB}$ = –5 dBm to –50 dBm		0.2		dB
	PHASE OUTPUT				
Dynamic Range	Less than ±1 Degree Deviation from Best Fit Line		145		Degree
	Less than 10% Deviation in Instantaneous Slope		143		Degree
Slope (Absolute Value)	From Linear Regression about –90° or +90°		10		mV/Degree
Deviation vs. Temperature	Deviation from Output at 25°C				
	–40°C ≤ T_A ≤ +85°C, Delta Phase = 90 Degrees		0.7		Degree
	Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, Delta Phase = ±30 Degrees		0.7		Degree

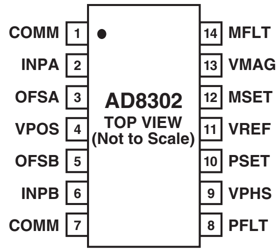
Parameter	Conditions	Min	Typ	Max	Unit
900 MHz	MAGNITUDE OUTPUT				
Dynamic Range	±1 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		58		dB
	±0.5 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		54		dB
	±0.2 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		42		dB
Slope	From Linear Regression		28.7		mV/dB
Deviation vs. Temperature	Deviation from Output at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = P_{INPB} = –30 dBm		0.25		dB
	Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = ±25 dB, P_{INPB} = –30 dBm		0.25		dB
Gain Measurement Balance	P_{INPA} = P_{INPB} = –5 dBm to –50 dBm		0.2		dB
	PHASE OUTPUT				
Dynamic Range	Less than ± 1 Degree Deviation from Best Fit Line		143		Degree
	Less than 10% Deviation in Instantaneous Slope		143		Degree
Slope (Absolute Value)	From Linear Regression about –90° or +90°		10.1		mV/Degree
Deviation	Linear Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, Delta Phase = 90 Degrees		0.75		Degree
	–40°C ≤ T_A ≤ +85°C, Delta Phase = ±30 Degrees		0.75		Degree
Phase Measurement Balance	Phase @ INPA = Phase @ INPB, P_{IN} = –5 dBm to –50 dBm		0.8		Degree
1900 MHz	MAGNITUDE OUTPUT				
Dynamic Range	±1 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		57		dB
	±0.5 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		54		dB
	±0.2 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		42		dB
Slope	From Linear Regression		27.5		mV/dB
Deviation vs. Temperature	Deviation from Output at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = P_{INPB} = –30 dBm		0.27		dB
	Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = ±25 dB, P_{INPB} = –30 dBm		0.33		dB
Gain Measurement Balance	P_{INPA} = P_{INPB} = –5 dBm to –50 dBm		0.2		dB
	PHASE OUTPUT				
Dynamic Range	Less than ±1 Degree Deviation from Best Fit Line		128		Degree
	Less than 10% Deviation in Instantaneous Slope		120		Degree
Slope (Absolute Value)	From Linear Regression about –90° or +90°		10.2		mV/Degree
Deviation	Linear Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, Delta Phase = 90 Degrees		0.8		Degree
	–40°C ≤ T_A ≤ +85°C, Delta Phase = ±30 Degrees		0.8		Degree
Phase Measurement Balance	Phase @ INPA = Phase @ INPB, P_{IN} = –5 dBm to –50 dBm		1		Degree
2200 MHz	MAGNITUDE OUTPUT				
Dynamic Range	±1 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		53		dB
	±0.5 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		51		dB
	±0.2 dB Linearity P_{REF} = –30 dBm (V_{REF} = –43 dBV)		38		dB
Slope	From Linear Regression		27.5		mV/dB
Deviation vs. Temperature	Deviation from Output at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = P_{INPB} = –30 dBm		0.28		dB
	Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, P_{INPA} = ±25 dB, P_{INPB} = –30 dBm		0.4		dB
Gain Measurement Balance	P_{INPA} = P_{INPB} = –5 dBm to –50 dBm		0.2		dB
	PHASE OUTPUT				
Dynamic Range	Less than ±1 Degree Deviation from Best Fit Line		115		Degree
	Less than 10% Deviation in Instantaneous Slope		110		Degree
Slope (Absolute Value)	From Linear Regression about –90° or +90°		10		mV/Degree
Deviation	Linear Deviation from Best Fit Curve at 25°C				
	–40°C ≤ T_A ≤ +85°C, Delta Phase = 90 Degrees		0.85		Degree
	–40°C ≤ T_A ≤ +85°C, Delta Phase = ±30 Degrees		0.9		Degree
REFERENCE VOLTAGE	Pin VREF				
Output Voltage	Load = 2 kΩ	1.7	1.8	1.9	V
PSRR	V_S = 2.7 V to 5.5 V		0.25		mV/V
Output Current	Source/Sink (Less than 1% Change)		5		mA
POWER SUPPLY	Pin VPOS				
Supply		2.7	5.0	5.5	V
Operating Current (Quiescent)	V_S = 5 V		19	25	mA
	–40°C ≤ T_A ≤ +85°C		21	27	mA

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage V_S . . . . 5.5 V
PSET, MSET Voltage . . . . V_S + 0.3 V
INPA, INPB Maximum Input . . . . –3 dBV
  Equivalent Power Re. 50 Ω . . . . 10 dBm
θ_{JA}[2] . . . . 150°C/W
Maximum Junction Temperature . . . . 125°C
Operating Temperature Range . . . . –40°C to +85°C
Storage Temperature Range . . . . –65°C to +150°C
Lead Temperature Range (Soldering 60 sec) . . . . 300°C

NOTES
[1]Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
[2]JEDEC 1S Standard (2-layer) board data.

PIN CONFIGURATION



PIN FUNCTION DESCRIPTIONS

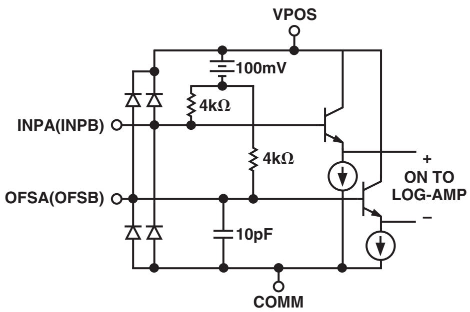
Pin No.	Mnemonic	Function	Equivalent Circuit
1, 7	COMM	Device Common. Connect to low impedance ground.	
2	INPA	High Input Impedance to Channel A. Must be ac-coupled.	Circuit A
3	OFSA	A capacitor to ground at this pin sets the offset compensation filter corner and provides input decoupling.	Circuit A
4	VPOS	Voltage Supply (V_S), 2.7 V to 5.5 V	
5	OFSB	A capacitor to ground at this pin sets the offset compensation filter corner and provides input decoupling.	Circuit A
6	INPB	Input to Channel B. Same structure as INPA.	Circuit A
8	PFLT	Low Pass Filter Terminal for the Phase Output	Circuit E
9	VPHS	Single-Ended Output Proportional to the Phase Difference between INPA and INPB.	Circuit B
10	PSET	Feedback Pin for Scaling of VPHS Output Voltage in Measurement Mode. Apply a setpoint voltage for controller mode.	Circuit D
11	VREF	Internally Generated Reference Voltage (1.8 V Nominal)	Circuit C
12	MSET	Feedback Pin for Scaling of VMAG Output Voltage Measurement Mode. Accepts a set point voltage in controller mode.	Circuit D
13	VMAG	Single-Ended Output. Output voltage proportional to the decibel ratio of signals applied to INPA and INPB.	Circuit B
14	MFLT	Low Pass Filter Terminal for the Magnitude Output	Circuit E

ORDERING GUIDE

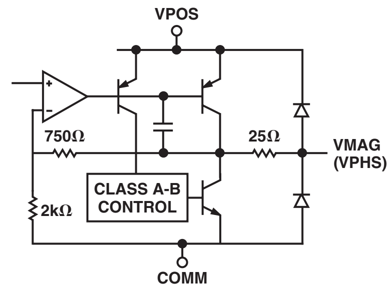
Model	Temperature Range	Package Description	Package Option
AD8302ARU	–40°C to +85°C	Tube, 14-Lead TSSOP	RU-14
AD8302ARU-REEL		13" Tape and Reel	
AD8302ARU-REEL7		7" Tape and Reel	
AD8302-EVAL		Evaluation Board	

CAUTION

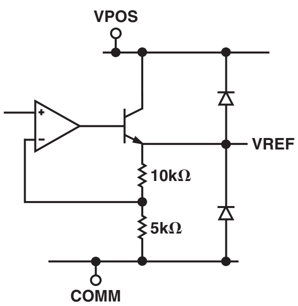
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AD8302 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



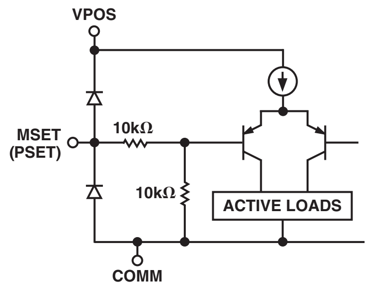
Circuit A



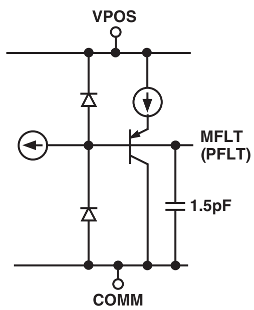
Circuit B



Circuit C



Circuit D



Circuit E

Figure 1. Equivalent Circuits

DOCKET ALARM

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