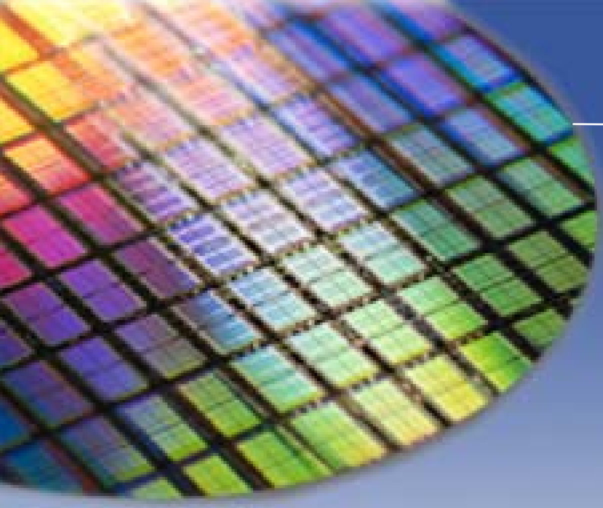

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Obscurities & Applications of RF Power Detectors

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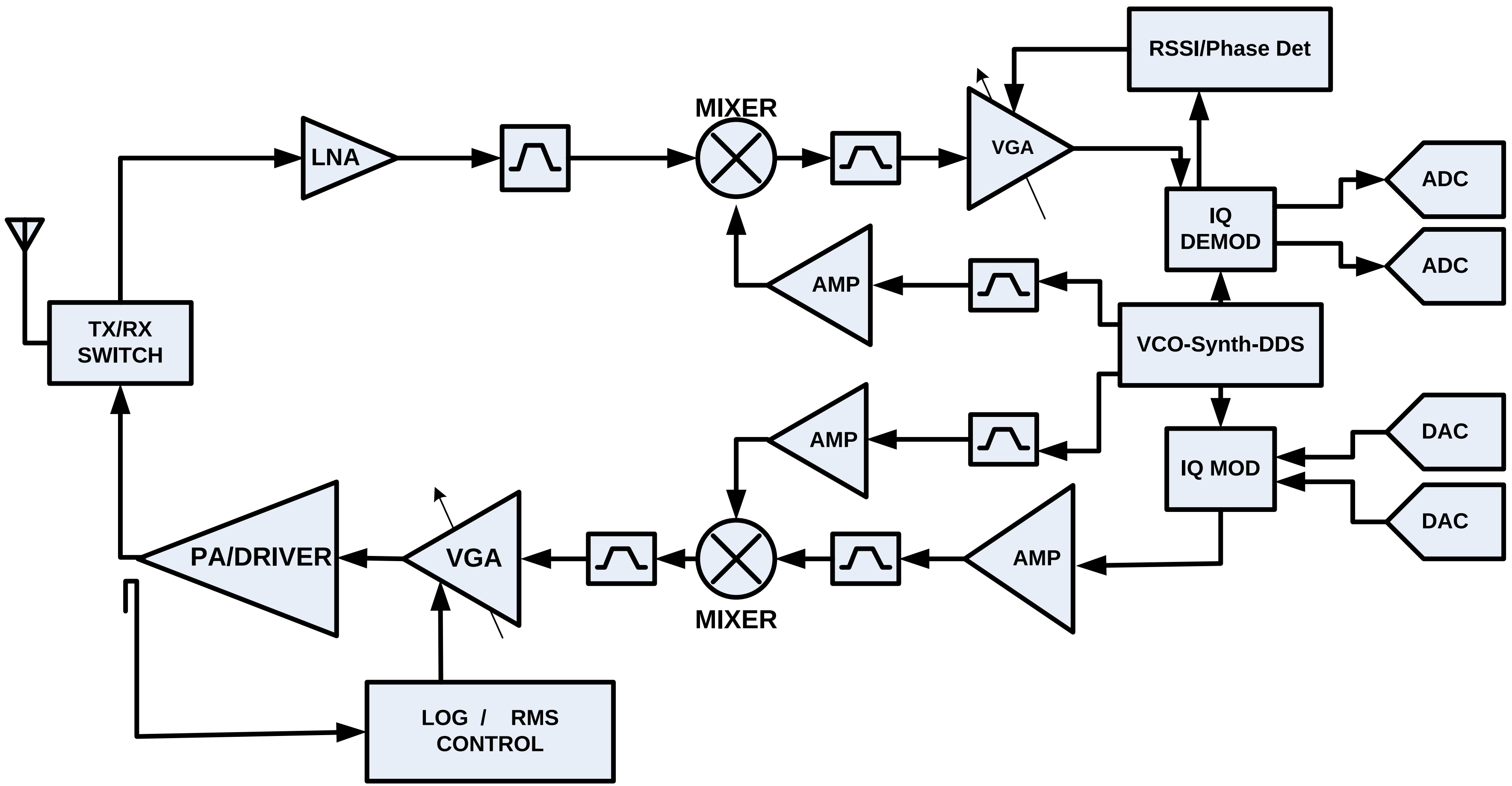
ANALOG DEVICES

Why measure RF/IF power?

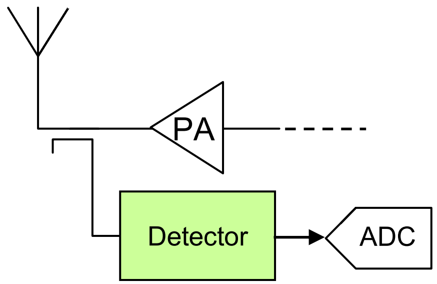
- Set mobile's power level (RSSI measurement in BTS receiver)
- Signal Leveling in receivers (high precision generally not required, usually done at IF)
- Prevent interference with other systems and other users in same cell (mobile handset).
- Improve mobile talk time (operate at low end of permissible range, reduce SAR).
- Improve network robustness (operate at high end of permissible range).
- Thermal Dimensioning (mostly HPA)

Typical RF Signal Chain

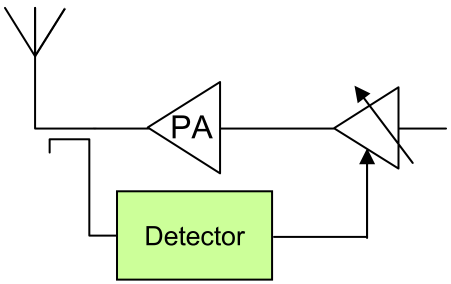


Typical Detector Applications

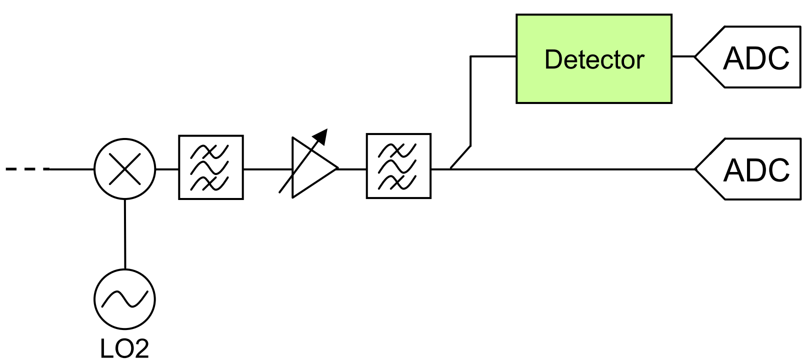
Tx Power Measurement



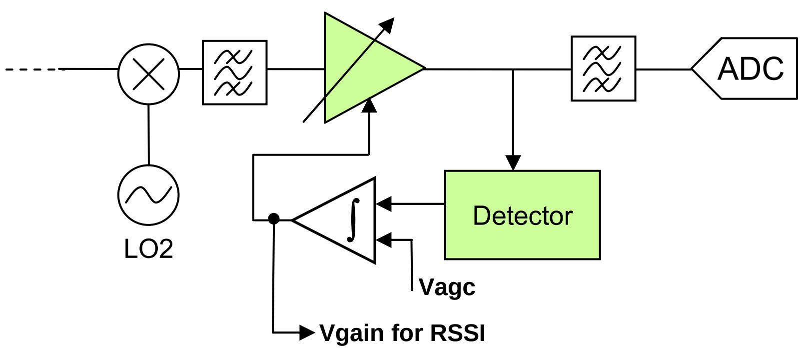
TX power control



Received Power Measurement

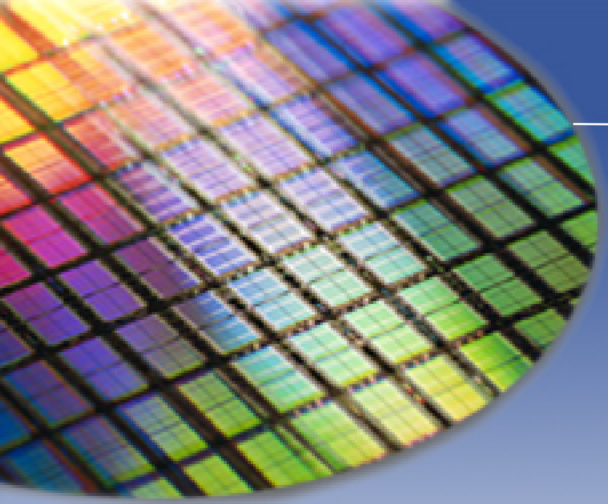


Received Power Control



RF Power Detectors
Critical Specifications

- Linearity and Temperature Stability of Output
- Dynamic Range
- Pulse Response
- Variations due to Power Supply and Frequency Changes
- Ease of Use and Calibration
- Change in response vs. signal crest factor
- Size and overall Component Count



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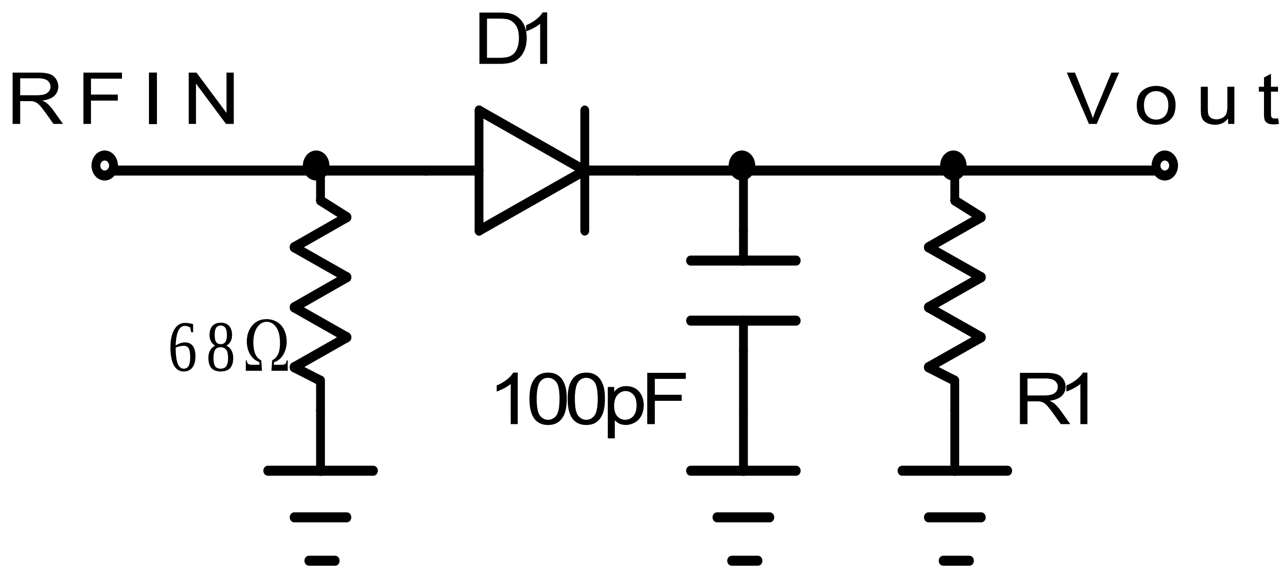
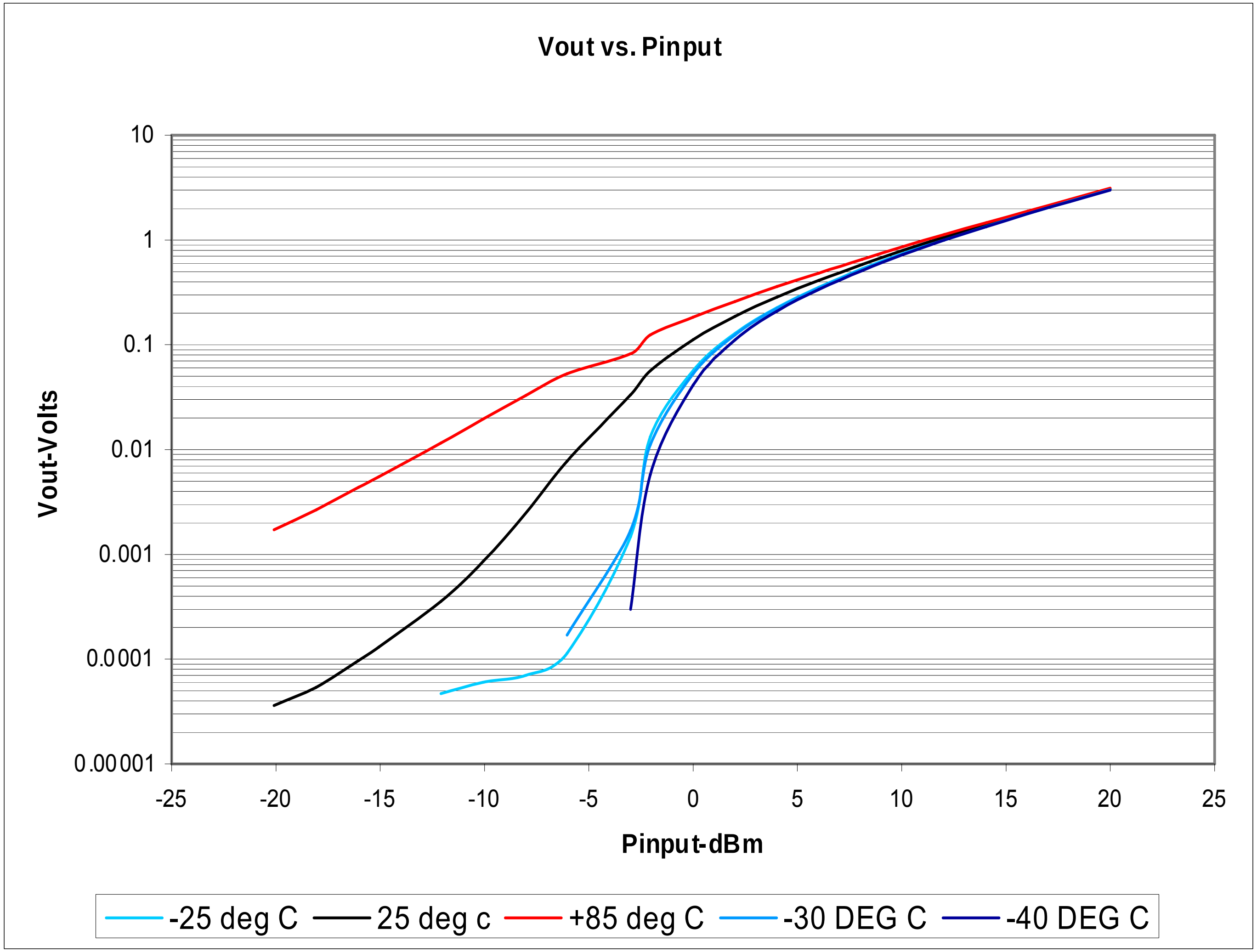
RF Power Measurement Techniques

Power Measurement Techniques
Diode Detection



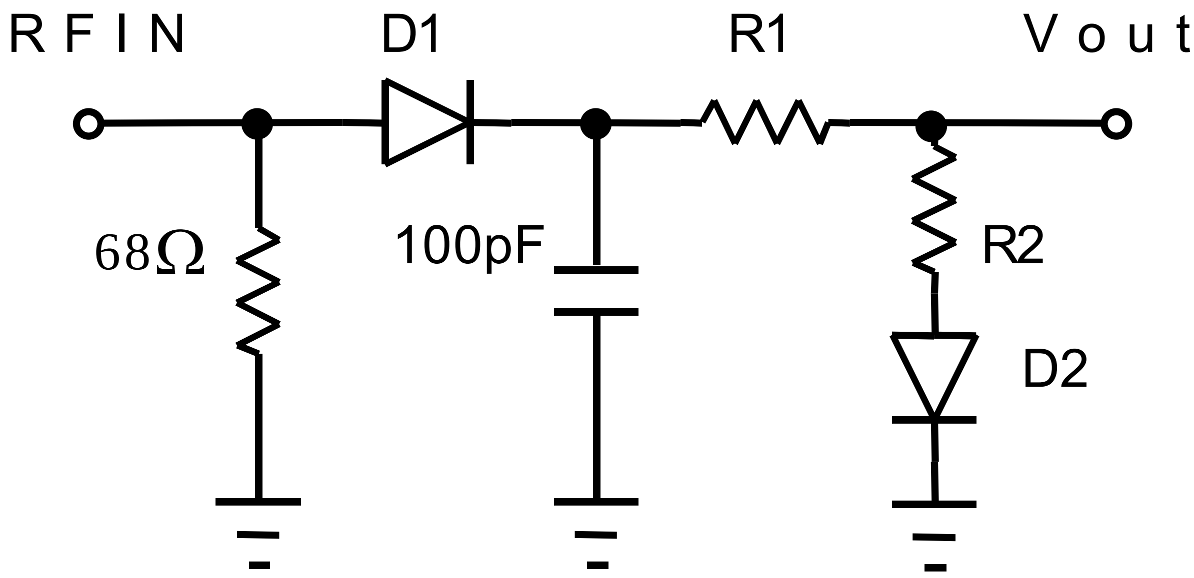
Source: "A Supressed Harmonic Power Detector for Dual Band Phones" Alan Rixon and Raymond Waugh "Applied Microwave and Wireless", November 1999

Transfer Function of Diode Detector



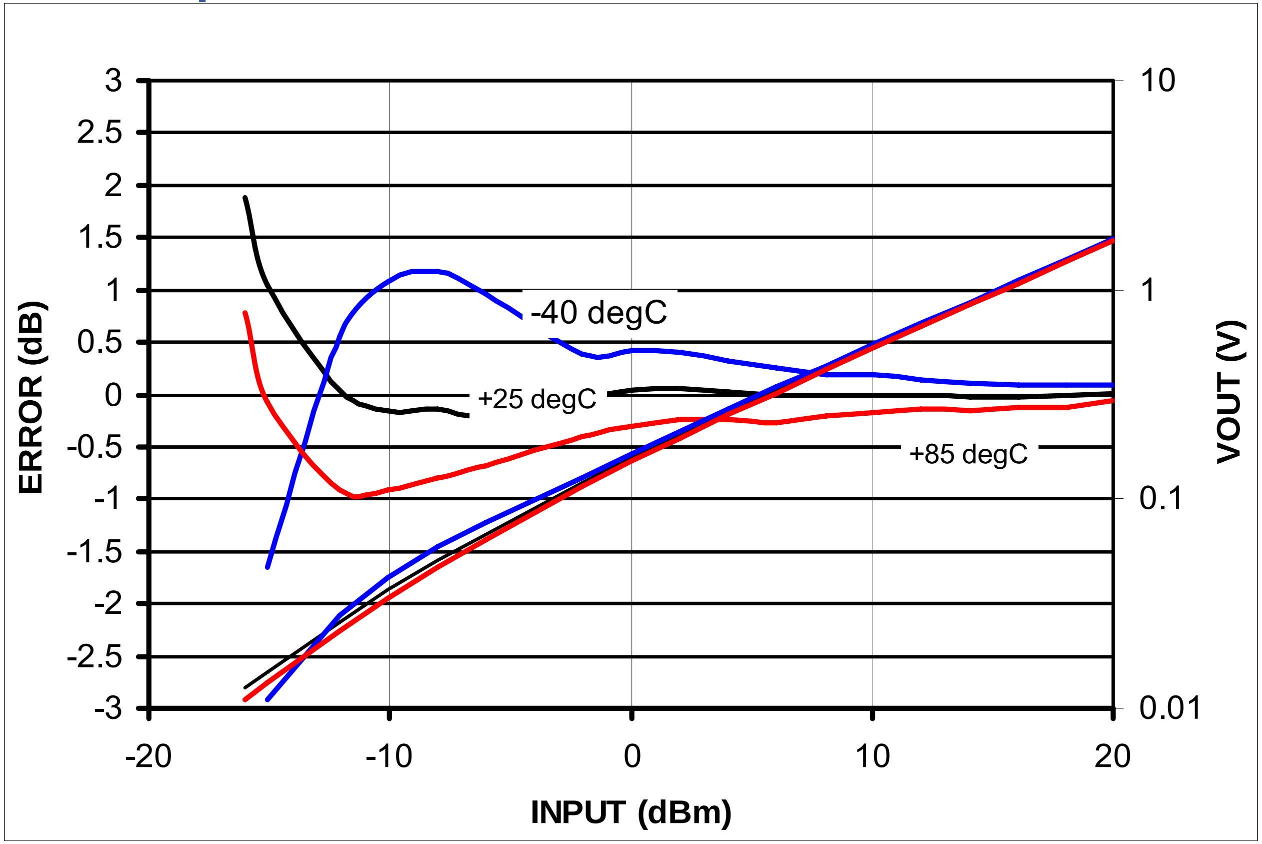
ANALOG DEVICES

Diode Detector with Temperature Compensation

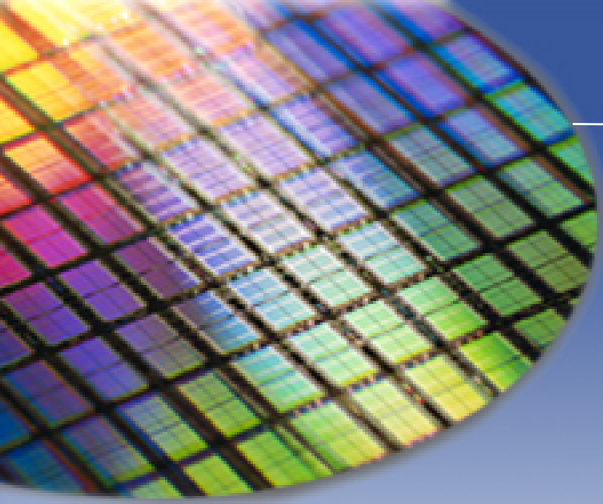


Source: "A Supressed Harmonic Power Detector for Dual Band Phones" Alan Rixon and Raymond Waugh "Applied Microwave and Wireless", November 1999

Transfer Function of Temperature Compensated Diode Detector



- ***Excellent temperature stability at high power***
- ***Limited Dynamic Range and poor low end temp. stability***
- ***High Resolution ADC required for low end power measurement***
- ***Lots of patented techniques which probably improve this performance***



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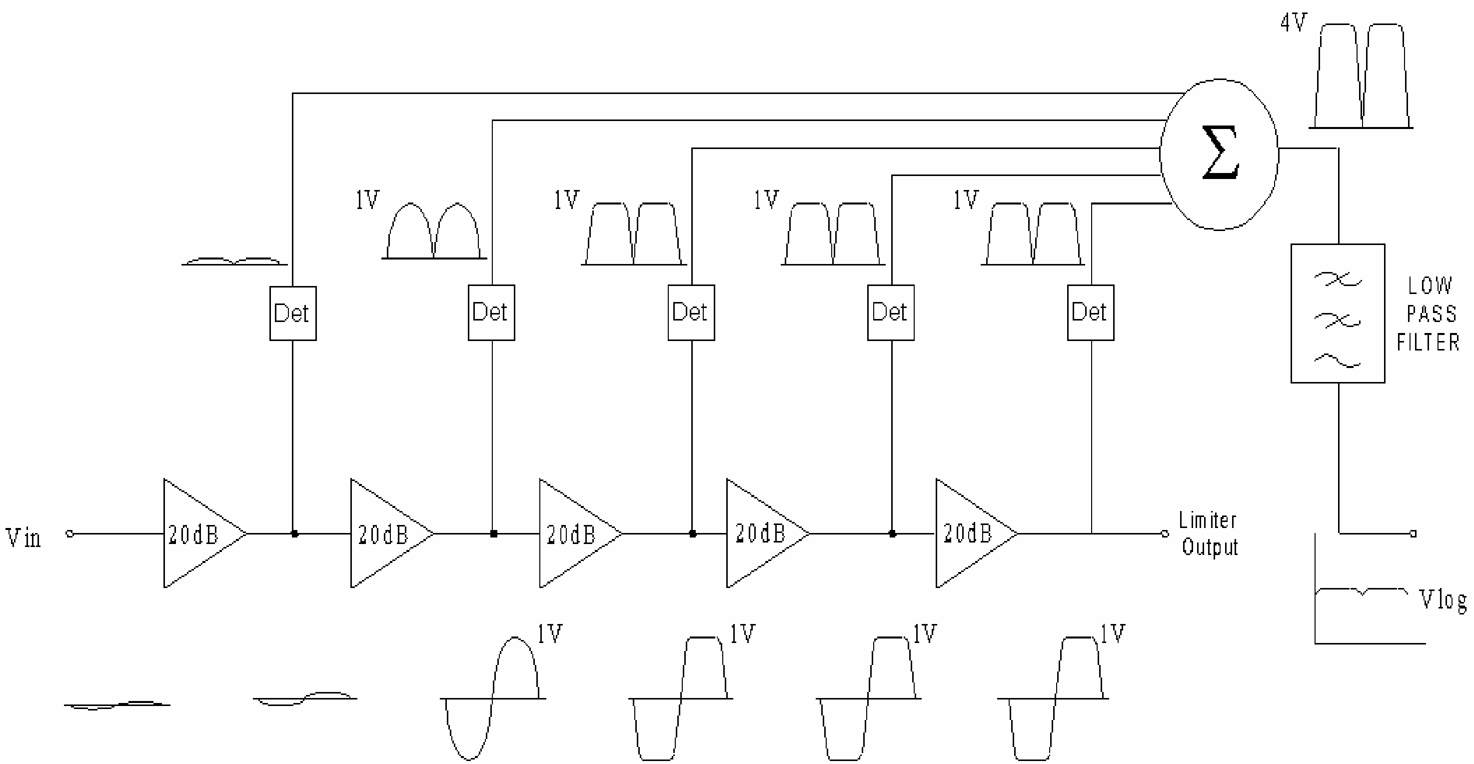
Logarithmic Amplifiers

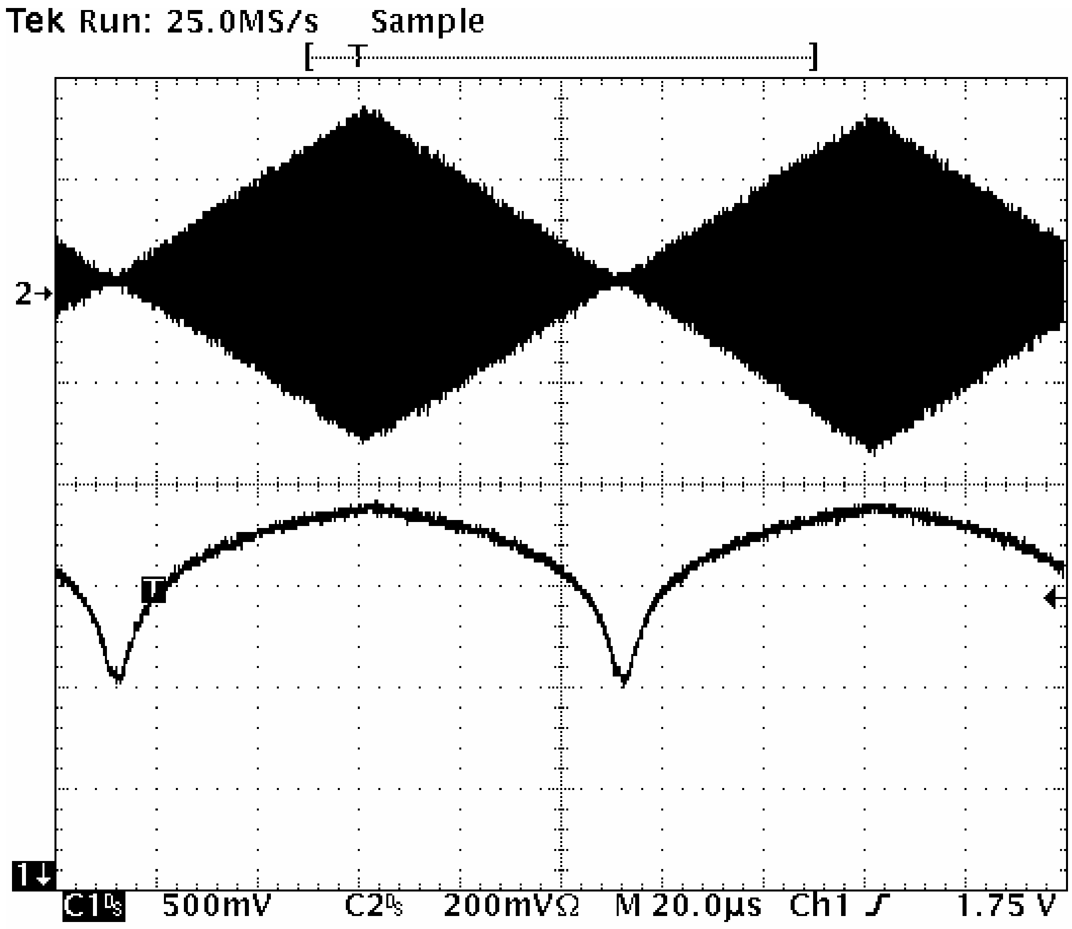
ANALOG DEVICES

Log Amp Block Diagram



- ❑Signal propagates through gain chain until it limits
- ❑Detectors full-wave rectify the signal at the output of each stage
- ❑Outputs of detectors are summed and low-pass filtered

Log Amp Transfer Function in Time Domain



ANALOG DEVICES

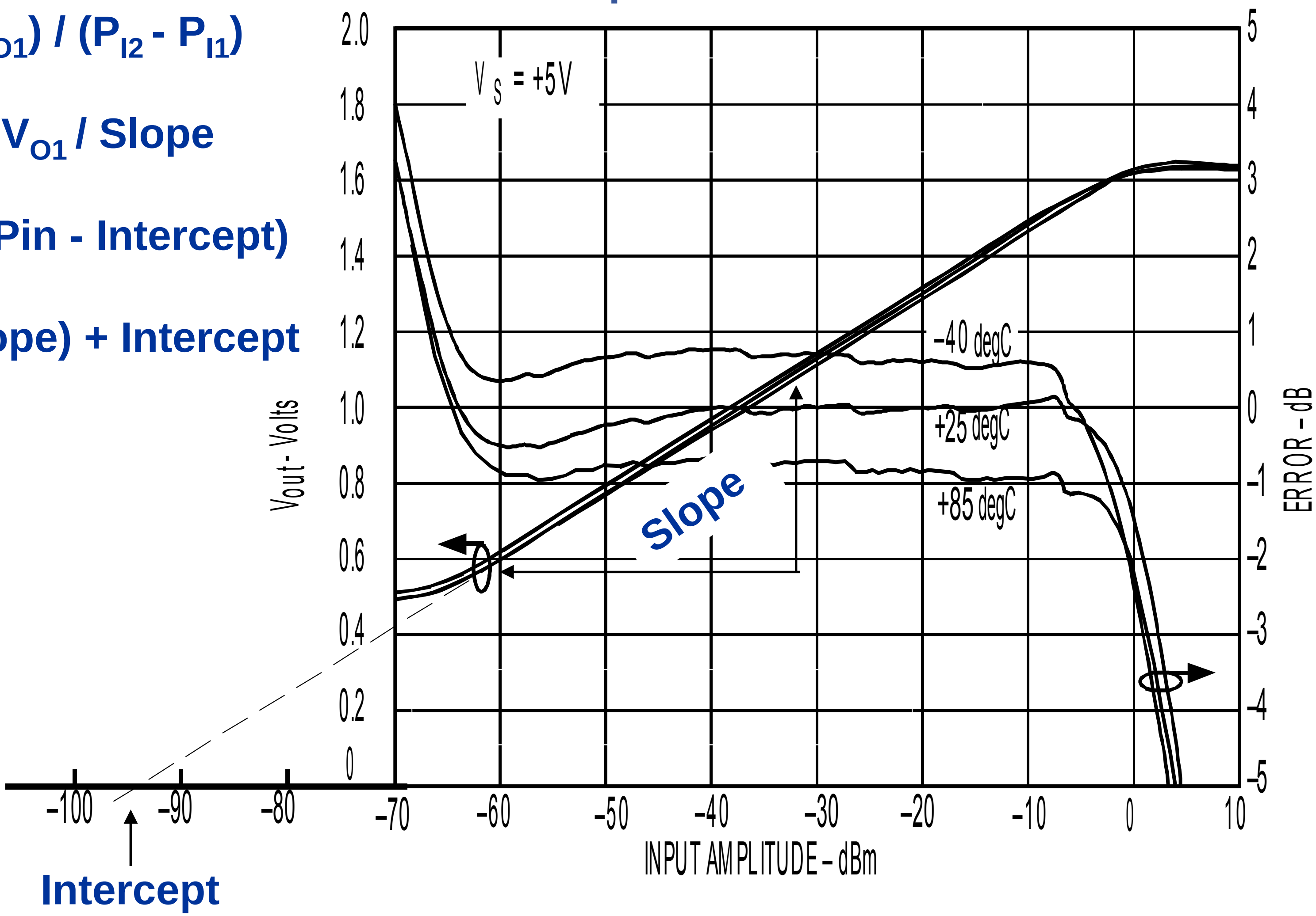
Log Amp Transfer Function - Slope and Intercept

Slope = $(V_{O2} - V_{O1}) / (P_{I2} - P_{I1})$

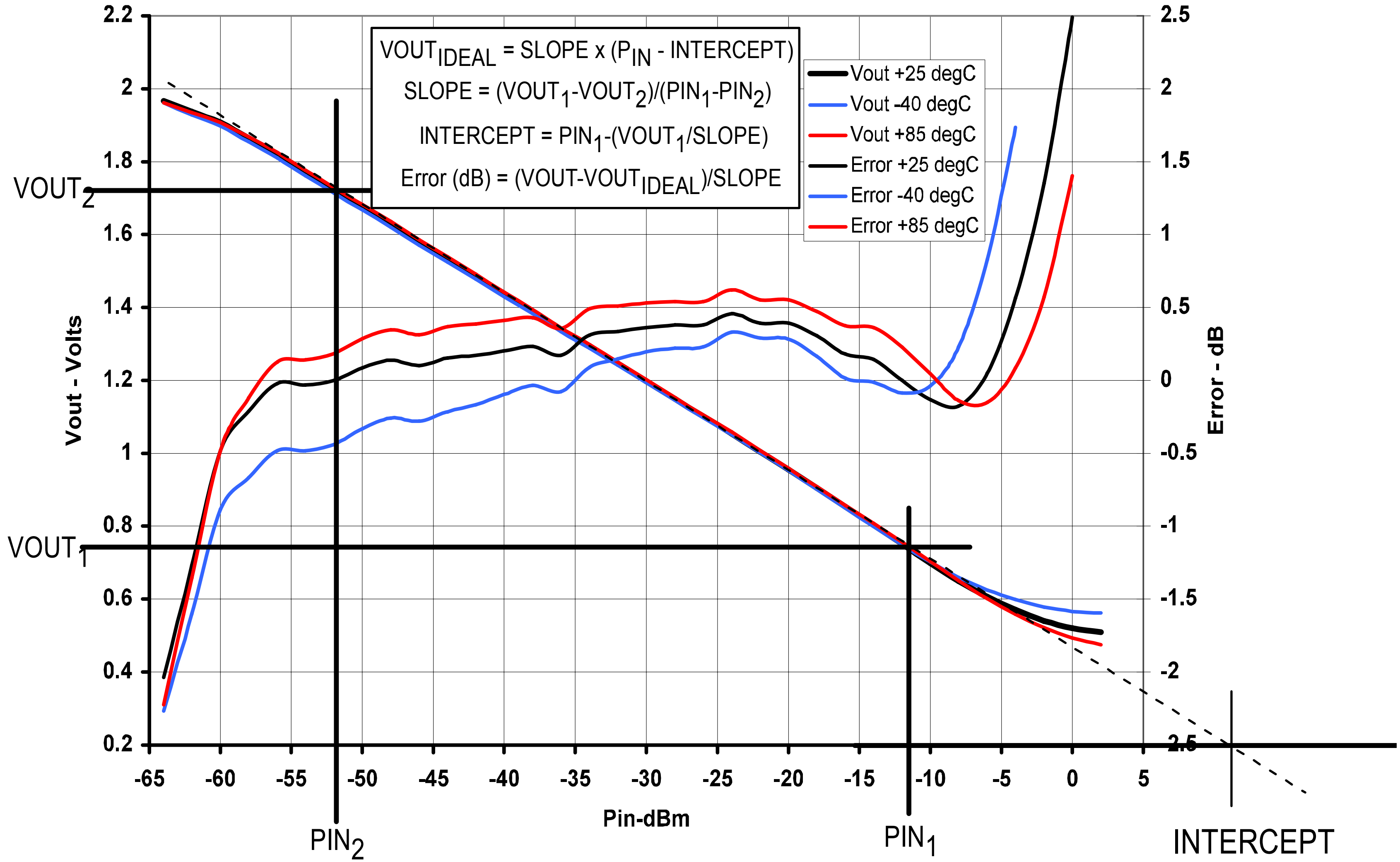
Intercept = $P_{I1} - V_{O1}$ / Slope

Vout = Slope · (Pin - Intercept)

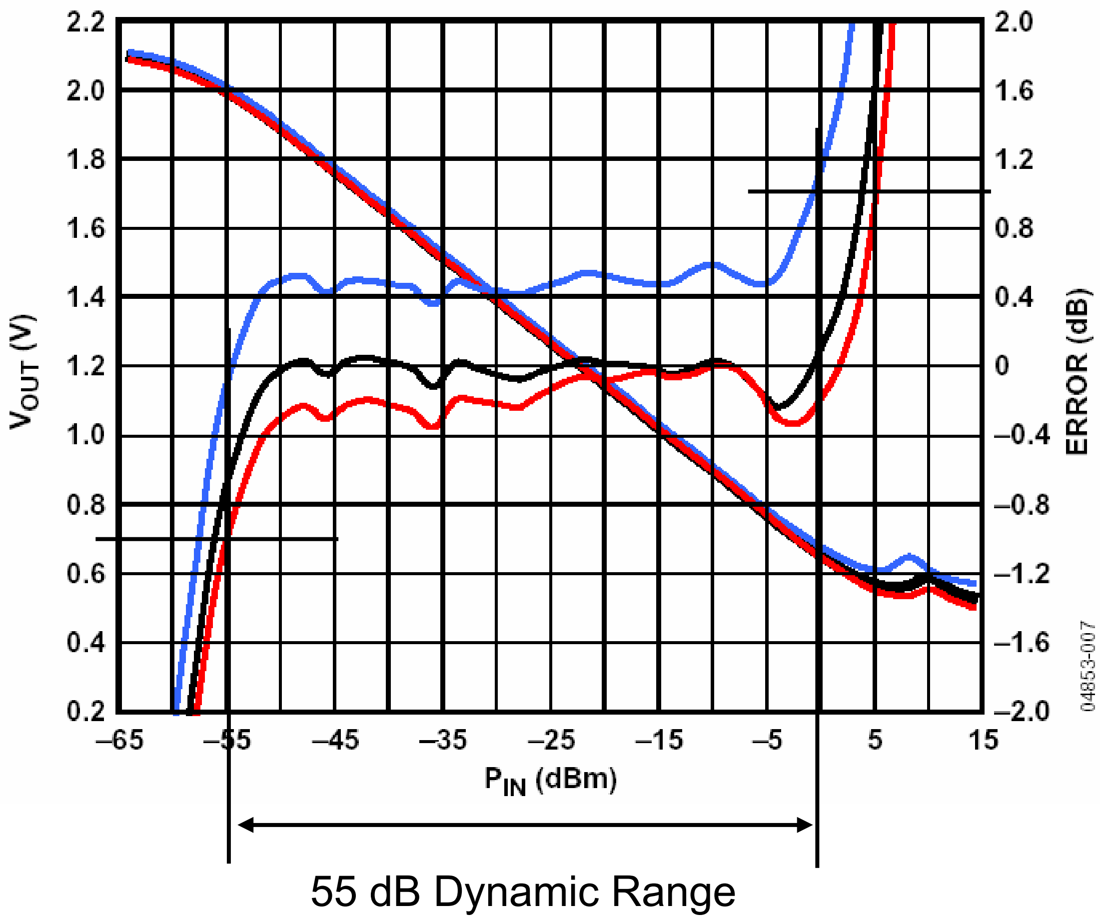
Pin = (Vout / Slope) + Intercept



RF Power Detector Calibration



±1 dB Dynamic Range

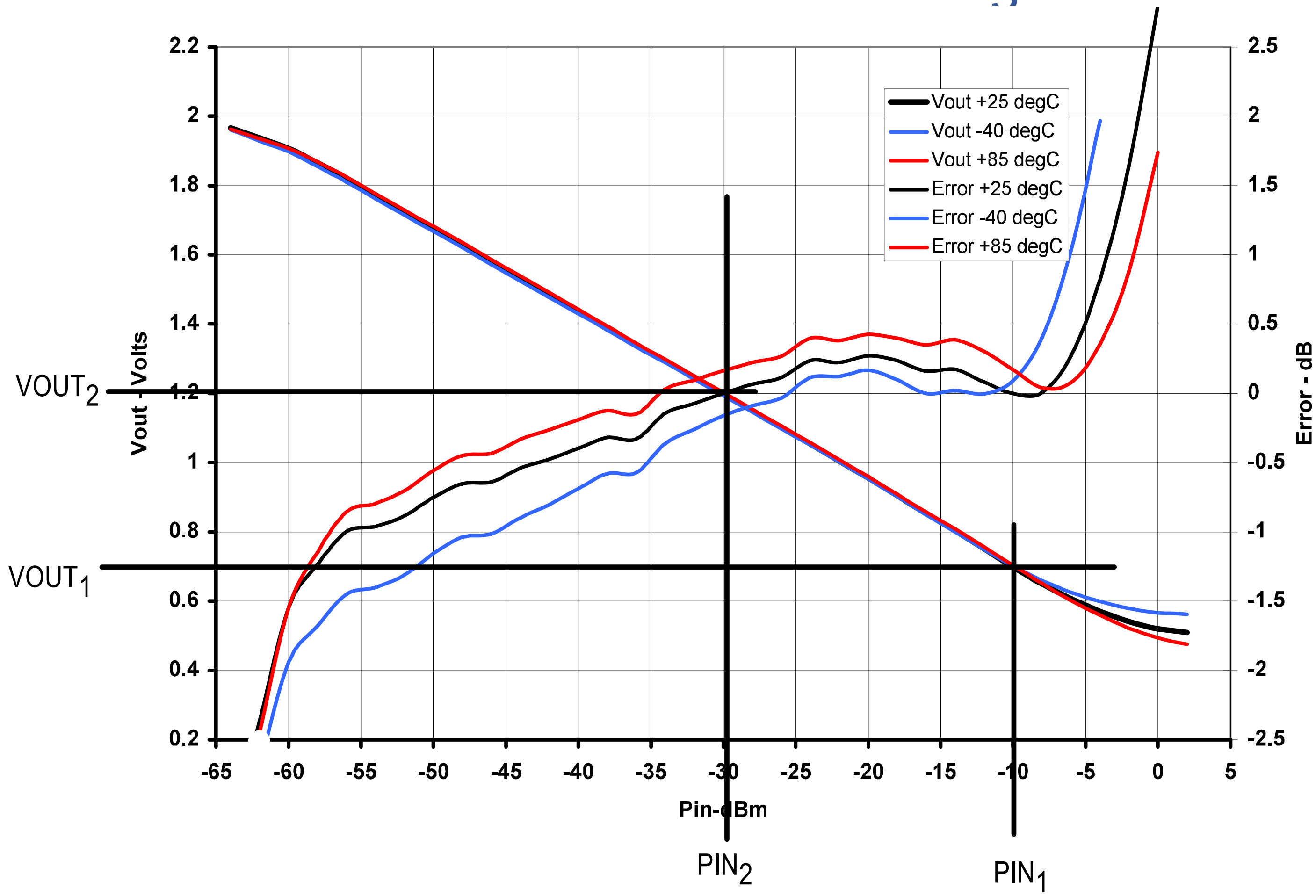


❑**Temperature Drift can reduce Dynamic Range**

Detector Calibration Procedure

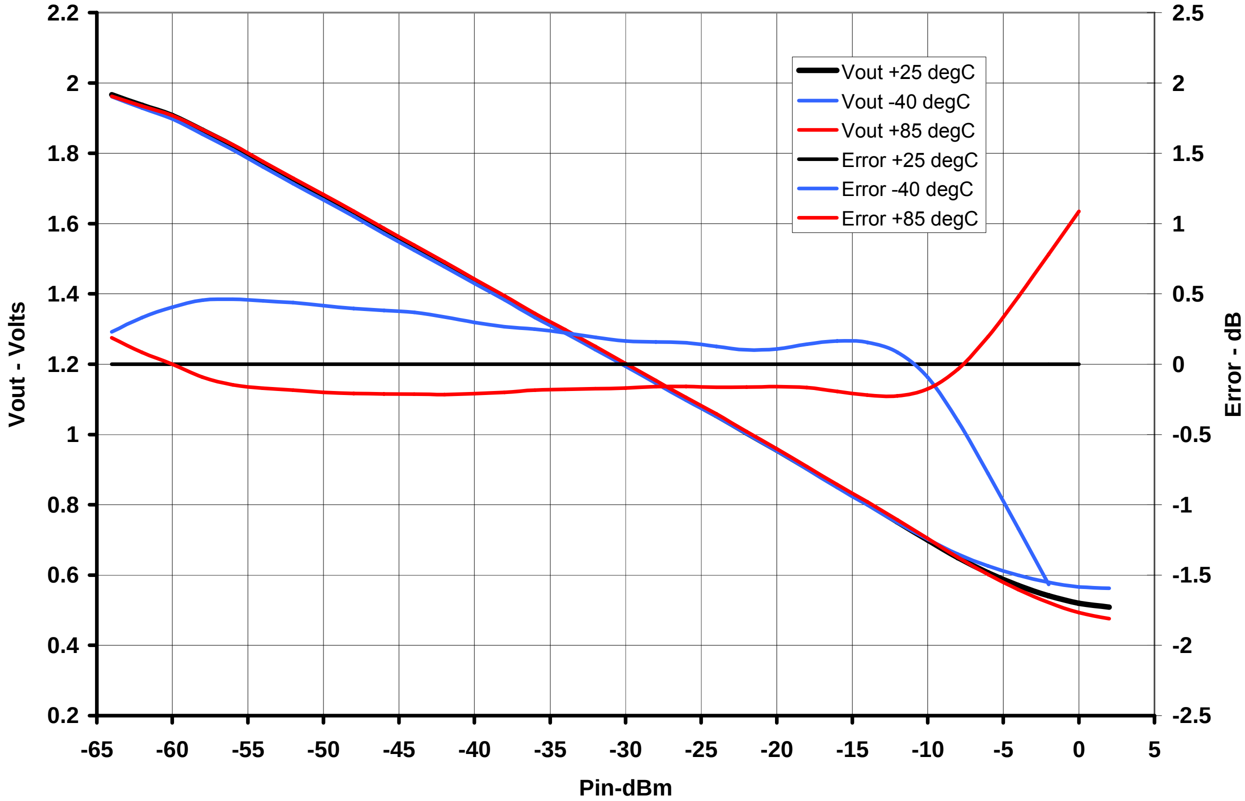
- Factory Calibration: Using a precise power source, measure output voltage from the detector with two known input powers at top and bottom of desired input range
- Perform calibration measurements only at room temperature
- Calculate SLOPE and INTERCEPT and store in non-volatile memory
- When equipment is in operation measure detector output voltage using ADC
- Calculate power using “Pin = (Vout/Slope) + Intercept”
- No temperature compensation necessary

Adjust Calibration Points for optimal accuracy over a narrow range



- Calibrate for highest accuracy at max RF power and degraded accuracy at lower powers

Temperature drift vs. Output Voltage at 25ºC



- Calibration eliminates error due to non-linearity at 25 ºC

Temperature drift vs. Output Voltage at 25ºC

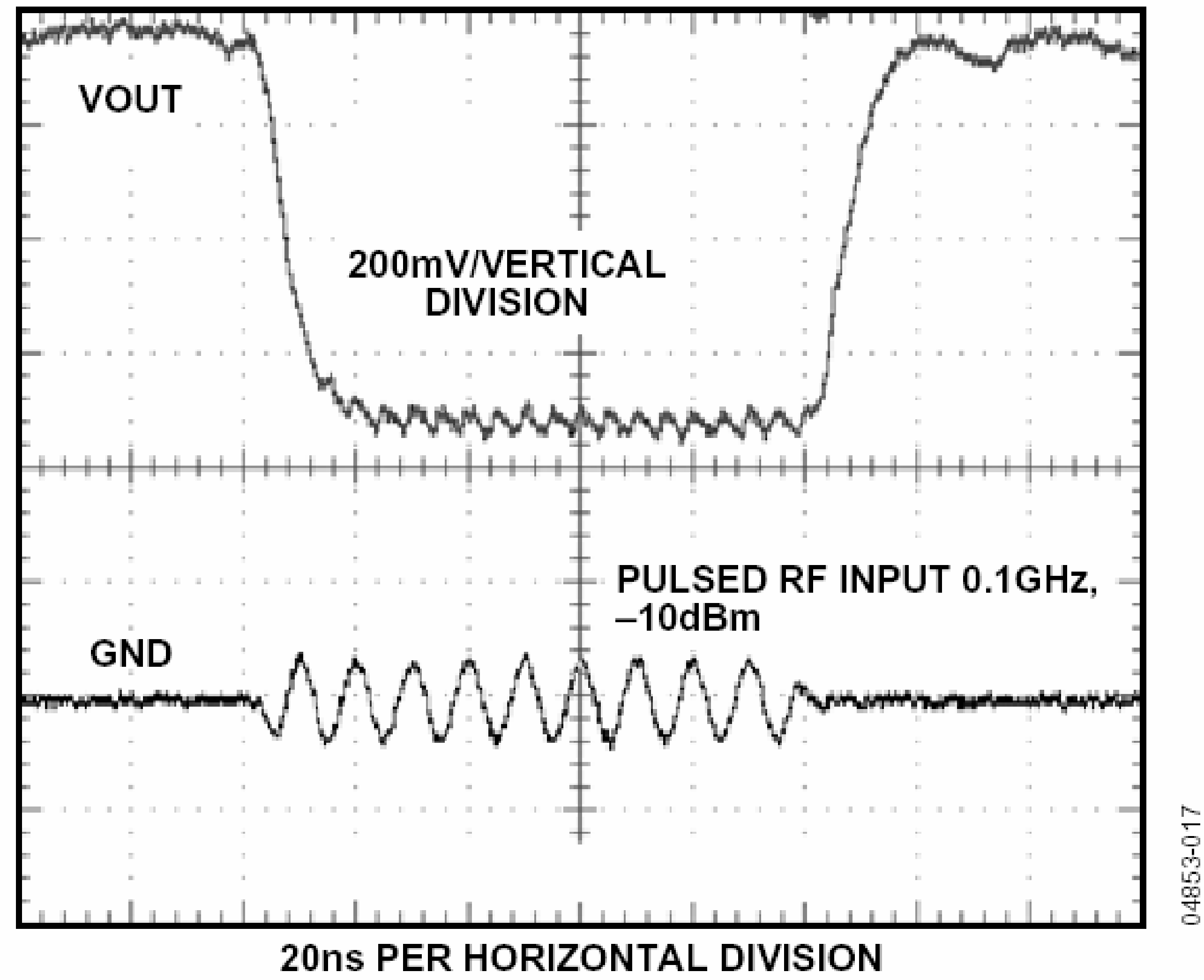
- ***Removes error due to non-linearity at 25ºC***
- ***Provides larger dynamic range and improved accuracy***
- ***Method however does not account for non-linearity in the transfer function at room temperature***
- ***For practical implementation, calibration measurements must be taken at multiple input powers (multi-point calibration vs. 2-point calibration)***

Log Amp Detectors vs. Diode Detectors

- **Log Amps have a higher dynamic range (40 dB or greater vs. 20-30 dB for a diode detector)**
- **Log Amps provide good temperature stability over a wide dynamic range.**
- **Diode detectors only provide good temperature stability at max input power (typically +15 dBm)**

Log Amp Pulse Response Time

10ns Response Time (10% - 90%)



ANALOG DEVICES

2nd Generation Log Amp Detectors

Part No.	*RF Freq (MHz)*	*Dynamic Range (dB)*	*Temp Drift (dB)*	Response Time (ns)	Package	Comments
AD8302	dc to 2700	60	±1	60	14-lead TSSOP	Dual gain & phase detector
AD8306	*5 to 400*	*100*	±1	73	16-lead SOP	Military specified part available
AD8307	*dc to 500*	*92*	±1	400	8-lead SOIC/DIP	-
AD8309	*5 to 500*	*100*	±1	67	16-lead TSSOP	Amplitude and limiter outputs
AD8310	*dc to 440*	*95*	±1	15	8-lead MSOP	Low cost
AD8313	*100 to 2500*	*70*	*±1.25*	40	8-lead MSOP	-
AD8314	*100 to 2700*	*45*	±1	70	8-lead MSOP/CSP	Small package, lower power

WIDEST RANGE AND BEST PERFORMANCE IN THE INDUSTRY!

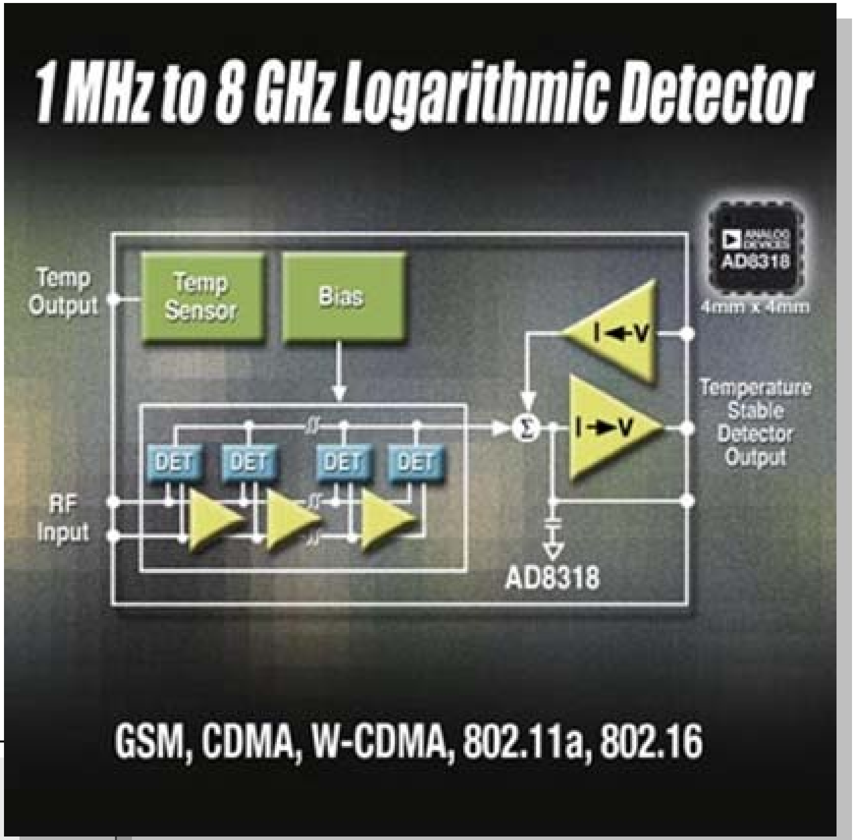
3rd Generation Log Amp Detectors

Part No.	*RF Freq (MHz)*	*Dynamic Range (dB)*	*Temp Drift (dB)*	Response Time (ns)	Package	Comments
AD8317	*1 to 10000*	*50*	*±0.5*	8	8-Lead 3x2 mm CSP	Smaller package, Lower cost version of AD8318
AD8318	*1 to 8000*	*60*	*±0.5*	10	16-Lead 4x4 mm CSP	50 ohm drive, Integrated Temp Sensor
AD8319	*1 to 10000*	*40*	*±0.5*	8	8-Lead 3x2 mm CSP	Reduced dynamic range and lower cost version of AD8317
ADL5519	*1 to 10000*	*50*	*±0.5*	<10	24-Lead LFCSP	Dual Log Detector

AD8318: Highest Performance Log Amp

KEY SPECIFICATIONS

- Bandwidth 1MHz to 8Ghz
- *Stability over temperature: ±0.5 dB*
- Pulse response time 10 ns
- Package: 4mm×4mm, 16-pin LFCSP

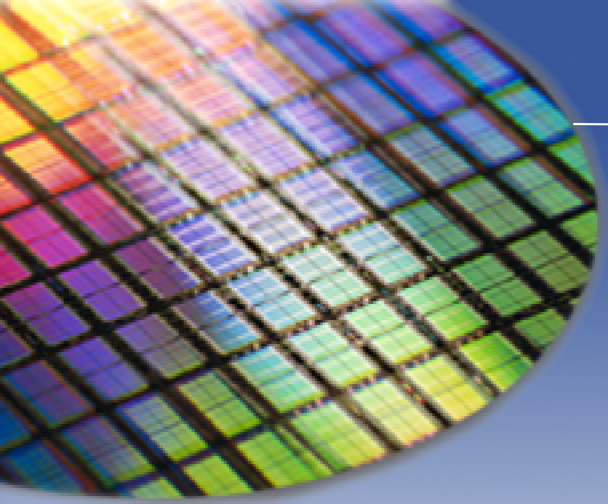


FEATURES

- Integrated temperature sensor
- Low noise measurement/controller output VOUT
- Power-down feature: <1.5 mW at 5 V
- Fabricated using high speed SiGe process

Log Amps - Summary

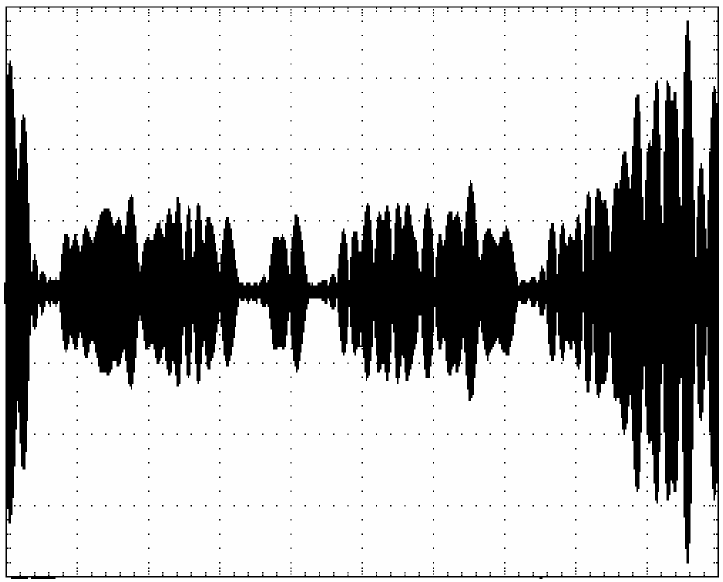
- Provide power detection over large dynamic range (up to 100 dB)
- Operation from DC to 10 GHz
- With 2-Point Calibration, measurement accuracy of << ±1 dB is achievable.
- Devices are generally configured to provide a broadband 50 Ω match
- Pulse Response times of <10 ns are achievable.
- Power consumption varies from 5 mA to 70 mA

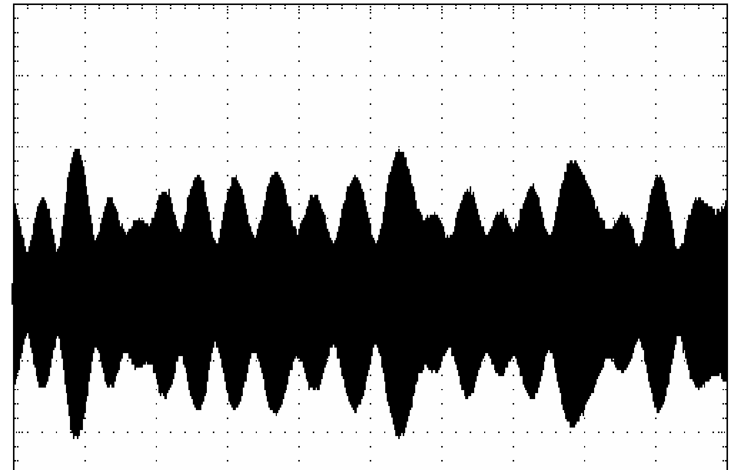


RMS-Responding RF Detectors

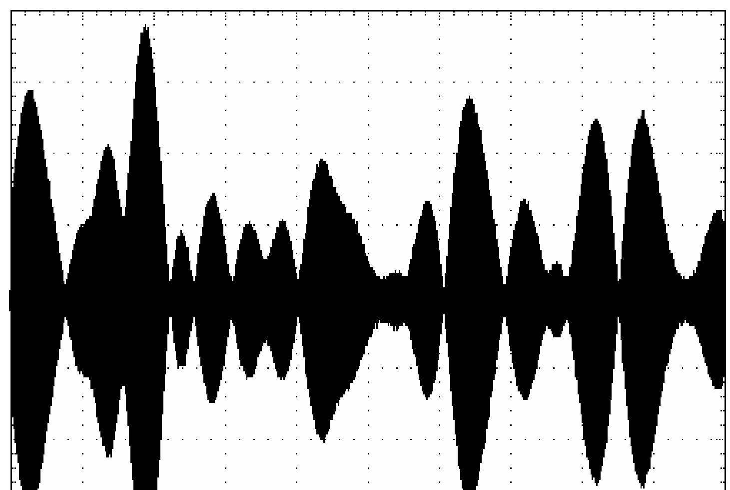
Difficult Measurements: Complex Waveforms

W-CDMA Forward Link, 4 Channels



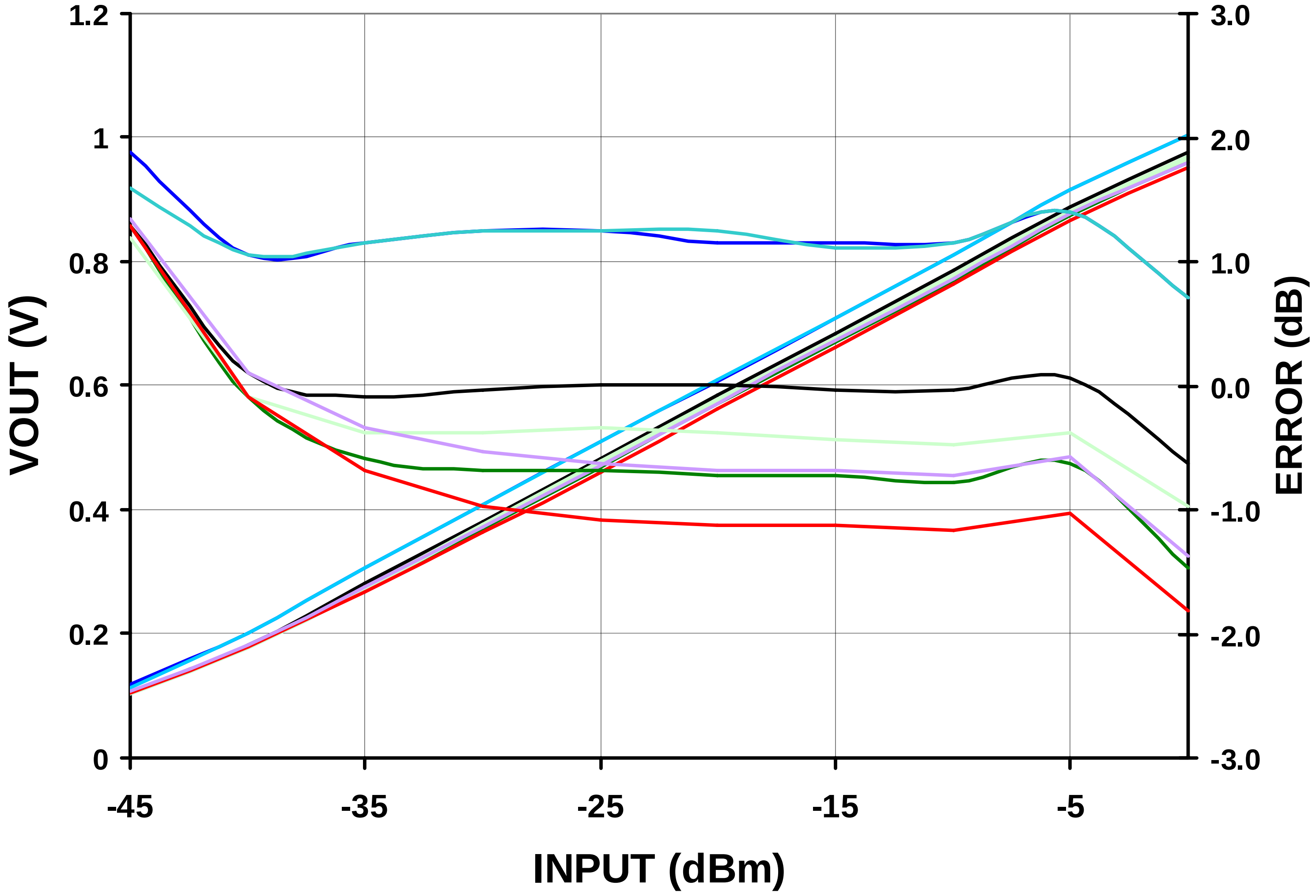


IS-95 Reverse Link

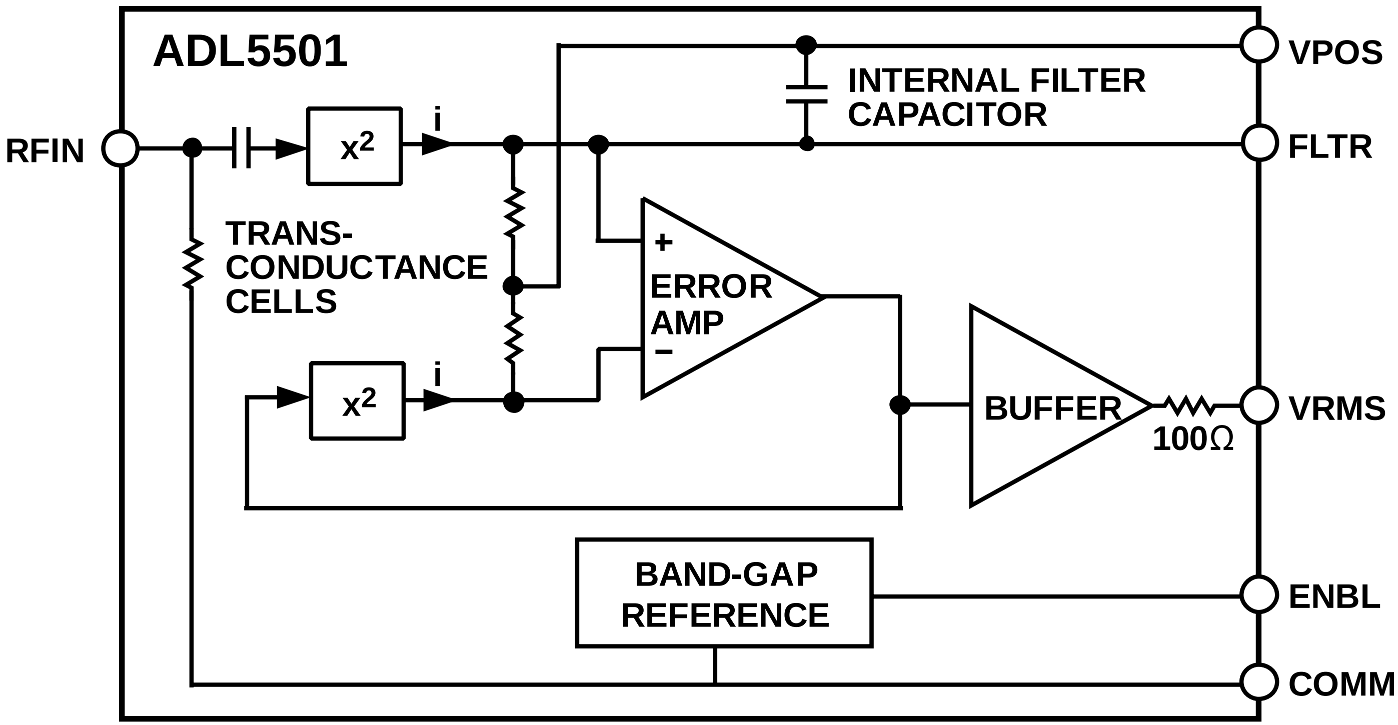


IS-95 Forward Link (8Ch)

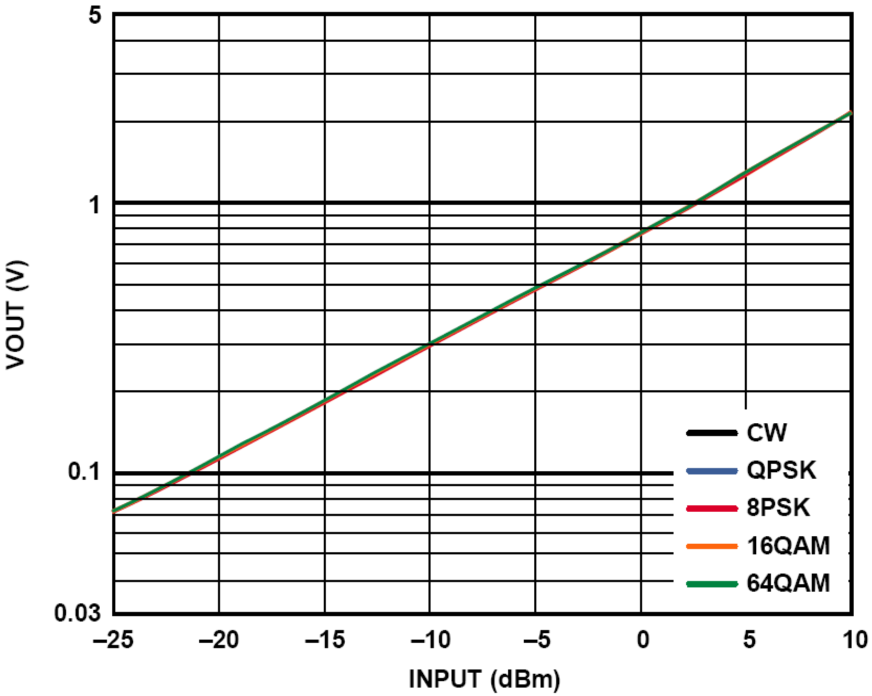
Response of a Successive Detection Log Amp to Varying Signals with Various Crest Factors

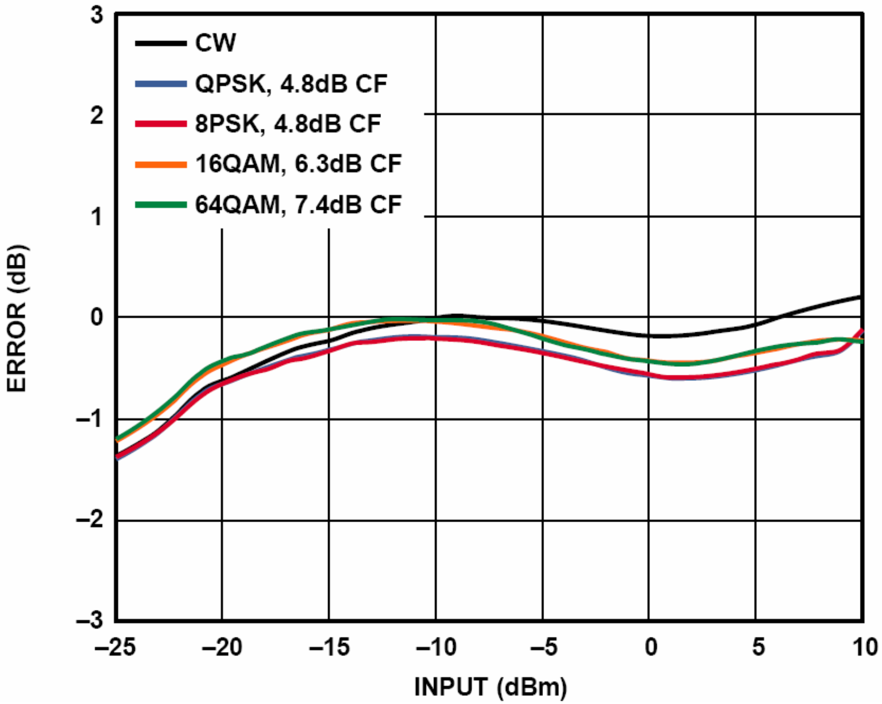


RMS-Responding RF Detector

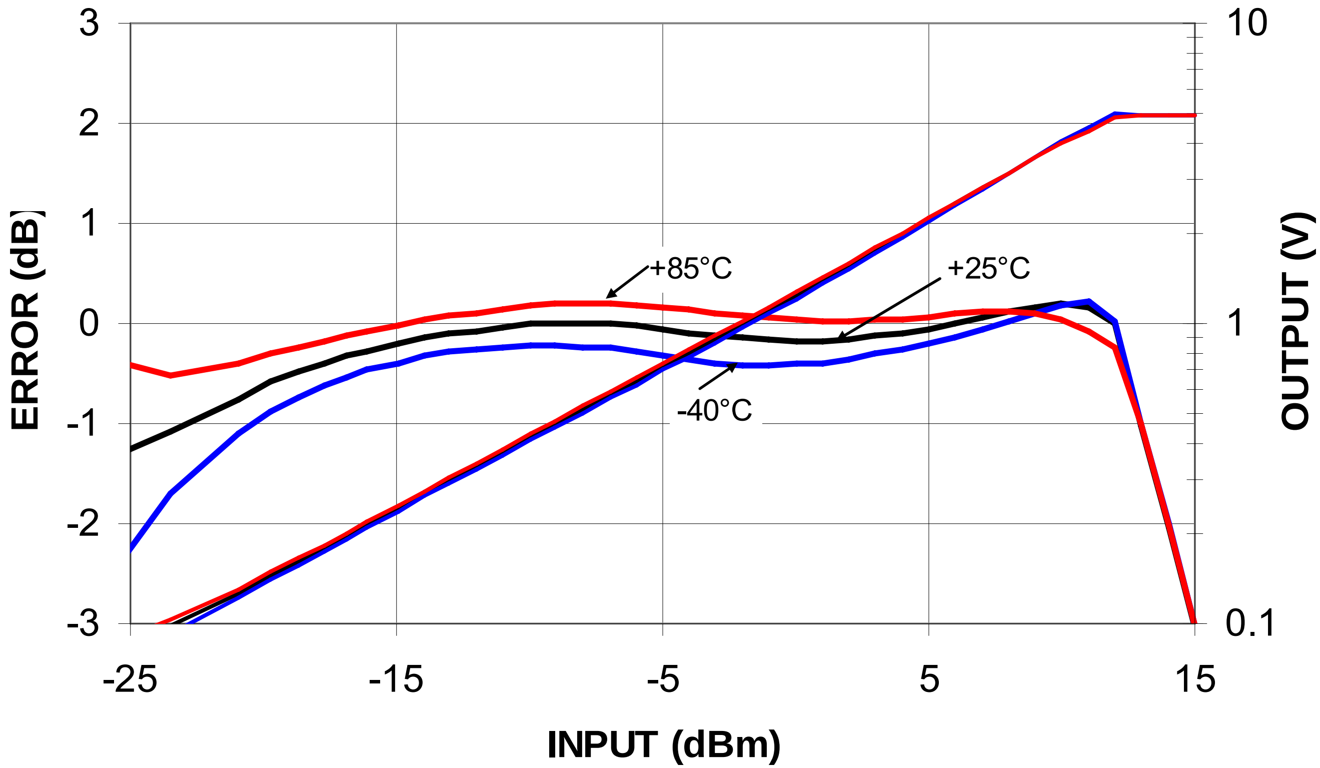


RMS Detector Waveform Independence

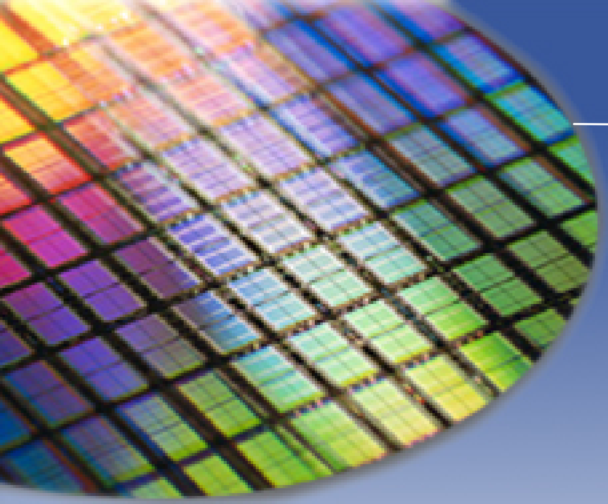




Transfer Function and Temperature Drift RMS-To-DC Converter



- Output Voltage increases exponentially as input increases in dB (i.e. response is linear in V/V, not logarithmic
- Device achieves best temperature stability at max power (desirable for most applications)



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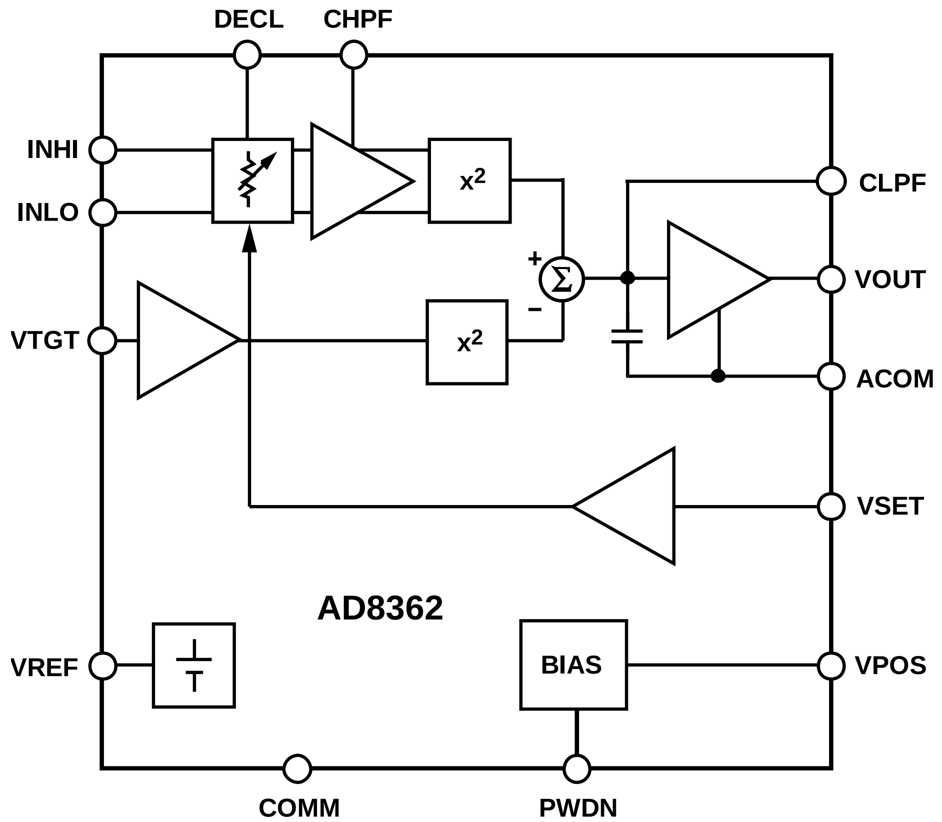
High Dynamic Range RMS Detection

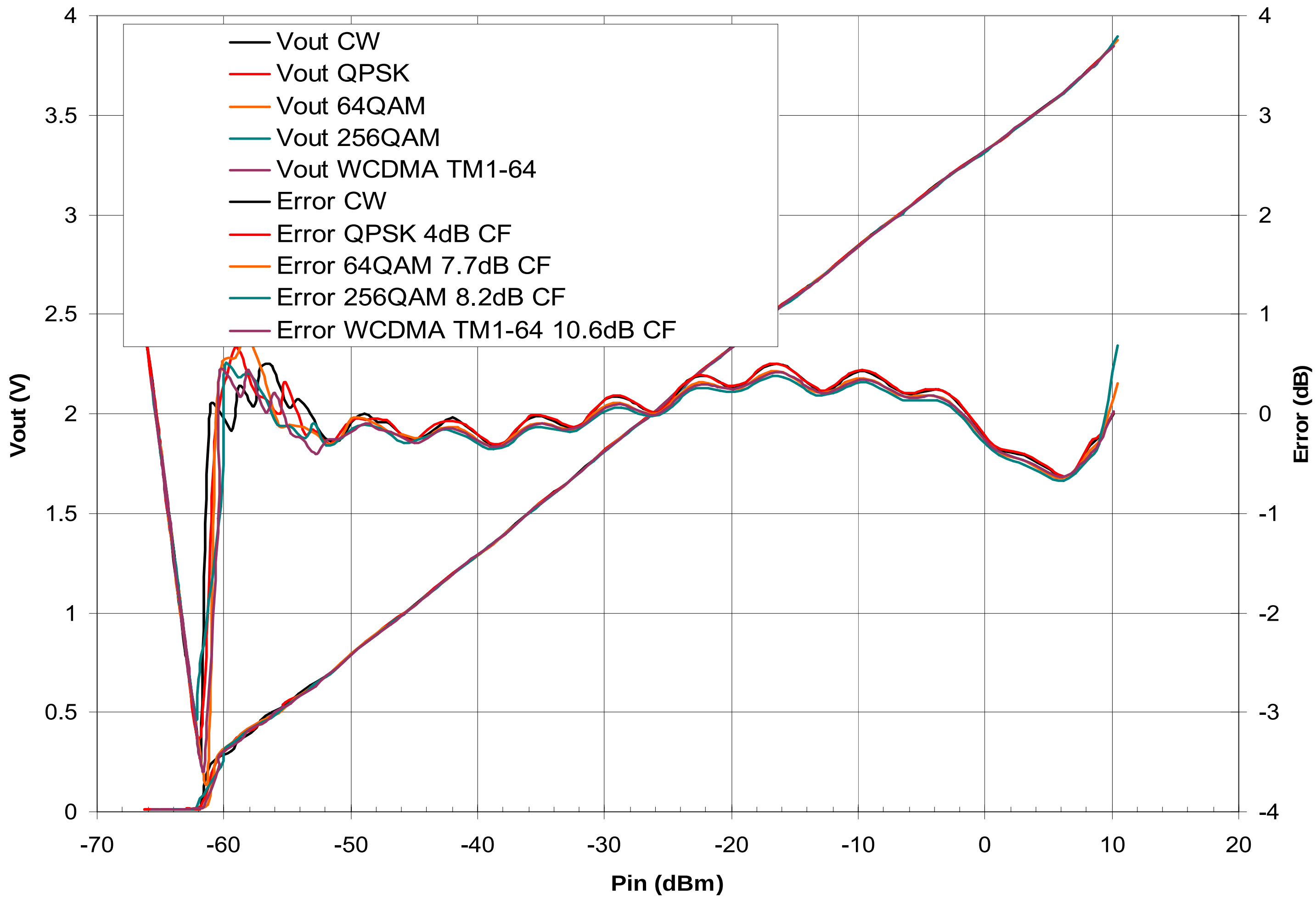
ANALOG DEVICES

60 dB TruPwr ™ RMS Detector



- Waveform and Modulation Independent
- Linear-in-dB output

Response of AD8362 RMS Detector to CW, QPSK and QAM Signals



@1.9 GHz, Vtgt = 0.625 V

TruPwr™ RMS Detectors

- *Modulation Independent RF Measurements*

Part#	*RF Freq (MHz)*	*Dynamic Range (dB)*	*Temp Stability (dB)*	Voltage Supply (V)	Supply Current (mA)	Package
AD8361	*2500*	*30*	*±0.25*	2.7 to 5.5	1.1	6-Lead SOT-23, 8-Lead uSOIC
ADL5501	***4000***	***30***	***±0.1***	**2.7 to 5.5**	**1.0**	**SC-70**
AD8362	*2700*	*60*	*±1*	4.5 to 5.5	20	16-Lead SOP
AD8364 (Dual Channel)	***2700***	***60***	***±0.5***	**4.5 to 5.5**	**72**	**32-Lead LFCSP**

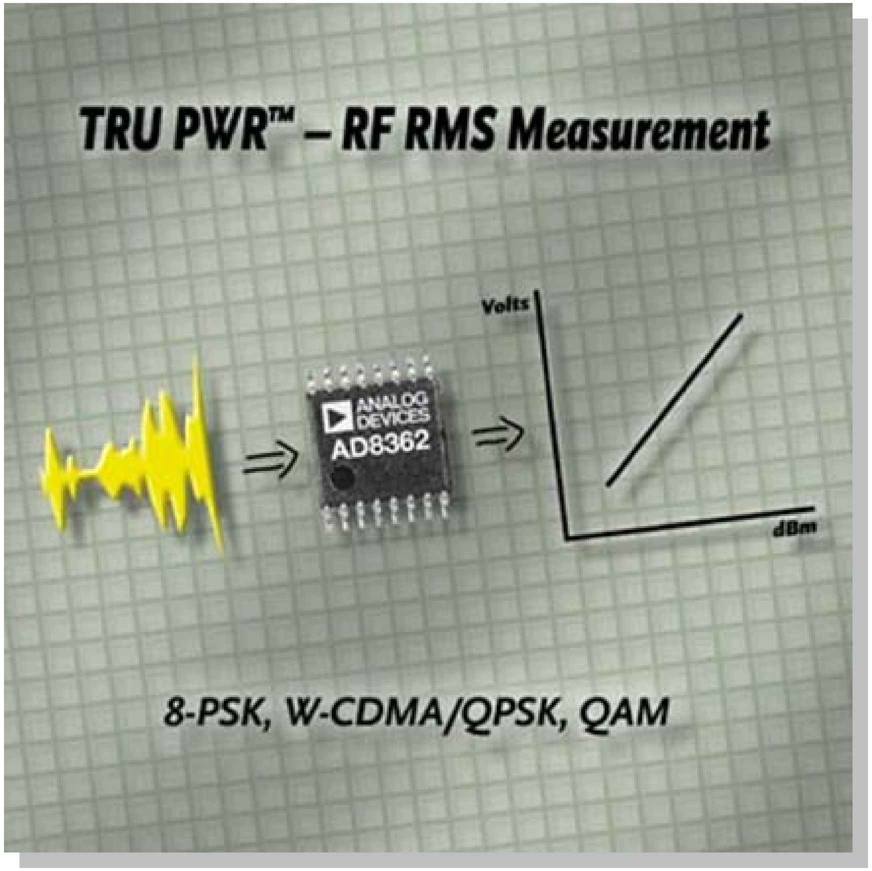
AD8362 TruPwr ™ RMS Detector

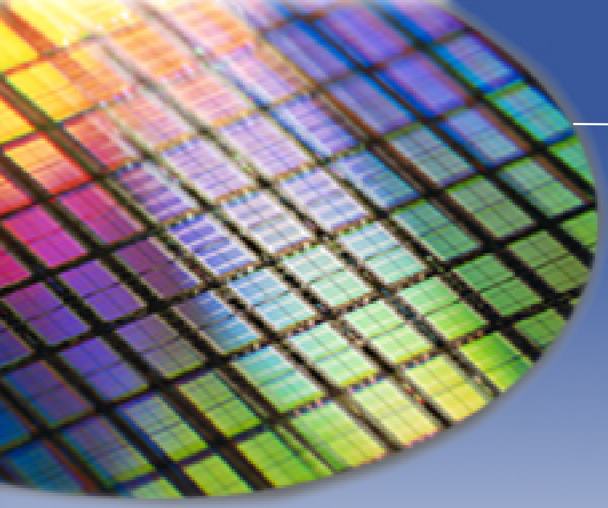
KEY SPECIFICATIONS

- Dynamic Range: >60dB
- Temperature Stability: +/-1dB
- Frequency Range: LF to 2.7GHz
- Package: 16 Lead TSSOP

FEATURES

- True RMS responding power detector
- Waveform and Modulation Independent
- Linear-in-dB output





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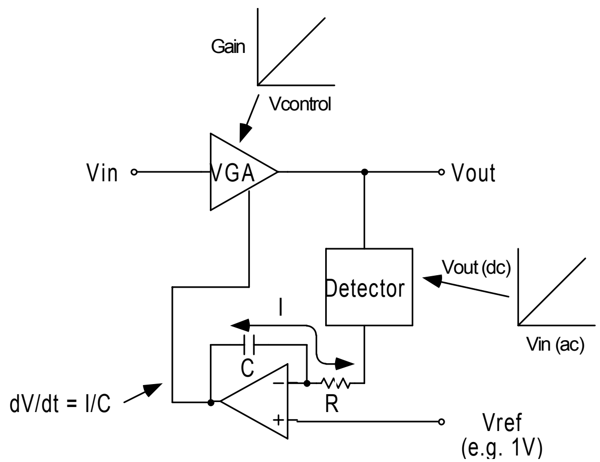
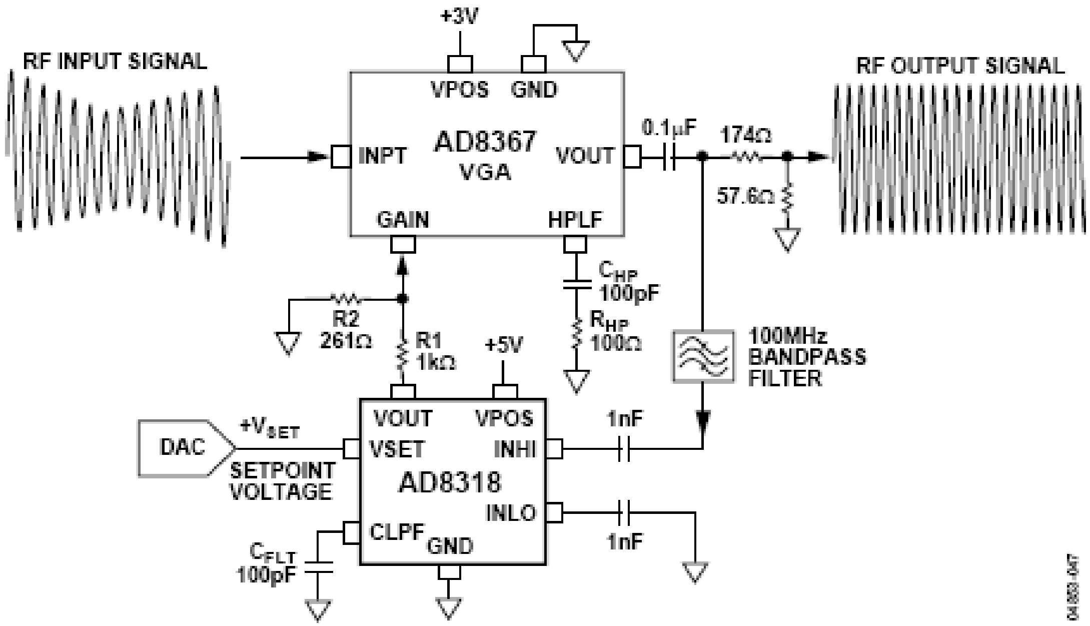
Controlling AGC Loops with RF Detectors

A Typical AGC Loop



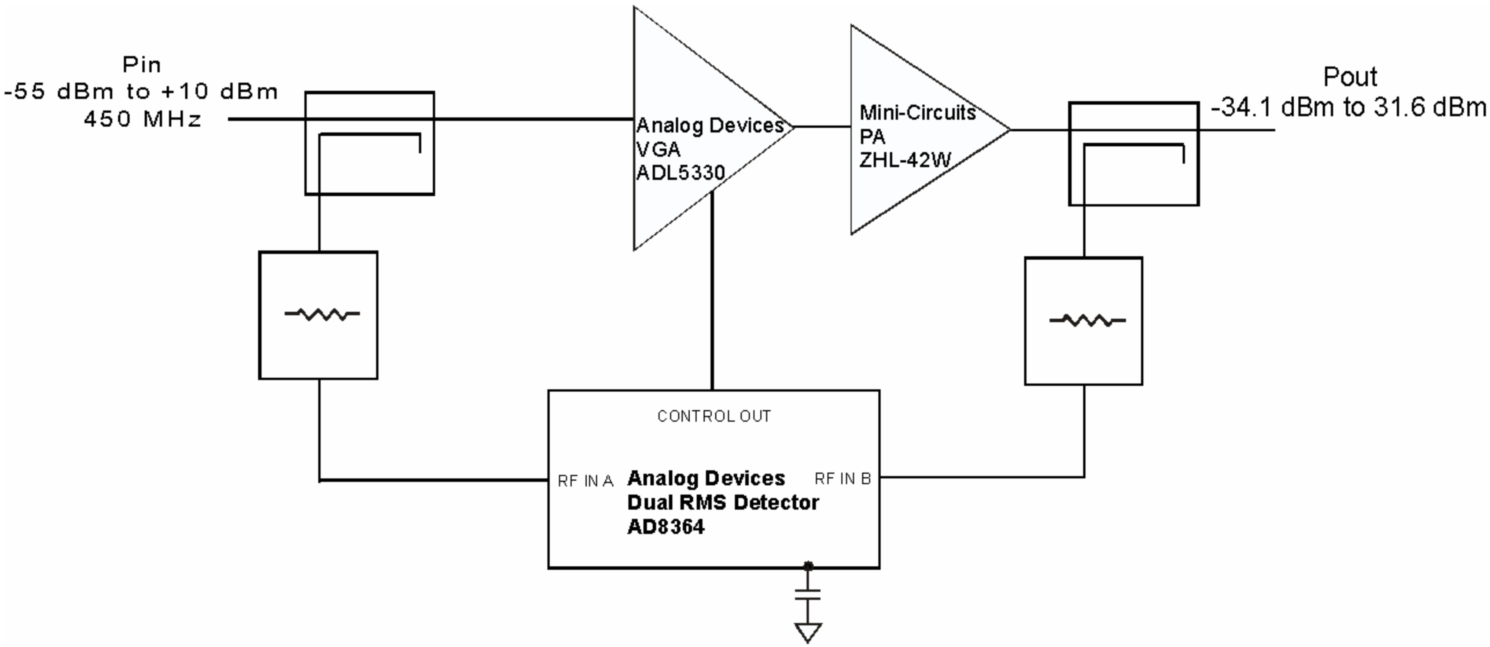
- **Detector measures output power from a variable gain amplifier or power amplifier**
- **Measured result is compared to a setpoint value**
- **Error amplifier/Integrator adjusts gain so that output power corresponds to setpoint**
- **Integrator capacitor/resistor set response time of loop**
- **Many of ADI's detectors have an integrated "Controller Mode"**

A Practical AGC Loop using a Log Amp



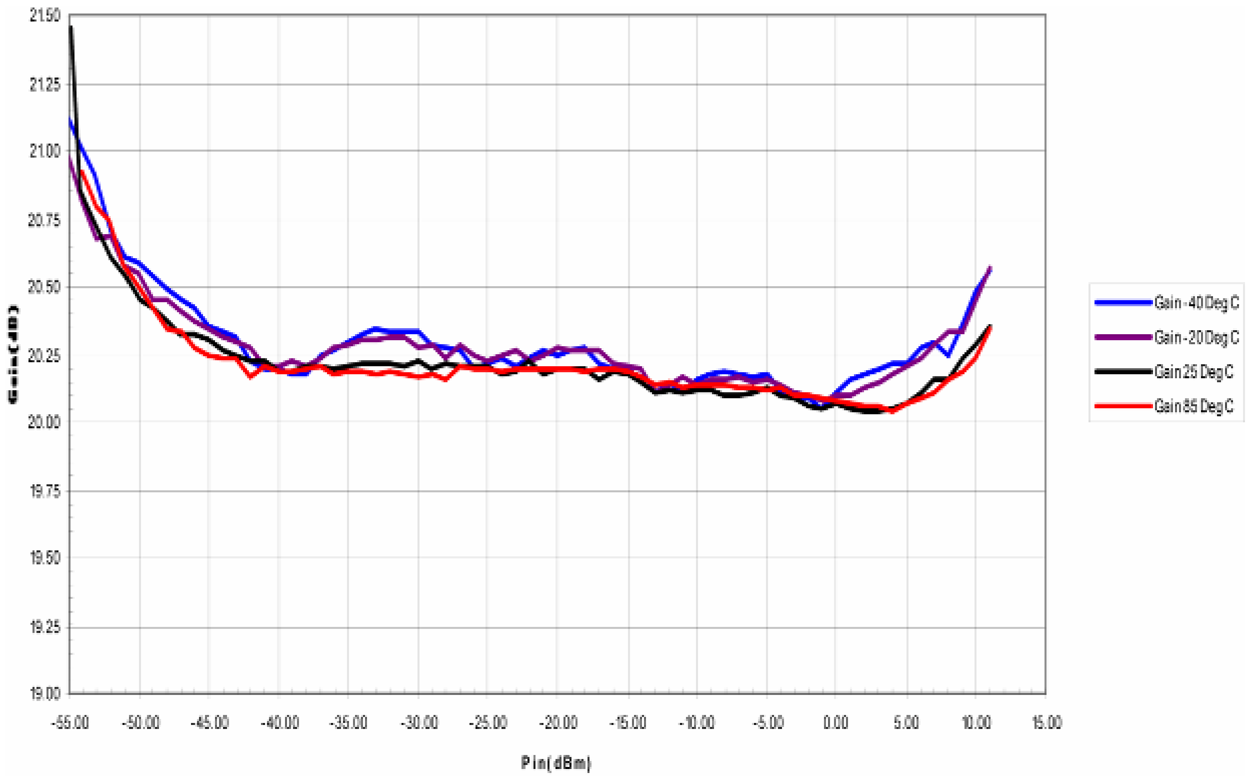
- Setpoint is applied to Detector VSET input
- Vout varies up or down to balance loop
- Use to set output to a fixed value (fixed VSET, variable input power) or to vary output power (variable VSET, fixed or variable input power)
- Set response time of loop by varying Cflt

Controlling Gain with a Dual RMS Detector



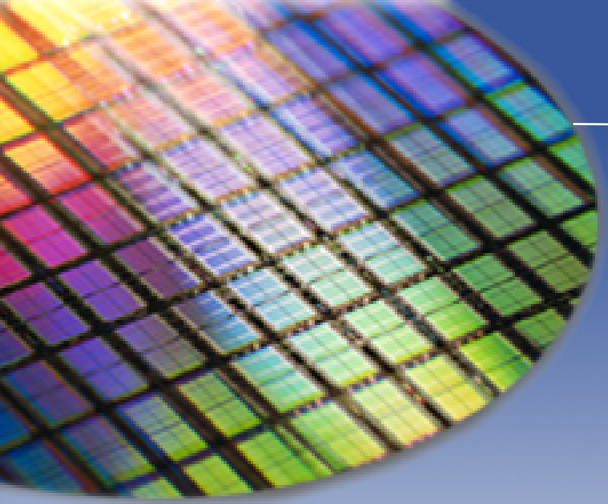
- Dual RMS Detector can also operate in Controller Mode
- Detector measures and controls VGA in an analog loop
- Detector tries to balance input power at its two RF inputs
- Gain setpoint is controlled by difference in external attenuators

Gain vs. Input Power for Analog Gain Control Loop



- ❑ **Gain varies by only +/-0.25 over a 60 dB input range**
- ❑ **Excellent stability over temperature**

ANALOG DEVICES



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ANALOG DEVICES