RF25A

RF25A for CDMA, and AMPS Applications

The RF25A device includes the following functional blocks:

- Low Noise Amplifier (LNA)
- RF Downconverted Mixer
- Intermediate Frequency (IF) Variable Gain Amplifier (VGA)
- In-Phase and Quadrature (I/Q) Demodulator
- Voltage Controlled Oscillator (VCO)

The RF25A Application-Specific Integrated Circuit (ASIC) is a dual-mode, single-band receiver (Rx) intended for use in Code Division Multiple Access (CDMA) portable phones in the cellular band. It can be used in CDMA mode or Advanced Mobile Phone System (AMPS) mode. The ASIC provides excellent RF performance with low DC power dissipation and is assembled in a low cost, high performance, 40-pin Land Grid Array (LGA) 6 x 6 mm package.

The device incorporates all the components required to implement the complete dual-mode receiver front end; from the Low Noise Amplifier (LNA) to the In-Phase and Quadrature (I/Q) demodulator stages, except for external SAW filters. The LNA amplifies the incoming signal and outputs to an external SAW filter. After filtering, the signal goes to the mixer for downconversion. The mixer output for the AMPS mode is single-ended, followed by the external AMPS Intermediate Frequency (IF) Surface Acoustic Wave (SAW) filter. The mixer output for the CDMA mode mixer has balanced outputs for external IF SAW filtering. The IF SAW filters are followed by a Variable Gain Amplifier (VGA) and and I/Q demodulator. The mode selection is controlled by a mode control pin.

The IF filter outputs are buffered at the input of the VGA, which has a dynamic range greater than 90 dB.

The on-chip Very High Frequency (VHF) Voltage Controlled Oscillators (VCO) operates with an external tank circuit to provide the Local Oscillator (LO) signal for the I/Q demodulator.

The Gain, Noise Figure (NF), and third order Input Intercept (IIP3) of each stage in the receiver chip are optimized to meet the system requirements for AMPS and CDMA modes according to the TIA/EIA 98-B standard. Employing silicon bipolar technology, the ASIC is designed for high performance with a high level of integration and provides a cost-effective RF solution for dual-mode phone applications

The RF25A pin-out is shown in Figure 1, a functional block diagram is illustrated in Figure 2, and a schematic diagram in Figure 3.

Features

- Dual-Mode Operation
- Battery operation 2.7 to 3.6 V
- High level of integration
- Differential I/Q outputs for baseband interfaces
- On-chip 100 to 600 MHz VCO
- Low DC consumption: < 60 mA
- 40-pin Land Grid Array (LGA) 6 x 6 mm package

Applications

- CDMA and AMPS handset in the cellular band:
  - AMPS
  - CDMA (US)
  - CDMA (Japan)

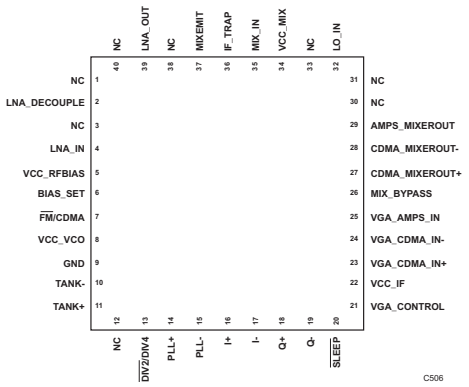


Figure 1. RF25A Rx ASIC Pin-out
40-Pin LGA Package

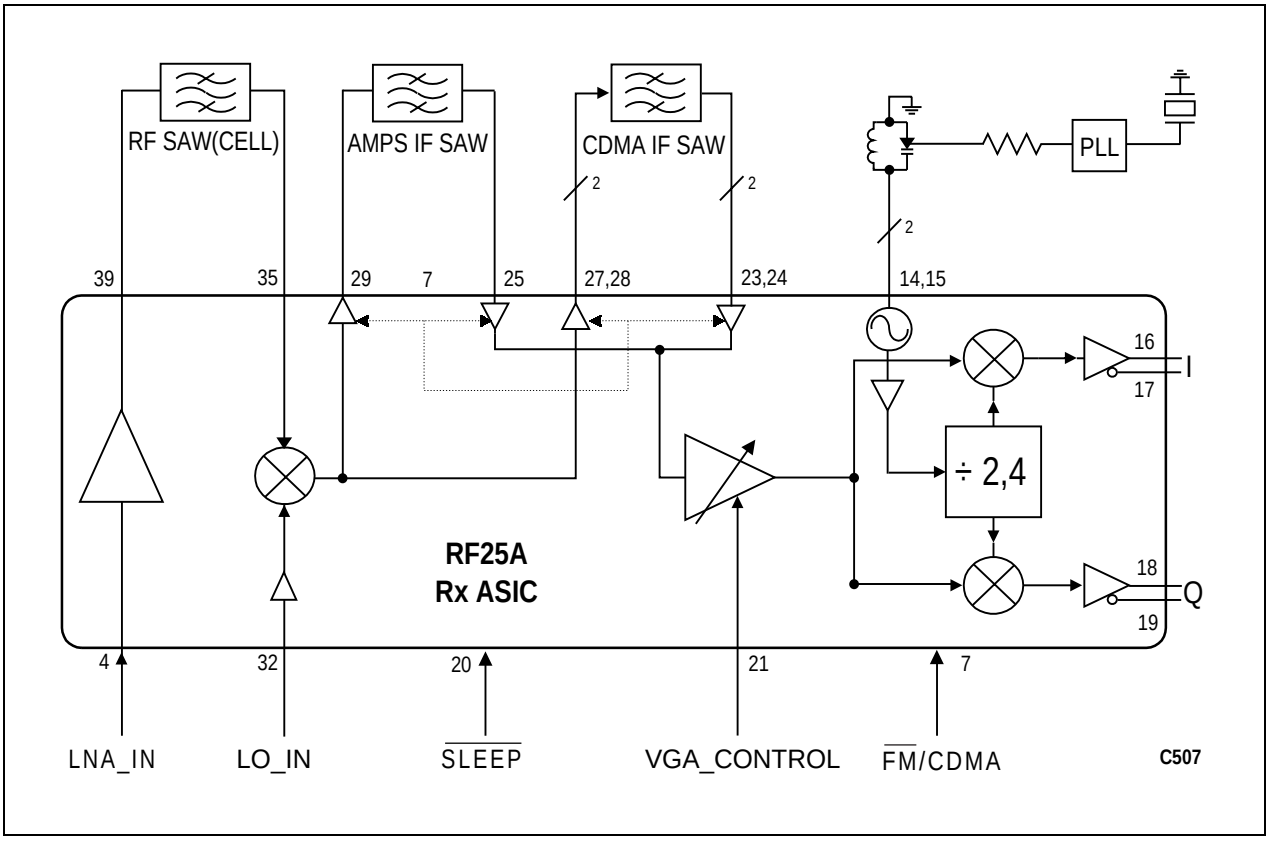


Figure 2. RF25A Rx ASIC Block Diagram

Technical Description

Low Noise Amplifier (LNA). The LNA is designed with a high gain, low noise figure, and high 3rd order input intercept (IIP3) performance. These parameters can be optimized with the mixer gain, noise figure, and IIP3 to achieve the cascade NF and IIP3 system requirements. RF25A pin 2 is LNA decoupled, requiring a RF bypass capacitor to ground with minimal trace length. Input and output matching networks are external to the Rx ASIC.

Mixers. The active double balanced mixer is designed for high gain, a low noise figure, and high IIP3 performance. The mixer can also be optimized for RF performance to complement the LNA RF performance, and satisfy overall Rx NF and IIP3 system requirements. The LO port operates with a typical LO drive level of -10 dBm. The mixer has a balanced output to drive the IF SAW filter in CDMA mode, and single-ended output to drive the IF SAW filter in the AMPS mode.

Variable Gain Amplifier (VGA). The high dynamic range required by a CDMA handset is achieved by the VGA, which has a minimum dynamic range of 90 dB and a control voltage range from 0.5 to 2.5 V. The VGA is common in both modes (CDMA and AMPS) by switching its internal input buffers.

I/Q Demodulator. The I/Q Demodulator is designed for mobile handset application. It has an on-chip generated VHF LO with a typical operating range of 100 to 600 MHz and a typical I/Q output operating range of 0 to 5 MHz. The I/Q Demodulator is internally connected to the VGA output, and is fully differential to reduce common mode noise. DC offsets between differential I/Q outputs, and between I and Q channels, are extremely low to facilitate compatibility with baseband interfaces. The I/Q Demodulator is also designed to have very low amplitude and phase imbalance.

VHF Oscillator. With external tank circuits, the VCO provides the LO signal to drive the demodulator, and the prescaler of an external Phase Locked Loop (PLL). The oscillator can operate at two or four times at twice the IF frequency. Using a selectable divide ratio, the LO for the I/Q demodulator is derived. The logic signal to select the divider ratio (2 or 4) is available on Pin 13 (DIV2/DIV4).

Mode Control. The operation of the chip is controlled by signals at Pin 7 (FM/CDMA), Pin 20 (SLEEP), and Pin 13 (DIV2/DIV4). All the switching is done internally. The supply voltage should be present at all the VCC pins for normal operation. The modes selected are shown in Table 4.

Electrical and Mechanical Specifications

Included in this document are Tables 1 through 5 and Figures 1 through 4, which define and illustrate the electrical and mechanical specifications of the RF25A.

Table 1:	RF25A Pin Assignments and Signal Descriptions
Table 2:	Absolute Maximum Ratings
Table 3:	Recommended Operating Conditions
Table 4:	Mode Control Select Signal Switching
Table 5:	RF25A RX ASIC Electrical Specifications
Figure 1:	RF25A Rx ASIC Pin-out - 40-Pin LGA 6 x 6 mm Package
Figure 2:	RF25A Rx ASIC Block Diagram
Figure 3 – 19:	Typical Functional Block Performance
Figure 20:	RF25A Schematic Diagram
Figure 21:	RF25A Package Dimensions – 40-Pin LGA 6 x 6 mm Package
Figure 22:	40-Pin LGA Tape and Reel Dimensions

ESD Sensitivity

The RF25A is a Class 1 device. The following extreme Electrostatic Discharge (ESD) precautions are required according to the Human Body Model (HBM):

- Protective outer garments.
- Handle device in ESD safeguarded work area.
- Transport device in ESD shielded containers.
- Monitor and test all ESD protection equipment.

The HBM ESD withstand threshold value, with respect to ground, is ±1.5 kV. The HBM ESD withstand threshold value, with respect to VDD (the positive power supply terminal) is also ±1.5 kV.

Table 1. RF25A Pin Assignments and Signal Descriptions (1 of 3)

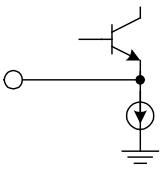
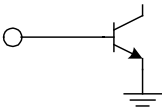
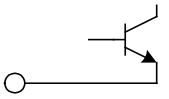
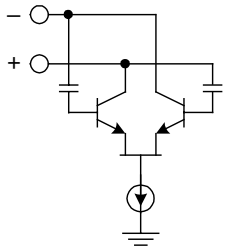
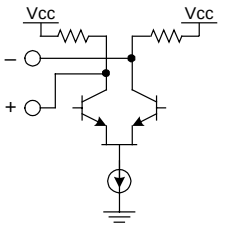
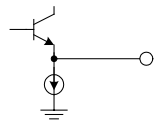
Pin #	Name	Description	Equivalent Circuit
1	NC	No connection.	
2	LNA_DECOUPLE	An RF bypass capacitor (1000 pF) with very short trace should be connected to this pin.	
3	NC	No connection	
4	LNA_IN	The input to LNA needs external matching. The matching network should be placed as close to this pin as possible. High Q components are recommended to minimize the effect on the noise figure. A DC blocking capacitor is necessary at the input.	
5	VCC_RFBIAS	Supply voltage to the RF bias. An RF bypass capacitor should be connected from the pin to ground with short traces.	
6	BIAS_SET	This pin sets the cellular RF bias current. Typically, a 180 Ω resistor is connected from the pin to ground.	
7	$\overline{\text{FM}}$/CDMA	Cellular band mode select: 0 = AMPS; 1 = CDMA.	
8	VCC_VCO	Voltage supply pin to the VCO buffer. A bypass capacitor should be placed close to the device from pin 8 to pin 9. The trace should be short and connected immediately to the ground plane for best performance.	
9	GND	Ground return from the VCO buffer.	
10	TANK-	Differential tank connection for the cellular band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.	
11	TANK+	Differential tank connection for the cellular band VCO. Care should be taken during the layout of the external tank circuit to prevent parasitic oscillations.	
12	NC	No connection.	
13	$\overline{\text{DIV2}}$/DIV4	Selects the divide ratio of the VCO to the LO port of the I/Q demodulator: 0 = divide by 2, 1 = divide by 40.	
14	PLL+	Differential buffered VCO output	
15	PLL-	Differential buffered VCO output	
16	I+	I channel differential output.	
17	I-	I channel differential output.	
18	Q+	Q channel differential output.	
19	Q-	Q channel differential output.	
20	$\overline{\text{SLEEP}}$	Activates sleep mode: 0 = sleep; 1 = enable	

Table 1. RF25A Pin Assignments and Signal Descriptions (2 of 3)

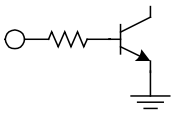
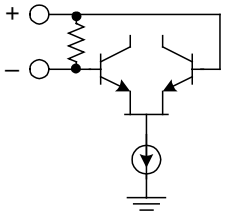
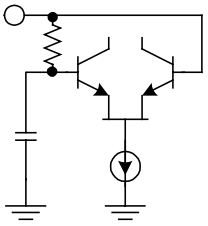
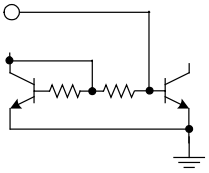
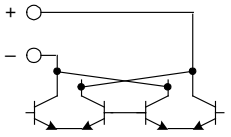
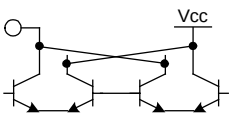
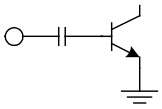
Pin #	Name	Description	Equivalent Circuit
21	VGA_CONTROL	VGA voltage input. Input impedance is greater than 50K Ω.	
22	VCC_IF	Voltage supply to VGA and I/Q demodulator stages. Supply should be well regulated and bypassed to prevent modulation of the signal by the supply ripple.	
23	VGA_CDMA_IN+	CDMA differential VGA input	
24	VGA_CDMA_IN-	CDMA differential VGA input	
25	VGA_AMPS_IN	AMPS VGA input.	
26	MIX_BYPASS	Low frequency bypass for the amps mixer.	
27	CDMA_MIXEROUT+	CDMA differential mixer output. Requires an external inductor to VCC. An external match sets output impedance.	
28	CDMA_MIXEROUT-	CDMA differential mixer output. Requires an external inductor to VCC. An external match sets output impedance.	
29	AMPS_MIXEROUT	AMPS mixer output. Requires an external inductor to VCC. An external match sets output impedance.	
30	NC	No connection.	
31	NC	No connection.	
32	LO_IN	The mixer local oscillator input drive is typically –10 dBm.	
33	NC	No connection.	

Table 1. RF25A Pin Assignments and Signal Descriptions (3 of 3)

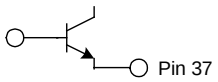
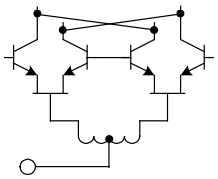
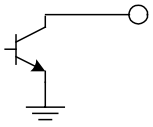
Pin #	Name	Description	Equivalent Circuit
34	VCC_MIX	Voltage supply pin for the mixers. An RF bypass capacitor should be connected from this pin to ground. It should be connected as close to the device as possible with very short trace lengths.	
35	MIX_IN	Cellular mixer input.	
36	IF_TRAP	The parallel LC circuit is tuned to the cellular IF frequency.	
37	MIXEMIT	Typical ground connection, but a 1.5 nH emitter degeneration can be used to improve mixer input IP3.	See Pin 35
38	NC	No connection.	
39	LNA_OUT	This is an open collector LNA output. An inductor must be connected to VCC. The matching is done externally to the chip.	
40	NC	No connection.	

Table 2. Absolute Maximum Ratings

Parameter	Minimum	Maximum	Units
Supply voltage (VCC)	-0.3	5.0	V
Input voltage range	-0.3	VCC	V
LNA input power		+5	dBm
Power dissipation		600	mW
Operating temperature	-30	+80	°C
Storage temperature	-40	+125	°C

Table 3. Recommended Operating Conditions

Parameter	Min	Typical	Max	Units
Supply voltage (VCC)	2.7	3.0	3.6	V
Operating temperature	-30	+25	+80	°C
Impedance of logic inputs		50		KΩ
Logic 0	0.0		0.5	V
Logic 1	VCC - 0.5		VCC	V

Table 4. Mode Control Select Signal Switching

Pin #	Name	AMPS	CDMA
7	$\overline{\text{FM}}$/CDMA	0	1
13	$\overline{\text{DIV2}}$/DIV4	0	0
20	$\overline{\text{SLEEP}}$	1	1
Key: 0 = LOW 1 = HIGH			

Table 5. RF25A Rx ASIC Electrical Specifications (1 of 2)
TA = 25° C, VCC = 3.0 V, PLO = -10 dBm

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Cellular LNA						
Gain @ 881 MHz				14.5		dB
Gain variation over band (869-894 MHz)					0.5	dB
Gain variation over temperature					1.5	dB
Noise figure @ 881 MHz				1.6		dB
Reverse isolation				20		dB
P1dB @ input				-5		dBm
IP3 @ input				8		dBm
Input return loss (869-894 MHz)					-12	dB
Output return loss (869-894 MHz)				-15		dB
Total supply current (adjustable)				11		mA
Cellular Mixer						
Conversion gain (power): CDMA mode AMPS mode				 14 11		 dB dB
Single-sideband noise figure: CDMA mode AMPS mode				 7.5 8		 dB dB
P1dB @ input: CDMA mode AMPS mode				 -6 -9		 dBm dBm
IP3 @ input: CDMA mode AMPS mode				 +5 +3		 dBm dBm
Mixer RF input return loss, RF port 1 (869-894 MHz)				-15		dB
LO input power level				-10		dBm
IF output resistance: CDMA mode (differential) AMPS mode (single-ended)				 3000 1000		 Ω Ω
IF frequency range					300	MHz
LO/RF input isolation				20		dB
Total supply current (Adjustable)				18		mA
Rx VGA - I/Q Demodulator						
Frequency range			50		300	MHz
Input impedance: CDMA input (differential) AMPS input (single-ended)				 1000 1000		 Ω Ω
Gain: Maximum Minimum Maximum (AMPS) Minimum (AMPS)			 53 –47 61 -39	 54 –42 62 –34	 55 –37 63 -29	 dB dB dB dB

Table 5. RF25A Rx ASIC Electrical Specifications (2 of 2)
TA = 25° C, VCC = 3.0 V, PLO = -10 dBm

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Rx VGA - I/Q Demodulator (continued)						
Gain slope				45		dB/V
Gain slope linearity (over any 6 dB segment)			-3		+3	dB
IF amplifier IIP3: @ Maximum gain (CDMA mode) @ Maximum gain (AMPS mode)				 -50 -58		 dBm
Input 1 dB compression @ minimum gain				-10		dBm
IF amplifier noise figure: @ Maximum CDMA gain @ Minimum CDMA gain @ Maximum AMPS gain				 6 50 8		 dB dB dB
Output level: CDMA AMPS				 2.75 5.5		 mVrms mVrms
Maximum output level			1.4			Vp-p
Gain variation over frequency: CDMA (1-630 kHz) AMPS (0.1-12.2 kHz)				 0.1 0.1	 0.3 0.3	 dB dB
I+, I-, and Q+, Q- DC offset					6	mVrms
I/Q gain mismatch				0.2	0.3	dB
I/Q phase mismatch				2	4	deg
I to Q DC offset					30	mV
Total supply current (includes I/Q mixers, LO buffers, and dividers)				12		mA
Oscillator						
Frequency range			100		600	MHz
Phase noise (fc = 200 MHz, unloaded Q = 20) @ 100 kHz offset				-117		dBc/Hz
Second harmonic distortion (application dependent)				-30	-26	dBc
Output level to PLL (differential)				300		mVp-p
Output impedance to PLL (differential)				300		Ω
Reverse isolation			-30		-40	dB
Total supply current				8		mA

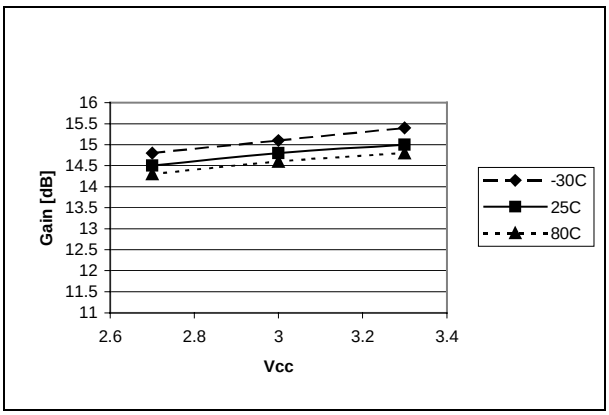


Figure 3. Cellular LNA Gain @ 881 MHz

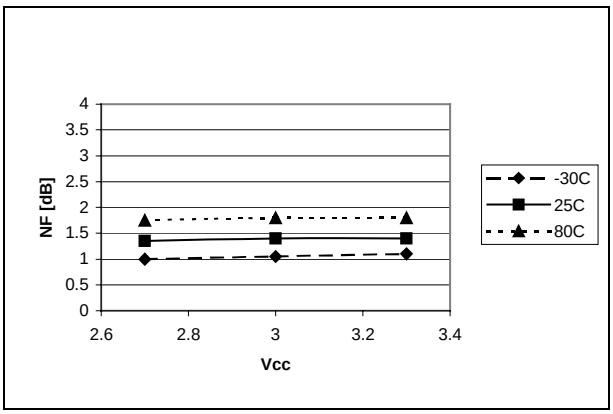


Figure 4. Cellular LNA Noise Figure @ 881 MHz

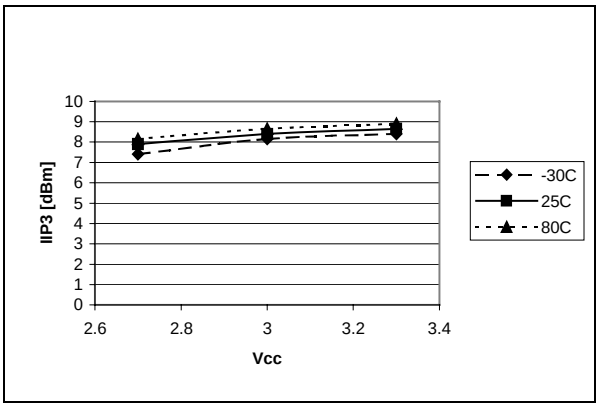


Figure 5. Cellular LNA IIP3 @ 881 MHz

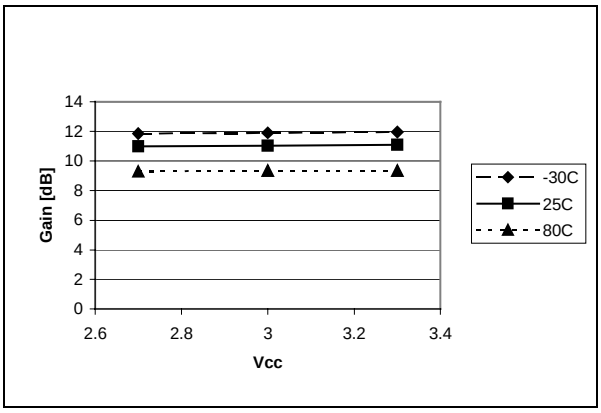


Figure 6. AMPS Mixer Gain
(RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

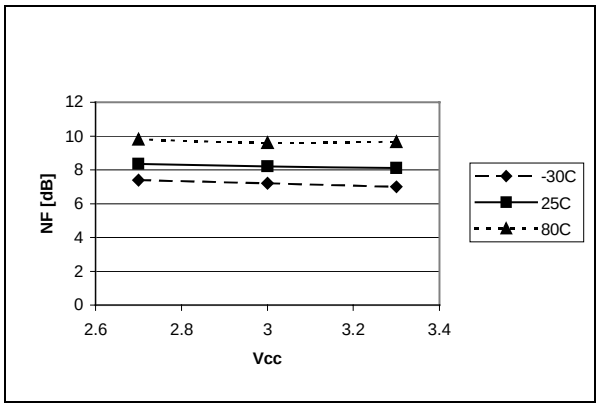


Figure 7. AMPS Noise Figure
(RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

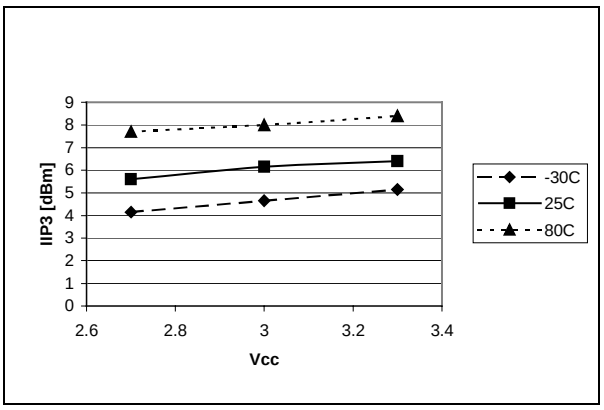


Figure 8. AMPS Mixer IIP3
(RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

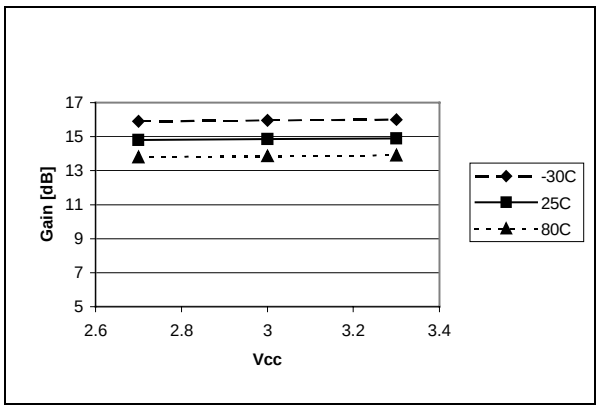


Figure 9. CDMA Mixer Gain (RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

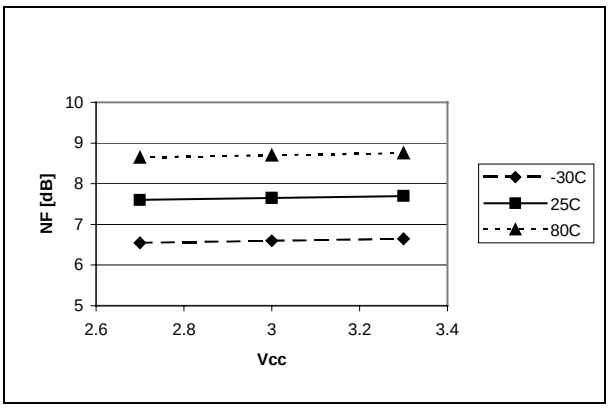


Figure 10. CDMA Mixer Noise Figure (RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

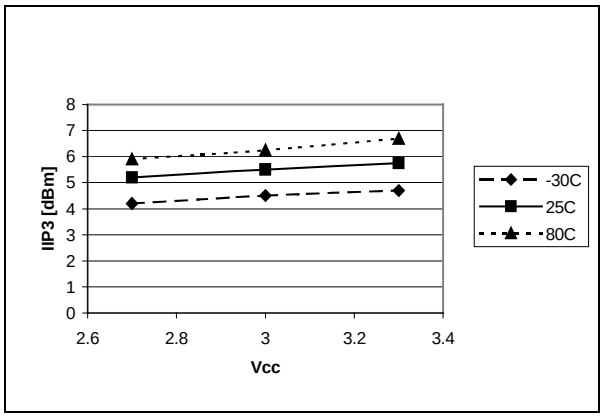


Figure 11. CDMA Mixer IIP3 (RF Frequency = 881.52 MHz, LO Frequency = 966.90 MHz, IF Frequency = 85.38 MHz)

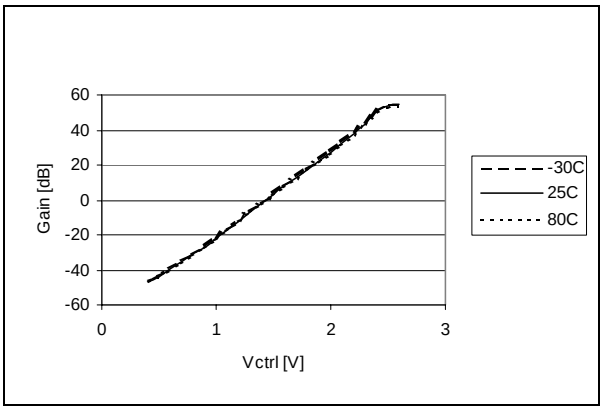


Figure 12. CMDA VGA + I/Q Gain vs. Temperature (IF Frequency = 85.38 MHz)

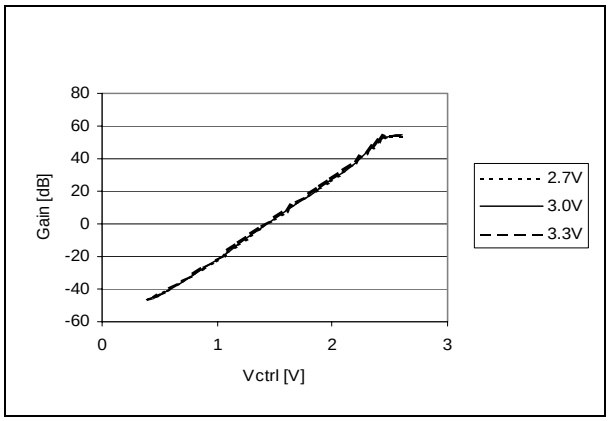


Figure 13. CDMA VGA + I/Q Over Supply (IF Frequency = 85.38 MHz)

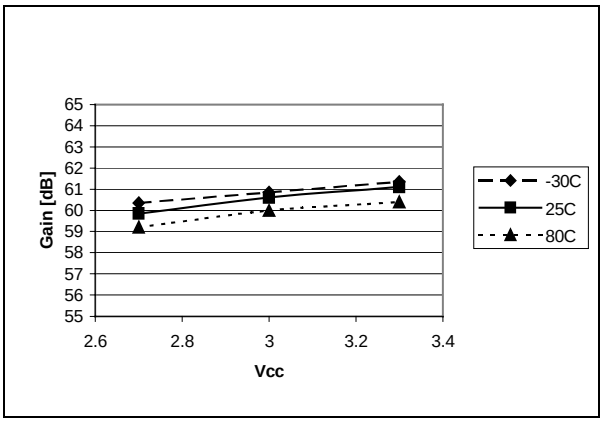


Figure 14. VGA + I/Q Gain in AMPS Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

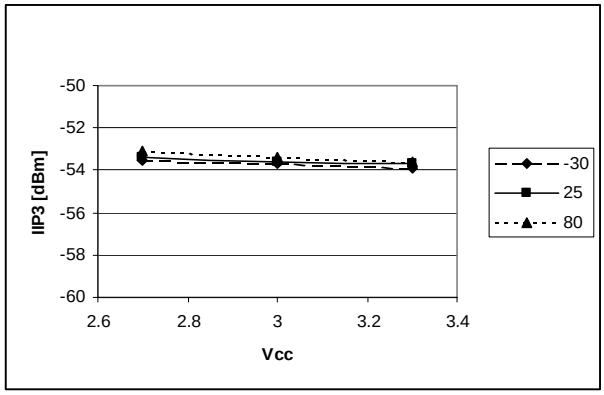


Figure 15. VGA + I/Q IIP3 in AMPS Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

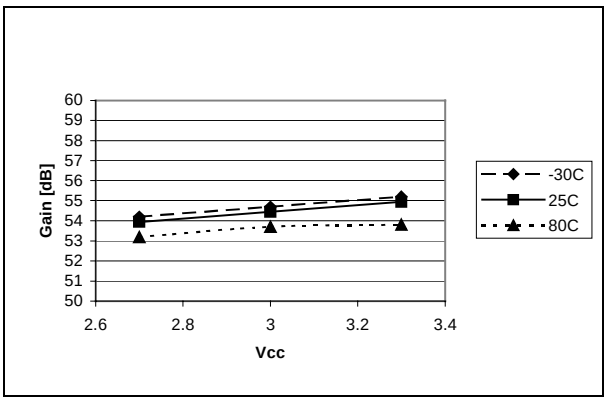


Figure 16. VGA + I/Q Gain in CDMA Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

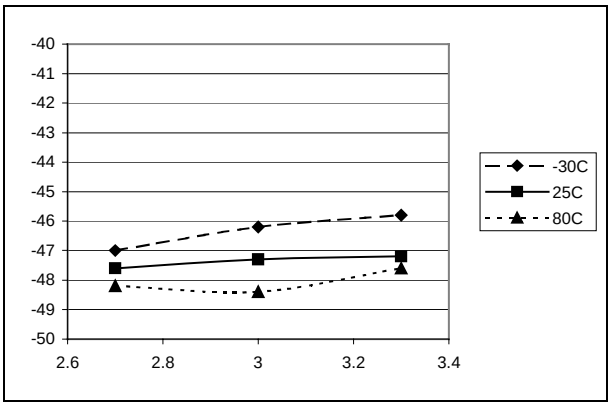


Figure 17. VGA + I/Q IIP3 in CDMA Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

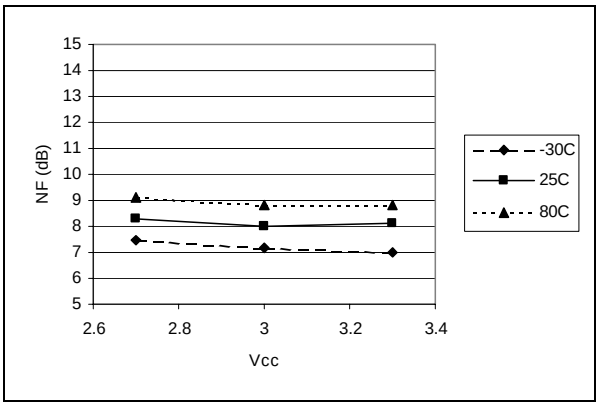


Figure 18. VGA + I/Q Noise Figure in AMPS Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

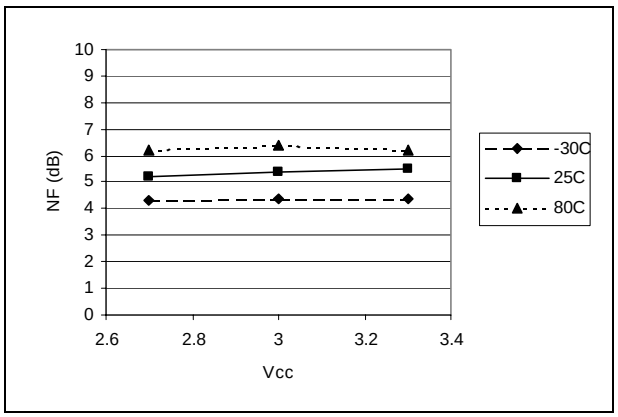


Figure 19. VGA + I/Q Noise Figure in CDMA Mode (Vcontrol = 2.5 V, Frequency = 85.38 MHz)

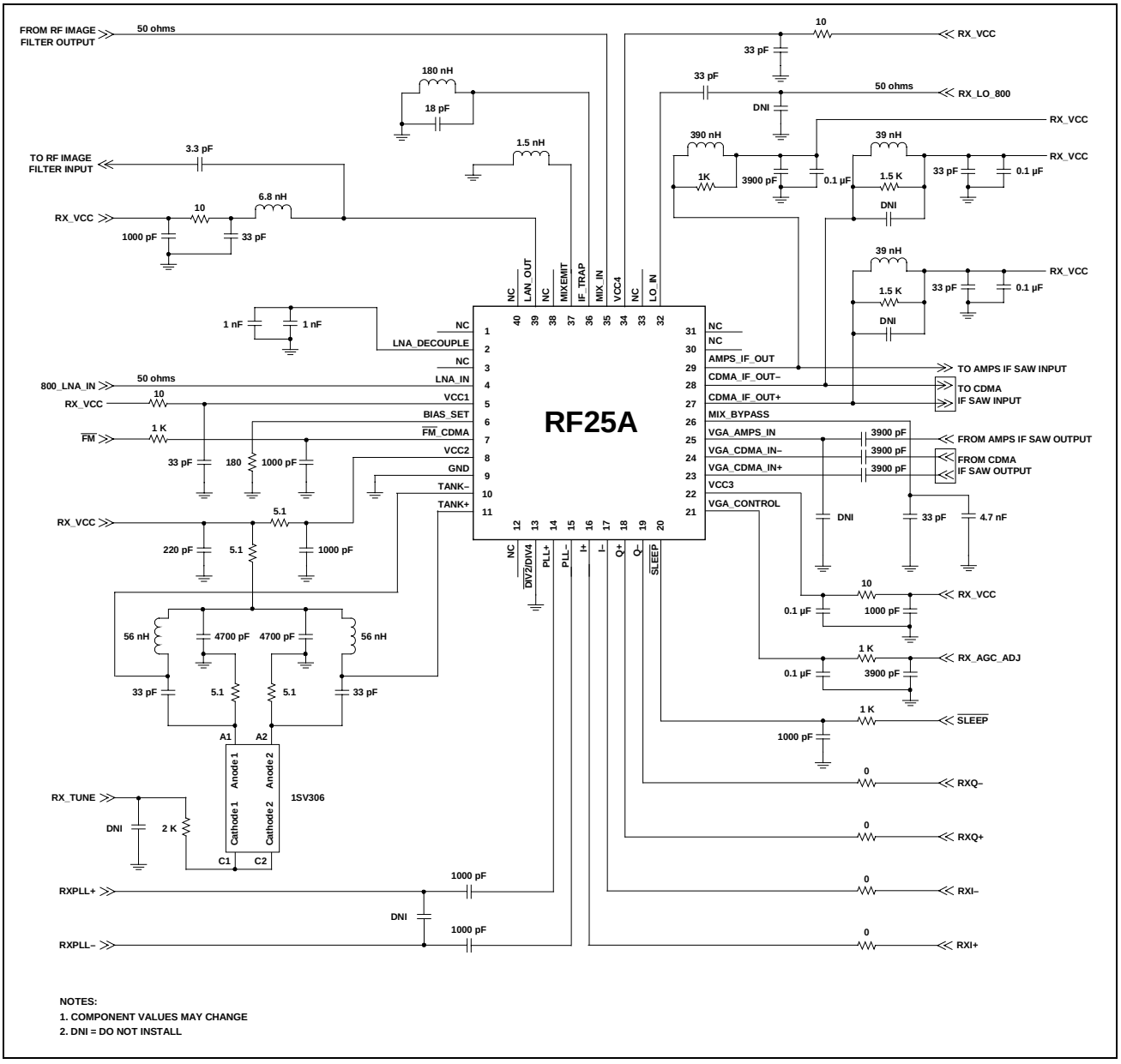


Figure 20. RF25A Schematic Diagram

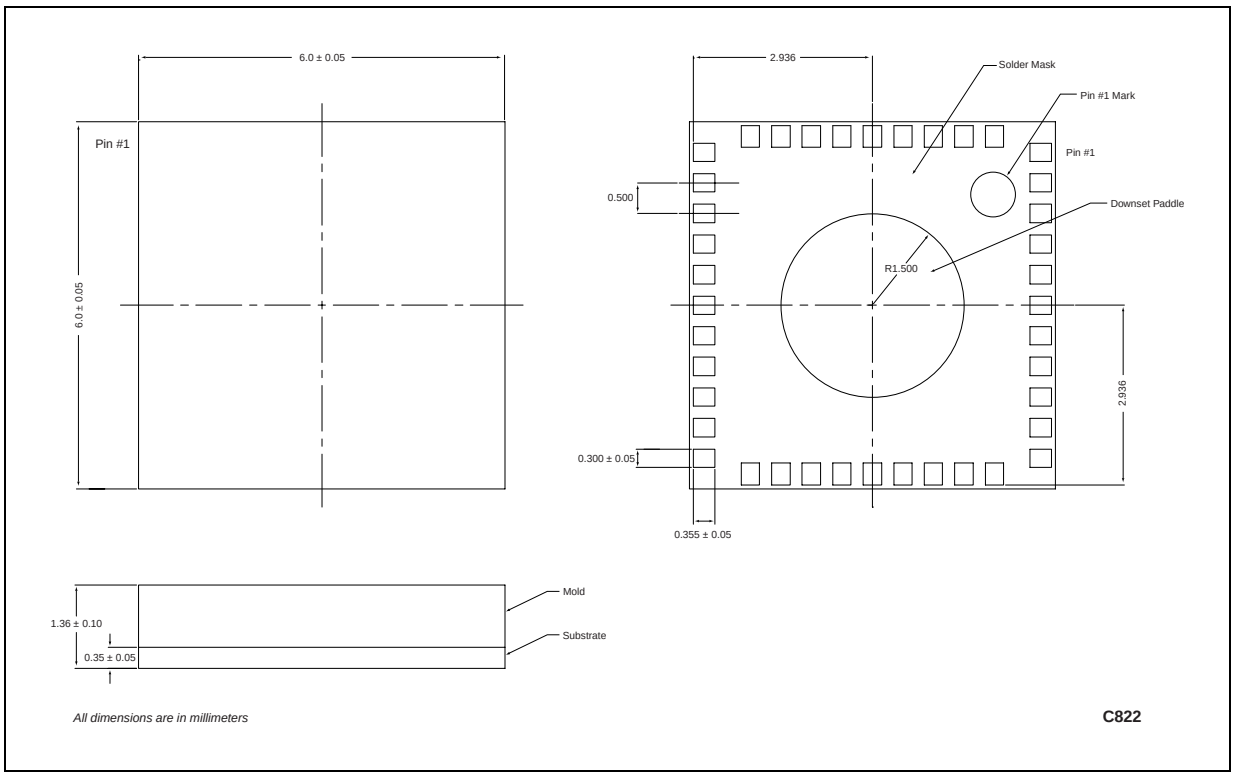
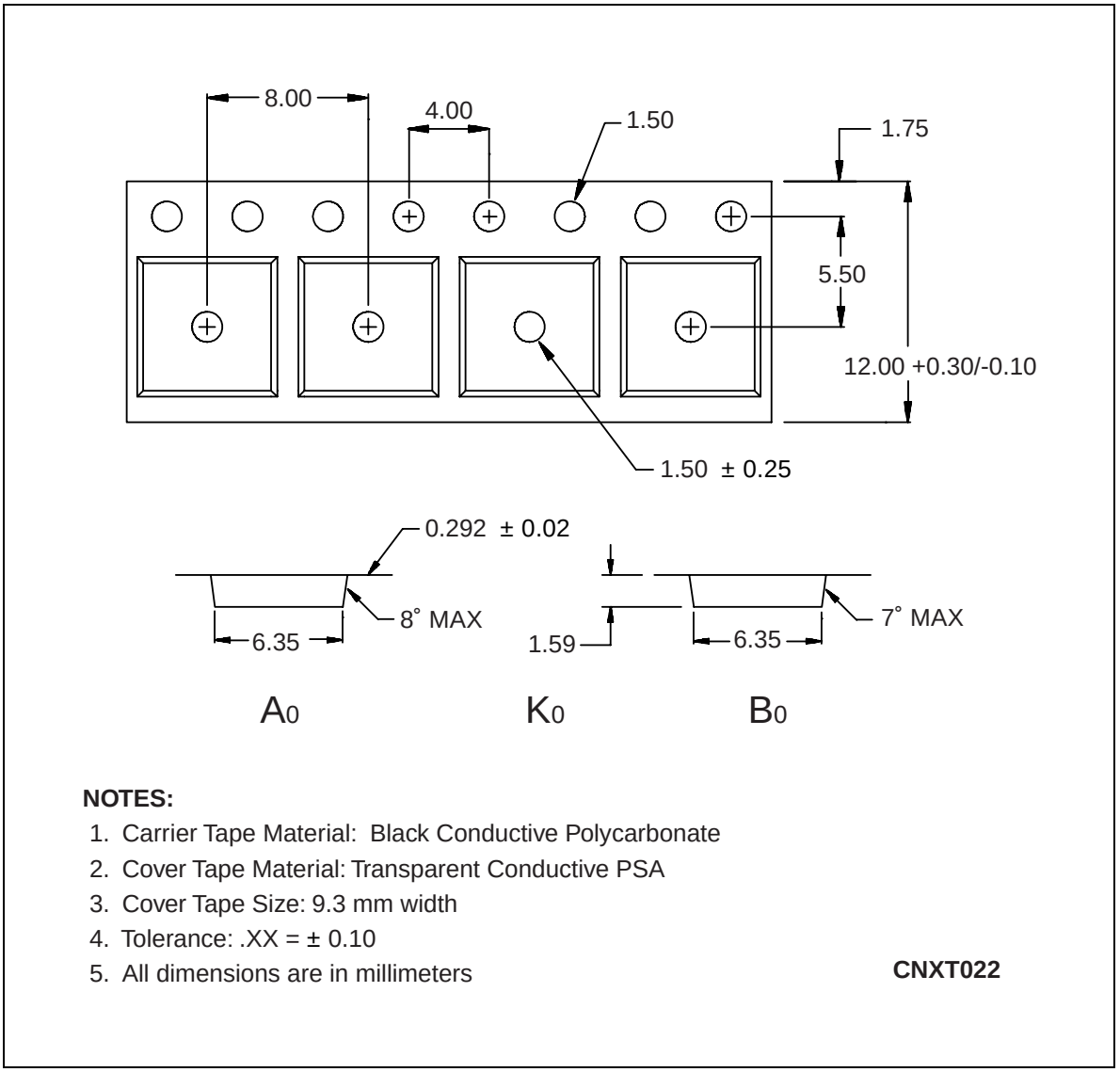


Figure 21. RF25A Package Dimensions - 40-pin LGA 6 x 6mm Package



NOTES:

1. Carrier Tape Material: Black Conductive Polycarbonate
2. Cover Tape Material: Transparent Conductive PSA
3. Cover Tape Size: 9.3 mm width
4. Tolerance: .XX = ± 0.10
5. All dimensions are in millimeters

CNXT022

Figure 22. 40-pin LGA Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Product Revision
RF25A	RF25A-12	12

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