PEREGRINE SEMICONDUCTOR

AN9: Application Note

Performance Advantages of the PE3236 compared to Qualcomm's Q3236

Features

- PE3236 offers 10 dB of phase noise improvement over Q3236
- PE3236 consumes only one-tenth the power of Q3236
- These advantages are achieved without any penalty in reference spurs, lock time, or temperature stability

Introduction

The performance of PE3236 and Qualcomm Q3236 was characterized and compared at a VCO frequency slightly above 2 GHz. This data included phase noise, spurious signal levels, and lock times at comparison frequencies of 1, 2.5, and 5 MHz for temperatures of 25°C and 85°C.

The PE3236 was measured with the 3236 evaluation kit (PE3236-EK) and the Q3236 was measured with the Q0420 evaluation kit. The latter kit includes a divide-by-two prescaler preceding the RF input.

The comparison of the PE3236 versus the Q3236 demonstrates the following:

- *Lower power consumption*. The PE3236 consumes 48 mW; the Q3236 consumes 540 mW.
- *Lower phase noise*. At an output frequency of 2.15 GHz and comparison frequency of 1 MHz, the phase noise of the PE3236 at 1 and 10 kHz offsets is -88 and -93 dBc / Hz, respectively. The Q3236's phase noise at the same offset is -82 and –81 dBc / Hz, a 6 to 12 dB difference. The RMS noise integrated from 10 Hz to 1 MHz measures 0.61 and 2.28 degrees for the PE3236 and Q3236 devices respectively, an advantage of almost 4x for the Peregrine device.
- *Improved spur levels*. Reference spurs of the PE3236 are from 10 to 20 dB better over temperature and comparison frequency. (Spur measurements are loop filter and board dependent due to the active filter implementation of the designs. Both evaluation boards were tuned for optimum spur performance.)
- *Comparable, fast lock time*. The lock times range from 71 µs to 80 µs to settle to within 10 kHz of the final frequency, and from 122 µs to 133 µs to settle to within 1 kHz. These measurements were taken at a comparison frequency of 1 MHz with a slightly lower loop bandwidth (80 kHz vs. 100 kHz) on the Peregrine board.
- *Comparable temperature stability*. The temperature dependence of spurs and lock time between 25° to 85°C was negligible for all three parts. The change in PE3236 phase noise is negligible at offsets of 5 kHz and above, and bounded to 4 dB or less in the neighborhood of 1 kHz offset. The change in phase noise for the Q3236 due to temperature was less than 2 dB.

Table 1. Setup

Part	EV Board	VCO	Kvco	Loop Filter	LF BW
PE9601	PE9600	MW 520	95 MHz / V	2nd order passive	70 kHz @ f_c =1 MHz
PE3236	PE9600	MW 514	79 MHz / V	2nd order active	50 kHz @ f_c =1 MHz
Q3236	Q0420*	MS3500C-2032T	114 MHz / V	2nd order active	50 kHz @ f_c =1 MHz

* On-board divide-by-two prescaler was used.

The HP8561E spectrum analyzer was used for all phase noise measurements. A Vectron 10-MHz low noise crystal oscillator with a LVCMOS buffer was used as the reference for both the PLL and the spectrum analyzer.

Table 2. Program Parameters (**Note:** 10 MHz reference frequency.)

Parts	Fvco (MHz)	f_c (MHz)	R	M	A
PE9601	1895	1	9	188	5
		2.5	3	74	8
		5	1	36	9
PE3236	2150	1	9	214	0
		2.5	3	85	8
		5	1	42	0
Q3236*	2150	1	9	106	5
		2.5	3	42	0
		5	1	20	5
Q3236*	2700	1	9	134	0
		2.5	3	53	0
		5	1	26	0

*On board divide-by-two prescaler was used.

Power Consumption

The voltage, current and power consumption are listed in Table 3. The Peregrine devices draw only 10% to 12% of the power required by the Q3236.

Table 3. Power Consumption Results

PLL	PE9601	PE3236	Q3236
Vcc (V)	3	3	5
Icc (mA)	21	16	108
Power (mW)	63	48	540

Lock Time

A frequency change of 40 MHz was commanded, and the time to settle to within 10, 1, and 0.2 kHz of the final frequency was measured. Table 4 lists the actual frequencies and VCO tuning voltages used.

Table 4. Lock Frequency and VCO Tuning Voltage

Part	Frequency Transition (40 MHz)
PE9601	From 1885 MHz (Vt = 1.412 V) to 1925 MHz (Vt = 1.814 V)
PE3236	From 2130 MHz (Vt = 1.225 V) to 2170 MHz (Vt = 1.772 V)
Q3236	From 2500 MHz (Vt = 7.04 V) to 2540 MHz (Vt = 7.39 V)

Table 5 shows the measured lock times at comparison frequencies of 1, 2.5, and 5 MHz and temperatures of 25°C and 85°C. Lock time improves as f_c increases. In some cases, the Q3236 locked up slightly faster than the PE9601 and PE3236. Temperature has very little effect on the lock time.

Table 5. Lock Time Comparison Frequency and Temperature

		Lock Time (us) at 25° C			Lock Time (us) at 85° C		
Part	**f_c (MHz)**	**to +/- 10 kHz**	**to +/- 1 kHz**	**to +/- 200 kHz**	**to +/- 10 kHz**	**to +/- 1 kHz**	**to +/- 200 kHz**
PE9601	1	80	133	178	58	122	222
	2.5	62	122	178	62	111	178
	5	58	122	156	58	100	156
PE3236	1	76	122	200	67	122	200
	2.5	71	111	200	71	122	200
	5	71	111	178	67	122	178
Q3236	1	71	122	156	76	122	156
	2.5	44	88	156	49	78	156
	5	49	89	156	49	78	156

Phase Noise and Spur

The measured phase noise and spurious signal level at comparison frequencies of 1, 2.5, and 5 MHz and temperatures of 25°C and 85°C are shown in Table 6.

Table 6. Phase Noise and Spur Comparison

Part	f_c (MHz)	fvco (MHz)	Temp (°C)	Spur (dBc)	Phase Noise (dBc / Hz) at offset 100 Hz	1 kHz	10 kHz	100 kHz	RMS noise (Deg.)
PE9601	1	1895	25	-47	-78.7	-90.7	-96.0	-101.3	0.48
			85	-47	-76.3	-86.5	-95.0	-101.3	0.51
PE3236	1	2150	25	-55	-77.0	-87.7	-92.7	-99.2	0.61
			85	-64	-75.3	-86.2	-90.8	-98.7	0.69
Q3236	1	2150	25	-44	-79.0	-82.3	-80.5	-87.5	2.28
			85	-42	-79.0	-81.3	-80.2	-87.5	2.4
Q3236	1	2700	25	-41	-77.8	-80.3	-78.0	-90.8	2.55
			85	-41	-76.5	-80.0	-77.8	-89.3	2.76
PE9601	2.5	1895	25	-48	-76.2	-91.3	-98.3	-100.7	0.5
			85	-48	-79.2	-87.2	-97.8	-100.7	0.44
PE3236	2.5	2150	25	-62	-79.8	-89.8	-96.5	-98.5	0.49
			85	-54	-77.3	-87.2	-94.0	-98.3	0.57
Q3236	2.5	2150	25	-45	-84.7	-86.8	-85.8	-89.0	1.62
			85	-43	-84.7	-86.7	-86.3	-88.3	1.66
Q3236	2.5	2700	25	-45	-82.3	-84.8	-83.8	-89.0	1.92
			85	-42	-80.7	-85.3	-84.0	-87.7	1.88
PE9601	5	1895	25	-51	-73.3	-91.5	-98.7	-102.2	0.47
			85	-51	-76.3	-87.0	-98.5	-101.8	0.46
PE3236	5	2150	25	-60	-79.5	-90.2	-97.8	-100.0	0.5
			85	-47	-75.5	-87.2	-96.2	-99.0	0.56
Q3236	5	2150	25	-50	-84.3	-90.5	-89.9	-99.0	1.33
			85	-46	-85.8	-90.0	-90.0	-89.2	1.5
Q3236	5	2700	25	-48	-83.7	-88.0	-87.8	-89.0	1.46
			85	-45	-82.7	-87.8	-87.2	-88.3	1.90

Q3236, PE3236 and PE9601 Phase Noise Comparisons

Figures 1-6 directly compares the phase noise performance of the PE9601, PE3236, and Q3236 devices. In general, the phase noise of the PE3236 and PE9601 is better than that of Q3236. For some comparison frequencies (f_c) this difference can be dramatic. A comparison frequency of 1 MHz results in the largest difference in performance This difference decreases as f_c increases and a 1/f phase noise floor in the Peregrine devices limits improvement.

Figures 4-6 compares the 85°C phase noise of PE9601, PE3236, and Q3236. Peregrine devices continue to provide a significant performance advantage over temperature.

Figures 7-12 shows how temperature affects the phase noise of the three devices. There is only a very slight degradation of phase noise as temperature increases. This degradation holds for each of the three parts.

Figure 1. Phase Noise of PE9601, PE3236, and Q3236 at f_c =1 MHz, 25°C

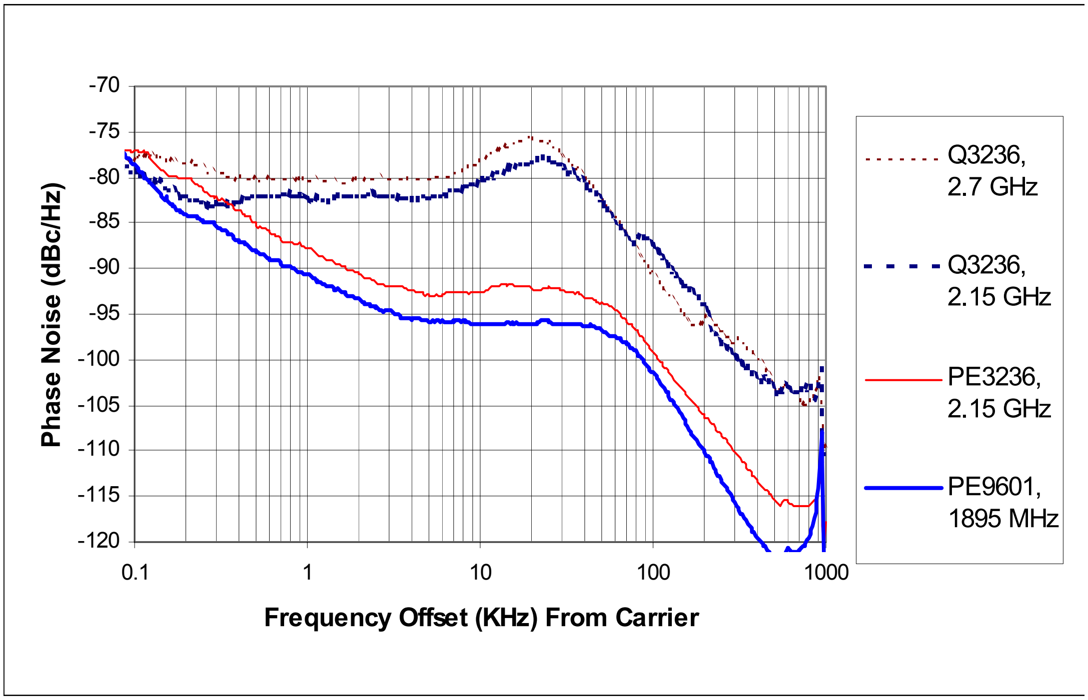


Figure 2. Phase Noise of PE9601, PE3236 and Q3236 at f_c =2.5 MHz, 25°C

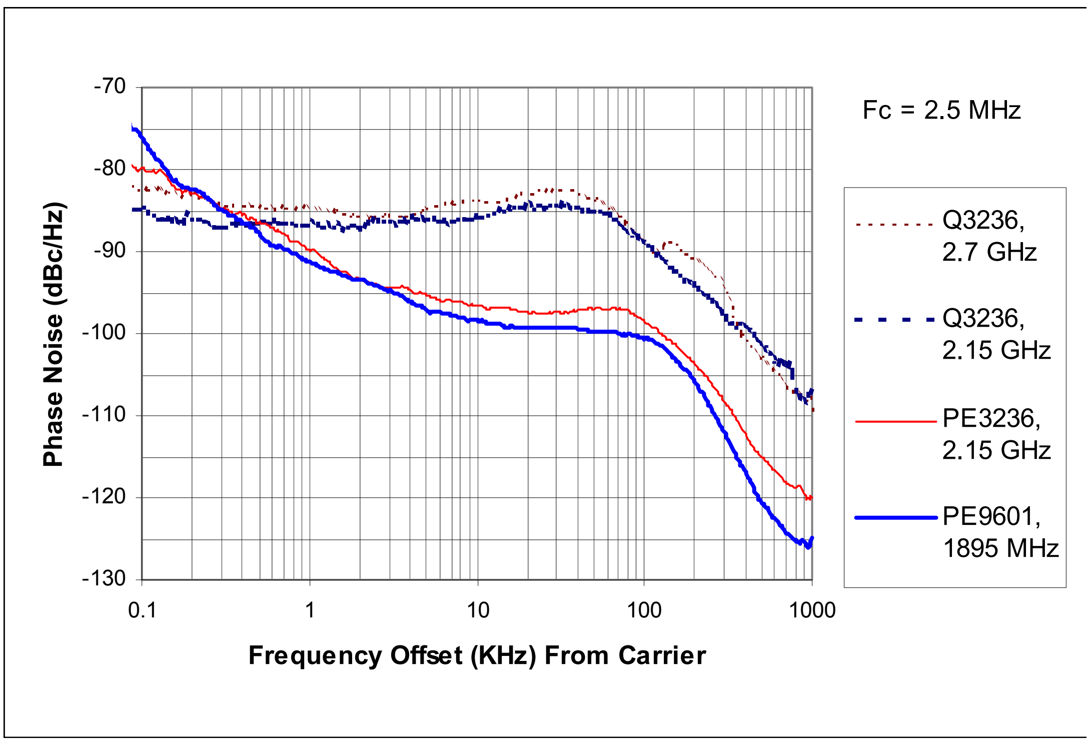


Figure 3. Phase Noise of PE9601, PE3236 and Q3236 at f_c =5 MHz, 25°C

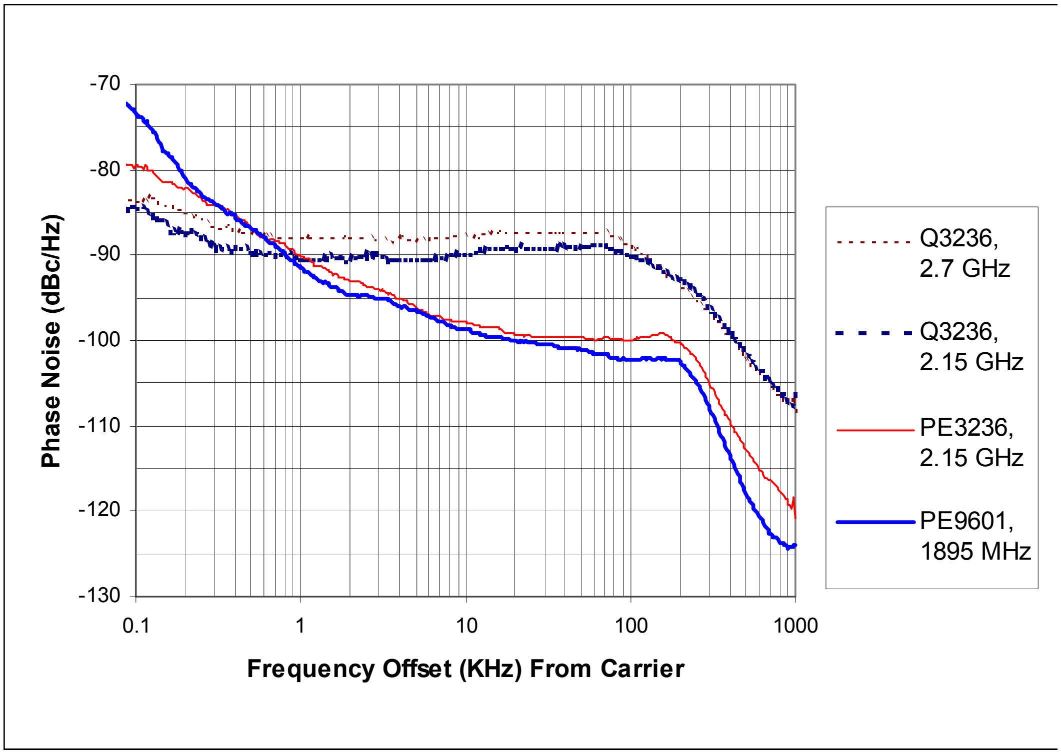


Figure 4. Phase Noise of PE9601, PE3236 and Q3236 at f_c =1 MHz, 85°C

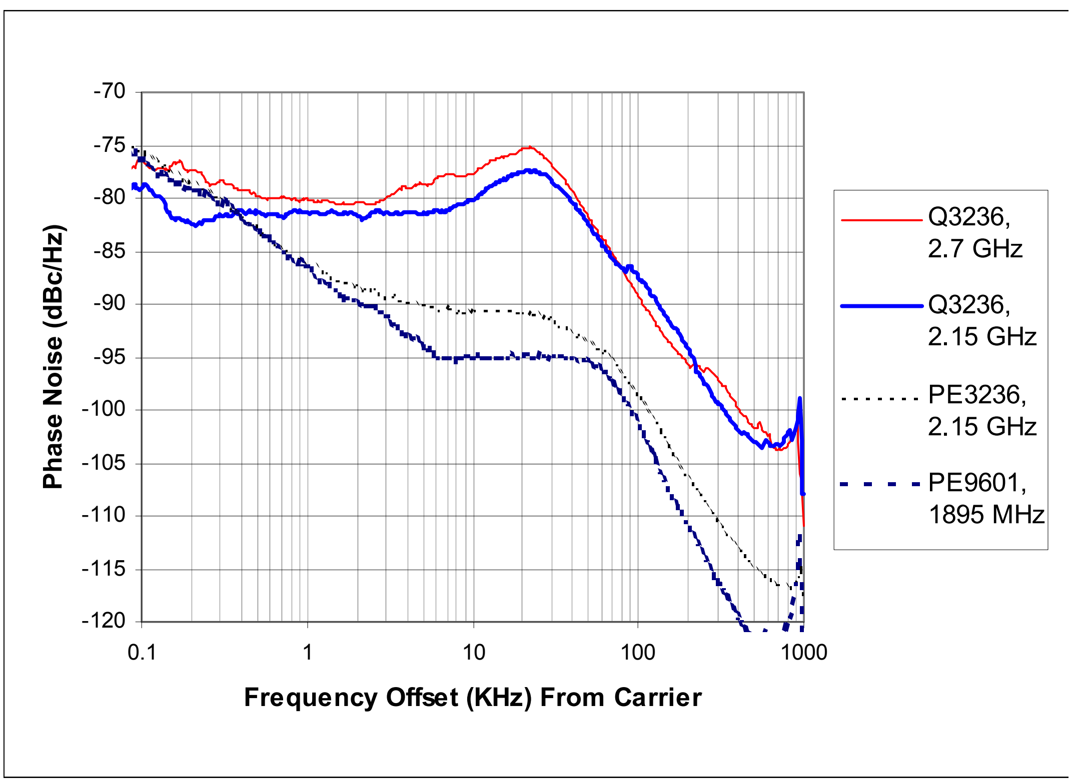


Figure 5. Phase Noise of PE9601, PE3236 and Q3236 at f_c =2.5 MHz, 85°C

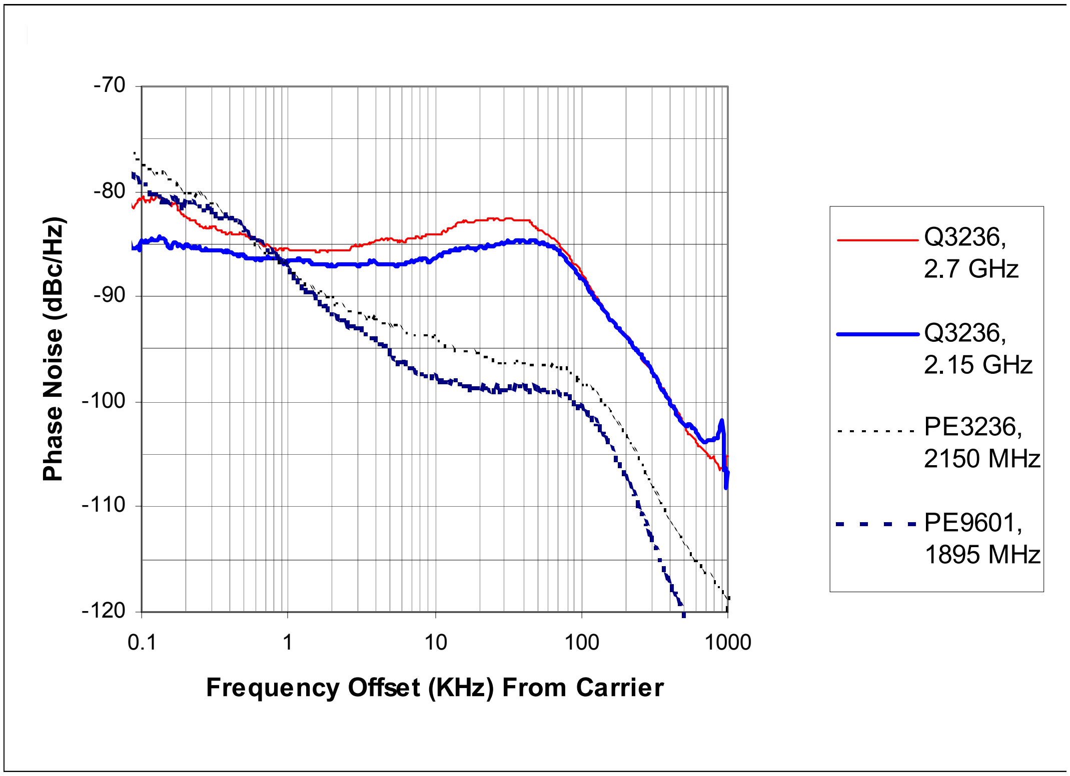


Figure 6. Phase Noise of PE9601, PE3236 and Q3236 at f_c =5 MHz, 85°C

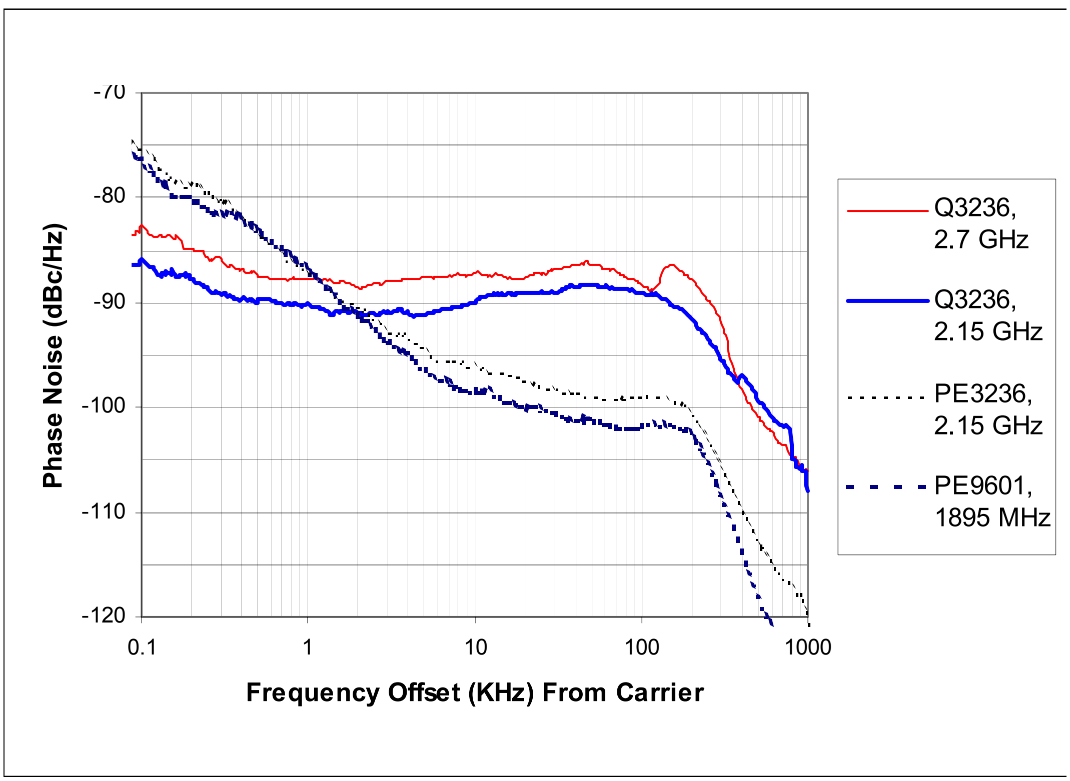


Figure 7. Temperature Effect of Phase Noise on PE3236 and PE9601 at f_c =1 MHz

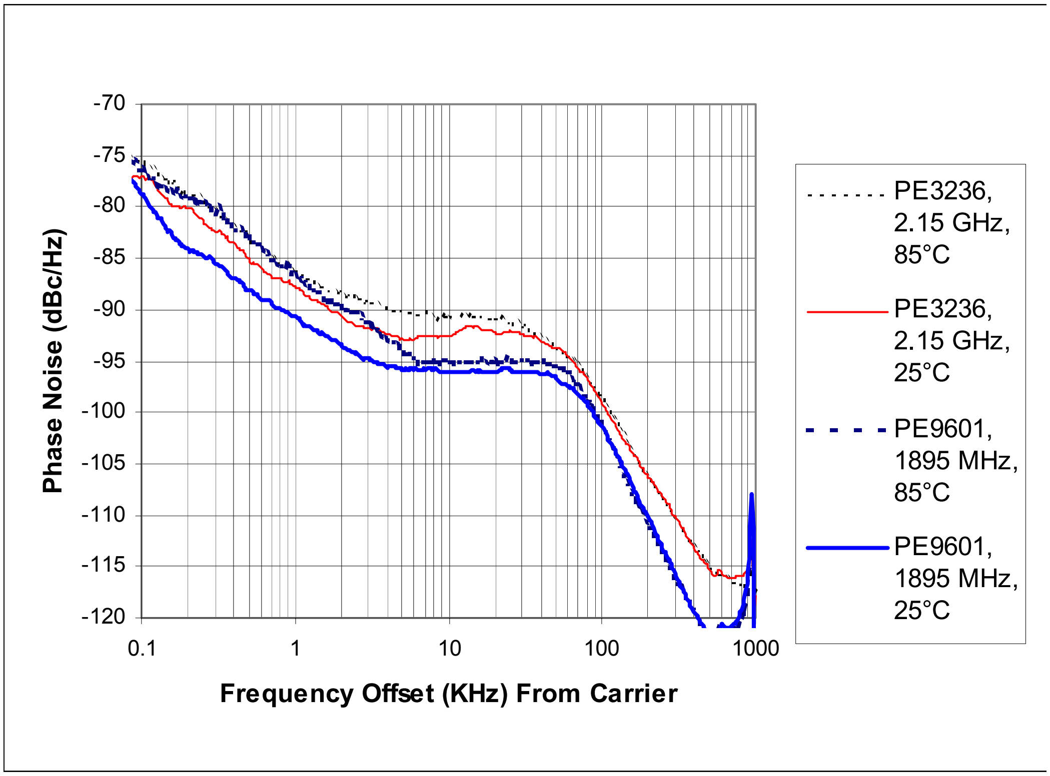


Figure 8. Temperature Effect of Phase Noise on Q3236 at f_c =1 MHz

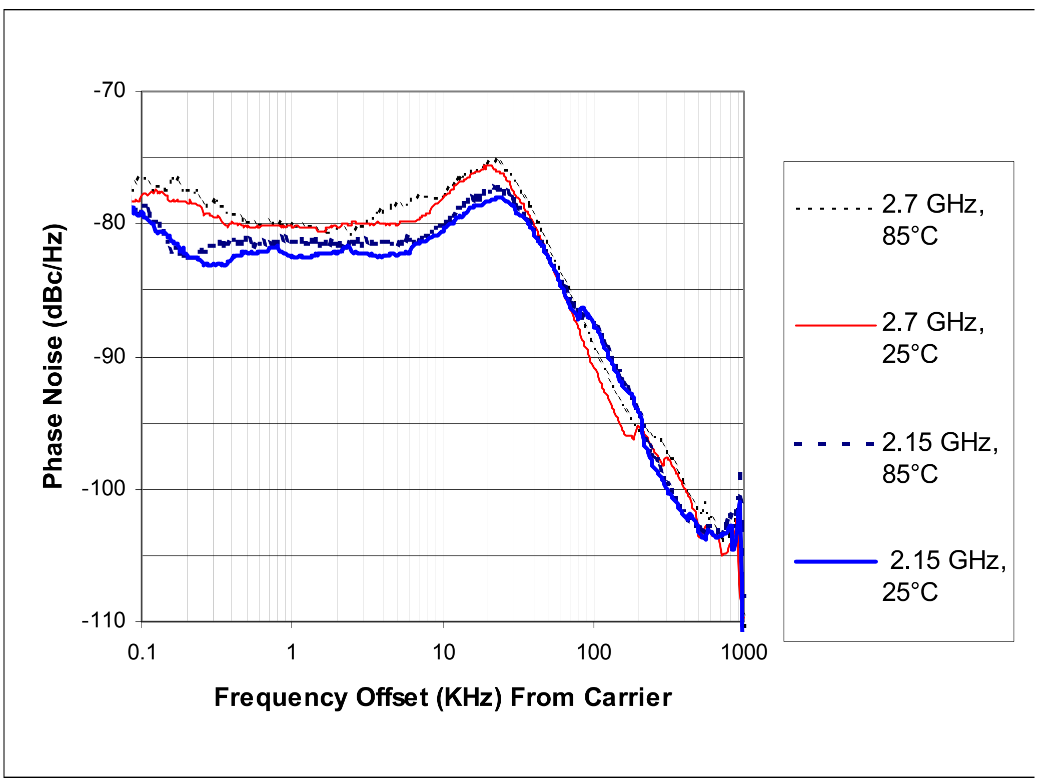


Figure 9. Temperature Effect on Phase Noise of PE3236 and PE9601 at f_c =2.5 MHz

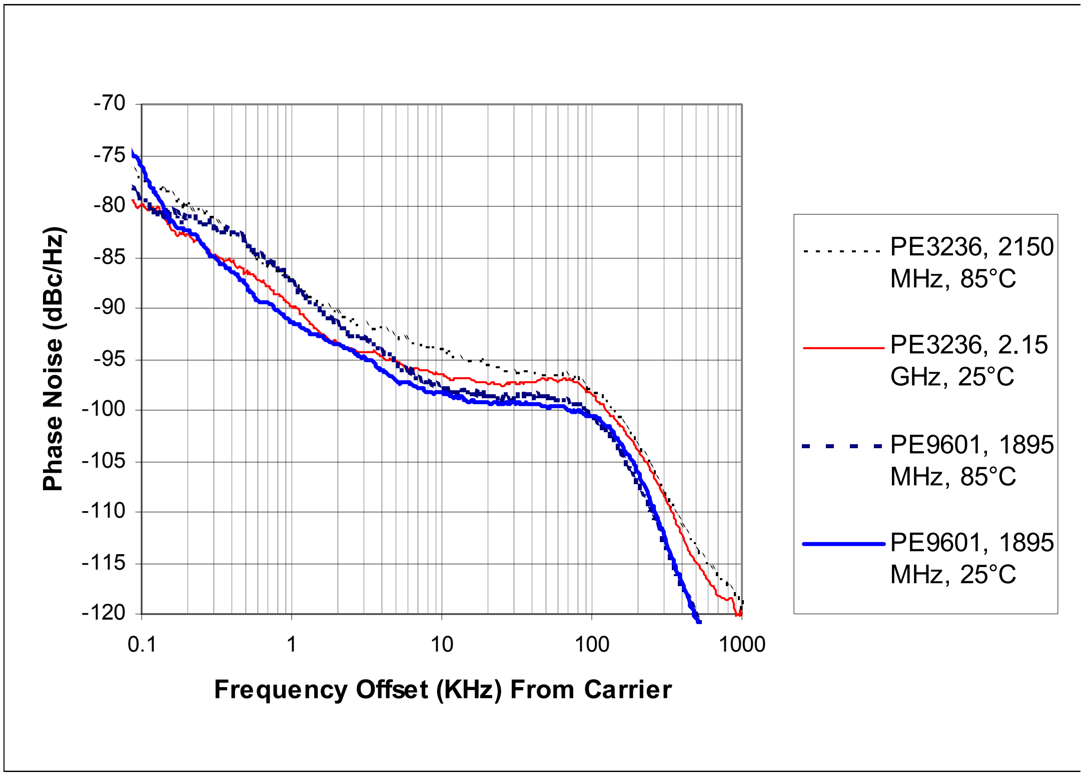


Figure 10. Temperature Effect on Phase Noise of Q3236 at f_c =2.5 MHz

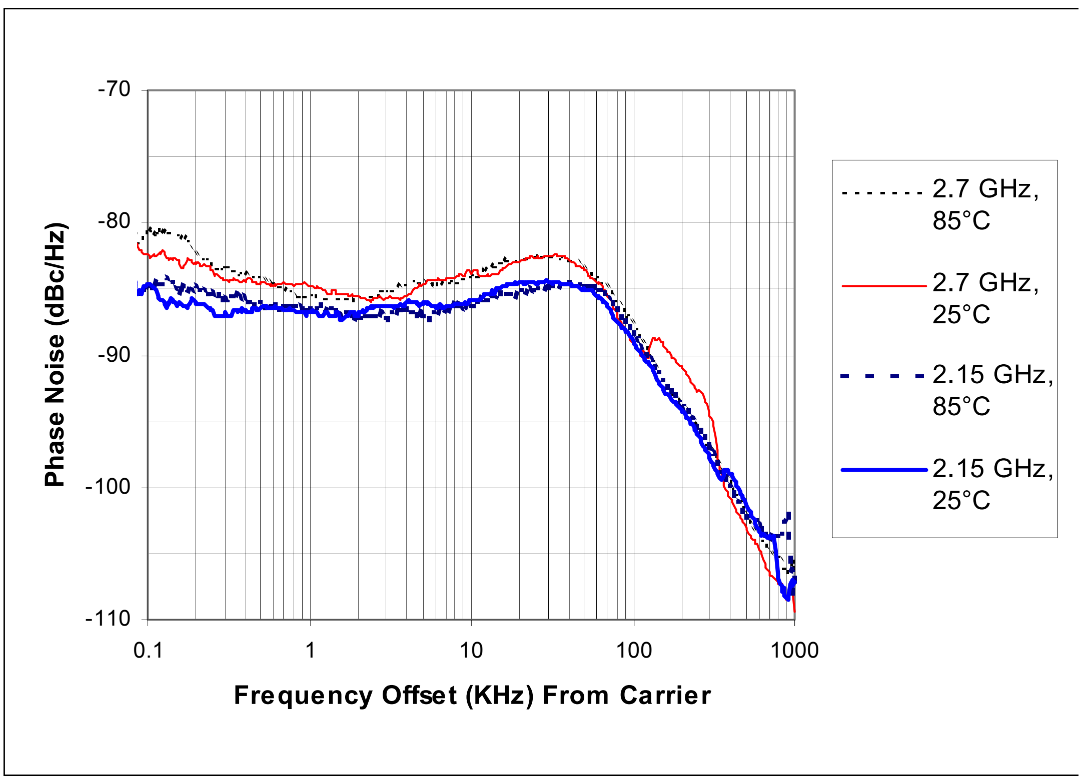


Figure 11. Temperature Effect on Phase Noise of PE3236 and PE9601 at f_c =5 MHz

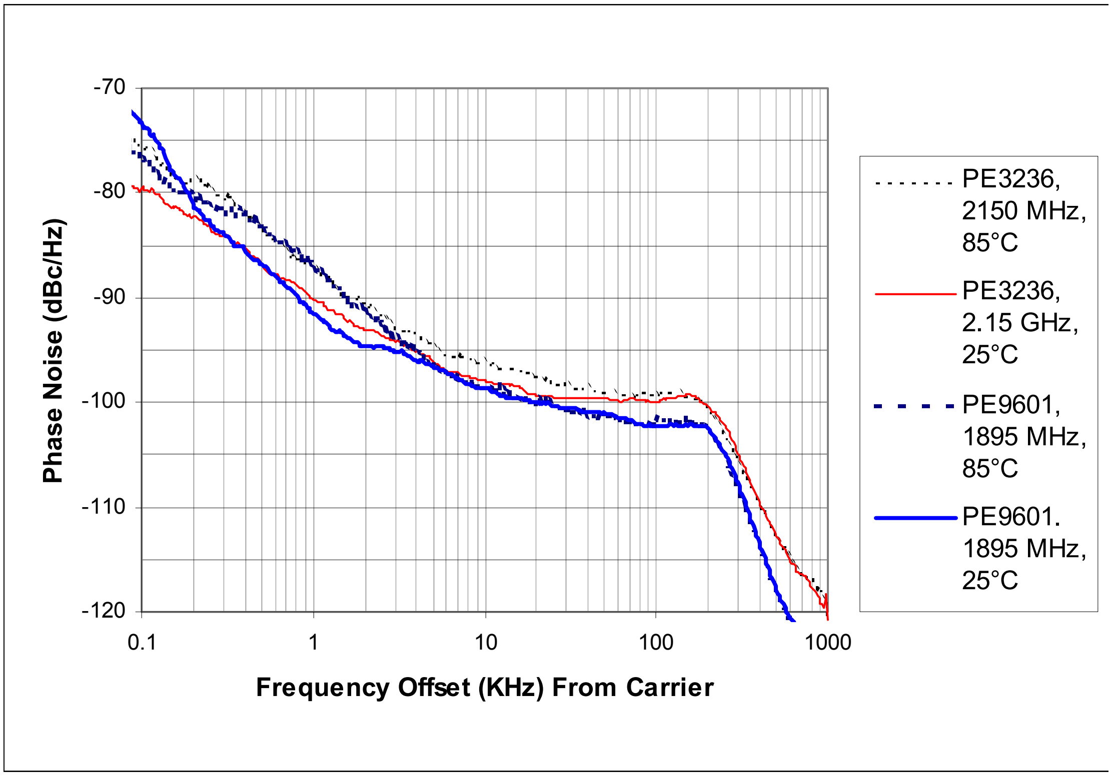
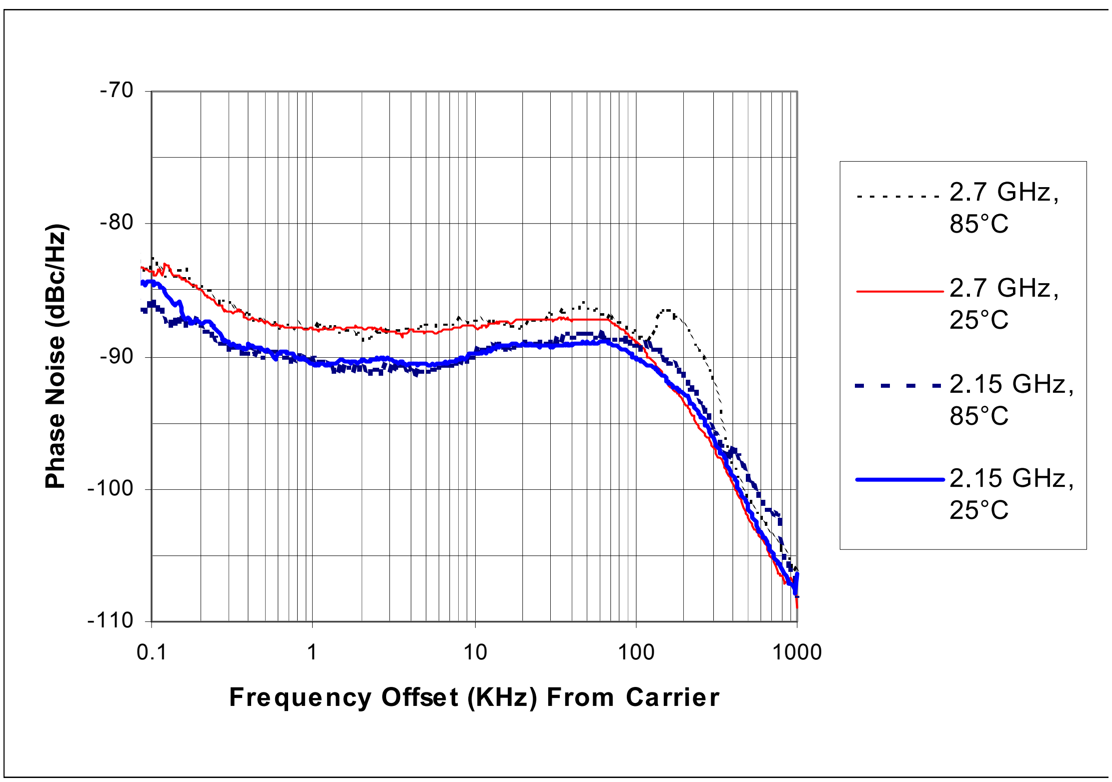


Figure 12. Temperature Effect of Phase Noise of Q3236 at f_c =5 MHz



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