# APPLICATION NOTE

## AN1890

# Using the SA7025 (RevA) and SA8025A for narrow band systems

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1997 Aug 20

Philips
Semiconductors

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## INTRODUCTION

The SA7025 (RevA) and SA8025A are improved versions of the SA7025 and SA8025 suitable for narrow band systems like the America Digital Cellular System (IS-54) and Japan Personal Digital Cellular System (PDC). The new design improves the performance of the fractional spurs compensation, which is a by-product of the fractional-N divider. Complete design procedure and performance measurements on both the SA7025 (RevA) and SA8025A are included in this document.

The basics of the fractional-N PLL frequency synthesizers can be found in Philips Semiconductors application note AN1891, “SA8025 Fractional-N synthesizer for 2GHz band applications”. AN1891 can be used in conjunction with this document for designing-in the SA7025, SA8025, SA7025 (RevA), and SA8025A.

## Fractional Spurs Compensation

The fractional-N divide ratio is achieved by changing the divide ratio between N and N+1. In lock condition, this technique will introduce an instantaneous phase error in the phase detector. This causes the VCO to generate unwanted spurs at the offset of the fractions of the comparison frequency.

On the new SA7025 (RevA) and SA8025A, the fractional compensation circuitry was re-designed to achieve better performance. Three improvements can be found on the SA7025 (RevA) and SA8025A due to this modification:

1. The CN range is much tighter. The CN values are the binary current setting factor for the charge pumps. These values may be varied across the desired frequency band (e.g. 25MHz) for fractional spurs compensation. For the SA7025/SA8025, the CN range is greater than 50 for narrow band systems (e.g. channel spacing, $f_{CH}$=30kHz). For the new SA7025 (RevA)/SA8025A, this range is much tighter and a **fixed** CN value is usually good enough for all synthesized frequencies on the SA7025 (RevA)/SA8025A.
2. A more accurate calculation of the resistor RF, which determines the amount of fractional compensation current. Eq. 1 gives an approximate value of $I_{RF}$. RF can be calculated using Eq. 2, which is the same as the one for calculating resistor RN. To obtain an optimum performance, the CN value can be adjusted accordingly.

$$I_{RF} = \frac{3 \cdot I_{RN} \cdot CN \cdot f_{XTAL}}{Q \cdot f_{VCO}} \qquad (1)$$

$$RF = \frac{V_{DDA} - 0.9 - 150 \cdot \sqrt{I_{RF}}}{I_{RF}} \qquad (2)$$

3. Better performance over temperature. The variation of fractional spurs was minimized over the rated temperature range (-40 to +80°C).

## Compatibility Between the SA7025/SA8025 and SA7025 (RevA)/SA8025A

The SA7025/SA8025 and SA7025 (RevA)/SA8025A are pin-to-pin compatible and have exactly the same performance except for the fractional compensation section. When replacing the SA7025/SA8025 with SA7025 (RevA)/SA8025A, new values for CN and resistor RF may have to be used. Users should calculate resistor RF using Eq. 1 and 2 and experiment with it on the bench with the new RF value.

## PLL Design Equations

$\delta$ : final frequency resolution after settling.

$$\delta = \frac{\text{frequency error after settling}}{\text{switching step}} \qquad (3)$$

$t_{SW}$ : switching time (sec)
$f_N$ : natural frequency of the 2nd order system(Hz) , $\omega_N = 2\pi f_N$ (rad/s)
N : total divide ratio
$\xi$: : damping factor of the 2nd order system. Typical value is 0.707.
$K_{VCO}$: VCO gain (Hz/V) or $2\pi$ * VCO gain (rad/V)
$K_\phi$ : phase detector gain = $I_{CP}/2\pi$ (A/rad)

$$\omega_N = \frac{-\ln\left(\delta \cdot \sqrt{1 - \xi^2}\right)}{\xi \cdot t_{SW}} \qquad (4)$$

$$C_1 = \frac{K_\phi \cdot K_{VCO}}{N\omega_N{}^2} \qquad (5)$$

$$R_1 = 2 \cdot \xi \left(\frac{N}{K_\phi \cdot K_{VCO} \cdot C_1}\right)^{0.5} \qquad (6)$$

$$C_2 \le \frac{C_1}{10} \qquad (7)$$

$$\omega = \frac{1}{C_3 \cdot R_2} \qquad (8)$$

$\omega$ should be at least 10 times larger than $\omega_N$

Note: The unit of the factor $K_\phi \cdot K_{VCO}$ is unity when all the variables are expressed in radians. Therefore, designers can simply multiply the charge pump output current ($I_{CP}$) with the VCO gain in Hz/V to obtain this factor.

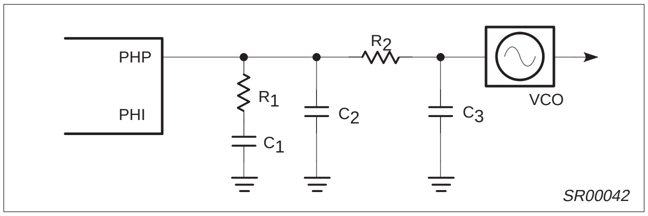


**Figure 1. 3-Poles RC Lowpass Loop Filter**

## SA7025 (RevA) Design Example

This section shows a design example using the SA7025 (RevA) for the IS-54. The system parameters are as follows:

VCO frequency ($f_{VCO}$) = 913 to 938MHz
Channel spacing ($f_{CH}$) = 30kHz
Comparison frequency ($f_{COMP}$) = 8 * 30 kHz = 240kHz
Switching time ($t_{SW}$) = 1.5ms
Switching step = 25MHz
Frequency error = within 1 kHz
VCO gain ($K_{VCO}$) = 12MHz/V (measured), Murata MQE001-926
Reference Crystal ($f_{REF}$) = 14.4MHz

## 1. Determine total divide ratio N

To synthesize channels from 913 to 938MHz with $f_{COMP}$=240kHz, N should be between 3804 and 3908. For the same loop components, a larger value of N yields lower natural frequency ($f_N$). So, jumping from high-end to low-end (larger N) is slower than from low-end to high-end (smaller N). To ensure the same switching time from both directions, we use N=3908 for the worst case.

## 2. Determine $\omega_N$

Using Eq. 3 $$\delta = \frac{1000}{25e6} = 0.04e\text{-}3$$

Pick $\xi = 0.707$ and use $t_{SW} = 1.5$ms.

Using Eq. 4 $$\omega_N = \frac{-\ln(0.04e\text{-}3 \cdot 0.707)}{0.707 \cdot 1500e\text{-}6} = 9830$$

## 3. Determine RN and $I_{CP}$

Pick RN = 51 kΩ and CN = 200. $I_{RN}$ becomes 58µA when $V_{DDA}$=5V.

Using the PHP charge pump current equation

$$I_{CP} = 200\left(\frac{58e\text{-}6}{32}\right) = 363\mu A$$

## 4. Determine $R_1$, $C_1$, and $C_2$

Using Eq. 5 with the 2π's from $K_{VCO}$ (rad/V) and $K_\phi$ (A/rad) cancel out

$$C_1 = 12e6\left(\frac{363e\text{-}6}{3908 \cdot 9830^2}\right) = 11.5nF$$

Using Eq. 6 $$R_1 = 2 \cdot 0.707 \cdot \left(\frac{3908}{12e6 \cdot 363e\text{-}6 \cdot 11.5e\text{-}9}\right)^{0.5} = 13k\Omega$$

Using Eq. 7 $$C_2 = \frac{11.5e\text{-}9}{10} = 1.15nF$$

## 5. Determine $R_2$ and $C_3$

$R_2$ and $C_3$ can help attenuate the comparison spurs at 240kHz offset.

Using Eq. 8 $$\omega = \frac{1}{R_2 \cdot C_3} \geq 10\omega_N$$

## 6. Determine RF

Crystal frequency ($f_{XTAL}$) = 14.4MHz
Mid VCO frequency ($f_{VCO}$) = 926MHz
Q (fractional modulus) = 8
Using Eq. 1 and Eq. 2

$$I_{RF} = \frac{3 \cdot 58e\text{-}6 \cdot 200 \cdot 14.4e6}{8 \cdot 926e6} = 67.65\mu A$$

$$RF = \frac{5 - 0.9 - 150 \cdot \sqrt{67.65e\text{-}6}}{8 \cdot 926e6} = 43k\Omega$$

A minor adjustment of CN maybe required if optimum fractional spurs suppression is needed across the 25MHz band. The experimental results yielded the best spurious suppression at a value of RF=47kΩ.

Component values used on the SA7025(Rev A) demo board:
C31 = 10 nF
R23 = 13 kΩ
C32 = 1 nF
R24 = 100 kΩ
C33 = 18 pF
R21 = 47 kΩ (RF)
R22 = 51 kΩ (RN)
CN = 200
Strobe width = 260µs

## Measurement Results of the SA7025 (RevA)

Figure 2 shows the measured close-in noise at 940.05MHz. The phase noise at 1kHz carrier offset is -49.4 - 10 * log (100) = -69.4 dBc/Hz. Fractional spurs performance is shown in Figures 3 to 6. The worst case spurs occur when NF=1 and NF=7 are less than -60dBc. Spurs at the alternate channel, the 60kHz carrier offset required by the IS-54, are totally suppressed. Figures 7 and 8 show the measured switching times. These results show that the PLL can jump a 25MHz step in less than 1.5ms from both directions.

Table 1 shows the difference in performance between the SA7025 and SA7025 (RevA) using the same demoboard. Unless otherwise mentioned, CN=200, RN=51kΩ, RF=47kΩ.

## Speed-up Design for Achieving Better Close-in Noise

Better close-in noise can be achieved at the expense of operational current. The PHP charge pumps on the SA7025 (RevA) and SA8025A are both capable of delivering more than 1.5mA in the speed-up mode. To stay in this mode, the STROBE signal has to be kept high after the programming word 'A' is sent. The CL register sets the amount of charge pump current which is either 3 times (CL=0), 5 times (CL=1), or 9 times (CL=2) higher than the current in normal mode. Assume that we want to modify the previous design and use speed-up with CL=1. This implies that the charge pump output current becomes 5*363µA = 1.8mA. In order to maintain the same natural frequency, the value of C31 and C32 is increased by a factor of 5 and R23 is decreased by the same factor of 5. Therefore, the new values used on the demo board are:

C31 = 100nF in parallel with 100nF
C32 = 4.7nF
R23 = 2.4kΩ

Figure 9 compares the close-in phase noise of the two designs with the same natural frequency. The bottom trace has a 4dB improvement in the close-in noise when speed-up mode (higher current) is used. Since the phase noise beyond the loop bandwidth is solely determined by the VCO phase noise, two traces start to merge together at about 5kHz offset.

## SA8025A Design Example

This section shows a design example using the SA8025A for the Personal Digital System (PDC1500), a narrow band system. The design procedure is the same as the previous section. The system parameters are as follows:

VCO frequency ($f_{VCO}$) = 1607 to 1631 MHz
Channel spacing ($f_{CH}$) = 25kHz
Comparison frequency ($f_{COMP}$) = 8 * 25kHz = 200kHz
Switching time ($t_{SW}$) = 1.5ms
Switching step = 24MHz
Frequency error = within 1kHz
VCO gain ($K_{VCO}$) = 24 MHz/V (measured), Murata MQE060-1619
Reference Crystal ($f_{REF}$) = 19.2MHz

### Table 1. Performance Comparison: SA7025 to SA7025 (Rev A)

| | SA7025 | SA7025 (Rev A) | Figure |
|---|---|---|---|
| Fractional spurs (dBc) @30kHz, VCO=912.99MHz | -57.6<br>(CN=200, RF=2MΩ) | -63.6 | 3 |
| Fractional spurs (dBc) @60kHz, VCO=912.99MHz | not present<br>(CN=200, RF=2MΩ) | not present | 3 |
| Fractional spurs (dBc) @30kHz, VCO=939.87MHz | -63.5<br>(CN=100, RF=2MΩ) | -63.9 | 5 |
| Fractional spurs (dBc) @60kHz, VCO=939.87MHz | not present<br>(CN=100, RF=2MΩ) | not present | 5 |
| Close-in noise (dBc/Hz) @1kHz, VCO=1631.025MHz | -69 | -69 | 2 |
| $I_{TOTAL}$ (mA) for the demo board | 21.2 | 21.2 | |
| Switching time (ms) | <1.5 | <1.5 | 7, 8 |

## 1. Determine total divide ratio N

$$N = \frac{1631\text{MHz}}{200\text{kHz}} = 8155$$

## 2. Determine $\omega_N$

Using Eq. 3

$$\delta = \frac{1000}{24e6} = 0.042e\text{-}3$$

Pick $\xi = 0.707$ and use $t_{SW} = 1.5$ms.

Using Eq. 4

$$\omega_N = \frac{-\ln\,(0.042e\text{-}3 \cdot 0.707)}{0.707 \cdot 1500e\text{-}6} = 9830$$

## 3. Determine $R_N$ and $I_{CP}$

Pick RN = 51kΩ and CN = 200. $I_{RN}$ becomes 58µA when $V_{DDA}$=5V.

Using the PHP charge pump current equation

$$I_{CP} = 200\left(\frac{58e\text{-}6}{32}\right) = 363\mu A$$

## 4. Determine $R_1$, $C_1$, and $C_2$

Using Eq. 5

$$C_1 = 24e6\left(\frac{363e\text{-}6}{8155 \cdot 9830^2}\right) = 11.1\text{nF}$$

Using Eq. 6

$$R_1 = 2 \cdot 0.707 \cdot \sqrt{\left(\frac{8155}{24e6 \cdot 363e\text{-}6 \cdot 11.1e\text{-}9}\right)} = 13\text{k}\Omega$$

Using Eq. 7

$$C_2 = \frac{11.1e\text{-}9}{10} = 1.1\text{nF}$$

## 5. Determine $R_2$ and $C_3$

$R_2$ and $C_3$ can help attenuate the comparison spurs at 200kHz offset.

Using Eq. 8

$$\omega = \frac{1}{R_2 \cdot C_3} \geq 10\omega_N$$

Pick $R_2$ = 360kΩ, then $C_3$ = 18pF.

## 6. Determine RF

Crystal frequency ($f_{XTAL}$) = 19.2MHz
Mid VCO frequency ($f_{VCO}$) = 1619MHz
Q (fractional modulus) = 8
Using Eq. 1 and Eq. 2

$$I_{RF} = \frac{3 \cdot 58e\text{-}6 \cdot 200 \cdot 14.4e6}{8 \cdot 926e6} = 67.65\mu A$$

$$RF = \frac{5 - 0.9 - 150 \cdot \sqrt{67.65e\text{-}6}}{8 \cdot 926e6} = 43\text{k}\Omega$$

Minor adjustment of CN is required if optimum fractional spurs suppression is needed.

Component values used on the demo board:
C31 = 10nF
R23 = 13kΩ
C32 = 1nF
R24 = 360kΩ
C33 = 18pF
R21 = 56kΩ (RF)
R22 = 51kΩ (RN)
CN = 200
Strobe width = 260µs

## Measurement Results of the SA8025A

Close-in phase noise spectrum is shown in the Figure 10. At 1kHz carrier offset, the phase noise is -45.3 - 10*log (100) = -65.3 dBc/Hz. The 3dB loop bandwidth is 3kHz, which is about twice as much as the loop natural frequency ($f_N$). Fractional spurs performance is shown in Figure 11 to 14. Worst case spurs when NF=1 and NF=7 for the low and high bands are all less than -59dBc. Spurs at 50kHz carrier offset, the alternate channel for PDC1500, were totally suppressed. Switching time measurements are shown in Figure 15 and 16. The PLL can reach the desired frequency for a 24MHz jump in less than 1.5ms from both directions.

Table 2 shows the difference in performance between the SA8025 and SA8025A using the same demoboard. Unless otherwise mentioned, CN=200, RN=51kΩ, RF=56kΩ.

## Table 2. Performance Comparison: SA8025 to SA8025A

| | SA8025 | SA8025A | Figure |
|---|---|---|---|
| Fractional spurs (dBc) @25kHz, VCO=1606.625MHz | -41.5<br>(CN=250, RF=560kΩ) | -60.6 | 11 |
| Fractional spurs (dBc) @50kHz, VCO=1606.625MHz | not present<br>(CN=250, RF=560kΩ) | not present | 11 |
| Fractional spurs (dBc) @25kHz, VCO=1631.025MHz | -59.0<br>(CN=200, RF=560kΩ) | -59.5 | 13 |
| Fractional spurs (dBc) @50kHz, VCO=1631.025MHz | not present<br>(CN=200, RF=560kΩ) | not present | 13 |
| Close-in noise (dBc/Hz) @1kHz, VCO=1631.025MHz | -65 | -65 | 10 |
| $I_{TOTAL}$ (mA) for the demo board | 28.3 | 28.3 | |
| Switching time (ms) | <1.5 | <1.5 | 15, 16 |

## SA8025A for the PHS System

Philips Semiconductors applications note AN1891, “Using the SA8025 in 2GHz band applications”, shows a design for the PHS system based on the SA8025. If the SA8025A is used in the same design, only RF needs to be changed.

Crystal frequency ($f_{XTAL}$) = 19.2MHz
Mid VCO frequency ($f_{VCO}$) = 1665MHz
Q (fractional modulus) = 8
$I_{RN}$ = 80µA
CN = 100
Using Eq. 1 and Eq. 2

$$I_{RF} = \frac{3 \cdot 80e\text{-}6 \cdot 100 \cdot 19.2e6}{8 \cdot 1865e6} = 34.6\mu A$$

$$RF = \frac{3 - 0.9 - 150 \cdot \sqrt{34.6e\text{-}6}}{34.6e\text{-}6} = 35.2k\Omega$$

On the demo board, RF=36kΩ was used. The measured fractional spurs when NF=1 and NF=7 are both better than -70dBc.

Table 3 summarizes the components change for the SA7025/SA8025 and the SA7025 (RevA)/SA8025A demo boards.

## Table 3. Summary of Component Changes

| Component | SA7025 | SA7025 (Rev A) | SA8025 | SA8025A |
|---|---|---|---|---|
| R21 | 560kΩ | 47kΩ | 560kΩ | 36kΩ |
| R22 | 33kΩ | 51kΩ | 10kΩ | 10kΩ |
| R23 | 24kΩ | 13kΩ | 10kΩ | 10kΩ |
| R24 | 22kΩ | 100kΩ | 18kΩ | 18kΩ |
| R25 | 22kΩ | 0Ω | 0Ω | 0Ω |
| C30 | 330pF | NL | NL | NL |
| C31 | 3.3nF | 10nF | 3.9nF | 3.9nF |
| C32 | 220pF | 1nF | 390pF | 390pF |
| C33 | 220pF | 18pF | 150pF | 150pF |
| C34 | 100pF | NL | NL | NL |

NL = Not Loaded

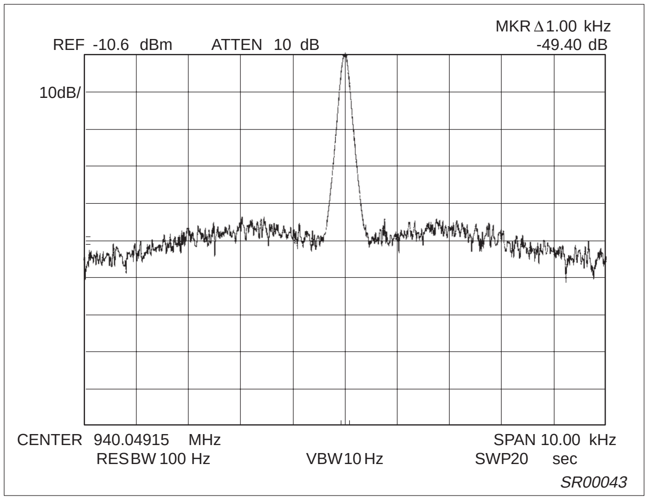


Figure 2. Close-In Noise at 940.05MHz

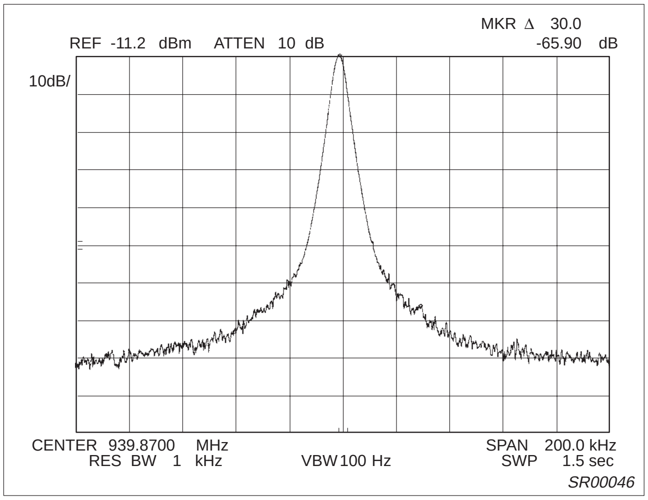


Figure 5. Fractional Spurs, ($f_{VCO}$ = 939.87MHz; NF = 1)

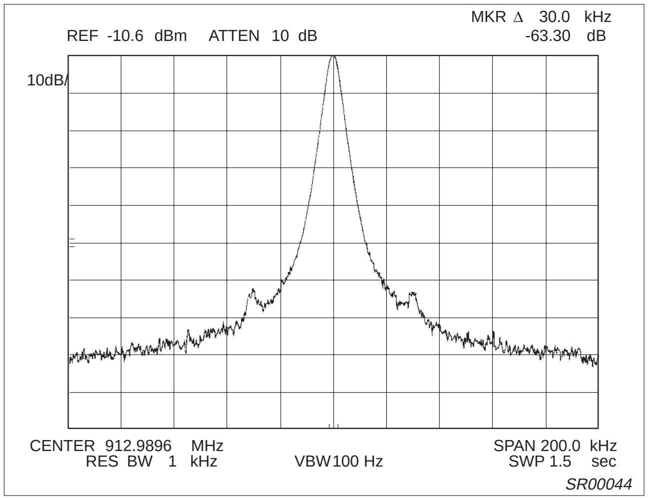


Figure 3. Fractional Spurs, ($f_{VCO}$ = 912.99MHz; NF = 1)

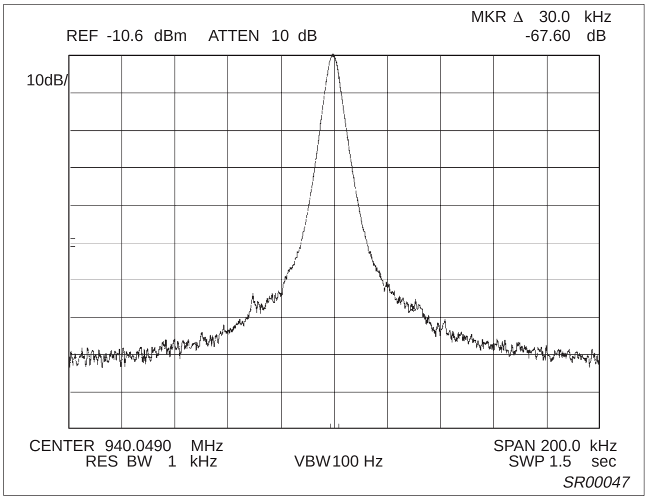


Figure 6. Fractional Spurs, ($f_{VCO}$ = 940.05MHz; NF = 7)

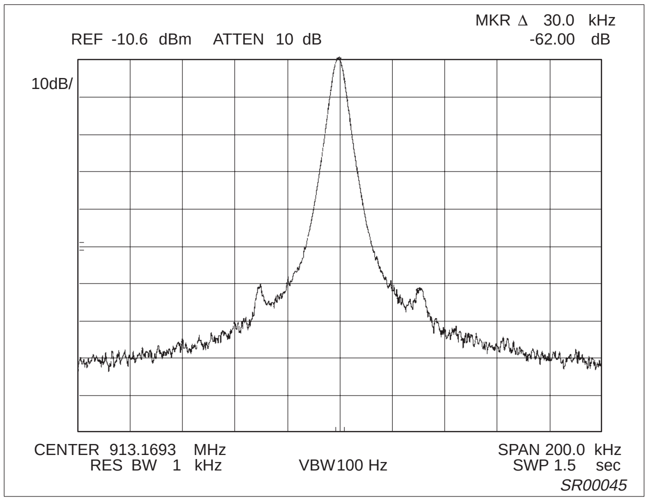


Figure 4. Fractional Spurs, ($f_{VCO}$ = 913.17MHz; NF = 7)

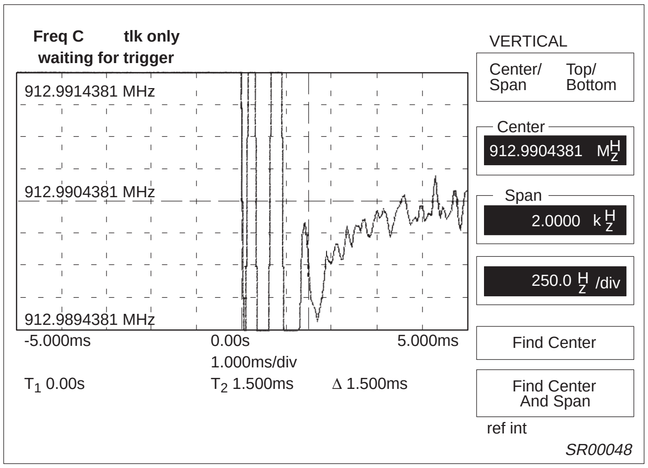


Figure 7. Switching Time
(939.87 to 912.99MHz Step to Within 1kHz)

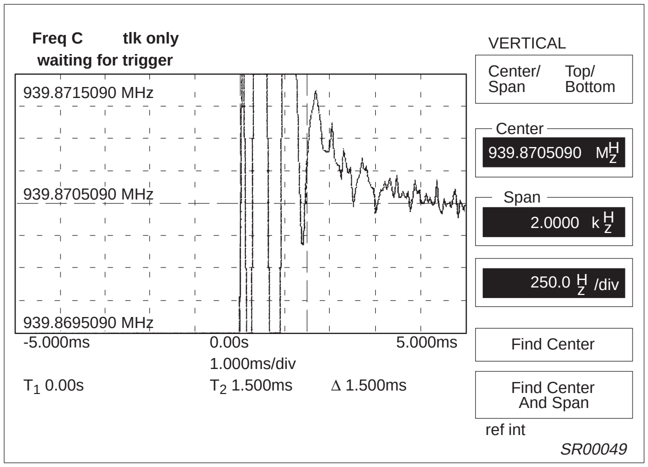


Figure 8. Switching Time
(912.99 to 939.87MHz Step to Within 1kHz)

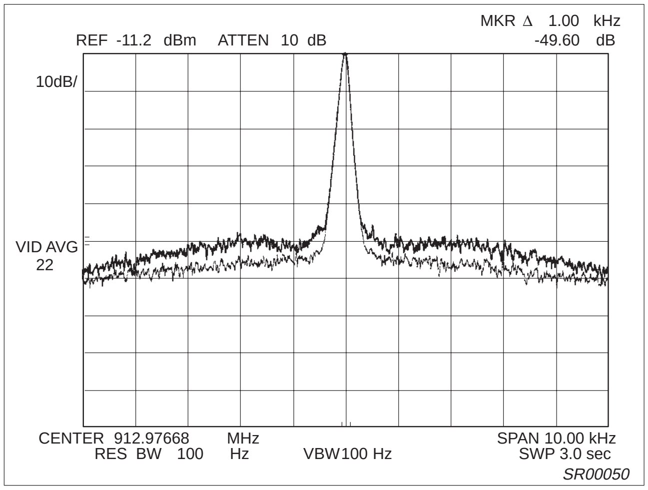


Figure 9. Close-In Phase Noise When CL = 1

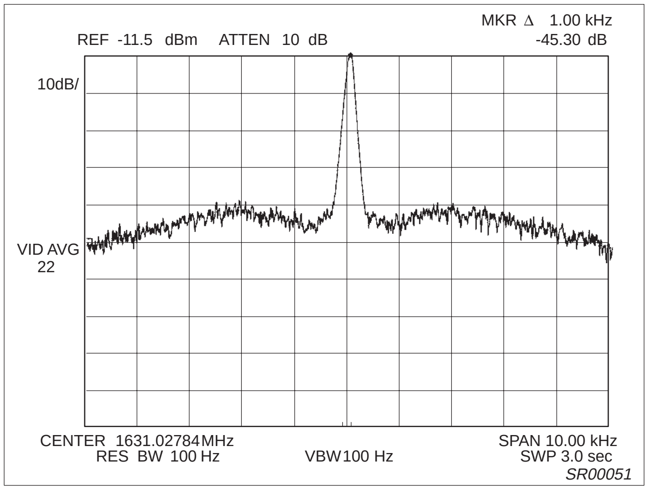


Figure 10. Close-In Phase Noise at 1631.025MHz

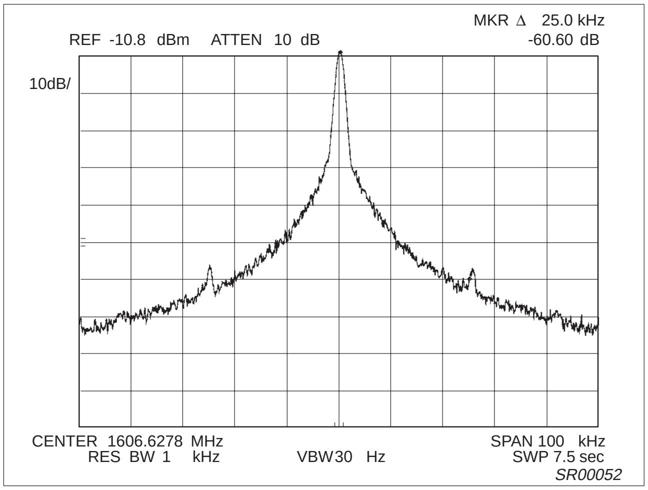


Figure 11. Fractional Spurs, ($f_{VCO}$ = 1606.625MHz; NF = 1)

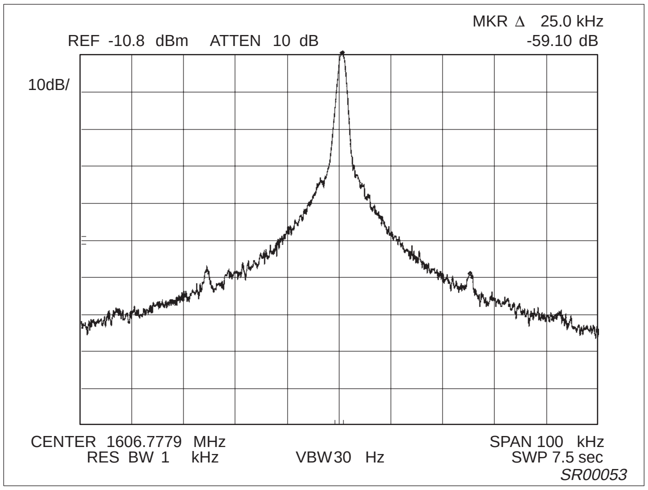


Figure 12. Fractional Spurs, ($f_{VCO}$ = 1606.775MHz; NF = 7)

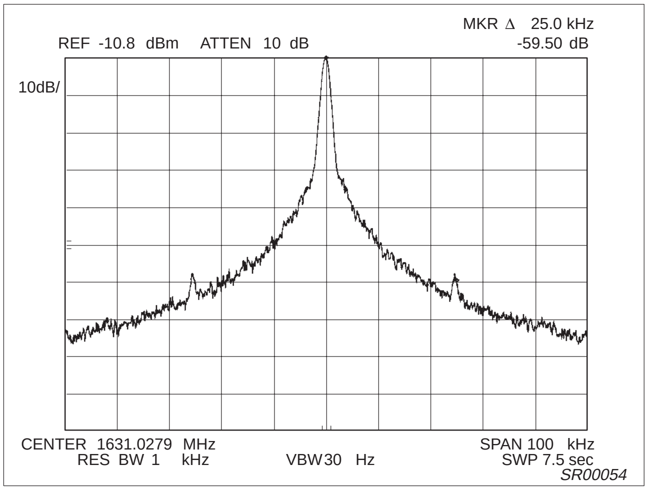


Figure 13. Fractional Spurs, ($f_{VCO}$ = 1606.775MHz; NF = 7)

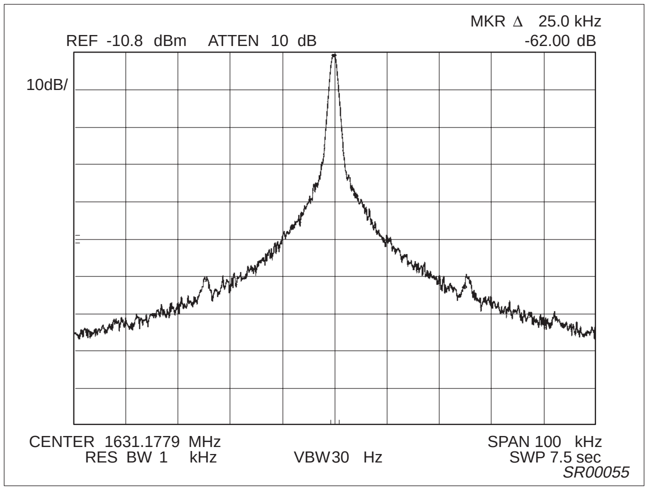


Figure 14. Fractional Spurs, ($f_{VCO}$ = 1631.175MHz; NF = 7)

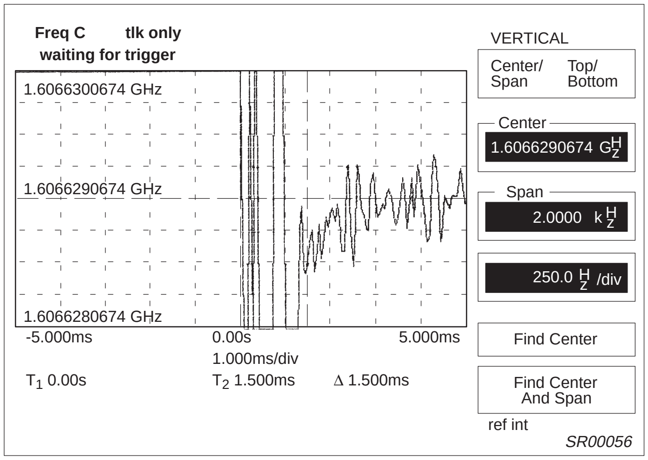


Figure 15. Switching Time
(1631.025 to 1606.625MHz Step to Within 1kHz)

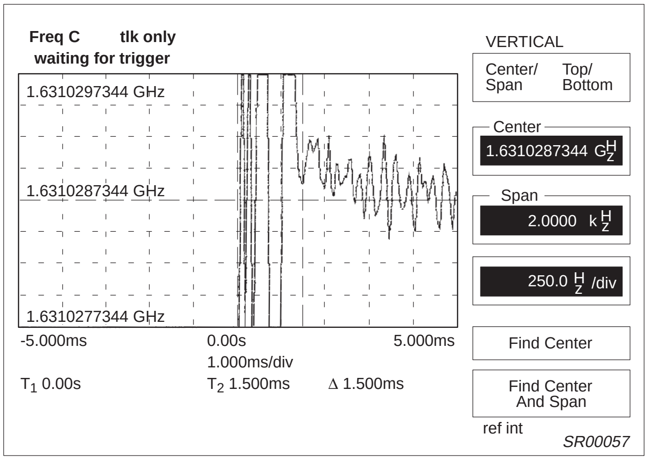


Figure 16. Switching Time
(1606.625 to 1631.025MHz Step to Within 1kHz)

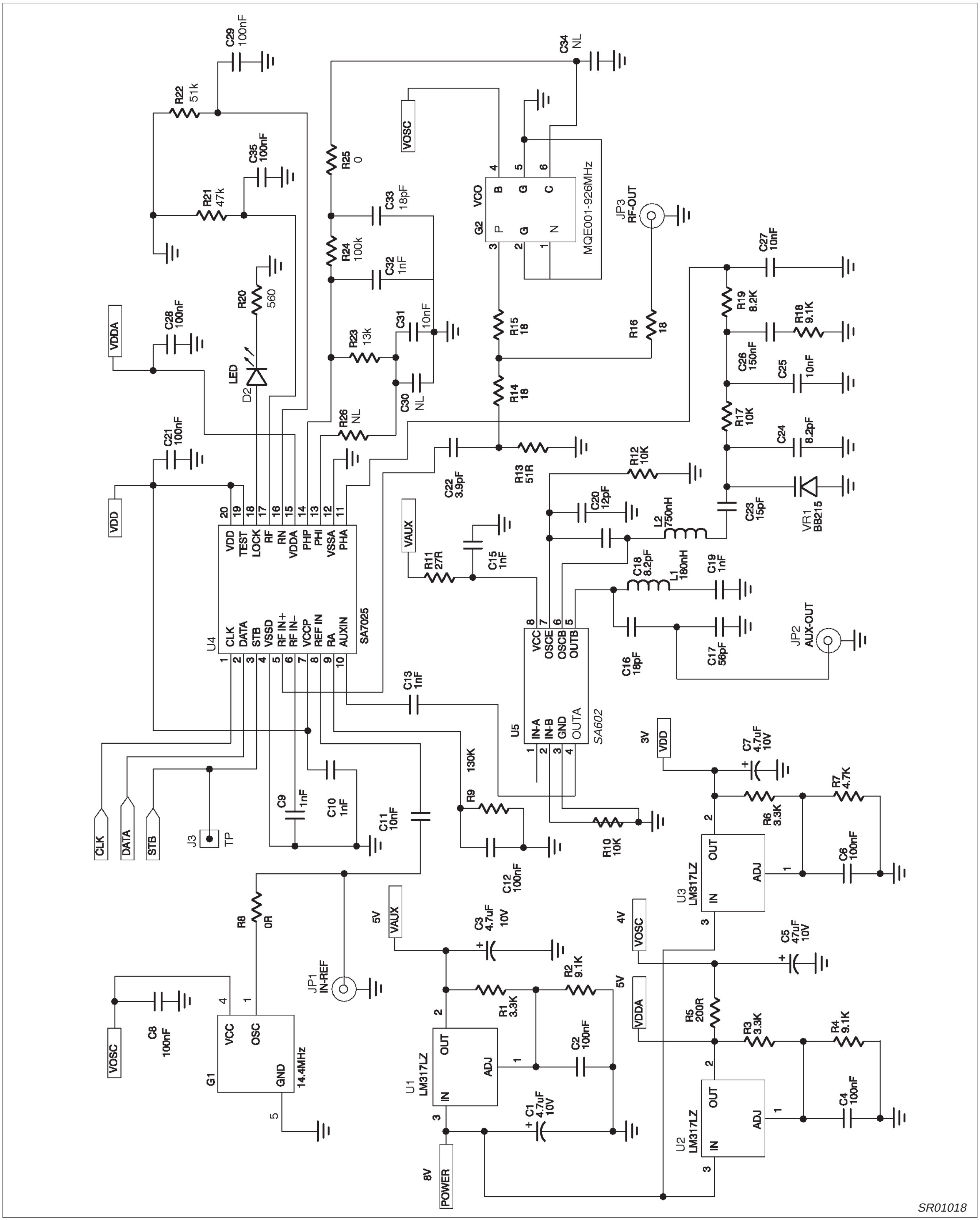


**Figure 17. SA7025DK Application Circuit**

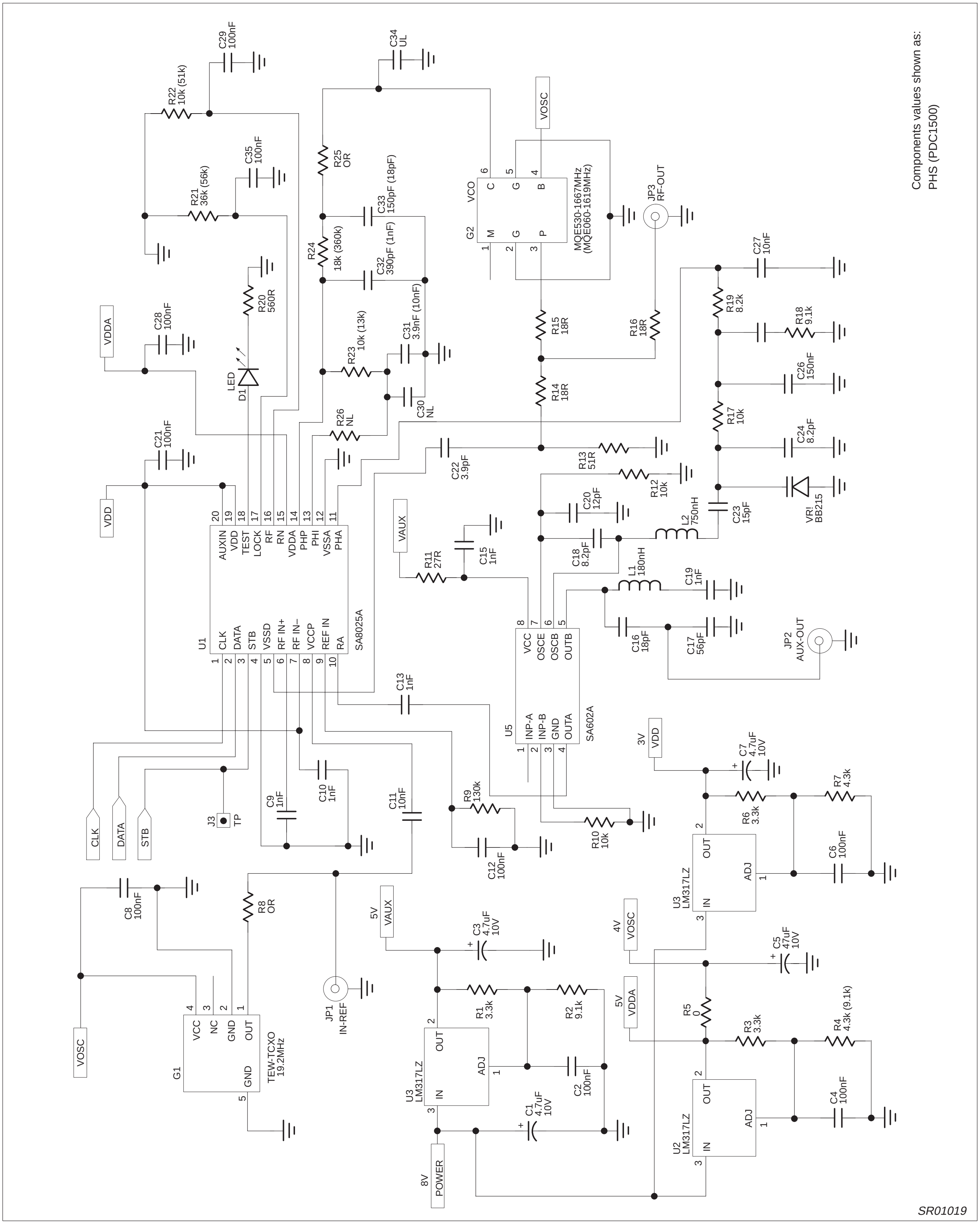
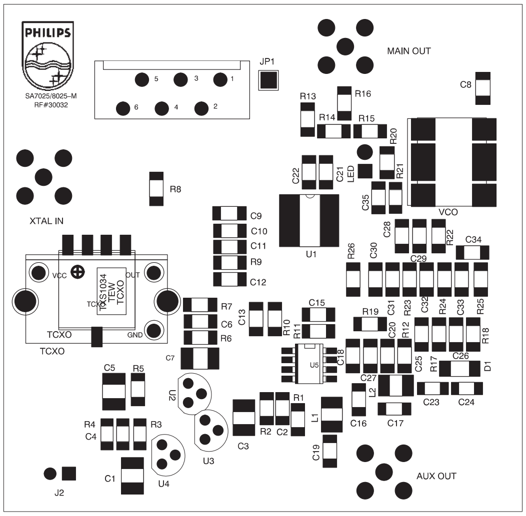
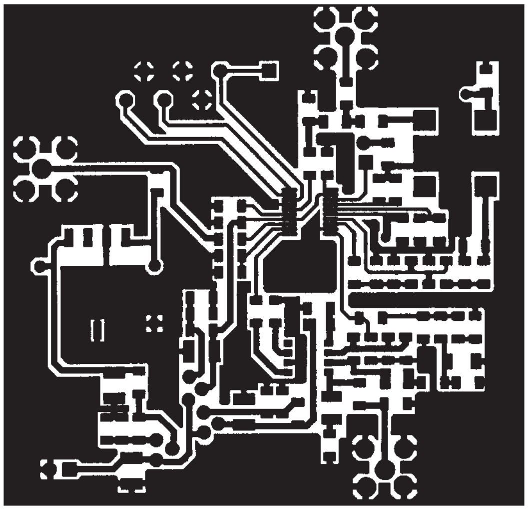


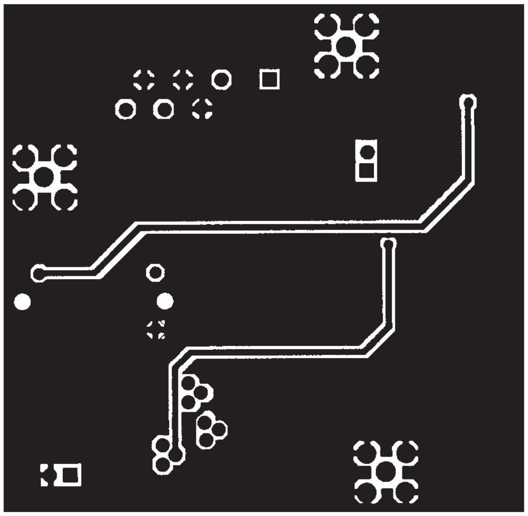
Figure 18. SA8025ADK Application Circuit



**TOP SILK SCREEN**



**TOP VIEW**



**BOTTOM VIEW**

*SR01020*

Figure 19. SA8025ADK Demoboard Layout (NOT ACTUAL SIZE)

### Table 4. Customer Application Component List for SA7025DK

| Qty. | Value | Volt | Part Reference | Part Description | Vendor | Mfg | Part Number |
|---|---|---|---|---|---|---|---|
| **Surface Mount Capacitors** | | | | | | | |
| 1 | 3.9pF | 50V | C22 | Cap. cer. 1206 NPO ±0.5pF | Garrett | Rohm | MCH315A3R9CK |
| 2 | 8.2pF | 50V | C24, C18 | Cap. cer. 1206 NPO ±0.5pF | Garrett | Rohm | MCH315A8R2CK |
| 1 | 12pF | 50V | C20 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A120JK |
| 1 | 15pF | 50V | C23 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A150JK |
| 2 | 18pF | 50V | C16, C33 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A180JK |
| 1 | 56pF | 50V | C17 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A560JK |
| 6 | 1000pF | 50V | C9, C10, C13, C15, C19, C32 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315A102JP |
| 4 | 0.01µF | 50V | C11, C25, C27, C31 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C103KK |
| 9 | 0.1µF | 50V | C2, C4, C6, C8, C12, C21, C28, C29, C35 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C104KP |
| 1 | 0.15µF | 16V | C26 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C154KP |
| 4 | 4.7µF | 10V | C1, C3, C5, C7 | Tant. chip cap. A 3216 ±10% | Garrett | Philips | 49MC475B010KOAS |
| **Surface Mount Resistors** | | | | | | | |
| 2 | 0Ω | 50V | R8, R25 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW000E |
| 3 | 18Ω | 50V | R14, R15, R16 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW180E |
| 1 | 27Ω | 50V | R11 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW270E |
| 1 | 51Ω | 50V | R13 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW510E |
| 1 | 100Ω | 50V | R5 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW101E |
| 1 | 560Ω | 50V | R20 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW561E |
| 3 | 3.3kΩ | 50V | R1, R3, R6 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW332E |
| 1 | 4.7kΩ | 50V | R7 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW472E |
| 1 | 8.2kΩ | 50V | R19 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW822E |
| 3 | 9.1kΩ | 50V | R2, R18, R4 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW912E |
| 3 | 10kΩ | 50V | R10, R12, R17 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW103E |
| 1 | 13kΩ | 50V | R23 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW133E |
| 1 | 47kΩ | 50V | R21 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW473E |
| 1 | 51kΩ | 50V | R22 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW513E |
| 1 | 100kΩ | 50V | R24 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW104E |
| 1 | 130kΩ | 50V | R9 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW134E |
| 1 | 560kΩ | 50V | R21 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW564E |
| **Surface Mount Diodes** | | | | | | | |
| 1 | | | VR1 (Varactor) | Variable capacitance SMD diode | Digikey | Philips | BB215 |
| 1 | | | D1 | SM Led | Digikey | | |
| **Surface Mount Inductors** | | | | | | | |
| 1 | 0.18µH | | L1 | Chip inductor 1008 ±10% | Coilcraft | Coilcraft | 1008CS-181XKBB |
| 1 | 0.75µH | | L2 | Chip inductor 1008 ±10% | Coilcraft | Coilcraft | 1008CS-751XKBB |
| **Voltage Regulators** | | | | | | | |
| 3 | 100mA | | U1, U2, U3 | Voltage regulator | Digikey | National | LM317LZ |
| **TCXO** | | | | | | | |
| 1 | 14.4MHz | | G1 | Temp. controlled crystal osc. | TEW | TEW | TXS0924M-14.4MHz |
| **VCO** | | | | | | | |
| 1 | 926MHz | | G2 | Voltage controlled osc. | Murata | Murata Erie | MQE001-926 |
| **Surface Mount Integrated Circuits** | | | | | | | |
| 1 | | | U4 | 1GHz Fractional-N Synthesizer | Philips | Philips | SA7025DK |
| 1 | | | U5 | Double Balanced Mixer Oscillator | Philips | Philips | SA602A |
| **Miscellaneous** | | | | | | | |
| 3 | | | JP1, JP2, JP3 | SMA right angle jack receptacle | Newark | EF Johnson | 142-0701-301 |
| 1 | | | J1 | Male 6-pins connector | STOCKO | STOCKO | MKS1956-6-0-606 |
| 1 | | | J2 | Male 2-pins connector | STOCKO | STOCKO | MKS1851-6-0-202 |
| 1 | | | J3 | Test point | Digikey | 3M | 929647-36 |
| 1 | | | | Printed circuit board | Philips | Philips | SA7025/8025-M |
| **75 Total Parts** | | | | | | | |

**Table 5. Customer Application Component List for SA8025ADK**

| Qty. | Part Value | Volt | Part Reference | Part Description | Vendor | Mfg | Part Number |
|---|---|---|---|---|---|---|---|
| **Surface Mount Capacitors** | | | | | | | |
| 1 | 3.9pF | 50V | C22 | Cap. cer. 1206 NPO ±0.5pF | Garrett | Rohm | MCH315A3R9CK |
| 2 | 8.2pF | 50V | C24, C18 | Cap. cer. 1206 NPO ±0.5pF | Garrett | Rohm | MCH315A8R2CK |
| 1 | 12pF | 50V | C20 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A120JK |
| 1 | 15pF | 50V | C23 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A150JK |
| 1 | 18pF | 50V | C16 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A180JK |
| 1 | 56pF | 50V | C17 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A560JK |
| 1 | 150pF | 50V | C33 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A151JK |
| 1 | 390pF | 50V | C32 | Cap. cer. 1206 NPO ±5% | Garrett | Rohm | MCH315A391JK |
| 5 | 1000pF | 50V | C9, C10, C13, C15, C19 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315A102JP |
| 1 | 3900pF | 50V | C31 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C392KK |
| 3 | 0.01µF | 50V | C11, C25, C27 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C103KK |
| 9 | 0.1µF | 50V | C2, C4, C6, C8, C12, C21, C28, C29, C35 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C104KP |
| 1 | 0.15µF | 16V | C26 | Cap. cer. X7R ±10% | Garrett | Rohm | MCH315C154KP |
| 4 | 4.7µF | 10V | C1, C3, C5, C7 | Tant. chip cap. A 3216 ±10% | Garrett | Philips | 49MC475B010KOAS |
| **Surface Mount Resistors** | | | | | | | |
| 3 | 0Ω | 50V | R5, R8, R25 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW000E |
| 3 | 18Ω | 50V | R14, R15, R16 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW180E |
| 1 | 27Ω | 50V | R11 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW270E |
| 1 | 51Ω | 50V | R13 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW510E |
| 1 | 560Ω | 50V | R20 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW561E |
| 3 | 3.3kΩ | 50V | R1, R3, R6 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW332E |
| 2 | 4.3kΩ | 50V | R4, R7 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW432E |
| 1 | 8.2kΩ | 50V | R19 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW822E |
| 2 | 9.1kΩ | 50V | R2, R18 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW912E |
| 5 | 10kΩ | 50V | R10, R12, R17, R22, R23 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW103E |
| 1 | 18kΩ | 50V | R24 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW183E |
| 1 | 36kΩ | 50V | R21 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW364E |
| 1 | 130kΩ | 50V | R9 | Res. chip 1206 1/8W ±5% | Garrett | Rohm | MCR18JW134E |
| **Surface Mount Diodes** | | | | | | | |
| 1 | | | VR1 (Varactor) | Variable capacitance SMD diode | Digikey | Philips | BB215 |
| 1 | | | D1 | SM Led | Digikey | | |
| **Surface Mount Inductors** | | | | | | | |
| 1 | 0.18µH | | L1 | Chip inductor 1008 ±10% | Coilcraft | Coilcraft | 1008CS-181XKBB |
| 1 | 0.75µH | | L2 | Chip inductor 1008 ±10% | Coilcraft | Coilcraft | 1008CS-751XKBB |
| **Voltage Regulators** | | | | | | | |
| 3 | 100mA | | U1, U2, U3 | Voltage regulator | Digikey | National | LM317LZ |
| **TCXO** | | | | | | | |
| 1 | 19.2MHz | | G1 | Temp. controlled crystal osc. | TEW | TEW | TXS1034N-19.2MHz |
| **VCO** | | | | | | | |
| 1 | 1667MHz | | G2 | Voltage controlled osc. | Murata | Murata Erie | MQE530-1667 |
| **Surface Mount Integrated Circuits** | | | | | | | |
| 1 | | | U4 | 2GHz Fractional-N Synthesizer | Philips | Philips | SA8025ADK |
| 1 | | | U5 | Double Balanced Mixer Oscillator | Philips | Philips | SA602A |
| **Miscellaneous** | | | | | | | |
| 3 | | | JP1, JP2, JP3 | SMA right angle jack receptacle | Newark | EF Johnson | 142-0701-301 |
| 1 | | | J1 | Male 6-pins connector | STOCKO | STOCKO | MKS1956-6-0-606 |
| 1 | | | J2 | Male 2-pins connector | STOCKO | STOCKO | MKS1851-6-0-202 |
| 1 | | | T3 | Test point | Digikey | 3M | 929647-36 |
| 1 | | | | Printed circuit board | Philips | Philips | SA7025/8025-M |
| **75 Total Parts** | | | | | | | |