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DATA SHEET

# SKY73021: 1700 – 2200 MHz High Gain and Linearity Diversity Downconversion Mixer for 2G/3G Base Station Transceiver Applications

## Applications

- 2G/3G base station transceivers:
  – GSM/EDGE, CDMA, UMTS/WCDMA, PHS
- Land mobile radio
- Wireless Local Loop
- High performance radio links
- Private mobile radio

## Features

- Operating frequency range: 1700 to 2200 MHz
- IF frequency range: 40 to 300 MHz
- Conversion gain: 6.0 dB
- Input IP3: 26.0 dBm
- Output IP3: 32.0 dBm
- Noise figure: 9.6 dB
- Integrated LO drivers
- Integrated low loss RF baluns
- High linearity IF amplifiers
- On-chip SPDT LO switch (greater than 50 dB LO-to-LO isolation)
- Small, MCM (36-pin, 6 x 6 mm) Pb-free package (MSL3, 260 °C per JEDEC J-STD-020)

NEW Skyworks offers lead (Pb)-free RoHS (Restriction of Hazardous Substances) compliant packaging.

## Description

The SKY73021 is a fully integrated diversity mixer that includes Local Oscillator (LO) drivers, an LO switch, high linearity mixers, and large dynamic range Intermediate Frequency (IF) amplifiers. Low loss RF baluns have also been included to reduce design complications and lower system cost.

The SKY73021 features an input IP3 of 26.0 dBm and a Noise Figure (NF) of 9.6 dB, making the device an ideal solution for high dynamic range systems such as 2G/3G base station receivers. The LO switch provides more than 50 dB of isolation between LO inputs and supports the switching time required for GSM/EDGE base stations.

The SKY73021 is manufactured using a robust silicon BiCMOS process and has been designed for optimum long-term reliability. The SKY73021 diversity downconversion mixer is provided in a compact, 36-pin 6 x 6 mm Multi-Chip Module (MCM). A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

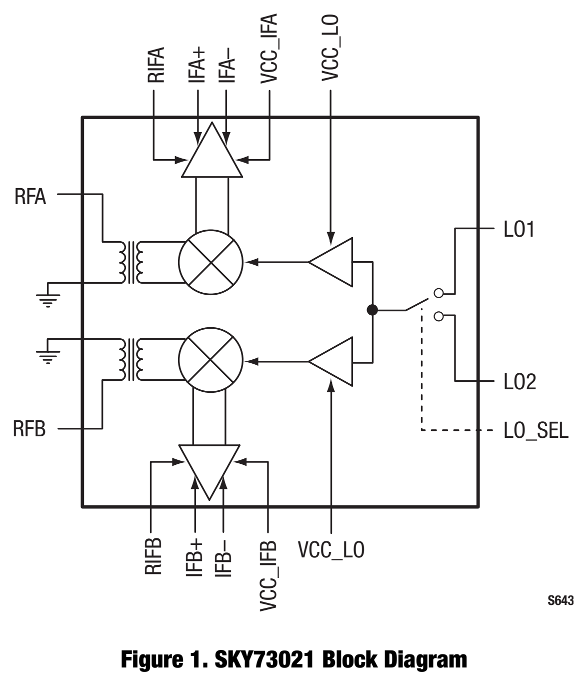



**Figure 1. SKY73021 Block Diagram**

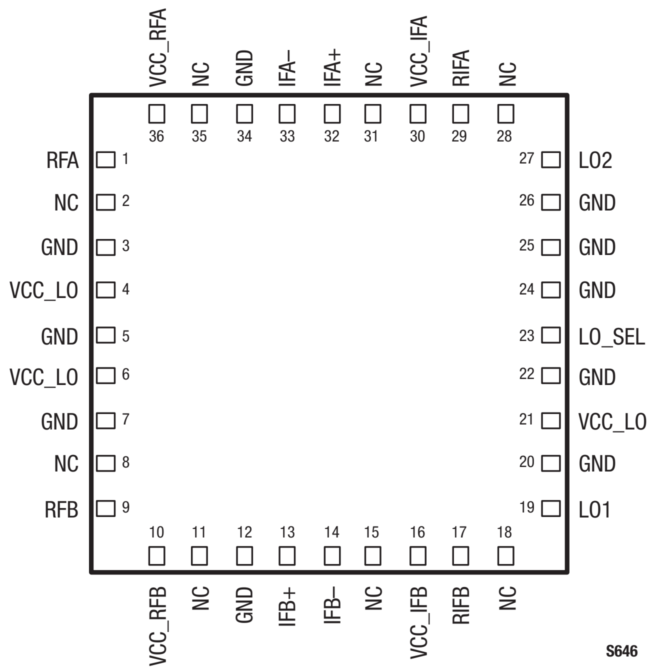



**Figure 2. SKY73021 Pinout – 36-Pin MCM**

**Table 1. SKY73021 Signal Descriptions**

| Pin # | Name | Description | Pin # | Name | Description |
|---|---|---|---|---|---|
| 1 | RFA | Channel A RF input | 19 | LO1 | Local oscillator 1 input |
| 2 | NC | No connect | 20 | GND | Ground |
| 3 | GND | Ground | 21 | VCC_LO | DC supply, +5 V |
| 4 | VCC_LO | DC supply, +5 V | 22 | GND | Ground |
| 5 | GND | Ground | 23 | LO_SEL | Local oscillator select switch control |
| 6 | VCC_LO | DC supply, +5 V | 24 | GND | Ground |
| 7 | GND | Ground | 25 | GND | Ground |
| 8 | NC | No connect | 26 | GND | Ground |
| 9 | RFB | Channel B RF input | 27 | LO2 | Local oscillator 2 input |
| 10 | VCC_RFB | Channel B RF DC supply, +5 V | 28 | NC | No connect |
| 11 | NC | No connect | 29 | RIFA | Channel A IF bias adjust |
| 12 | GND | Ground | 30 | VCC_IFA | Channel A IF DC supply, +5 V |
| 13 | IFB+ | Positive channel B IF output | 31 | NC | No connect |
| 14 | IFB– | Negative channel B IF output | 32 | IFA+ | Positive channel A IF output |
| 15 | NC | No connect | 33 | IFA– | Negative channel A IF output |
| 16 | VCC_IFB | Channel B IF DC supply, +5 V | 34 | GND | Ground |
| 17 | RIFB | Channel B IF bias adjust | 35 | NC | No connect |
| 18 | NC | No connect | 36 | VCC_RFA | Channel A RF DC supply, +5 V |

## Functional Description

The SKY73021 is a high gain diversity mixer, optimized for base station receiver applications. The device consists of two diversity channels (A and B), each consisting of a low loss RF balun, high linearity passive mixer, and a low noise IF amplifier.

Two LO amplifiers (independent of channels A and B) are also included that allow the SKY73021 to connect directly to the output of a Voltage Controlled Oscillator (VCO). This eliminates the extra gain stages needed by most discrete passive mixers. A Single Pole, Double Throw (SPDT) switch has been included to select between two different LO inputs for frequency hopping applications (i.e., GSM).

### RF Baluns and Passive Mixer

The RF baluns provide a single ended input, which can easily be matched to 50 Ω using a simple external matching circuit. The RF baluns offer very low loss, and excellent amplitude and phase balance.

The high linearity SKY73021 is a passive, double balanced mixer that provides a very low conversion loss and an excellent 3$^{rd}$ Order Input Intercept Point (IIP3).

Additionally, the balanced nature of the mixer provides for high port-to-port isolation.

### LO Buffers and SPDT LO Switch

The LO buffers allow the input power of the SKY73021 to be in the range of ±3 dBm. The LO section is optimized for low-side LO injection. However, each of the two LOs can be driven over a wide frequency range with only slight degradation in performance.

A high isolation SPDT switch allows the SKY73021 to be used for frequency hopping applications. This switch provides greater than 50 dB of LO1 to LO2 isolation:

| LO_SEL Input | LO Path Selected |
|---|---|
| High | LO1 (pin 19) enabled |
| Low | LO2 (pin 27) enabled |

For applications that do not require frequency hopping, LO_SEL is fixed to one state and the appropriate LO input is used. An internal pull-down resistor enables the LO2 input.

### IF Amplifier

The SKY73021 includes high dynamic range IF amplifiers that follow the passive mixers in the signal path. The outputs require a supply voltage connection using inductive chokes. These choke inductors should be high-Q and have the ability to handle 200 mA or greater.

A simple matching network allows the output ports to be matched to a balanced 200 Ω impedance. The IF amplifiers are optimized for IF frequencies between 40 and 300 MHz. The IF amplifiers can be operated outside of this range, but with a slight degradation in performance.

## Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY73021 are provided in Table 2 and the recommended operating conditions in Table 3. Electrical characteristics for the SKY73021 are provided in Table 4.

Typical performance characteristics of the SKY73021 are illustrated in Figures 3 through 35.

**Table 2. SKY73021 Absolute Maximum Ratings**

| Parameter | Symbol | Minimum | Maximum | Units |
|---|---|---|---|---|
| Supply voltage, +5 V (VCC_LO, VCC_RFA, VCC_RFB, VCC_IFA, VCC_IFB) | VCC | 4.5 | 5.5 | V |
| Supply current | $I_{CC}$ | | 440 | mA |
| RF input power | $P_{RF}$ | | 20 | dBm |
| LO input power | $P_{LO}$ | | 20 | dBm |
| Operating case temperature | $T_C$ | –40 | +85 | °C |
| Junction temperature | $T_J$ | | 150 | °C |
| Storage case temperature | $T_{STG}$ | –40 | +125 | °C |

**Note:** Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value.

Nominal thermal resistance (junction to center ground pad) is 5.1 °C/W.

**Table 3. SKY73021 Recommended Operating Conditions**

| Parameter | Symbol | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|
| Supply voltage, +5 V (VCC_LO, VCC_RFA, VCC_RFB, VCC_IFA, VCC_IFB) | VCC | 4.75 | 5.00 | 5.25 | V |
| Supply current | $I_{CC}$ | | 380 | | mA |
| LO input power | $P_{LO}$ | –6 | 0 | +6 | dBm |
| LO select input:<br>high<br>low | <br>$LO\_SEL_H$<br>$LO\_SEL_L$ | <br>2.2<br> | | <br><br>0.8 | <br>V<br>V |
| Operating case temperature | $T_C$ | –40 | | +85 | °C |
| RF frequency range | $F_{RF}$ | 1700 | | 2200 | MHz |
| LO frequency range (Note 1) | $F_{LO}$ | 1460 | | 2000 | MHz |
| IF frequency range | $F_{IF}$ | 40 | | 300 | MHz |

**Note 1**: The SKY73021 has been optimized for low side LO injection. However, the LO can be used outside of the specified frequency range with degraded performance.

**Table 4. SKY73021 Electrical Specifications (1 of 2)**
**(Voltage Supply = +5 V, $T_C$ = +25 °C, LO = 0 dBm, RF Frequency = 1750 MHz, IF Frequency = 201 MHz, LO Frequency = 1549 MHz, Unless Otherwise Noted)**

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Conversion gain | G | | 5.6 | 6.0 | 6.6 | dB |
| Gain versus temperature | | –40 to +85 °C | | ±0.7 | | dB |
| Noise Figure | NF | | | 9.6 | 10.9 | dB |
| Noise Figure versus temperature | | –40 to +85 °C | | ±0.8 | | dB |
| Noise Figure with a blocker signal | $NF_{BLK}$ | Blocking signal input power = +8 dBm | | 21 | 23 | dB |
| Third order input intercept point | IIP3 | $F_{RF}$ = 1750.0 MHz and 1750.8 MHz, $P_{RF}$ = –10 dBm/tone | 25.0 | 26.0 | | dBm |
| Third order input intercept point versus temperature | | –40 to +85 °C | | ±0.6 | | dB |
| Third order output intercept point | OIP3 | $F_{RF}$ = 1750.0 MHz and 1750.8 MHz, $P_{RF}$ = –10 dBm/tone | | 32.0 | | dBm |
| 2RF – 2LO | 2x2 | $P_{RF}$ = –10 dBm | | –66 | –57 | dBc |
| 3RF – 3LO | 3x3 | $P_{RF}$ = –10 dBm | | –80 | | dBc |
| Input 1 dB compression point | IP1dB | | 15.5 | 17.0 | | dBm |
| Output 1 dB compression point | OP1dB | | | 22.0 | | dBm |
| LO1-to-LO2 isolation | | | 40 | 50 | | dB |
| Channel-to-channel isolation | | | 30 | 47 | | dB |
| RF-to IF-isolation | | | 30 | 66 | | dB |

**Table 4. SKY73021 Electrical Specifications (2 of 2)**
**(Voltage Supply = +5 V, $T_C$ = +25 °C, LO = 0 dBm, RF Frequency = 1750 MHz, IF Frequency = 201 MHz, LO Frequency = 1549 MHz, Unless Otherwise Noted)**

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| LO leakage:<br>@ RF port<br>@ IF port | | | | <br>–41<br>–50 | <br>–24<br>–27 | <br>dBm<br>dBm |
| LO_SEL input | | | –20 | +150 | +250 | μA |
| LO switching time | | | | | 0.5 | μs |
| RF port input return loss | Zin_rf | With external matching components | 14 | | | dB |
| LO port input return loss | Zin_lo | With external matching components | 14 | | | dB |
| IF port input return loss | Zout_if | With external matching components | 14 | | | dB |

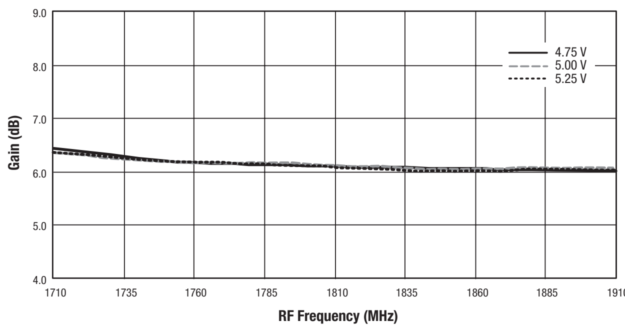



**Figure 3. Mixer A Gain vs Frequency and Supply Voltage**

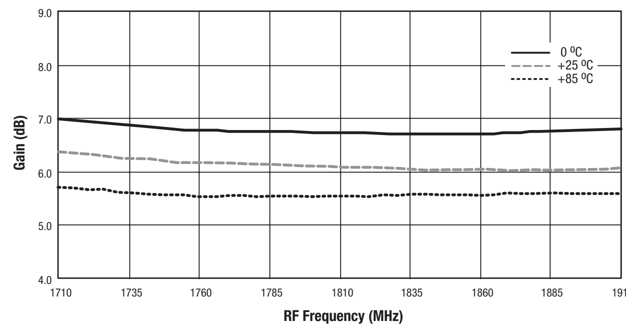



**Figure 4. Mixer A Gain vs Frequency and Temperature**

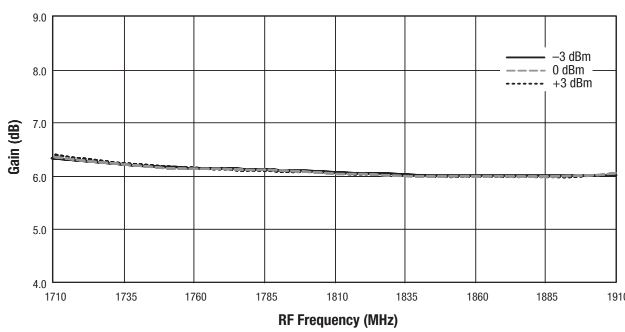



**Figure 5. Mixer A Gain vs Frequency and LO Power**

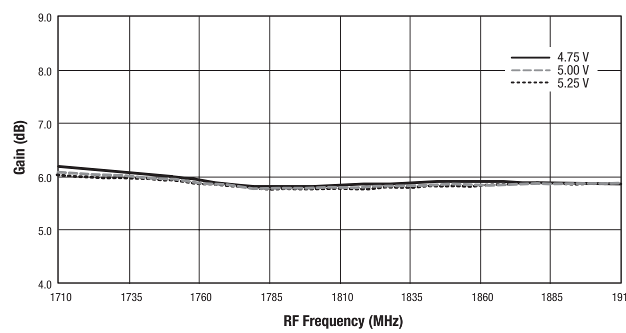



**Figure 6. Mixer B Gain vs Frequency and Supply Voltage**

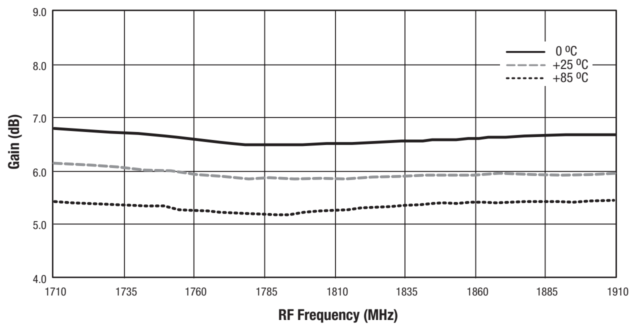



**Figure 7. Mixer B Gain vs Frequency and Temperature**

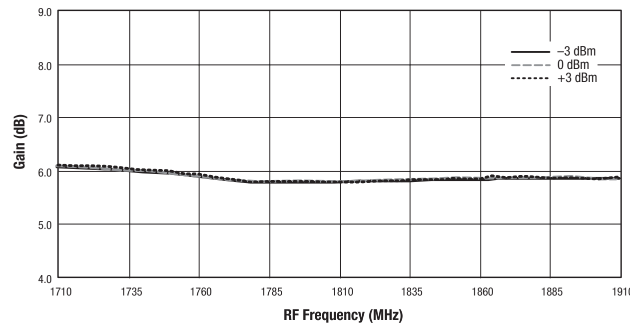



**Figure 8. Mixer B Gain vs Frequency and LO Power**

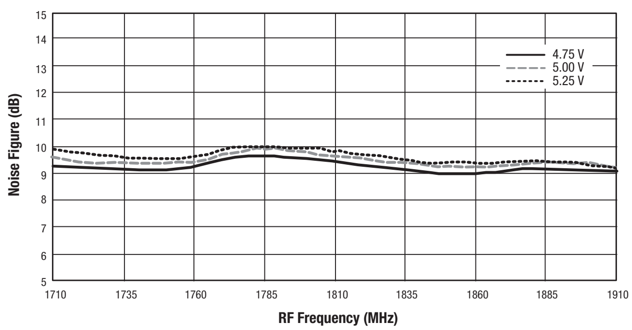



**Figure 9. Mixer A Noise Figure vs Frequency and Supply Voltage**

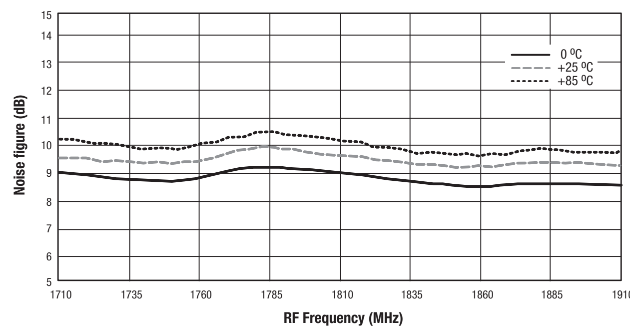



**Figure 10. Mixer A Noise Figure vs Frequency and Temperature**

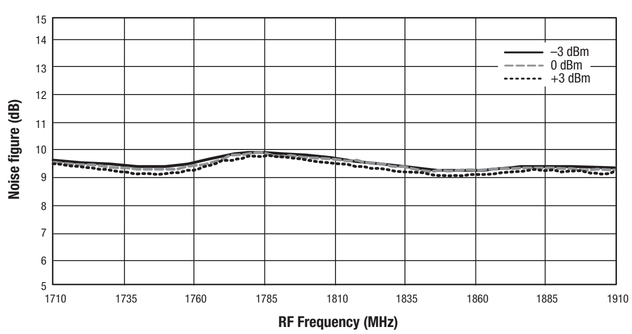



**Figure 11. Mixer A Noise Figure vs Frequency and LO Power**

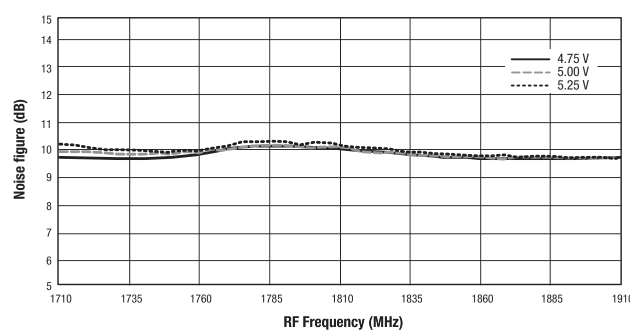



**Figure 12. Mixer B Noise Figure vs Frequency and Supply Voltage**

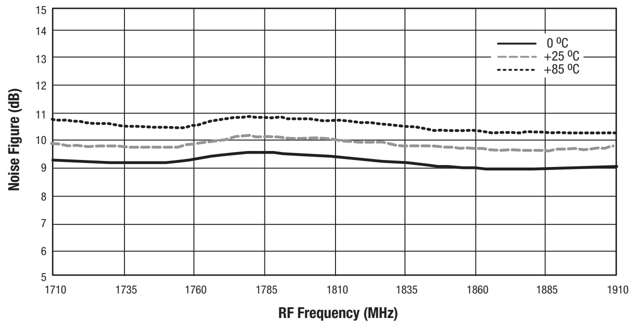



Figure 13. Mixer B Noise Figure vs Frequency and Temperature

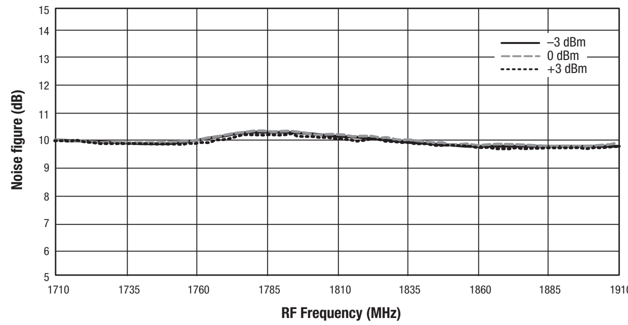



Figure 14. Mixer B Noise Figure vs Frequency and LO Power

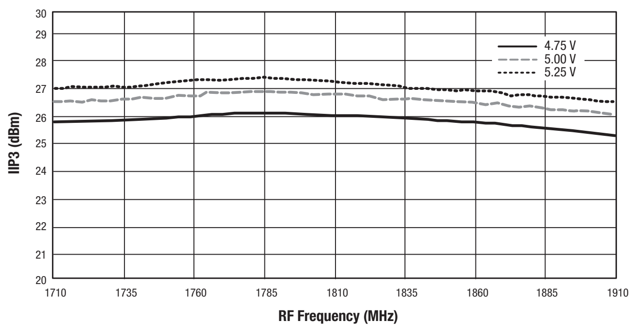



Figure 15. Mixer A IIP3 vs Frequency and Supply Voltage

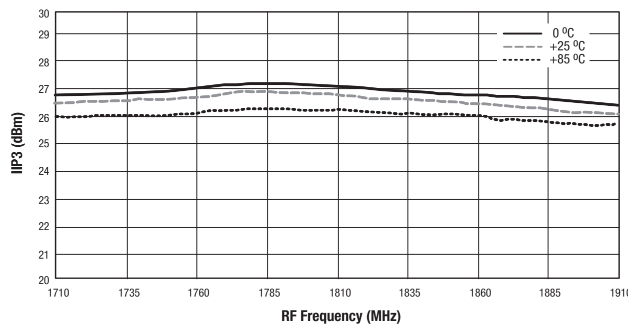



Figure 16. Mixer A IIP3 vs Frequency and Temperature

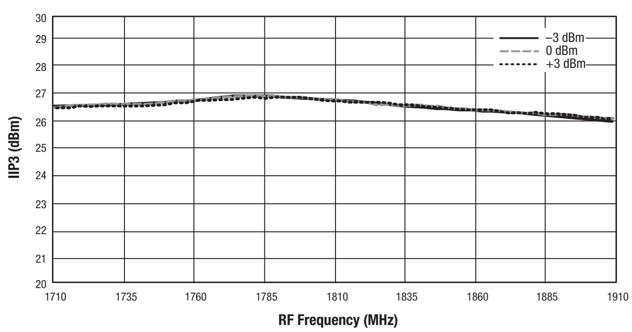



Figure 17. Mixer A IIP3 vs Frequency and LO Power

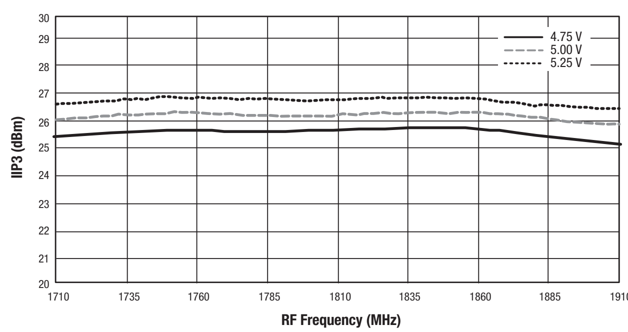



Figure 18. Mixer B IIP3 vs Frequency and Supply Voltage

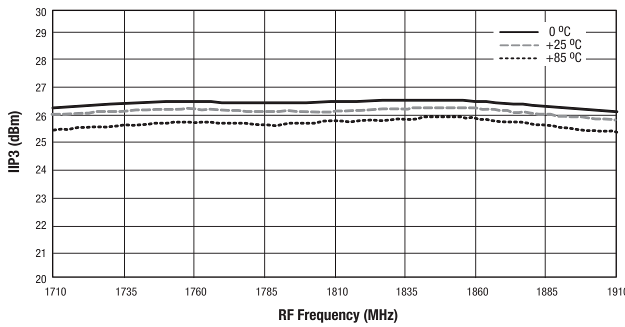



**Figure 19. Mixer B IIP3 vs Frequency and Temperature**

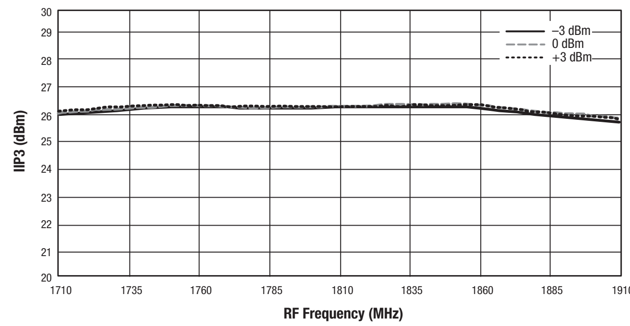



**Figure 20. Mixer B IIP3 vs Frequency and LO Power**

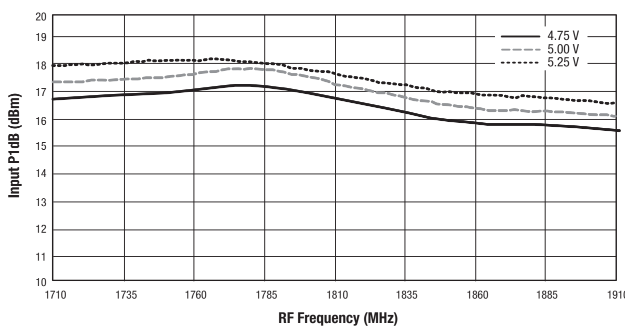



**Figure 21. Mixer A Input P1dB vs Frequency and Supply Voltage**

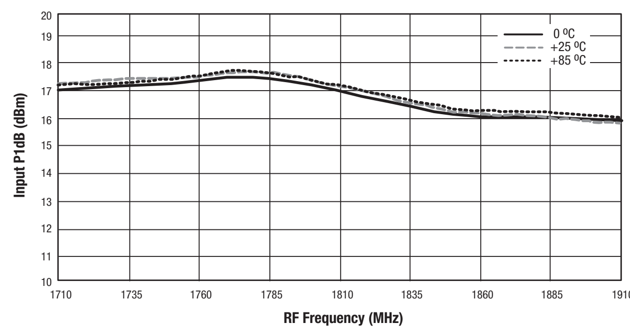



**Figure 22. Mixer A Input P1dB vs Frequency and Temperature**

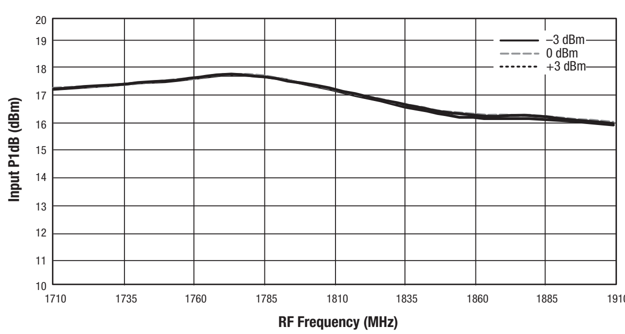



**Figure 23. Mixer A Input P1dB vs Frequency and LO Power**

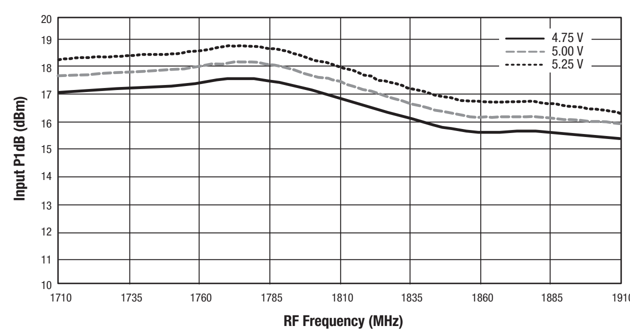



**Figure 24. Mixer B Input P1dB vs Frequency and Supply Voltage**

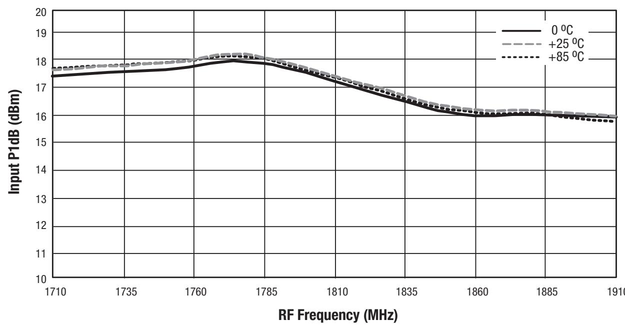



**Figure 25. Mixer B Input P1dB vs Frequency and Temperature**

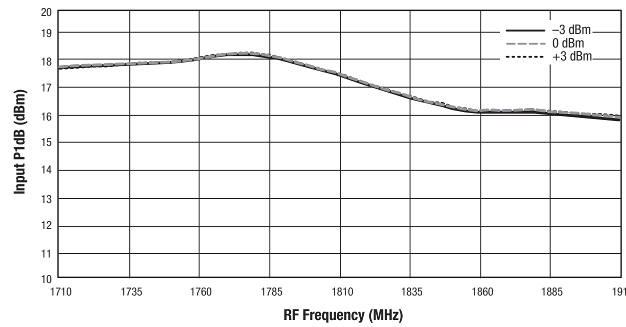



**Figure 26. Mixer B Input P1dB vs Frequency and LO Power**

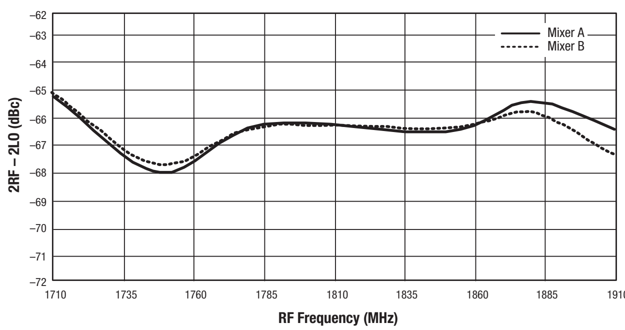



**Figure 27. Mixer A and B 2RF – 2LO vs Frequency**

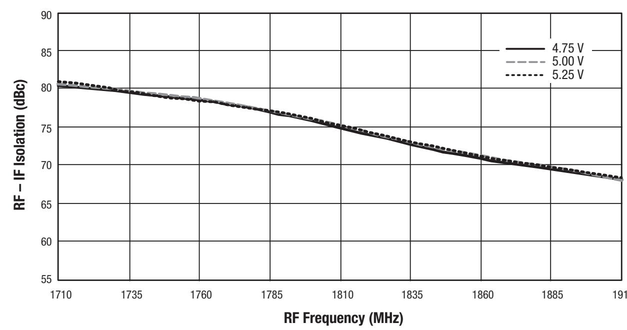



**Figure 28. Mixer A RF to IF Isolation vs Frequency and Supply Voltage**

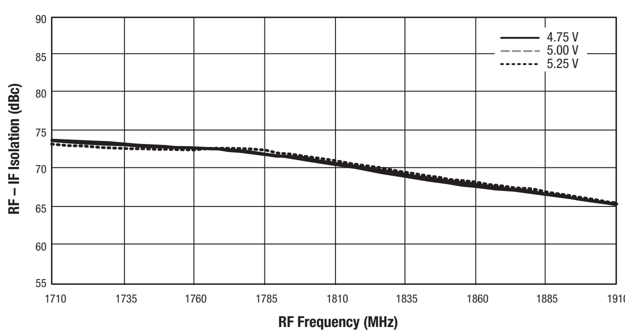



**Figure 29. Mixer B RF to IF Isolation vs Frequency and Supply Voltage**

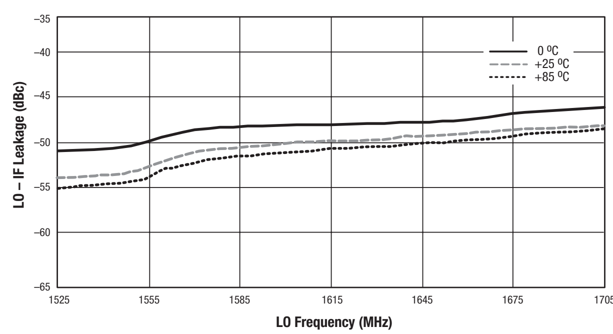



**Figure 30. Mixer A LO to IF Leakage vs Frequency and Temperature**

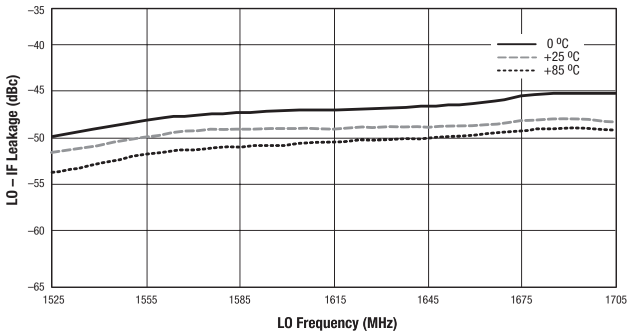



**Figure 31. Mixer B LO to IF Leakage vs Frequency and Temperature**

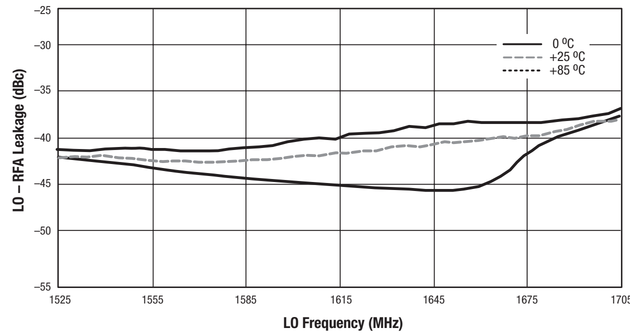



**Figure 32. Mixer A LO to RF Leakage vs Frequency and Temperature**

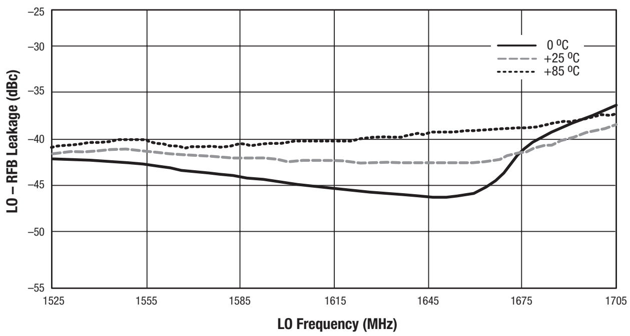



**Figure 33. Mixer B LO to RF Leakage vs Frequency and Temperature**

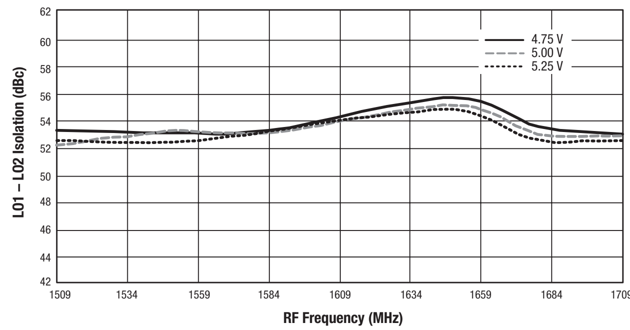



**Figure 34. LO1 to LO2 Isolation vs Frequency and Supply Voltage**

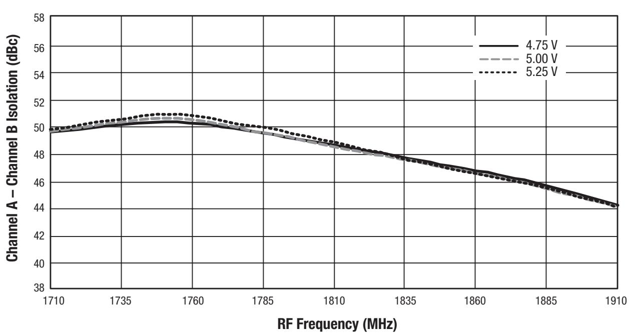



**Figure 35. Channel A to Channel B IF Isolation vs Frequency and Supply Voltage**

## Evaluation Board Description

The SKY73021 Evaluation Board is used to test the performance of the SKY73021 downconversion mixer. An assembly drawing for the Evaluation Board is shown in Figure 36 and the layer detail is provided in Figure 37.

### Circuit Design Configurations

The following design considerations are general in nature and must be followed regardless of final use or configuration:

1. Paths to ground should be made as short and as low impedance as possible.
2. The ground pad of the SKY73021 provides critical electrical and thermal functionality. This pad is the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the device. Therefore, design the connection to the ground pad to dissipate the maximum heat produced by the circuit board. For more information on soldering the SKY73021, refer to the Package and Handling Information section of this Data Sheet.
3. Skyworks recommends including external bypass capacitors on the VCC voltage inputs of the device.
4. Components L5, L6, L14, and L15 (see Figure 38) are high-Q, low loss inductors. These inductors must be able to pass currents in excess of 200 mA DC.
5. Components R1 and R2 (see Figure 38) allow for external adjustment of the IF amplifier bias points. For operation as specified in Tables 3 and 4, these resistors are not required.

A schematic diagram for the SKY73021 Evaluation Board is shown in Figure 38.

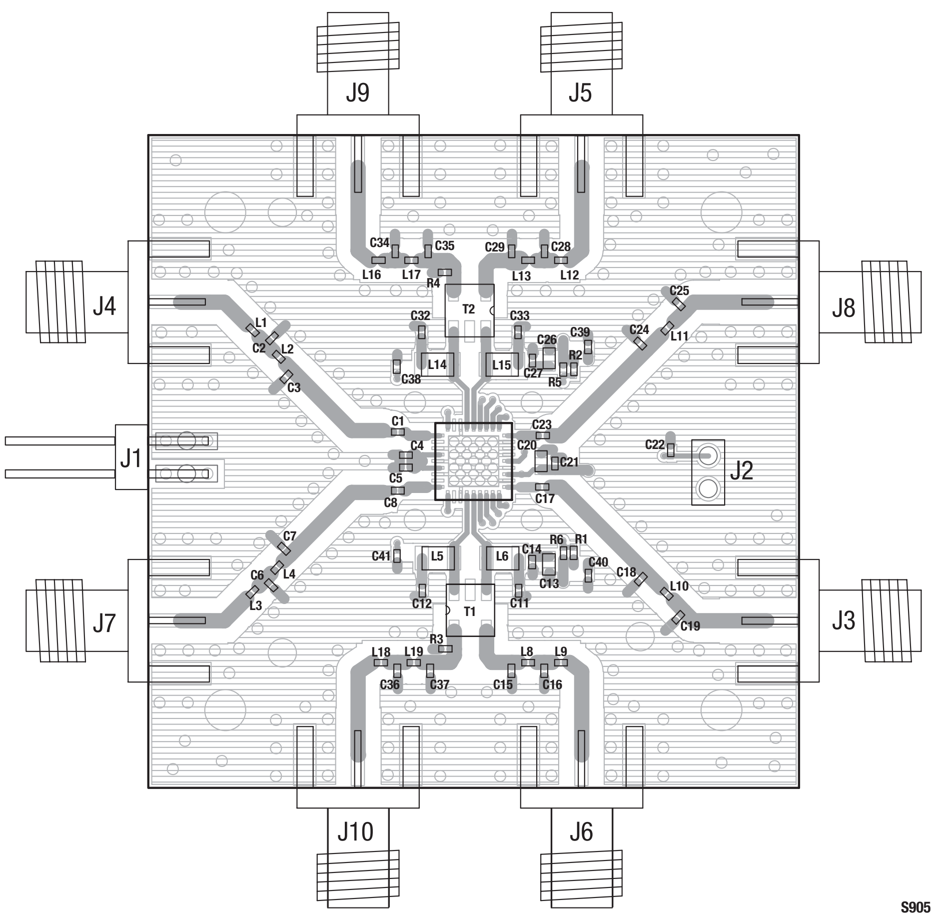
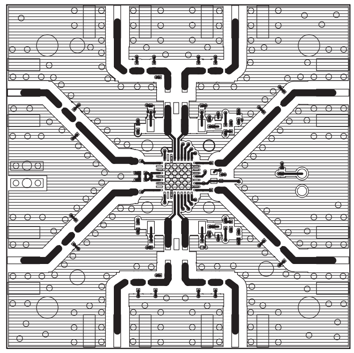
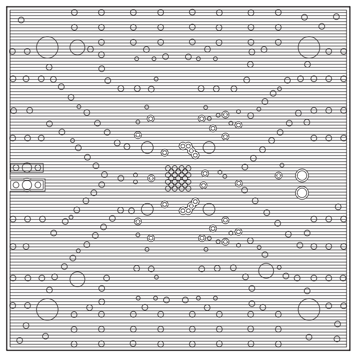


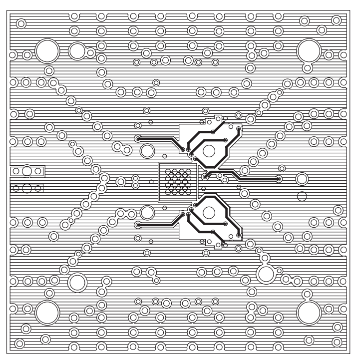

**Figure 36. SKY73021 Evaluation Board Assembly Diagram**



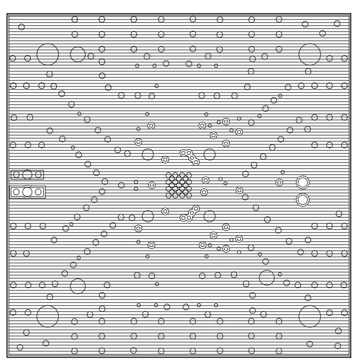
Layer 1: Top -- Metal



Layer 2: Ground



Layer 3: Power Plane



Layer 4: Solid Ground Plane

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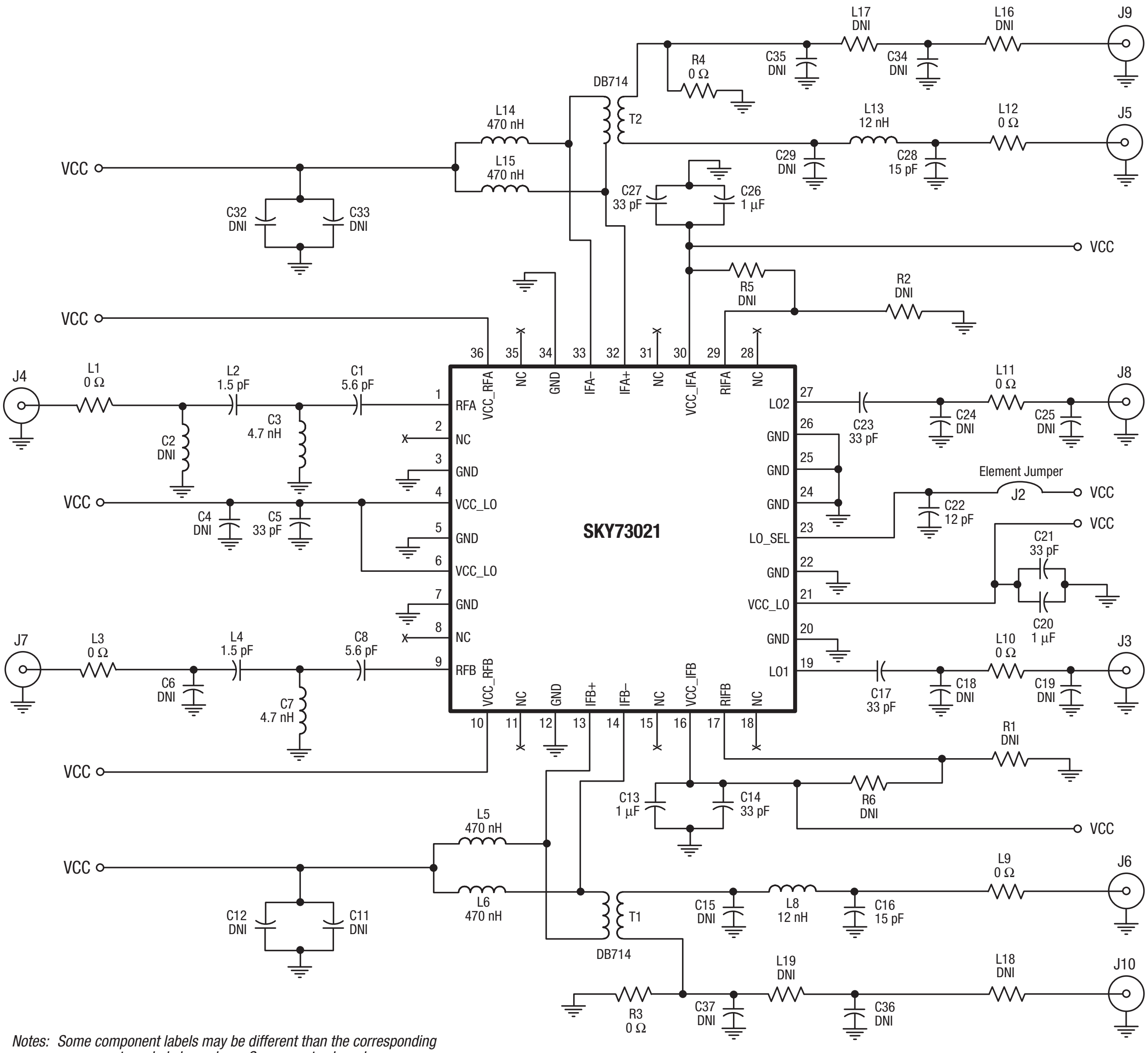
**Figure 37. SKY77021 Evaluation Board Layer Detail**




*Notes: Some component labels may be different than the corresponding component symbol shown here. Component values, however, are accurate as of the date of this Data Sheet.*

*The Evaluation Board can be converted to provide a differential output by removing components T1, T2, R3, and R4.*

**Figure 38. SKY73021 Evaluation Board Schematic**

## Package Dimensions

The PCB layout footprint for the SKY73021 is provided in Figure 39. Figure 40 shows the package dimensions for the 36-pin MCM, and Figure 41 provides the tape and reel dimensions.

## Package and Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

THE SKY73021 is rated to Moisture Sensitivity Level 3 (MSL3) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *PCB Design & SMT Assembly/Rework Guidelines for MCM-L Packages*, document number 101752.

Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format. For packaging details, refer to the Skyworks Application Note, *Tape and Reel*, document number 101568.

## Electrostatic Discharge (ESD) Sensitivity

The SKY73021 is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.

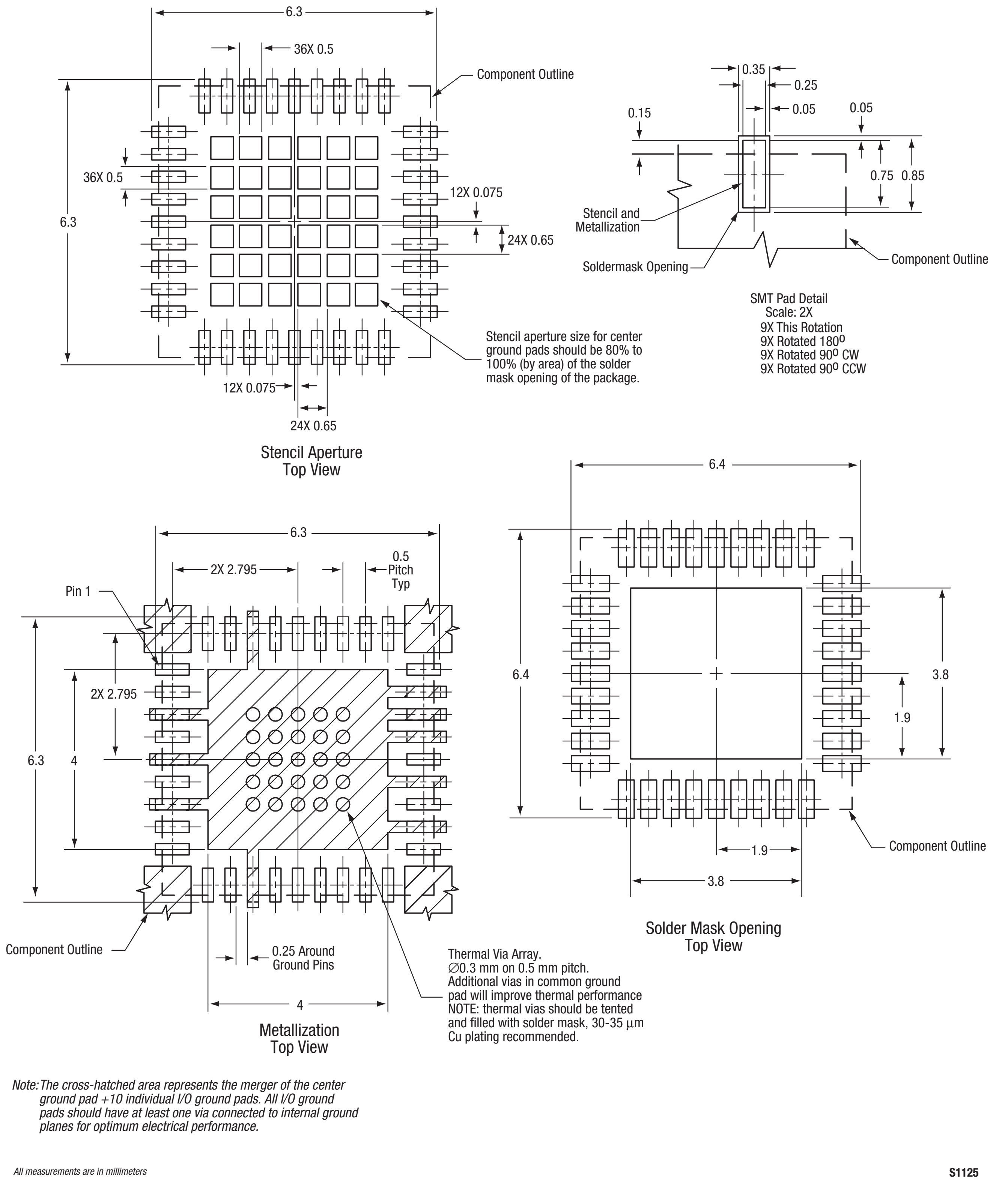
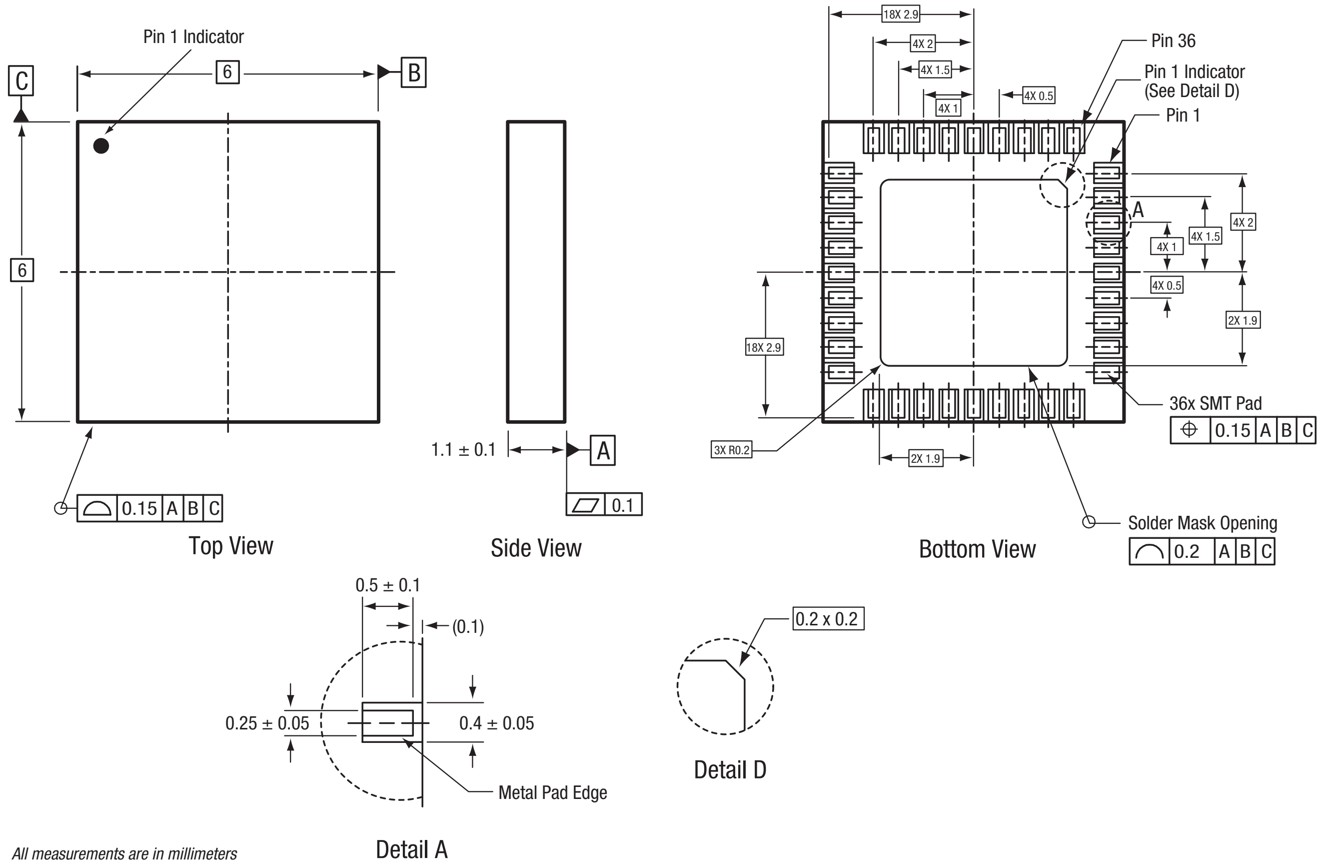



**Figure 39. PCB Layout Footprint for the SKY73021 6 x 6 mm MCM**




*All measurements are in millimeters*

*Pads are solder mask defined on one edge and metal defined on three edges.*

*Dimensioning and tolerancing according to ASME Y14.5M-1994*

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**Figure 40. SKY73021 36-Pin MCM Package Dimensions**

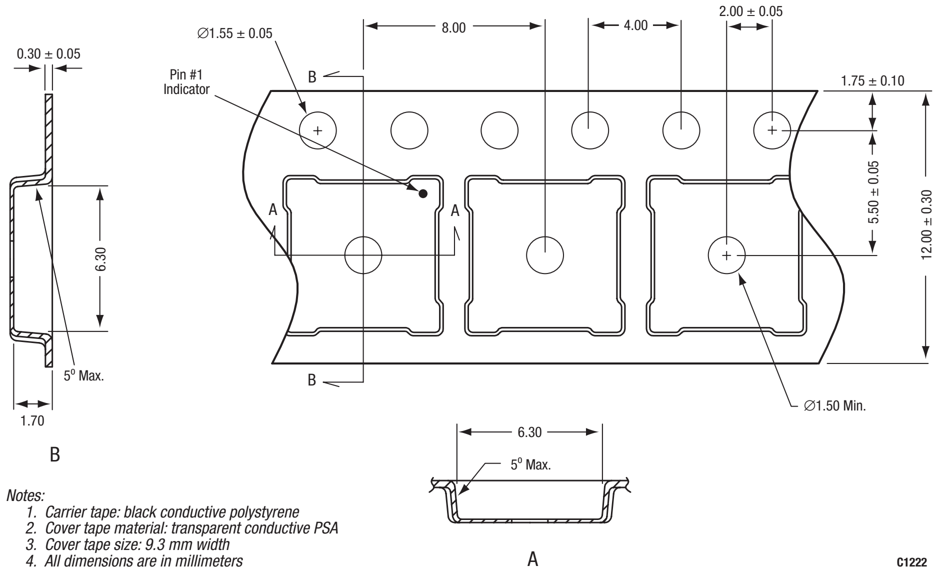


**Figure 41. SKY73021 Tape and Reel Dimensions**

## Ordering Information

| Model Name | Manufacturing Part Number | Evaluation Board Part Number |
|---|---|---|
| SKY73021 Downconversion Mixer | SKY73021-11 (Pb-free package) | TW16-D670 |

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