

EVK 6040 User Guide



The company's products are covered by one or more of the following:
 WO2008250262 (A1), US2008303720 (A1),
 US2008305750 (A1), WO2008154173 (A1).
 Other patents pending.

GENERAL

This document is designed to serve as a user guide for the VJ 6040 evaluation kit. It is recommended that this document be read after the following documents were viewed:

- VJ 6040 datasheet
- VJ 6040 application notes

EVALUATION KIT COMPONENTS

The evaluation kit is shown in figure 1. Table 1 details the kit components.

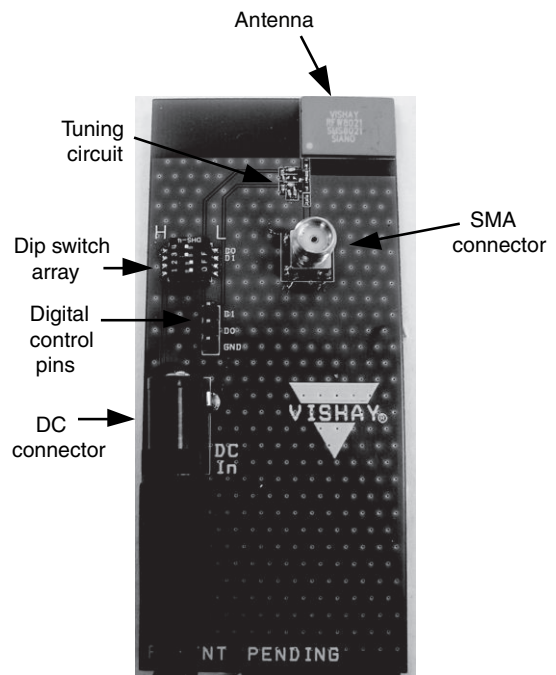


Fig. 1 - Evaluation Kit

| TABLE 1 - KIT COMPONENTS | |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| ITEM | FUNCTIONALITY |
| Antenna | Actual ceramic chip antenna |
| SMA connector | Connect a 50 Ω RF cable to this connector, to get signals received on the antenna end |
| Tuning circuit | A digital tuning circuit used to cover the entire UHF band with 2 control pins |
| Dip switch array | Used to control the tuning circuit manually. Only pins 3 and 4 (marked D0 and D1) are in use. Pins 1 and 2 are not connected |
| Digital control pins | Used to control the tuning circuit electrically. Pins D0 and D1 are standard CMOS level digital control pins capable of supplying at least 1 mA |
| DC connector | Used to feed power to the tuning circuit. This connector is used only in the manual tuning alternative set up |

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KIT SETUP

There are 2 recommended alternative ways to set up the evaluation kit for testing and use. The difference between these alternatives is in the way the tuning circuit is controlled. Both alternatives are described hereafter.

SET UP ALTERNATIVE 1 - MANUAL CONTROL

In this alternative, the tuning circuit is controlled by the on board mechanical dip switch array. The control line voltage in this setup should be applied to the on board DC connector. A voltage of 2 V to 30 V will ensure good performance. The evaluation kit is supplied with a battery house designed to provide 3 V using two AAA batteries.

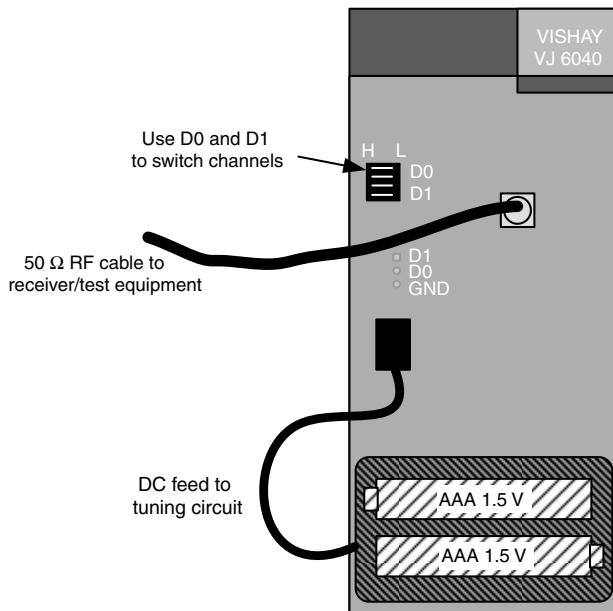


Fig. 2 - Manual Control

SET UP ALTERNATIVE 2 - ELECTRICAL CONTROL

In this alternative, the tuning circuit is controlled by the 5 pin digital connector. In order to function properly in this alternative and avoid short circuit, the following rules need to be followed:

1. Remove the batteries from the battery housing.
Disconnect the DC jack from the DC connector
2. Leave all dip switches in L position (in this position, the tuning circuit control pins are in High-Z impedance, and can be controlled by the external pins).
3. Connect the GND pin on the EVK to the common ground used by the external digital control circuit.

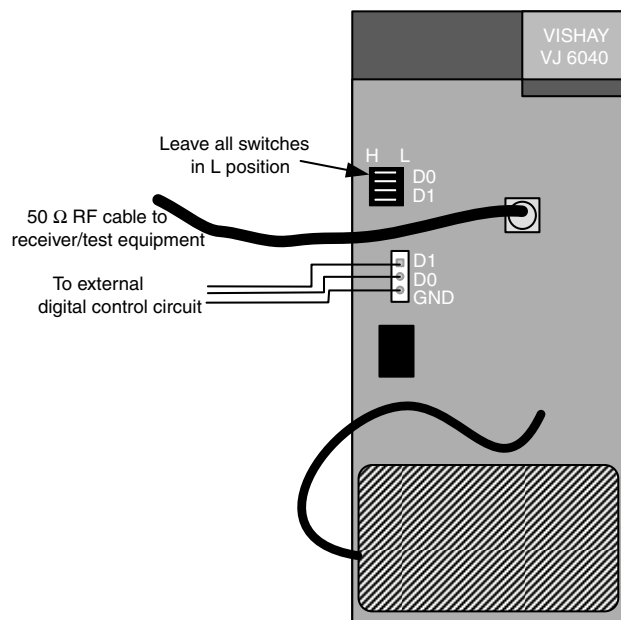


Fig. 3 - Electrical Control

The 3 pin digital connector is expected to be connected to an external control circuit. The digital control signals D0 and D1 are standard CMOS level signals.

Note

- Signal integrity is detailed in table 2

In set up alternative 1, the tuning circuit is driven and controlled by dip switches D0 and D1. The other two switches in the array are not connected. Maximum current consumed by the tuning circuit is less than 2 mA when operating at 3 V.

A 50 Ω RF cable, connected to the SMA connector, can be used to guide the received signals from the antenna to the desired applicable receiver/test equipment.

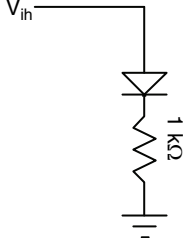
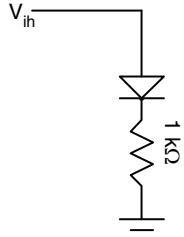
Note

- See table 3 for details regarding channel selection

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CONTROL SIGNAL INTEGRITY

Table 2 describes the desired control signal properties:

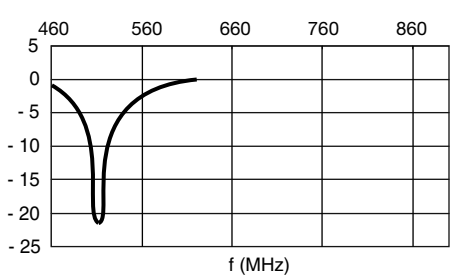
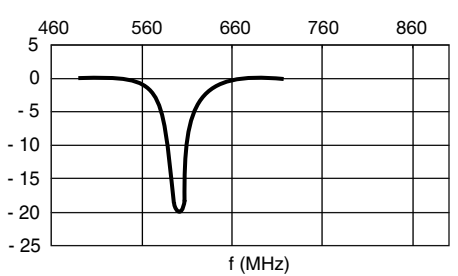
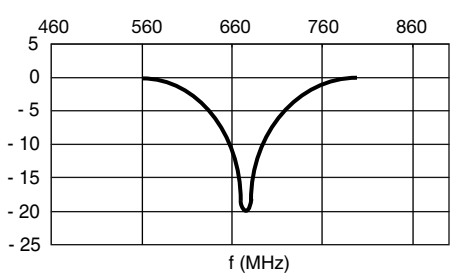
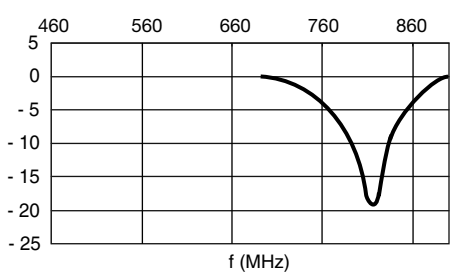
| TABLE 2 - SIGNAL INTEGRITY FOR ELECTRICAL CONTROL ALTERNATIVE | | | | | | |
|---------------------------------------------------------------|--------------|-------|------|------|-------|--------------------------------------------------------------------------------------------------------------|
| PARAMETER | SYMBOL | MIN. | TYP. | MAX. | UNITS | COMMENTS |
| Logical LOW | V_{il} | - 0.3 | 0 | 0.2 | V | Equivalent DC Circuit  |
| Logical HIGH | V_{ih} | 2 | 3 | 5 | V |  |
| Source current | I_{source} | 0 | 0.01 | 0.05 | mA | $V_{in} = 5\text{ V}$ This is diode reverse leakage current |
| Sink current | I_{sink} | 4 | 4.2 | 5 | mA | $V_{in} = - 0.5\text{ V}$ |

OPERATING THE KIT

To properly operate the kit, the antenna needs to be tuned to the required band. The kit is offering coverage of the entire UHF band, by dividing it into 4 sub-bands. Selecting the correct band is critical for antenna performance.

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Table 3 describes channel selection for both manual and electrical set up alternatives and typical...

| TABLE 3 - TUNING CIRCUIT BANDS | | | | |
|--------------------------------|----|----|------------|--------------------------------------------------------------------------------------|
| CHANNEL | D1 | D2 | BAND (MHz) | S11 (dB) |
| 1 | H | L | 470 to 540 |  |
| 2 | L | L | 540 to 620 |  |
| 3 | H | H | 620 to 750 |  |
| 4 | L | H | 750 to 860 |  |

Comment: The EVK tuning circuit is optimized to cover the band of 474 MHz to 800 MHz. There is an alternative tuning circuit available, to cover the band of 474 MHz to 860 MHz. For more information see "VJ 3505 application notes - tuning circuit".

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VJ 3505 EVALUATION KIT ANTENNA PERFORMANCE MEASURED PEAK GAIN AND EFFICIENCY

The Antenna radiation characteristics are influenced by several factors including ground plane dimensions and impedance matching network.

The antenna parameters presented hereafter were measured using to the configuration suggested by the VJ 6040 evaluation board.

Figure 4 shows radiation patterns of the EVK 6040 in various frequencies across the UHF band:

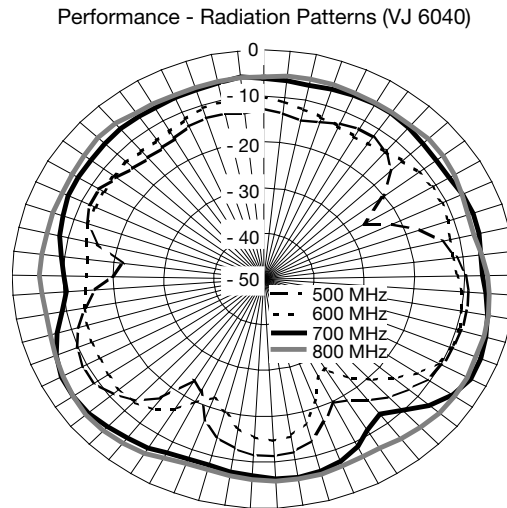


Fig. 4 - Peak Gain vs. Frequency

Applications that do not require full coverage of the UHF band can enjoy additional efficiency by removing the tuning circuit. In this case the antenna can be fixed to any 150 MHz band within the UHF range.

Figure 5 shows simulated peak gain and radiation efficiency of the VJ 6040 antenna over frequency throughout the UHF band, compared with the MBRAI requirements:

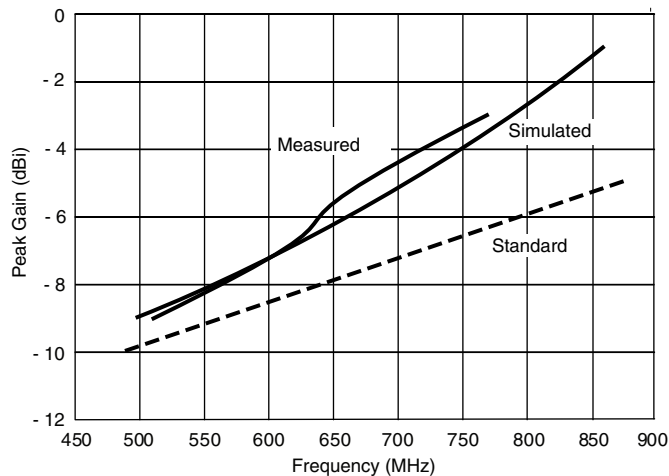


Fig. 5 - Peak Gain vs. Frequency

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SCHEMATIC DRAWING

Figure 6 below shows the schematic drawing of the evaluation kit. See tuning circuit application note for details regarding recommended BOM.

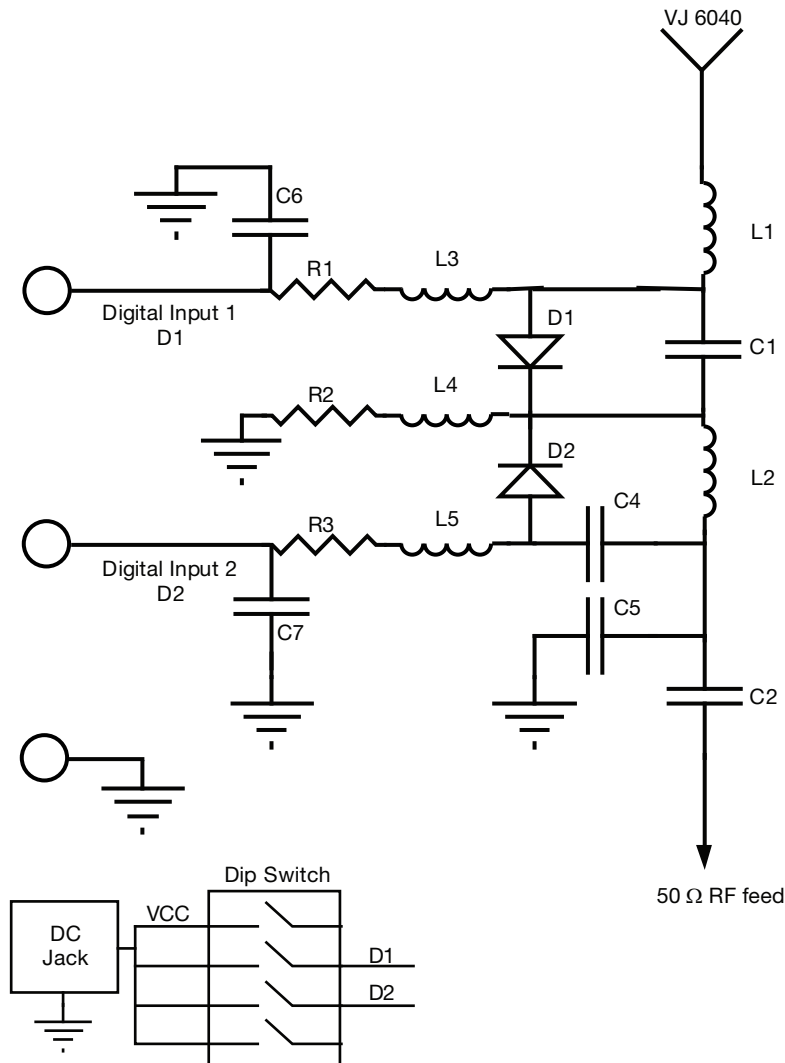


Fig. 6 - EVK 3505 Schematic

TABLE 4 - EVK6040 BOM LIST

| VALUE | REFERENCE | QUANTITY PER CIRCUIT | PART NUMBER | MANUFACTURER |
|-----------|----------------|----------------------|--------------------|--------------|
| Antenna | VJ 3505 | 1 | VJ 3505M011SXMSRA0 | Vishay |
| 120 nH | I3, I4, I5 | 3 | HK1005R12J-T | Taiyo Yuden |
| PIN diode | D1, D2 | 2 | BAR63-02V | Infineon |
| 27 nH | L1 | 1 | IMC0402ER27NJ | Vishay |
| 39 nH | L2 | 1 | IMC0402ER39NJ | Vishay |
| 3.3 pF | C1 | 1 | VJ0402A3R3BXACW1BC | Vishay |
| 2.2 pF | C5 | 1 | VJ0402A2R2BXACW1BC | Vishay |
| 220 pF | C2, C4, C6, C7 | 4 | VJ0402A221JXACW1BC | Vishay |
| 1 kΩ | R1, R3 | 2 | CRCW1KJNED | Vishay |
| 0 Ω | R2 | 1 | CRCW0R0Z0ED | Vishay |

Features are subject to revisions or changes without notification

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ELECTRICAL CHARACTERISTICS AND FUNCTIONAL DESCRIPTION

The tuning circuit herein is effectively an inductor, connected in series with a capacitor. The total impedance generated by this circuit can be described in the following equation (excluding the capacitors C2, C3 and C4):

$$Z = Z_{L_1} + Z_{C_1} + Z_{L_2} = j * (\omega L_1 - \frac{1}{\omega C_1} + \omega L_2)$$

$$\omega = 2\pi f$$

By connecting PIN diodes in parallel to C1 and L2, the tuning circuit can electrically short-circuit one of the two reactants or both. Table 2 is detailing all logical states of the tuning circuit, and the electrical effect as presented in the impedance Z. For the sake of small signal analysis, when the PIN diode is in forward conduction mode, it is represented as a 2 Ω resistor.

| TABLE 5 - TUNING CIRCUITS' IMPEDANCES | | | | |
|---------------------------------------|-----------------|--------|--------|--------------------------------------------------------|
| DIGITAL INPUT 1 | DIGITAL INPUT 2 | PIN 0 | PIN 1 | Z (Ω) |
| 0 | 0 | High Z | High Z | $j * (\omega L_1 - \frac{1}{\omega C_1} + \omega L_2)$ |
| 0 | 1 | High Z | 2 Ω | $j * (\omega L_1 - \frac{1}{\omega C_1}) + 2$ |
| 1 | 0 | 2 Ω | High Z | $j * (\omega L_1 + \omega L_2) + 2$ |
| 1 | 1 | 2 Ω | 2 Ω | $j * \omega L_1 + 4$ |

As evident from table 2, each one of the 4 possible logic states represents a different tuning circuit between the antenna and the receiver port.

By applying the values shown in table 1 to L1, C1 and L2 the 4 states cover the entire UHF band.

SELECTING THE RESISTIVE VALUES OF R

R1 resistor is used to DC bias the PIN diodes. Selecting the value for R1 can be derived for the following equation:

$$R = \frac{V_{\text{control}} - V_d}{I_d}$$

When:

R = resistive value (in Ω) for R1

V_{control} = control voltage (in volts) as generated by the controller

V_d = forward voltage (in V) generated on the PIN diode when biased

I_d = forward current (in A) through the PIN diode when biased

Example:

The PIN diode should be forward biased at 0.8 V to allow just over 1 mA to pass through it (see the graphs below). At 1 mA, the diode small signal impedance drops to its required value of 2 Ω.

Let's assume that the digital control line is 1.8 V when high. To allow a current of 1 mA, R1 should be set as follows:

$$R_1 = \frac{1.8 - 0.8}{0.001} = 1 \text{ k}\Omega$$

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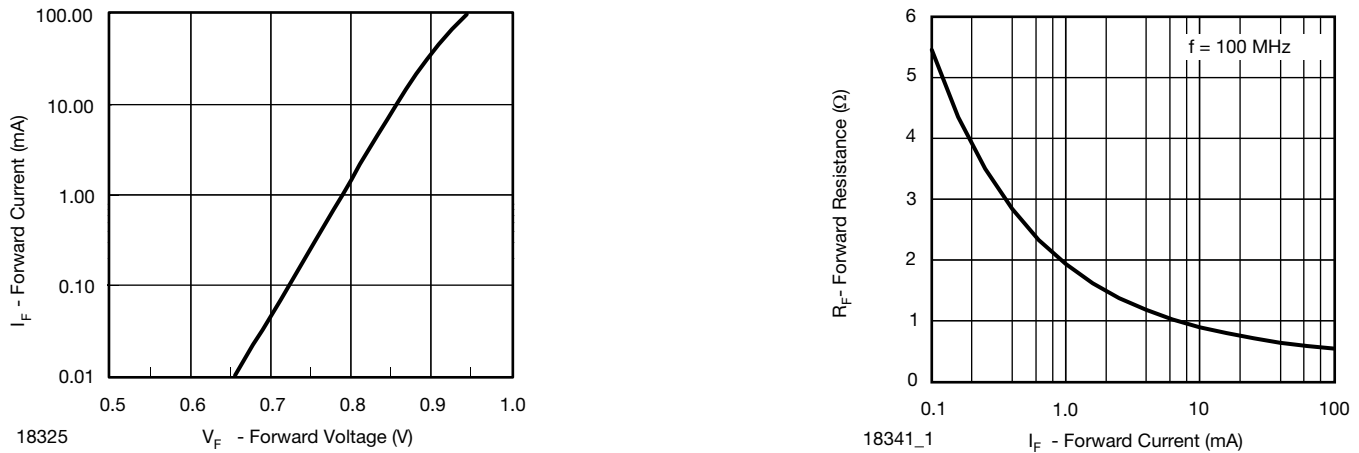


Fig. 7 - PIN Diode Characteristics

GROUND PLANE CONFIGURATION

General

The VJ 6040 antenna is unbalanced, therefore requiring a ground plane for its operation. The ground plane dimensions significantly influence the antenna performance. The rule of thumb in unbalanced antenna ground plane design is that antenna efficiency increases with ground plane size. The evaluation board demonstrates how the antenna complies with the EMBRAI standard when set against a ground plane small enough to fit into most cellular phone designs. Applications that allow larger ground planes can enjoy higher efficiency.

An important consideration in the design of this product into cell phone applications is the coexistence of the cell phone antenna with VJ 6040. The recommended ground plane configuration presented below includes recommendations regarding how to set the cellular antenna relative to the VJ 6040 to minimize losses to both antennas.

VJ 6040 evaluation board demonstrates exceptional antenna performance achieved with a 40 mm by 80 mm ground plane.

Figure 4 describes a recommended reference ground plane configuration.

The areas marked in green in the close proximity to the antenna should remain empty from large conducting surfaces including ground planes (outer or inner layers), batteries, connectors, buttons, or other large components.

Applications that require additional antennas, such as cell phones, should position the cellular antenna at the top left hand side while maintaining maximum distance from VJ 6040. The presence of an additional antenna might cause loss of efficiency to both antennas.

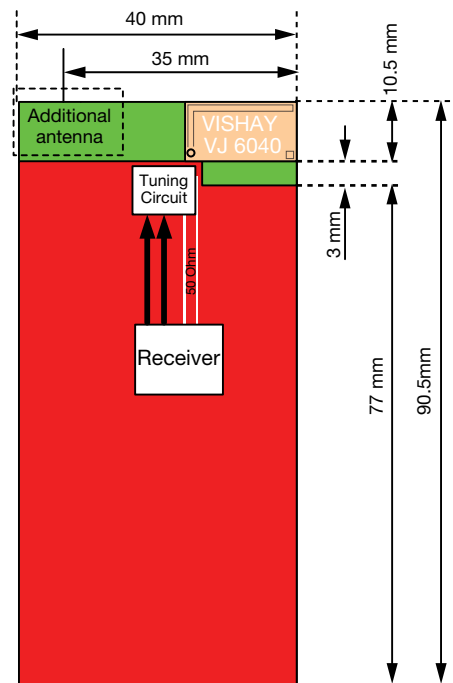


Fig. 8 - Recommended Ground Plane

APPLICATION NOTE