VJ 6040 Mobile Digital TV UHF Antenna Evaluation Board

GENERAL

VJ 6040 is a multilayer ceramic chip antenna designed for receiving mobile digital TV transmissions in the UHF band. The target application for the VJ 6040 antenna is the cellular phone. For this reason the following document refers to an antenna configuration small enough to fit into most cellular phones. Applications that allow larger ground planes can enjoy improved antenna efficiency.

To help in the design-in process, Vishay offers an antenna evaluation board by which designers can test the antenna performance. The evaluation board measures 40 mm by 90 mm and includes the following features:

- VJ 6040 antenna mounted against a 40 mm by 80 mm ground plane
- Active digital tuning circuit controlled by two input lines
- 50 Ω SMA termination

This document describes in detail the structure of the active digital tuning circuit needed to allow full coverage of the UHF band. It continues by describing a reference ground plane configuration. Designers who wish to make modifications in the values presented hereafter are encouraged to take advantage of the technical support offered by Vishay Vitramon division.

For any technical support please contact: mlcc@vishay.com

VJ 6040 TUNING CIRCUIT

The aggressive antenna miniaturization process that resulted in the ultra-small form factor of the antenna also had the unwanted effect of reducing the antenna bandwidth to approximately 120 MHz at - 3 dBi from its peak value. Full coverage of the UHF band (470 MHz to 860 MHz) can be achieved by implementing a simple four channel active digital tuning circuit. The tuning circuit shifts the central operating frequency of the antenna, thus allowing full coverage of the UHF band. Applications that require partial coverage of the UHF band can enjoy improved radiation efficiency by removing the tuning circuit and setting the antenna central frequency to the desired value using passive components.

This section in the document describes the recommended tuning circuit, as designed by Vishay Vitramon.

Tuning circuit key features are:

- Small outline - fits into a single side PCB of 5 mm x 5 mm
- Low cost BOM
- Digitally controlled - two digital control pins enable covering the entire band, by offering 4 combinations
- Also serves as a matching circuit reflecting a 50 Ω impedance

SCHEMATICS

Figure 1 presents the schematic drawing of the recommended tuning circuit.

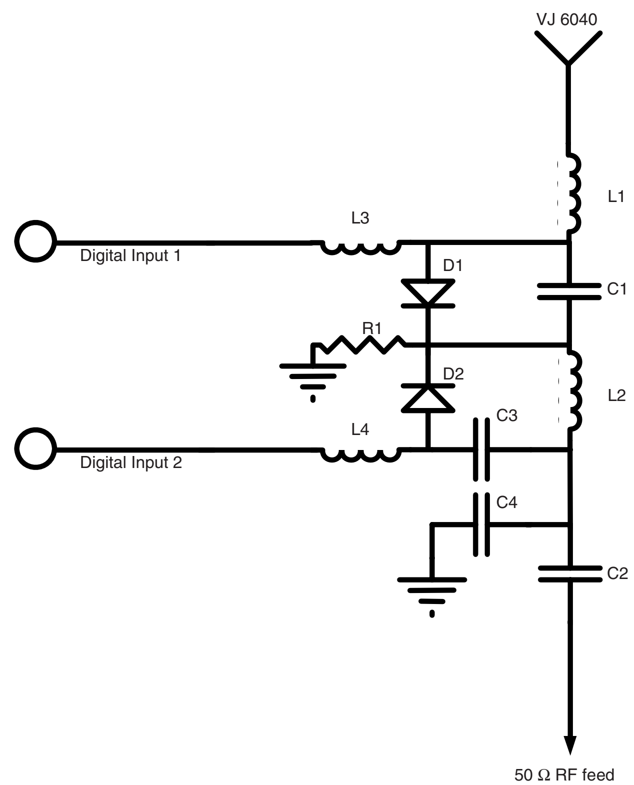


Fig. 1 - Tuning Circuit Schematics

VJ 6040 Mobile Digital TV UHF Antenna Evaluation Board

LAYOUT

Figure 2 shows the recommended layout of the tuning circuit. Layout should be as compact as possible. The striped area is GND plane.

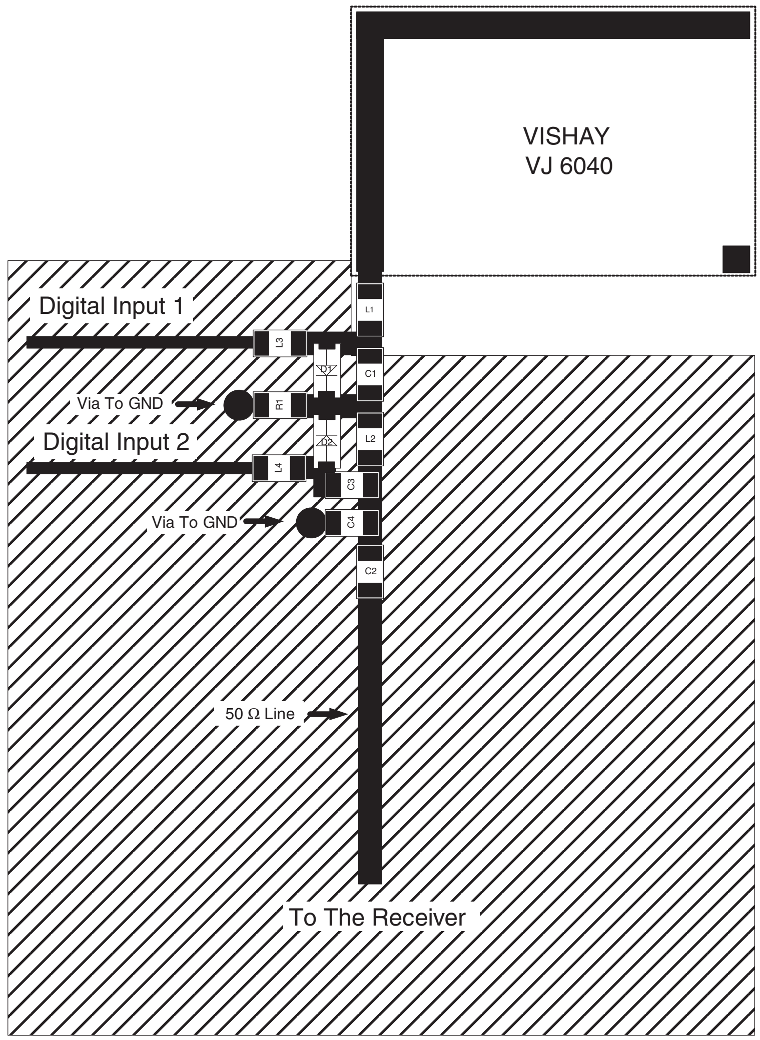


Fig. 2 - Tuning Circuit Layout

TABLE 1 - BOM OF THE TUNING CIRCUIT

COMPONENT	DESCRIPTION	VALUE	VENDOR	PART NUMBER
L1	Inductor	47 nH	Vishay	
L2	Inductor	39 nH	Vishay	
L3, L4	Inductor	120 nH	Taiyo Yuden	HK 1005 R12J
C1, C4	Capacitor	2.2 pF	Vishay	
C2, C3	Capacitor	220 pF	Vishay	
R1	Resistor	1 kW	Vishay	
D1, D2	PIN diode		Infineon	????

VJ 6040 Mobile Digital TV UHF Antenna Evaluation Board

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):

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

$$\omega = 2\pi f$$

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 conductance mode, it is represented as a 2 Ω resistor.

TABLE 2 - TUNING CIRCUITS' IMPEDANCES

DIGITAL INPUT 1	DIGITAL INPUT 2	PIN 0	PIN 1	Z (W)
0	0	High Z	High Z	$j * \left(\omega L_1 - \frac{1}{\omega C_1} + \omega L_2\right)$
0	1	High Z	2 W	$j * \left(\omega L_1 - \frac{1}{\omega C_1}\right) + 2$
1	0	2 W	High Z	$j * (\omega L_1 + \omega L_2) + 2$
1	1	2 W	2 W	$j * \omega L_1 + 4$

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:

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

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

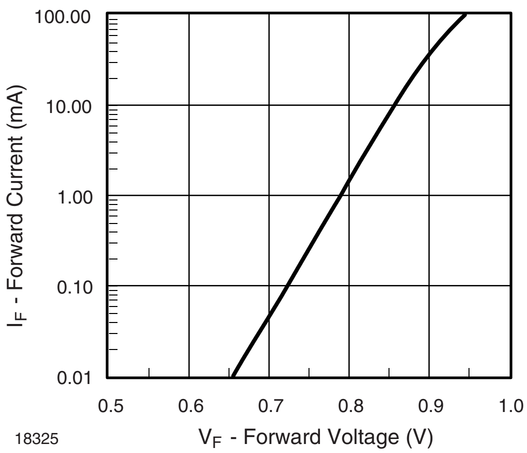
Example:

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:

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

VJ 6040 Mobile Digital TV UHF Antenna Evaluation Board



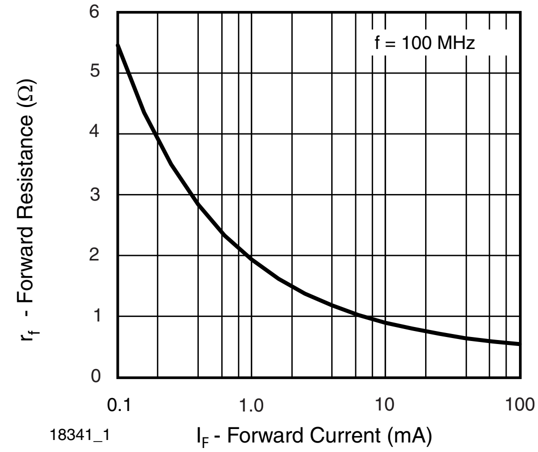


Fig. 3

Figure 3 displays the ???? 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.

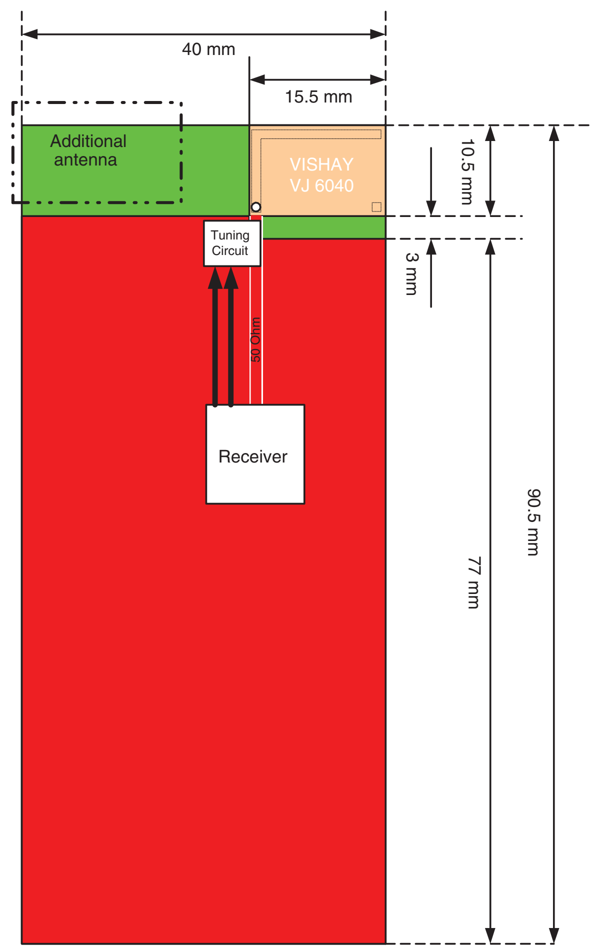


Fig. 4 - Recommended Ground Plane

VJ 6040 Mobile Digital TV UHF Antenna Evaluation Board

Features are subject to revisions or changes without notification

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

ORDERING INFORMATION	VISHAY MATERIAL	PACKAGING QUANTITY
VJ 6040	VJ6040M011SXISRA0	1000 pieces