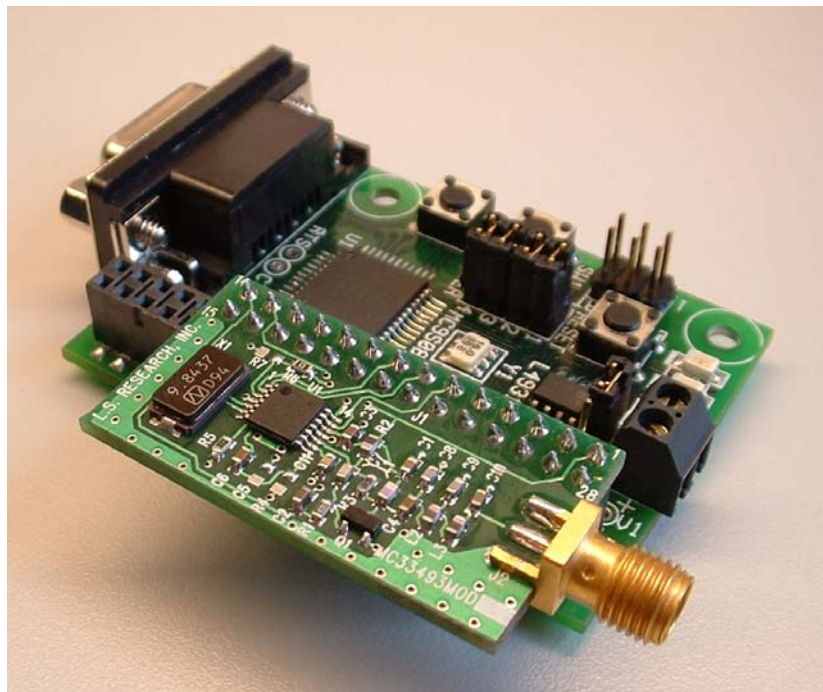


A Transmitter Using Tango3

Step-by-step Design for ISM Bands

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Introduction

This document provides a step-by-step approach to designing an optimized transmitter using Tango3¹.

Even though the description is based on a 433.92 MHz design, bills of material are provided for almost any ISM band: 315 MHz, 433.92 MHz, 868.3 MHz, and 916.5 MHz.

Tango3 Presentation

Main Features

Tango3 is a highly integrated circuit designed for data transfer applications. It includes a PLL² with a fully integrated VCO³ and a reference oscillator using an external crystal. It can be controlled by a microcontroller. Its main features are as follows.

- Selectable frequency bands: 315–433 MHz and 868–916 MHz⁴
- OOK⁵ and FSK⁶ modulation
- Adjustable output power up to 5 dBm
- 1.9V–3.6V supply voltage range
- Very low standby current 0.1 nA at 25°C
- TSSOP14 package

Tango3 is controlled through several pins:

- MODE: FSK or OOK operation
- DATA: data input
- BAND: switch between low band (315–433 MHz) and high band (868–916 MHz)
- ENABLE: standby/on control
- REXT: connected to an external resistor; allows control of the RFOUT power

It provides two signals:

1. RFOUT: the modulated RF signal
2. DATACLK: a reference frequency for the microcontroller for data clocking

1. Tango3 is the codename for MC33493DTB. For more technical data, refer to the MC33493DTB specification available on the Freescale Semiconductor web site at <http://www.freescale.com>.

2. Phase Locked Loop. In a PLL, a VCO is locked to a multiple of the frequency of a reference oscillator by mean of a feedback loop.

3. Voltage Controlled Oscillator.

4. Many frequencies are possible; consult Freescale Semiconductor prior to design.

5. On-Off Keying. A digital amplitude modulation system (sometimes called ASK — Amplitude Shift Keying) where the RF signal has only two levels — ON and OFF.

6. Frequency Shift Keying. A digital frequency modulation system where the RF signal has only two frequencies.

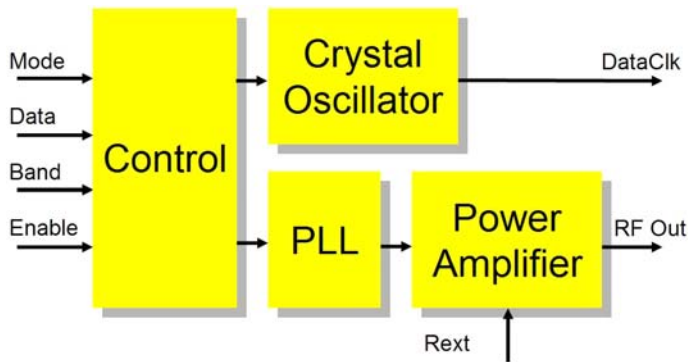


Figure 1. Tango3

Typical Application

A very basic transmitter can be realized with few external components.

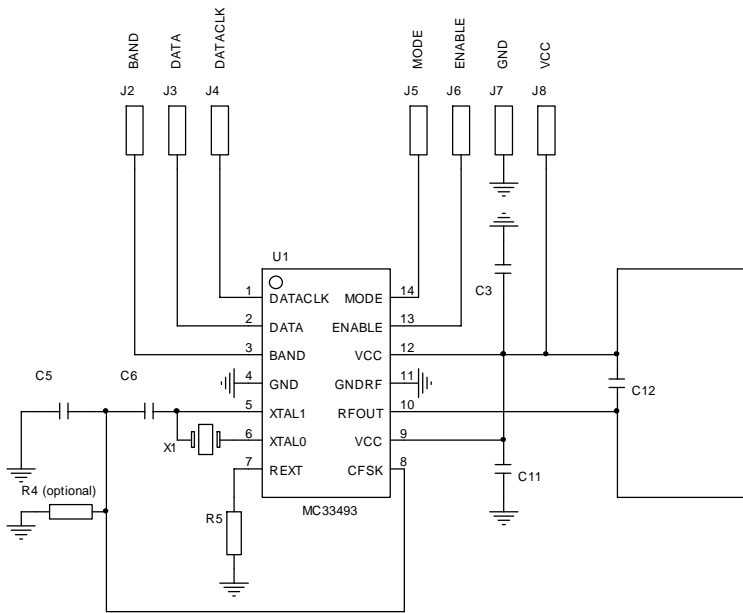


Figure 2. A Typical Application

U1 is Tango3. The internal PLL operates at a frequency that depends on the voltage level on pin BAND and the frequency of the crystal X1.

RF Module Specifications

C5 and C6 modify slightly the resonance frequency of the crystal oscillator. An internal switch on pin CFSK can short circuit C5 and thus allow frequency modulation. This kind of modulation is called “crystal polling”. R4 prevents spurious signals from occurring at high modulation frequencies.

The RF signal is available on pin RFOUT; the resistor connected to REXT controls its level. The output stage is a single ended RF current source, biased by the loop antenna.

The loop antenna is tuned by C12; its selectivity prevents radiation of harmonic signals.

C3 and C11 decouple the power supply (3V), to prevent parasitic oscillation of the circuit.

This transmitter can easily be driven by a microcontroller.

The software should first set BAND and MODE, according to the target frequency and type of modulation chosen (these signals can also be wired directly to ground or VCC), and then set ENABLE high, before sending data on the DATA pin.

The signal available on the DATACLK pin can be used by the microcontroller for its internal timing. Thus, the microcontroller does not require an accurate internal clock to achieve accurate timing.¹

This simple design has the following advantages.

- Cost effective
- Compact
- Low power consumption
- Tuning is not affected by touching the antenna

However, it does have the following drawback.

- Poor radiated level: loop antennas are not efficient, and the output power is not the maximum allowed by ETSI regulations EN300-220.

The proposed design should not suffer this drawback and should have increased radiated power.

RF Module Specifications

Overview

The Tango3 RF Module is part of a project to make a transmitter for long-range remote control.

1. This feature is fully exploited with the MC68HC908RF2 chip that includes both Tango3 and an HC08 MCU specially designed to use this signal.

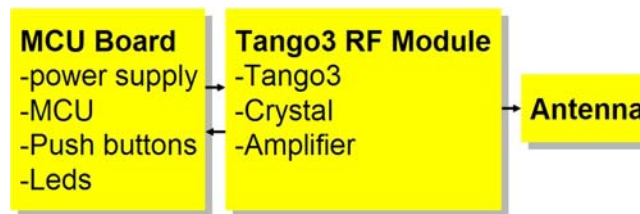


Figure 3. Transmitter Using the Tango3 RF Module

The transmitter is composed of three parts:

- An MCU board with battery and all logic components
- A Tango3 RF module with all RF components, reusable for other designs
- An antenna

Specifications

- 433.92 MHz operating frequency
- +10 dBm output power
- Output matched to 50 Ω
- 100% ASK capability (OOK)
- 100 kHz deviation FSK
- Data rate up to 10 kbps with Manchester coding
- 1.9V–3.6V power supply
- Low current

This leads to the following definition of the Tango3 RF Module for 433 MHz:

- Tango3 circuit with dedicated crystal
- Power amplifier using an external transistor
- Low-pass matching network between the power amplifier and the 50 Ω output

Tango3 RF Module

Schematic

The main improvements over typical application schematics are:

- Additional power amplifier around Q1
- Low-pass filtering and impedance matching network to 50 Ω

Tango3 RF Module

Some options on the board allow different configurations to be tested:

- Tango3 alone
- Tango3 and power amplifier

R2 biases the output of Tango3, and C7 delivers the RF signal to the power amplifier (PA) Q1.

The base of Q1 is biased by R1, which is driven by the ENABLEPA pin. When this pin is low, the PA current is cut. C2 bypasses the residual RF signals so that ENABLEPA is “RF cold”. L1 biases the collector of Q1 and blocks the RF signals. C4 delivers this signal to the matching network. C1 bypasses the power supply close to L1.

The matching network is composed of L2, L3, C8, C9, and C10. Because of its low-pass structure, it also helps to attenuate the level of harmonic signals.

To select the proper frequency range for Tango3, the BAND pin can be connected to VCC or GND with R6 or R7.

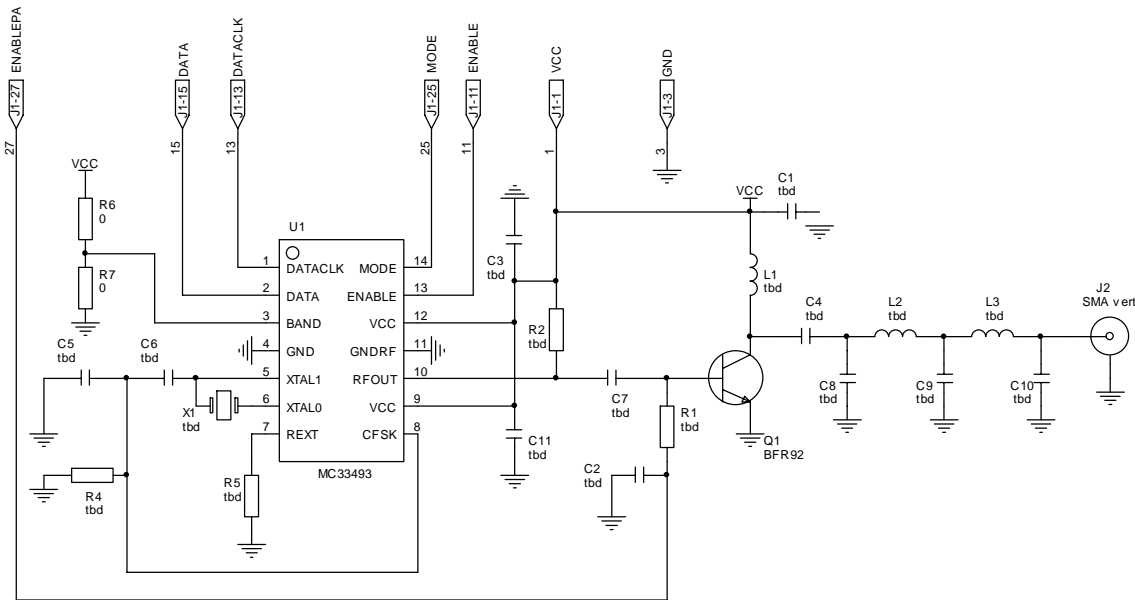


Figure 4. Initial Schematic Diagram

Computation of Values

Power Amplifier Biasing

R1 = 10 kΩ biases the base of the transistor with a 240 μA current. This current is switched when the Tango3 RF Module is not used (ENABLEPA = 0) and during the low level of OOK modulation. This simple biasing circuit has been tested during the evaluation of the BFR92A. When a constant 0dBm power generator was connected to the input, the output power of the amplifier varied less than 2dB over the

voltage range (1.9V to 3.6V) and over a large temperature range (-20°C to +60°C). The difference of behavior compared to a more complex voltage-regulated bias using diodes was too little to justify an increase in complexity (less than 1dB improvement over voltage range).

C2 = 100 pF presents a low impedance at 433 MHz compared to R1 and avoids having RF voltages on the ENABLEPA line.

C1 = 100 pF is the decoupling capacitor for the load of Q1.

The RF signal is applied to the base of Q1 with C7 = 4.7 nF (low impedance at 434 MHz compared to the input impedance of Q1).

Optimum Load Impedance

To achieve maximum efficiency of the power amplifier, it should work in C-class. In this case, the optimum value of the load of Q1 can be found from the following equation.

$$R_{Load} = \frac{(V_{cc} - V_{sat})^2}{2 \times P_{out}}$$

where...

V_{cc} = voltage of the power supply

V_{sat} = saturation voltage

P_{out} = wanted output power

Assuming:

- Output power = +13 dBm or 20mW
- V_{cc} = 3V
- V_{sat} = 1V

$$R_{Load} = \frac{(3 - 1)^2}{2 \times 0.2} = 100\Omega$$

Matching Network

A matching network has been defined to match R_{Load} to 50 Ω. Simple Smith chart software can be used to design this network, thereby avoiding extensive computation.

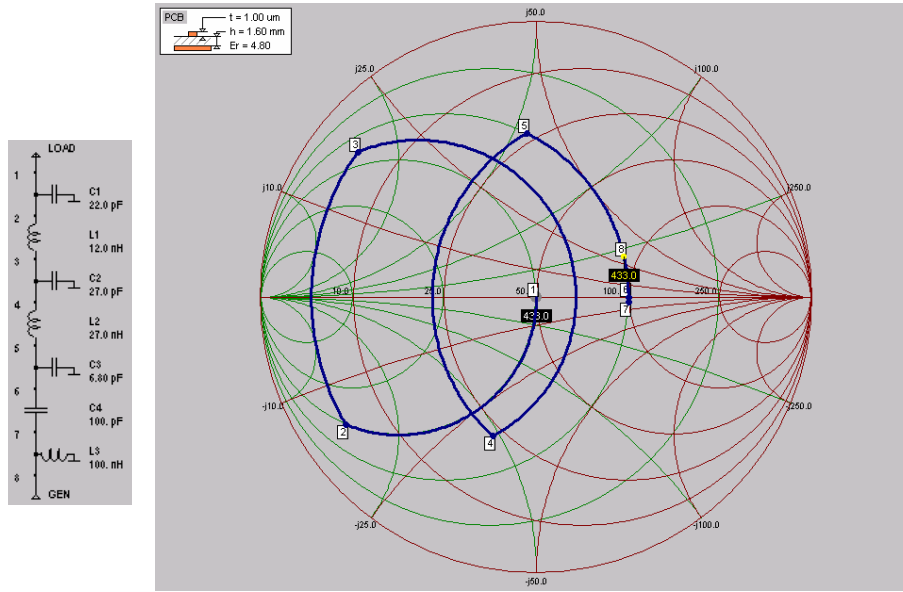


Figure 5. Matching Network and Simple Smith Chart

We chose $L1 = 100 \text{ nH}$ as the maximum inductance value on the circuit to avoid any effect the parallel resonance of the various coils, and to comply with commonly available values for 0603 inductors.

This gives:

- $L1 = 100 \text{ nH}$
- $C4 = 100 \text{ pF}$
- $C8 = 6.8 \text{ pF}$
- $L2 = 27 \text{ nH}$
- $C9 = 27 \text{ pF}$
- $L3 = 12 \text{ nH}$
- $C10 = 22 \text{ pF}$

This matching network also helps attenuate signal harmonics, as can be seen in the simulation in [Figure 6](#). The attenuation at 866 MHz (second harmonic of 433 MHz) is about 40dB.

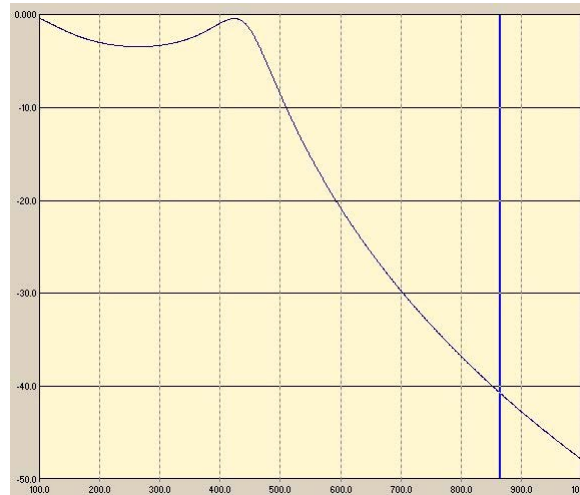


Figure 6. Signal Attenuation

Components Around Tango3

Starting values for C5 and C6 are the values from the data sheet: C5 = 2.2 pF, C6 = 10 pF.

X1 = 13.56 MHz will produce 433.92 MHz after a 32x multiplication with the PLL.

R4 is not used because of the low data rate. We will verify later (see “Measurements” on page 12) that it does not lead to any spurious signals caused by modulation.

R5 = 15 kΩ; this value lowers the output power of Tango3 and reduces the supply current.

R2 = 100 Ω is a starting value.

C11 = 22 nH and C3 = 100 pF, according to the data sheet.

Optimization and Final Schematics

The Tango3 RF Module can be simply tuned, without using the MCU board, by using a low-frequency generator to simulate the digital signal at 1200 bps, a power supply, and a spectrum analyzer¹.

The optimization process attempts to find, for each component, a value that will lead to a better result (maximum output power, lowest harmonic level and lowest current consumption), by testing the close values. Once each component has been optimized during the first pass of this optimization, a second pass is applied to finalize the work.

Increasing R2 does not lead to a major reduction in output power. 220 Ω is a good compromise between supply current and output power.

1. We do not recommend beginning the design of a transmitter without a spectrum analyzer to analyze the frequency deviation of the FSK modulation, the spectrum of the signal and its power.

Tango3 RF Module

To achieve the wanted frequency shift of 100 kHz in FSK modulation, C5 should be omitted because of the parasitic capacitance of the printed circuit board.

Some oscillation occurred between the PA and Tango3. The decoupling capacitors appear to be critical and we reversed the value of C3 and C11 and increased C1 to 10nF.

The matching network has been optimized to have the maximum fundamental frequency level with minimum harmonic level. The final values are:

- C8 = 3.9 pF
- L2 = 22 nH
- C9 = 8.2 pF
- L3 = 12 nH
- C10 = 6.8 pF

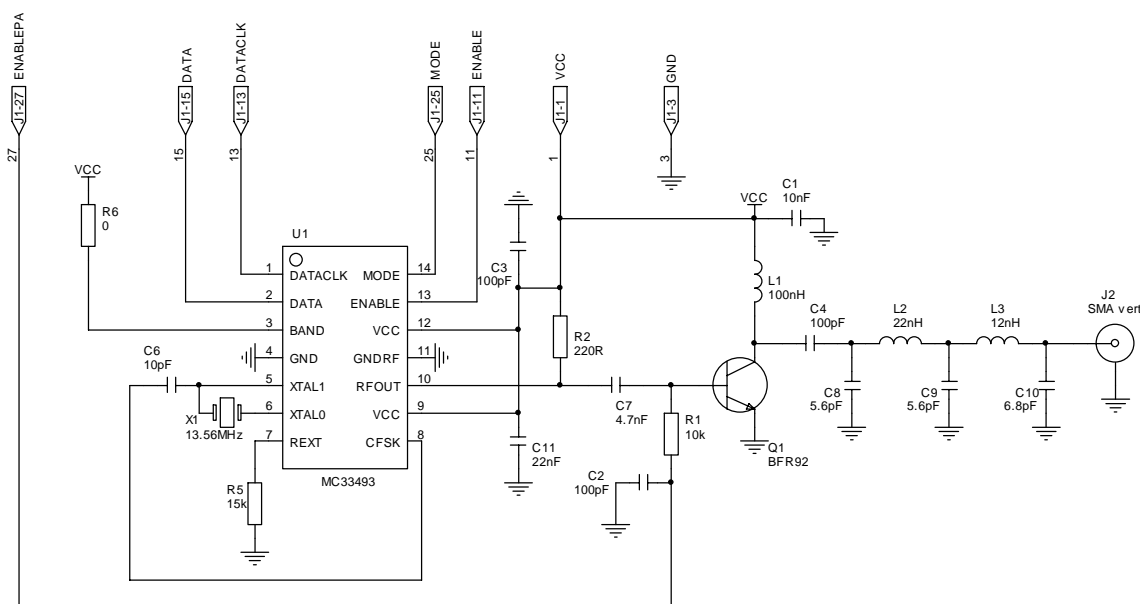


Figure 7. Final Optimized Schematic Diagram

How to Use the Tango3 RF Module

All the logic level signals available on J1 are referred to VCC and GND. Do not apply any signal higher than VCC or lower than GND to the module.

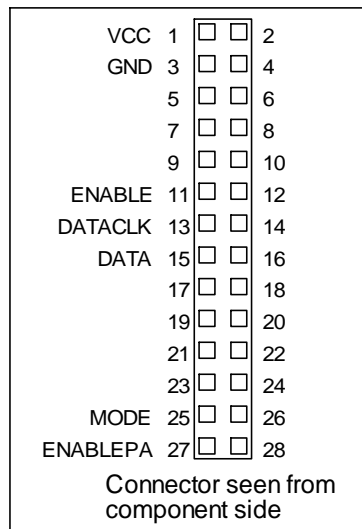


Figure 8. Connector J1 Connections

Table 1. Connector J1 Pin Assignments and Functions

Number	Name	Type	Function
1	VCC	Power supply	3V power supply
3	GND	Power supply	To be connected to a large ground plane
11	ENABLE	Input	0 = Tango3 is disabled 1 = Tango3 is enabled Should be set prior to transmission and after BAND and MODE signals.
13	DATACLK	Output	Clock available for the MCU The frequency of this signal is equal to the frequency of the crystal divided by 64. This frequency is 212 kHz for the Tango3 RF Module at 433MHz.
15	DATA	Input	Logic level data input Manchester coded data to transmit. Other kinds of modulation are possible (e.g. PWM, NRZ, Bi-phase)
25	MODE	Input	0 = OOK modulation 1 = FSK modulation
27	ENABLEPA	Input	0 = power amplifier is OFF 1 = power amplifier is ON High level during FSK transmission. Pulsed during OOK transmission to reduce consumption if required

Measurements

Software and MCU Board

Refer to AN2707 for more information on software drivers for this Tango3 RF Module.

Measurements

All RF measurements can be done without an MCU board. The Tango3 RF module can be controlled simply by applying voltages to each pin.

Operational Minimum Voltage

This measurement verified the ability of the Tango3 RF Module to work with various voltages. The Tango3 RF Module is fully functional over the measured voltage range.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1
Operating Voltage range (V)							
from :	2.00	1.99	2.01	2.11	1.99	2.11	1.98
to :	3.60	3.60	3.60	3.60	3.60	3.60	3.60

CW Supply Current

The current is measured at several voltages, while the Tango3 RF Module is transmitting a continuous wave (CW).

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1
Supply current (mA)							
2.1V	9.56	20.20	10.46	18.93	10.71	19.54	10.97
3V	10.17	27.60	11.15	24.98	11.41	26.50	11.67
3.6V	10.49	30.10	11.52	29.59	11.79	31.87	12.06

PLL Enable Supply Current

The current is measured at several voltages with the PLL enabled (ready to transmit) but with power the amplifier disabled.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	0	0	0	0	0	0	0
Data :	0	0	0	0	0	0	0
Supply current (mA)							
2.1V	4.14	4.19	4.06	4.26	4.26	4.42	4.38
3V	4.31	4.36	4.23	4.42	4.44	4.60	4.56
3.6V	4.41	4.46	4.31	4.51	4.52	4.70	4.65

Standby Supply Current

The current is measured at several voltages, with the Tango3 RF Module in standby.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	0	0	0	0	0	0	0
EnablePA :	0	0	0	0	0	0	0
Data :	0	0	0	0	0	0	0
Supply current (nA)							
2.1V	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA
3V	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA
3.6V	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA	<100nA

Measurements

Carrier Frequency

The carrier frequency is measured at several voltages, while the Tango3 RF Module is transmitting a continuous wave in OOK mode.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz

Tango3 RF Module setup

Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1

Spectrum Analyser setup

RBW (kHz) :	1	1	1	1	1	1	1
Span (kHz) :	10	10	10	10	10	10	10
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Acquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold

Frequency (MHz)

2.1V	315.0528	434.0030	434.0103	868.3912	868.3928	916.5685	916.5670
3V	315.0537	434.0046	434.0107	868.3929	868.3946	916.5703	916.5688
3.6V	315.0541	434.0052	434.0113	868.3936	868.3954	916.5711	916.5695

FSK Deviation

The FSK deviation is computed after measuring the frequency during transmission of a 1 and a 0.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz

Tango3 RF Module setup

Band :	1	1	1	0	0	0	0
Mode :	1	1	1	1	1	1	1
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1

Frequency (MHz)

0	315.0538	434.0028	434.0103	868.3930	868.3943	916.5707	916.5686
1	314.9997	433.9135	433.9138	868.2913	868.2897	916.4634	916.4637
FSK deviation (kHz)	54.10	89.34	96.50	101.66	104.64	107.32	104.92

Fundamental and Harmonics Power Level

The power of the fundamental signal and each harmonic are measured at several voltages while transmitting a continuous wave.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1
Spectrum Analyser setup							
RBW (kHz) :	3	3	3	3	3	3	3
Span (kHz) :	100	100	100	100	100	100	100
Fc (MHz) :	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold
Fc power level (dBm)							
2.1V	3.20	7.61	3.26	6.16	-1.16	6.12	-1.35
3V	3.95	9.96	4.25	8.85	-0.37	8.25	-0.65
3.6V	4.28	10.56	4.60	9.68	-0.07	8.77	-0.35
H2 power level (dBm)							
2.1V	-54.16	-37.39	-54.63	-57.74	-65.74	-52.86	-63.05
3V	-56.27	-38.39	-58.16	-50.15	-65.01	-44.23	-62.10
3.6V	-56.32	-36.42	-58.12	-45.33	-65.27	-42.59	-61.62
H3 power level (dBm)							
2.1V	-58.69	-55.37	-65.71	-55.74	-71.82	-53.48	-70.22
3V	-57.67	-56.44	-64.56	-56.02	-70.74	-57.17	-68.07
3.6V	-57.13	-55.45	-62.59	-58.88	-69.62	-58.48	-67.68
H4 power level (dBm)							
2.1V	-86.03	-52.11	-75.45	nc	nc	nc	nc
3V	-85.23	-54.17	-74.26	nc	nc	nc	nc
3.6V	-86.09	-56.25	-70.47	nc	nc	nc	nc

Measurements

CW Occupied Bandwidth

The bandwidth of the transmitted signal is measured during transmission of a continuous wave.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz

Tango3 RF Module setup

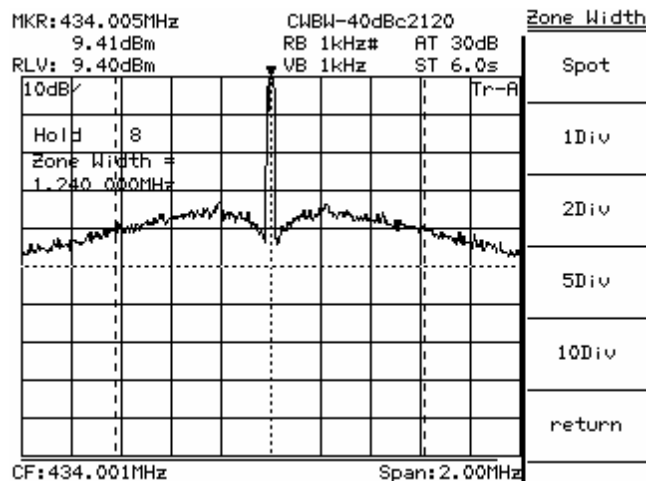
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1

Spectrum Analyser setup

RBW (kHz) :	1	1	1	1	1	1	1
Span (kHz) :	100	100	100	100	100	100	100
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold

Bandwidth (kHz)

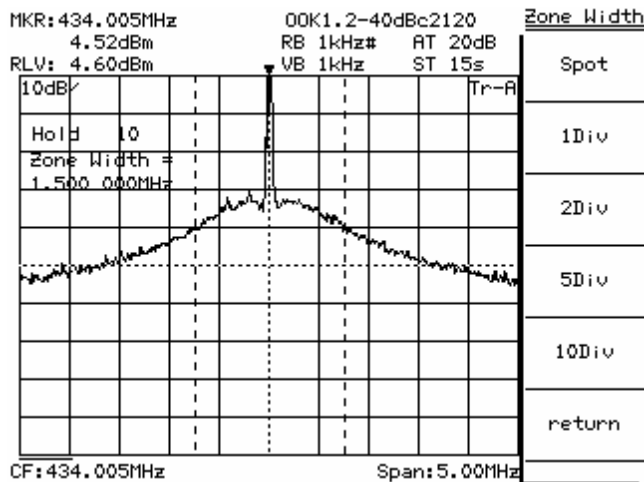
-10dBc	2.20	2.20	2.20	2.20	2.12	2.12	2.12
-20dBc	3.44	3.44	3.48	3.36	3.36	3.36	3.40
-30dBc	4.80	4.92	4.92	480.00	744.00	736.00	824.00
-40dBc	1016.00	1240.00	1256.00	1880.00	2120.00	2000.00	1900.00



1200 bps OOK Occupied Bandwidth

The bandwidth of the transmitted signal is measured during transmission of an OOK modulated wave at 1200 bps.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	modulated	modulated	modulated	modulated	modulated	modulated	modulated
Modulation :	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz
Spectrum Analyser setup							
RBW (kHz) :	1	1	1	1	1	1	1
Span (kHz) :	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold
Bandwidth (kHz)							
-10dBc	3.88	4.00	3.92	3.80	3.88	3.88	3.80
-20dBc	12.36	14.00	12.60	12.80	12.40	12.40	12.80
-30dBc	53.60	49.20	64.00	816.00	1096.00	1068.00	1048.00
-40dBc	1376.00	1500.00	1600.00	2340.00	2920.00	2740.00	2500.00



Measurements

9600 bps OOK Occupied Bandwidth

The bandwidth of the transmitted signal is measured during transmission of an OOK modulated wave at 9600 bps.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz

Tango3 RF Module setup

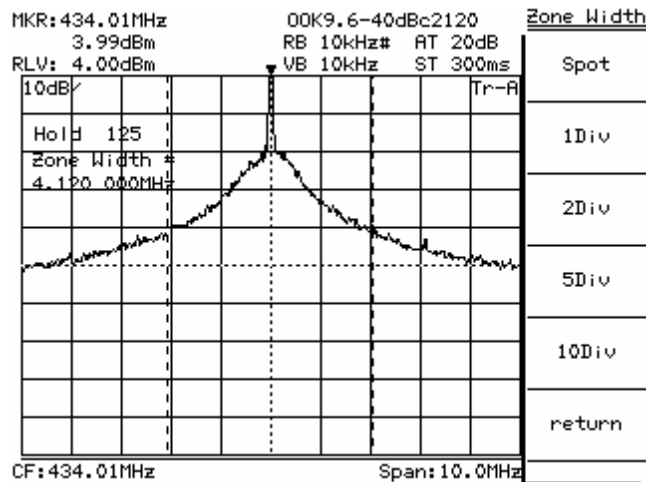
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	modulated	modulated	modulated	modulated	modulated	modulated	modulated
Modulation :	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz

Spectrum Analyser setup

RBW (kHz) :	10	10	10	10	10	10	10
Span (kHz) :	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold

Bandwidth (kHz)

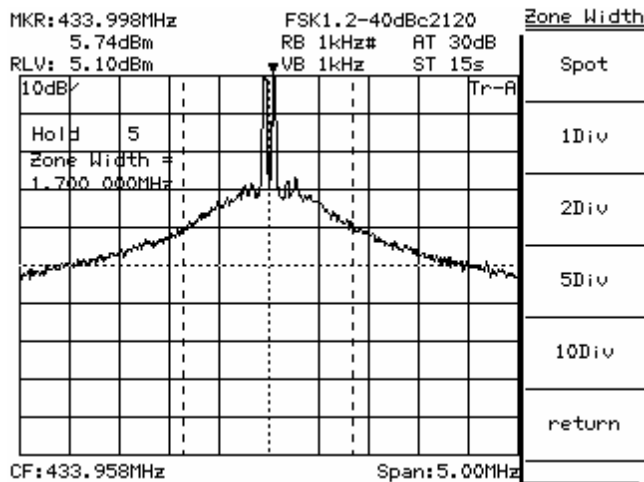
-10dBc	35.20	40.80	35.20	34.40	34.80	36.00	34.40
-20dBc	150.00	180.00	258.00	944.00	1120.00	888.00	1048.00
-30dBc	1360.00	1800.00	1500.00	2840.00	2700.00	2340.00	2700.00
-40dBc	3080.00	4120.00	3720.00	5680.00	6240.00	5920.00	6080.00



1200 bps FSK Occupied Bandwidth

The bandwidth of the transmitted signal is measured during transmission of an FSK modulated wave at 1200 bps.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	1	1	1	1	1	1	1
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	modulated	modulated	modulated	modulated	modulated	modulated	modulated
Modulation :	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz	1.2kHz
Spectrum Analyser setup							
RBW (kHz) :	1	1	1	1	1	1	1
Span (kHz) :	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold
Bandwidth (kHz)							
-10dBc	60.40	98.40	103.20	106.40	109.60	111.20	109.60
-20dBc	67.60	104.40	112.00	113.60	117.60	119.20	117.60
-30dBc	100.00	568.00	580.00	1040.00	1296.00	1152.00	1224.00
-40dBc	1600.00	1700.00	1760.00	2520.00	3140.00	2740.00	2800.00



Measurements

9600 bps FSK Occupied Bandwidth

The bandwidth of the transmitted signal is measured during transmission of an FSK modulated wave at 9600 bps.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz

Tango3 RF Module setup

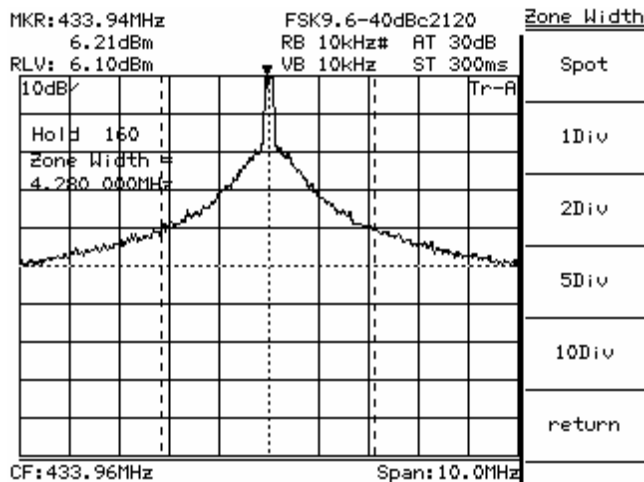
Band :	1	1	1	0	0	0	0
Mode :	1	1	1	1	1	1	1
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	modulated	modulated	modulated	modulated	modulated	modulated	modulated
Modulation :	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz	9.6kHz

Spectrum Analyser setup

RBW (kHz) :	10	10	10	10	10	10	10
Span (kHz) :	tbid	tbid	tbid	tbid	tbid	tbid	tbid
Fc (MHz) :	315	433.92	433.92	868.3	868.3	916.5	916.5
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold

Bandwidth (kHz)

-10dBc	92.80	134.00	132.80	136.00	152.00	152.80	146.40
-20dBc	472.00	440.00	636.00	1192.00	1440.00	1176.00	1224.00
-30dBc	1680.00	1660.00	1660.00	2940.00	2900.00	2808.00	2904.00
-40dBc	3600.00	4280.00	4080.00	6600.00	7680.00	6680.00	6960.00



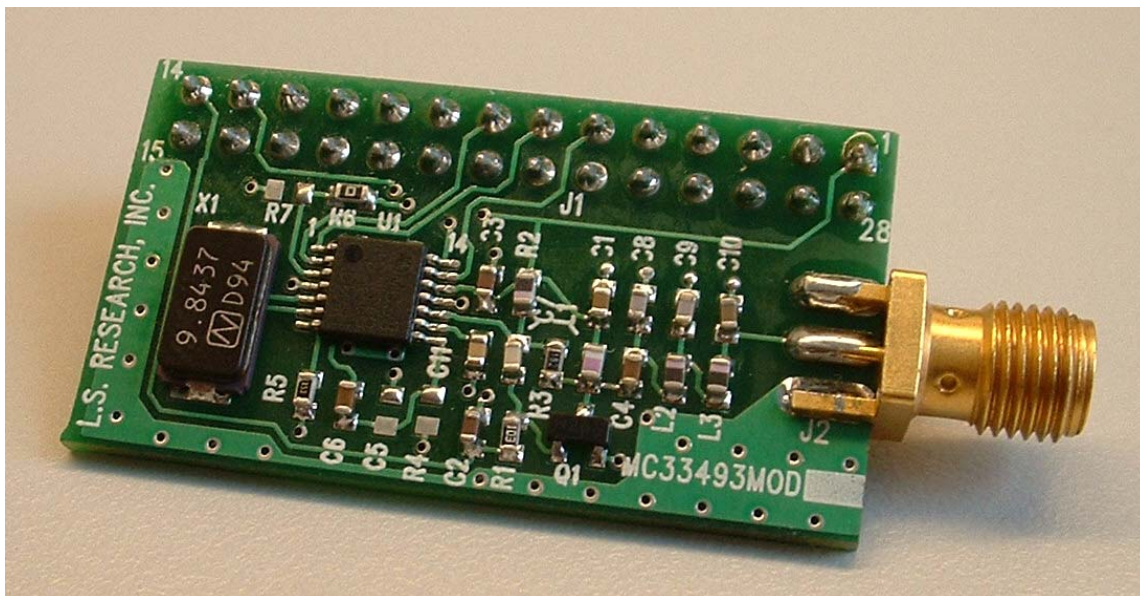
Spurious Level

The level of the signal is measured at several frequencies, paying special attention to the sideband signals created by the reference frequency of the PLL.

Ref :	2110	2120	2121	2130	2131	2140	2141
PA :	no	yes	no	yes	no	yes	no
Frequency :	315MHz	433.92MHz	433.92MHz	868.3MHz	868.3MHz	916.5MHz	916.5MHz
Tango3 RF Module setup							
Band :	1	1	1	0	0	0	0
Mode :	0	0	0	0	0	0	0
Enable :	1	1	1	1	1	1	1
EnablePA :	1	1	1	1	1	1	1
Data :	1	1	1	1	1	1	1
Modulation :	no	no	no	no	no	no	no
Spectrum Analyser setup							
RBW (kHz) :	30	30	30	30	30	30	30
Span (MHz) :	25	30	30	30	30	30	30
Fc (MHz) :	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Detector :	Peak	Peak	Peak	Peak	Peak	Peak	Peak
Aquisition :	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold	Maxhold
Frequency							
Fref :	9.8438	13.5600	13.5600	13.5672	13.5672	14.3203	14.3203
Fc :	315.0000	433.9200	433.9200	868.3000	868.3000	916.5000	916.5000
Fc+Fref :	324.8438	447.4800	447.4800	881.8672	881.8672	930.8203	930.8203
Fc-Fref :	305.1563	420.3600	420.3600	854.7328	854.7328	902.1797	902.1797
Fref power level (dBm)							
Fc :	3.95	9.96	4.25	8.85	-0.37	8.25	-0.65
Fc+Fref :	-31.66	-23.58	-29.41	-24.62	-47.74	-30.52	-40.82
Fc-Fref :	-22.36	-29.57	-23.45	-22.36	-34.26	-25.91	-34.87
Fref power level (dBc)							
Fc+Fref :	-35.61	-33.54	-33.66	-33.47	-47.37	-38.77	-40.17
Fc-Fref :	-26.31	-39.53	-27.70	-31.21	-33.89	-34.16	-34.22

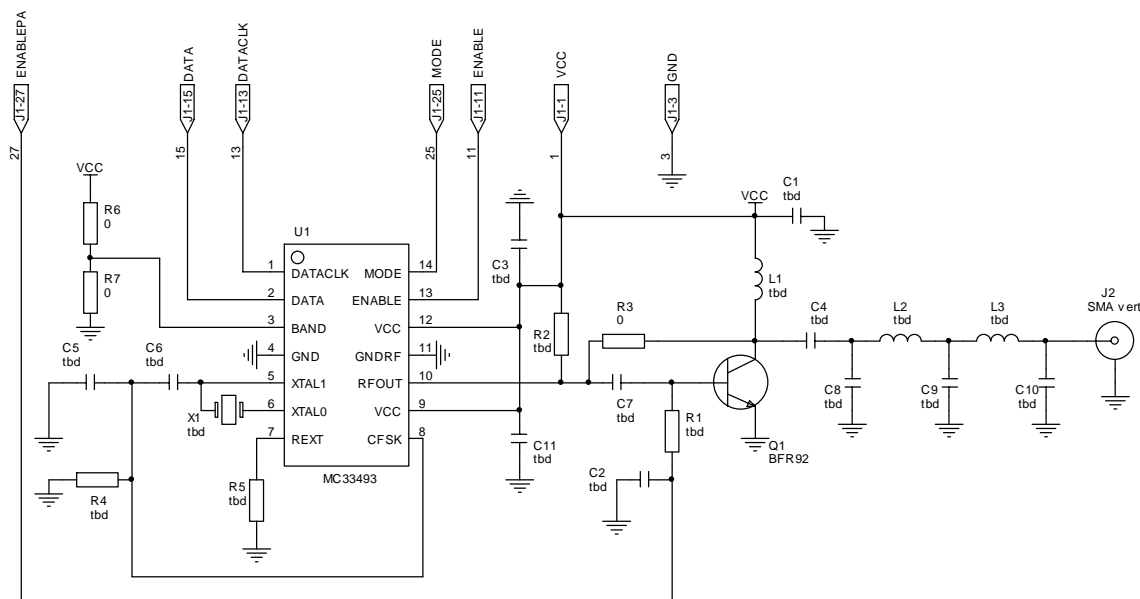
CAD Files

Generic Schematics



The following schematic diagram is a generic one that can be adapted for many configurations.

- With or without power amplifier
- Various frequencies
- Various output matching network types



A Transmitter Using Tango3, Rev. 0

Bill of Materials

The bill of materials below may differ from the computed values described earlier in this application note.

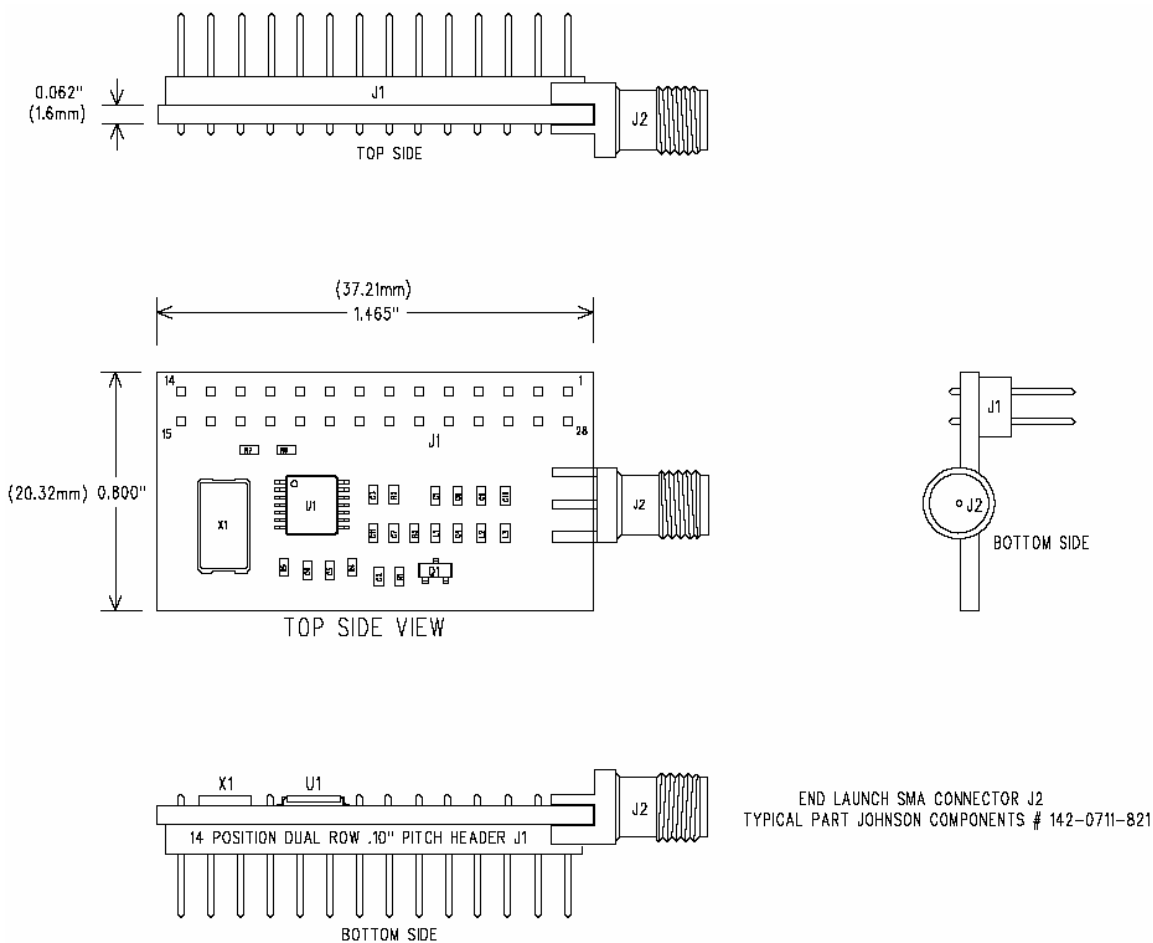
The step-by-step design is based on the Tango3 RF Module 433.92 MHz. While the same process can be used to design for 315, 868 and 916 MHz, these are not described in this document. Subsequent tests to verify compliance with FCC and CE regulations led to some changes of the bill of material.

<i>Module Ref. Frequency Equipment</i>		2110 315MHz Low power	2120 433.92MHz High power	2121 433.92MHz Low power	2130 868.3MHz High power	2131 868.3MHz Low power	2140 916.5MHz High power	2141 916.5MHz Low power
Ref.	Package							
R1	0603	not equipped	10k	not equipped	12k	not equipped	12k	not equipped
R2	0603	replaced by L4	220R	replaced by L4	replaced by L4	replaced by L4	replaced by L4	replaced by L4
R3	0603	0R	not equipped	0R	not equipped	0R	not equipped	0R
R4	0603	not equipped	not equipped	not equipped	not equipped	not equipped	not equipped	not equipped
R5	0603	15k	15k	15k	12k	12k	12k	12k
R6	0603	0R	0R	0R	not equipped	not equipped	not equipped	not equipped
R7	0603	not equipped	not equipped	not equipped	0R	0R	0R	0R
R8 (1)	0603	0R	replaced by L2	0R	replaced by L2	0R	replaced by L2	0R
C1	0603	not equipped	10nF	not equipped	10nF	not equipped	10nF	not equipped
C2	0603	not equipped	100pF	not equipped	100pF	not equipped	100pF	not equipped
C3	0603	100pF	100pF	100pF	100pF	100pF	100pF	100pF
C4	0603	100pF	100pF	100pF	100pF	100pF	100pF	100pF
C5	0603	not equipped	not equipped	not equipped	4.7pF	4.7pF	4.7pF	4.7pF
C6	0603	10pF	10pF	10pF	10pF	10pF	10pF	10pF
C7	0603	not equipped	4.7nF	not equipped	4.7nF	not equipped	4.7nF	not equipped
C8	0603	5.6pF	5.6pF	3.3pF	2.2pF	1pF	1.2pF	1pF
C9	0603	not equipped	5.6pF	not equipped	2.7pF	not equipped	1.8pF	not equipped
C10	0603	15pF	6.8pF	12pF	3.9pF	4.7pF	2.7pF	3.9pF
C11	0603	22nF	22nF	22nF	22nF	22nF	22nF	22nF
L1	0603	not equipped	100nH	not equipped	47nH	not equipped	47nH	not equipped
L2	0603	replaced by R8	22nH	replaced by R8	10nH	replaced by R8	15nH	replaced by R8
L3	0603	47nH	12nH	27nH	3.9nH	5.6nH	6.8nH	3.9nH
L4 (2)	0603	100nH	replaced by R2	100nH	47nH	47nH	47nH	47nH
Q1	SOT23	not equipped	BFR92	not equipped	BFR92	not equipped	BFR92	not equipped
U1		MC33493	MC33493	MC33493	MC33493	MC33493	MC33493	MC33493
X1		9.843750MHz	13.56MHz	13.56MHz	13.567188MHz	13.567188MHz	14.320313Mz	13.320313MHz
J1		28 pins	28 pins	28 pins	28 pins	28 pins	28 pins	28 pins
J2		SMA	SMA	SMA	SMA	SMA	SMA	SMA

Notes :

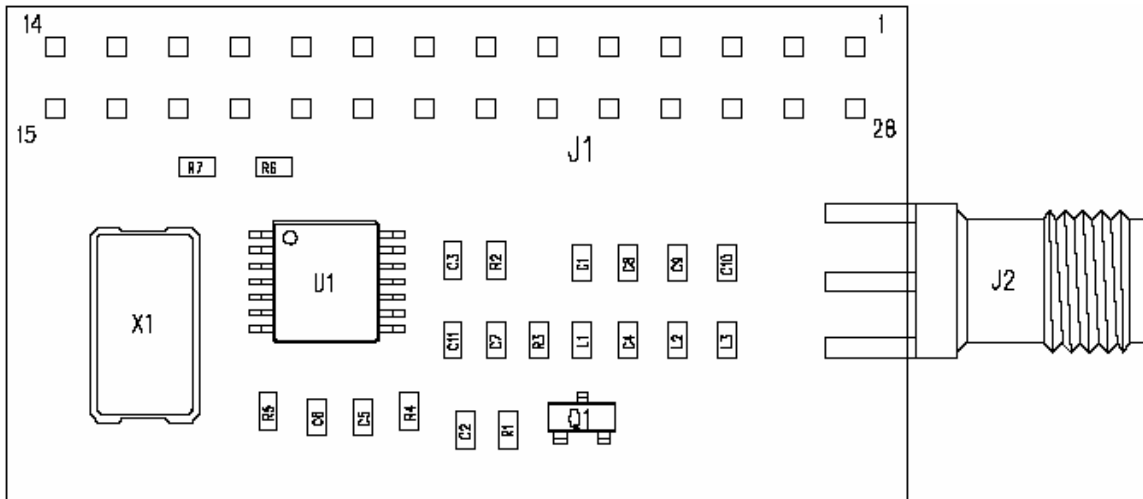
- 1 : R8 may replace L2
- 2 : L4 may replace R2

Board Geometry



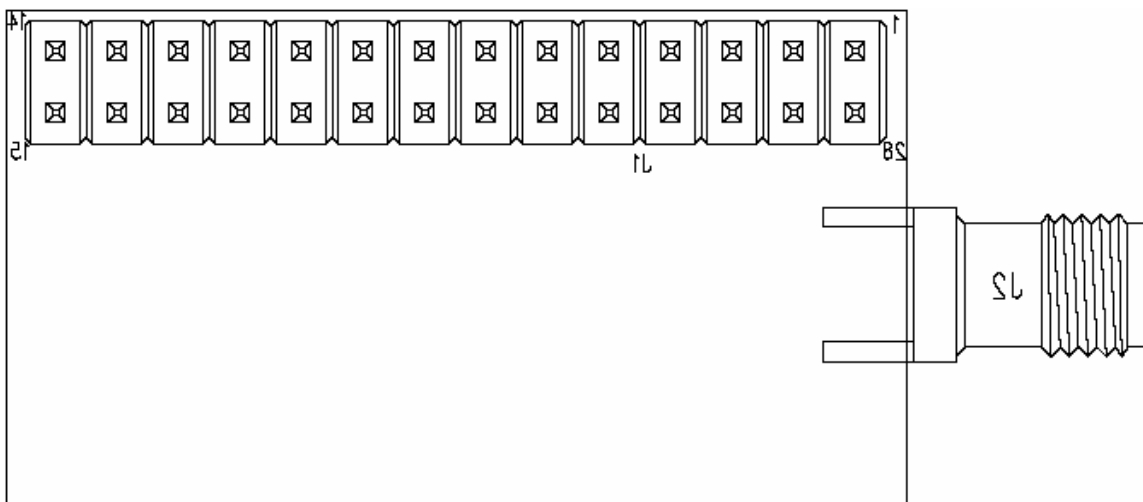
Refer to the updated pinout described in [“How to Use the Tango3 RF Module”](#) on page 10.

Component Placement Side 1



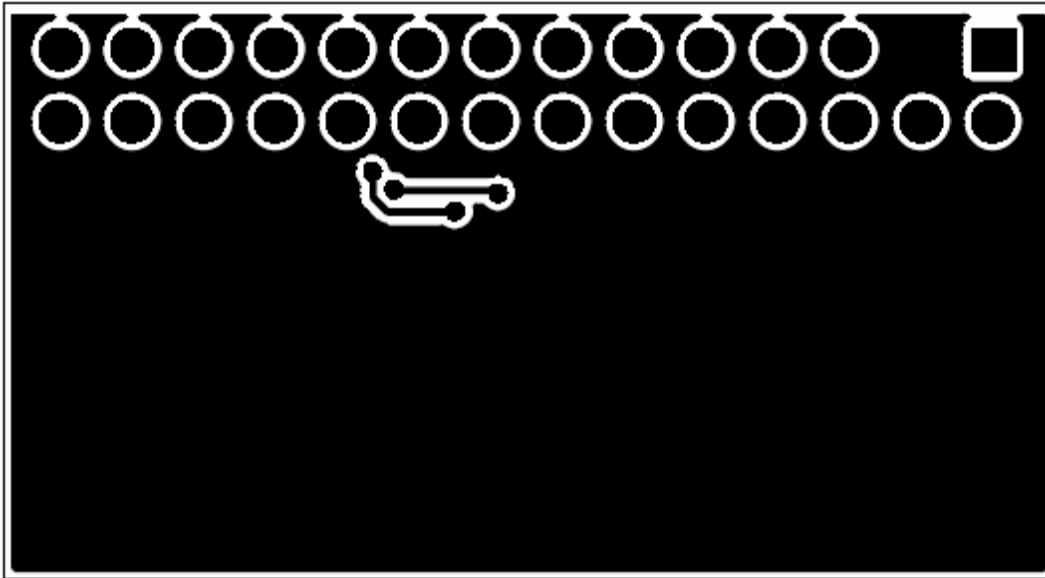
Refer to the updated pinout described in [“How to Use the Tango3 RF Module”](#) on page 10.

Component Placement Side 2

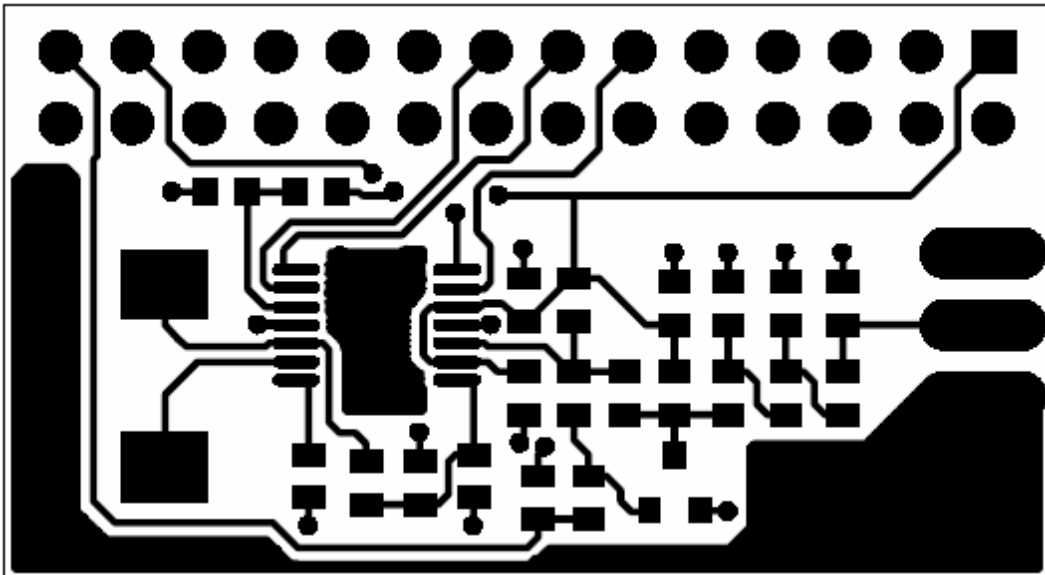


Refer to the updated pinout described in [“How to Use the Tango3 RF Module”](#) on page 10.

Copper Side 1



Copper Side 2



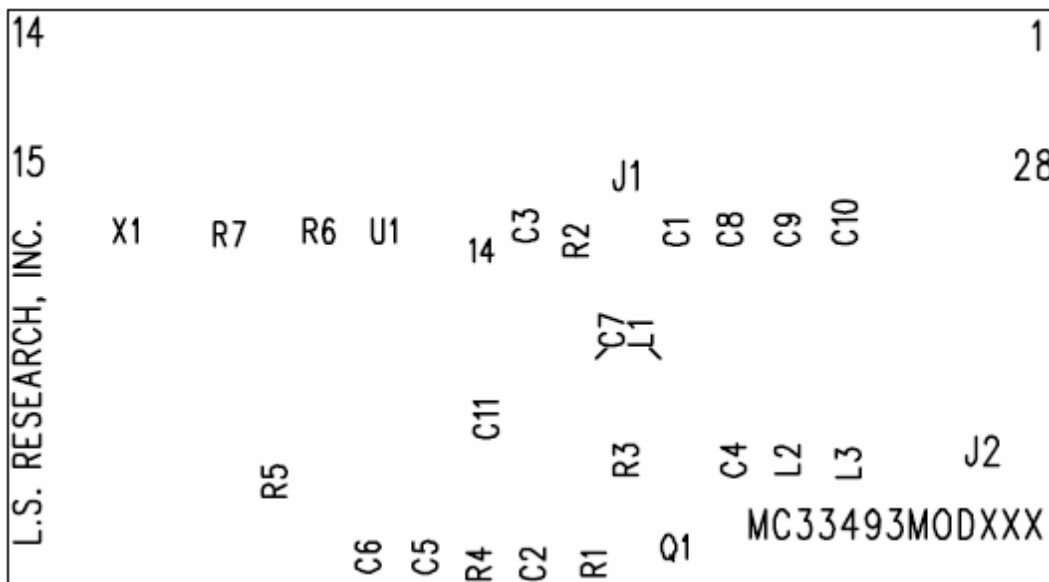
Varnish Side 1

Not available

Varnish Side 2

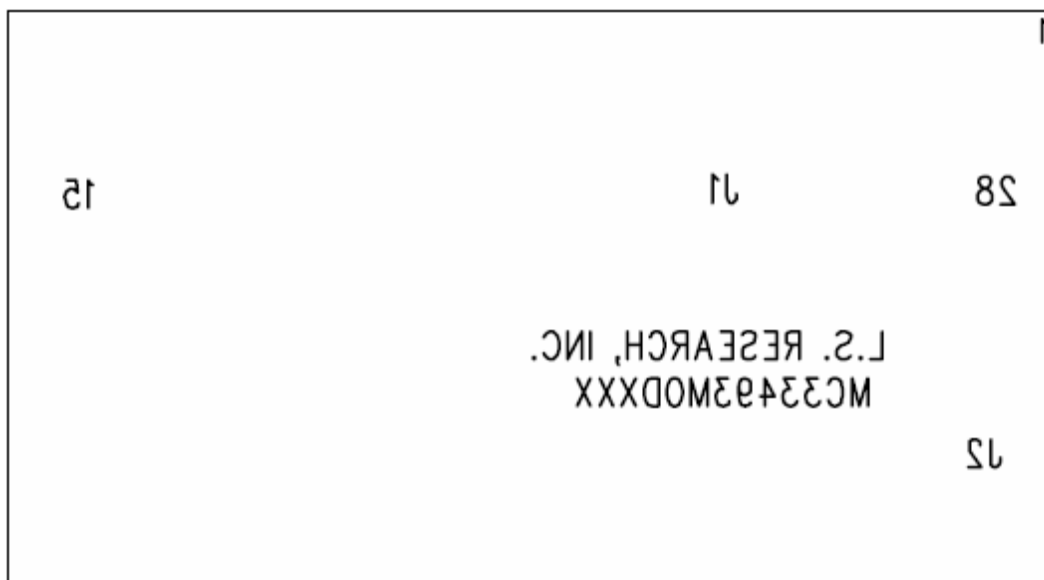
Not available

Silkscreen Side 1



Refer to the updated pinout described in [“How to Use the Tango3 RF Module”](#) on page 10.

Silkscreen Side 2

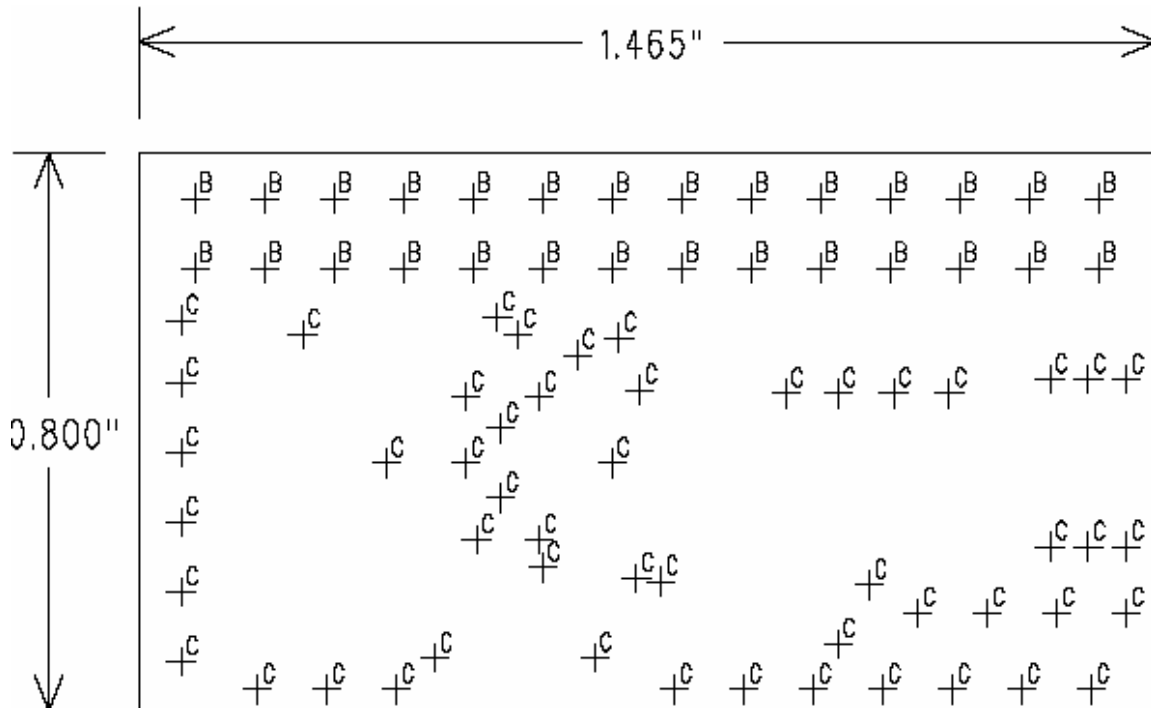


Refer to the updated pinout described in [“How to Use the Tango3 RF Module”](#) on page 10.

Drilling and Sizes

FABRICATION NOTES:

1. ALL BOARD DIMENSIONS IN INCHES. TOLERANCE = +/-0.005" UNLESS NOTED OTHERWISE.
2. BOARD MATERIAL - FR-4 GRADE GLASS EPOXY, 0.062" +/- .005" THICKNESS MEASURED OVER SOLDERMASK MINIMUM FLAMMABILITY RATING UL 94V-0
3. OUTER LAYER COPPER THICKNESS 0.0014" (1 OZ).
4. SOLDER MASK OVER BARE COPPER, LPI, CLASS 2 GEN. INDUSTRIAL REGISTRATION +/-0.004", GREEN. NO COVERAGE ON SOLDER PADS PERMITTED.
5. FINISH-TIN/LEAD REFLOWED OR HOT AIR SOLDER LEVELED-0.0002" TO 0.002" PLATING THICKNESS. NO EXPOSED BARE COPPER PERMITTED
6. WHITE SILKSCREEN LEGEND OVER GREEN SOLDERMASK - TOP SIDE
7. HOLE SIZE TOLERANCE = +/- 0.002" UNLESS NOTED OTHERWISE. HOLE CENTERS AND PAD CENTERS TO BE CONCENTRIC WITHIN 0.004"



SIZE	QTY	SYM	PLTD
35	28	B	PLTD
14	52	C	PLTD

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