

General Description

The MICRF113 is a high performance, easy to use, single chip ASK Transmitter IC for remote wireless applications in the 300 to 450MHz frequency band. This transmitter IC is a true “data-in, antenna-out” monolithic device. MICRF113 has three strong attributes: power delivery, operating voltage and operating temperature. In terms of power, the MICRF113 is capable of delivering +10 dBm into a 50Ω load. This power level enables a small form factor transmitter (lossy antenna) such as a key fob transmitter to operate near the maximum limit of transmission regulations. In terms of operating voltage, the MICRF113 operates from 1.8V to 3.6V. Many transmitter ICs in the same frequency band stop operating below 2.0V. The MICRF113 will work with most batteries to the end of their useful limits. In terms of operating temperature, the MICRF113 operates from -40°C to +85°C.

The MICRF113 is easy to use. It requires a reference frequency (RF carrier frequency divided by 32 times) generated from a crystal with a few additional external parts to create a complete versatile transmitter.

The MICRF113 operates with ASK/OOK (Amplitude Shift Keying/On-Off Keyed) UHF receiver types from wide-band super-regenerative radios to narrow-band, high performance super-heterodyne receivers. The MICRF113’s maximum ASK data rate is 10kbps (Manchester Encoding).

The MICRF113 transmitter solution is ideal for industrial and consumer applications where simplicity and form factor are important.

Features

- Complete UHF transmitter
- Frequency range 300MHz to 450MHz
- Data rates up to 10kbps ASK
- Output Power to 10dBm
- Low external part count
- Low voltage operation (down to 1.8V)
- Operate with crystals or ceramic resonators

Applications

- Fan Controllers
- Remote Power Switches
- Multi-Media Remote Control
- Remote Sensor Data Links
- Infrared Transmitter Replacement

Ordering Information

Part Number	Temp. Range	Package
MICRF113YM6	-40°C to +85°C	SOT23-6

Typical Application

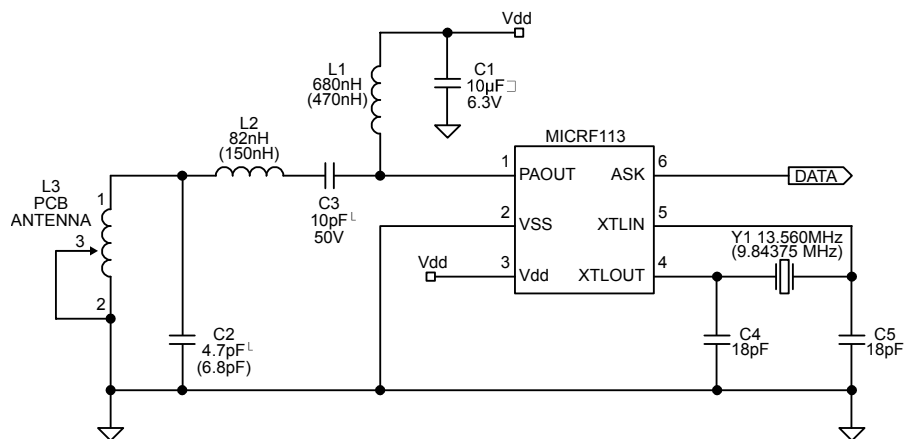


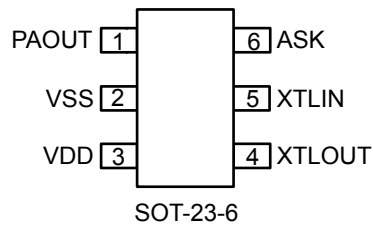
Figure 1. MICRF113 ASK Key Fob Design for 315 MHz and 433.92 MHz

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Note: Values indicated in parentheses are for 315MHz

Pin Configuration



Pin Description

Pin Number MSOP-6	Pin Name	Pin Function
1	PA_OUT	PA output
2	VSS	Ground
3	VDD	Voltage Drain Drain (Input): Positive Power Supply
4	XTLOUT	Crystal Out (Output): Reference oscillator output connection.
5	XTLIN	Crystal In (Input): Reference oscillator input connection.
6	ASK	ASK DATA Input

Absolute Maximum Ratings ⁽¹⁾

Supply Voltage VDD	+5.0V
Voltage on PAOUT.....	+7.2V
Voltage on I/O Pins	VSS-0.3 to VDD+0.3
Storage Temperature Range	-65°C to + 150°C
Lead Temperature (soldering, 10 seconds).....	+ 300°C
ESD Rating.....	2KV ⁽³⁾

Operating Ratings ⁽²⁾

Supply Voltage VDD	1.8V to 3.6V
Ambient Operating Temperature (TA)	-40°C to +85°C
Programmable Transmitter Frequency Range	300MHz to 450MHz

Electrical Characteristics ⁽⁴⁾

Specifications apply for VDD = 3.0V, TA = 25°C, Freq_{REFOSC} = 13.560MHz, EN = VDD.

Bold values indicate -40°C to 85°C unless otherwise noted. 1kbps data rate 50% duty cycle. RL 50ohm load (matched)

Parameter	Condition	Min	Typ	Max	Units
Power Supply					
Mark Supply Current I _{ON}	@ 315MHz, P _{OUT} = +10dBm		12.3		mA
	@ 433.92MHz, P _{OUT} = +10dBm		12.5		mA
SPACE supply current, I _{OFF}	@ 315MHz		2		mA
	@ 433.92 MHz		2		mA
RF Output Section and Modulation Limits:					
Output power level, P _{OUT} ASK "mark"	@315MHz ⁽⁴⁾		10		dBm
	@433.92MHz ⁽⁴⁾		10		dBm
Harmonics output for 315 MHz	@ 630MHz ⁽⁴⁾ 2nd harm.		-39		dBc
	@945MHz ⁽⁴⁾ 3rd harm.		-53		dBc
Harmonics output for 433.92 MHz	@ 867.84MHz ⁽⁴⁾ 2nd harm.		-55		dBc
	@1301.76MHz ⁽⁴⁾ 3rd harm.		-55		dBc
Extinction ratio for ASK			70		dBc
ASK Modulation					
Data Rate				10	kbps
Occupied Bandwidth	@315MHz ⁽⁶⁾		<700		kHz
	@433.92MHz ⁽⁶⁾		<1000		kHz
VCO Section					
315 MHz Single Side Band Phase Noise	@ 100kHz from Carrier		-76		dBc/Hz
	@ 1000kHz from Carrier		-79		dBc/Hz
433.92 MHz Single Side Band Phase Noise	@ 100kHz from Carrier		-72		dBc/Hz
	@ 1000kHz from Carrier		-81		dBc/Hz
Reference Oscillator Section					
XTLIN, XTLOUT	Pin capacitance		2		pF
External Capacitance	See Schematic C17 & C18		18		pF
Oscillator Startup Time ⁽⁵⁾	Crystal: HC49S		300		μs
Digital / Control Section					
Output Blanking	VDD transition from LOW to HIGH		500		μs

Electrical Characteristics (continued)

Parameter	Condition	Min	Typ	Max	Units
Digital Input ASK Pin	High (V_{IH})	$0.8 \times V_{DD}$			V
	Low (V_{IL})			$0.2 \times V_{DD}$	V
Digital Input Leakage Current ASK Pin	High (V_{IH})		0.05		μA
	Low (V_{IL})		0.05		μA
Under Voltage Lock Out (UVLO)			1.6		V

Notes:

1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.
4. Measured using Test Circuit in Figure 2.
5. Dependent on crystal
6. RBW = 100kHz, OBW measured at -20dBc.

Test Circuit

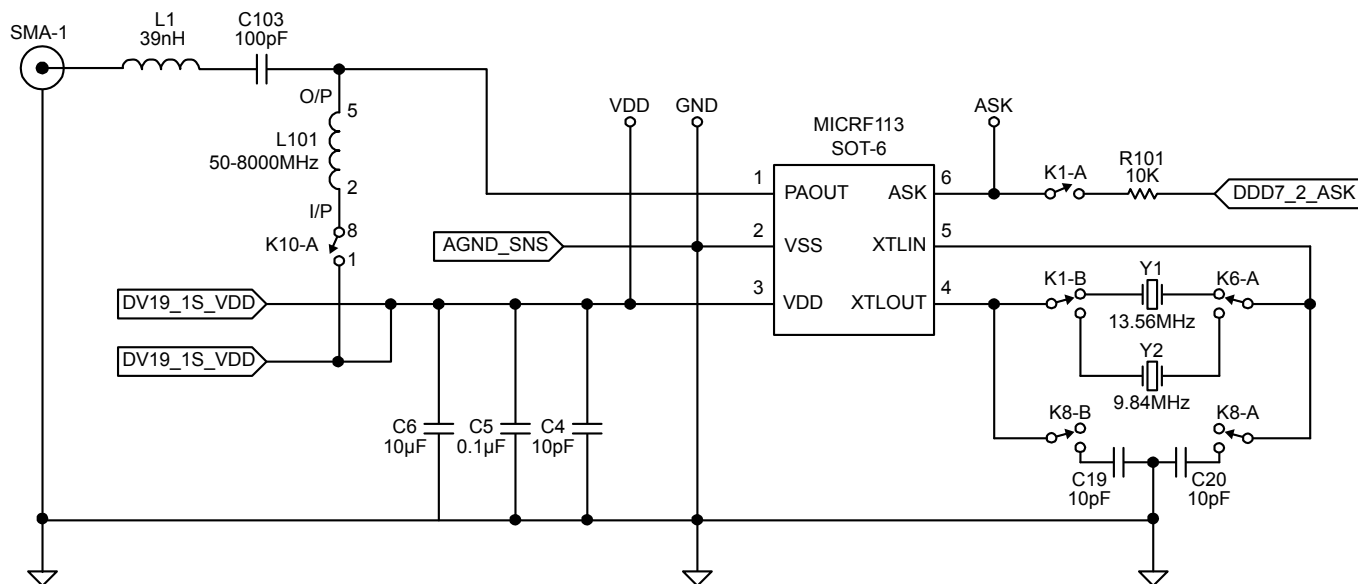
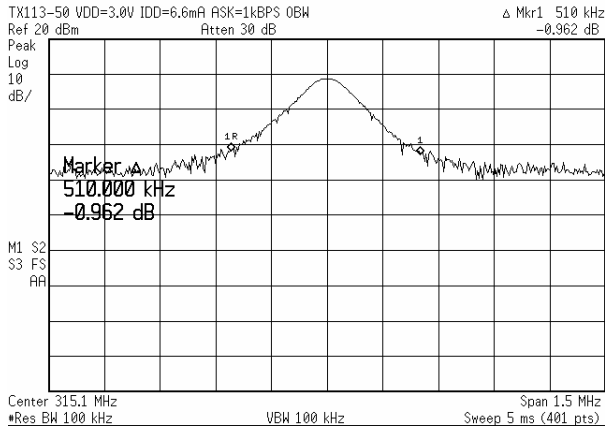


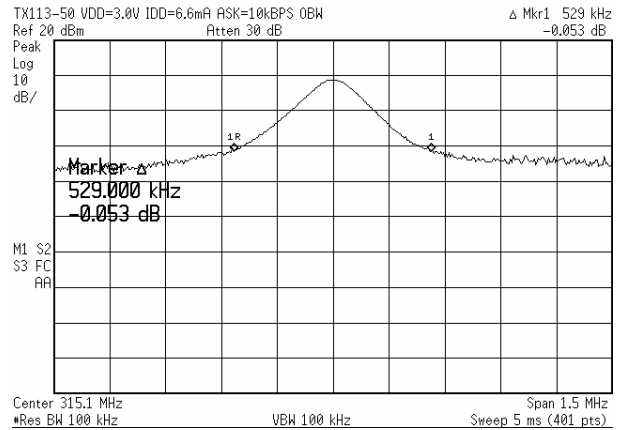
Figure 2. MICRF113 Test Circuit

Typical Characteristics Using MICRF113, 50Ω test Board

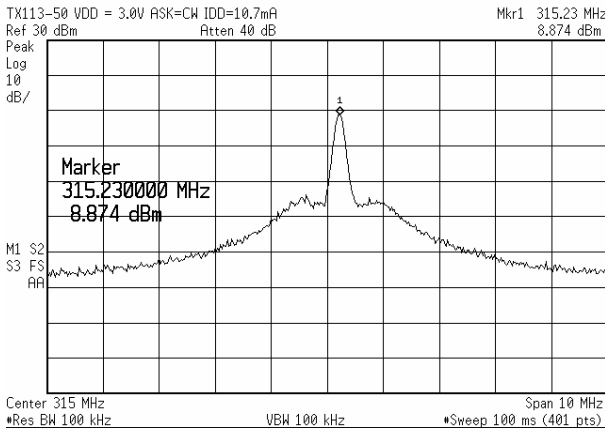
315MHz OBW, ASK = 1kHz



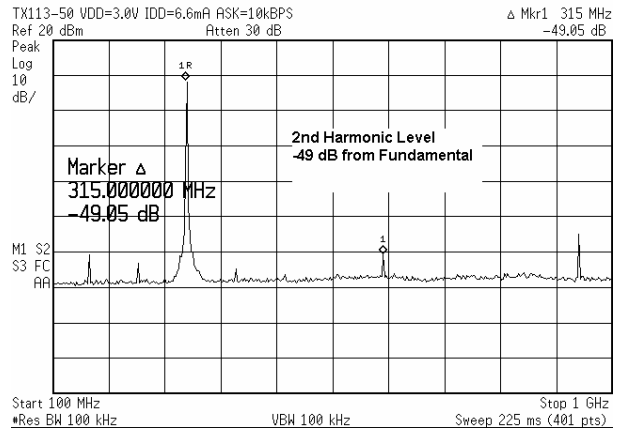
315MHz OBW, ASK = 10kHz



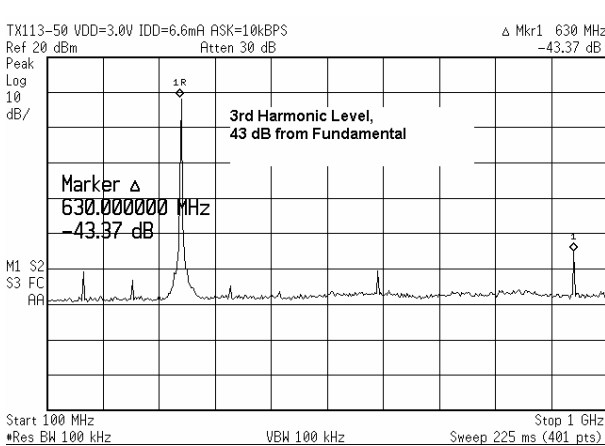
CW Max Power @ 3V, 315MHz, ASK = 1kHz, Note 1



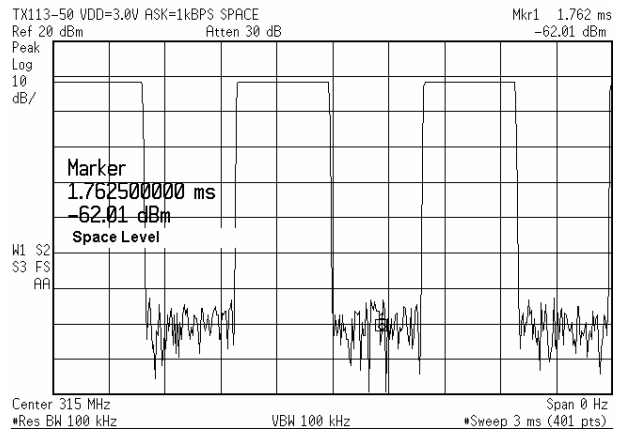
RF Spectrum 2nd Harmonic; Fundamental at 315 MHz



RF Spectrum 3rd Harmonic; Fundamental at 315 MHz

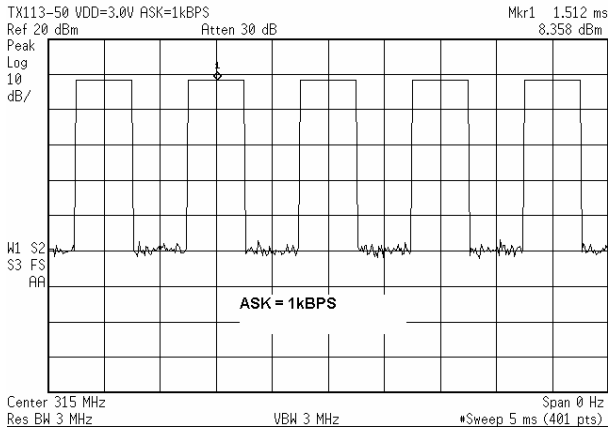


315MHz, Power Level at Space, VDD = 3.0V, ASK = 1kHz, -62dBm

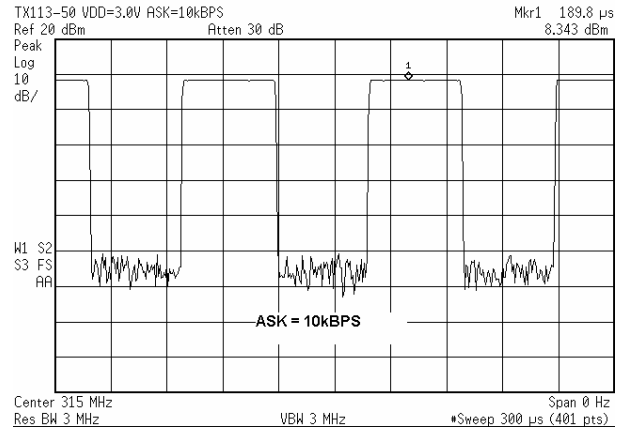


Note 1. 1.2dB cable loss.

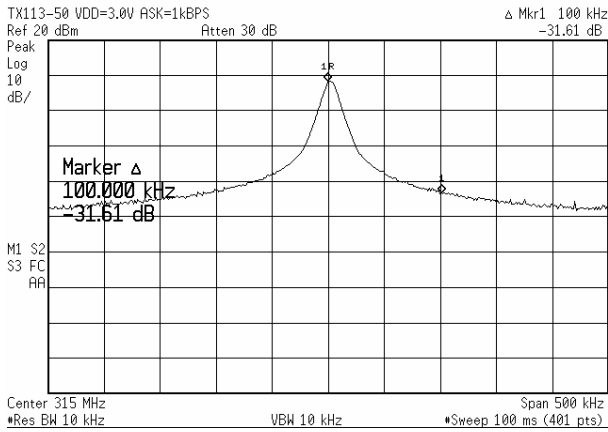
315MHz, Zero Span , ASK = 1kHz



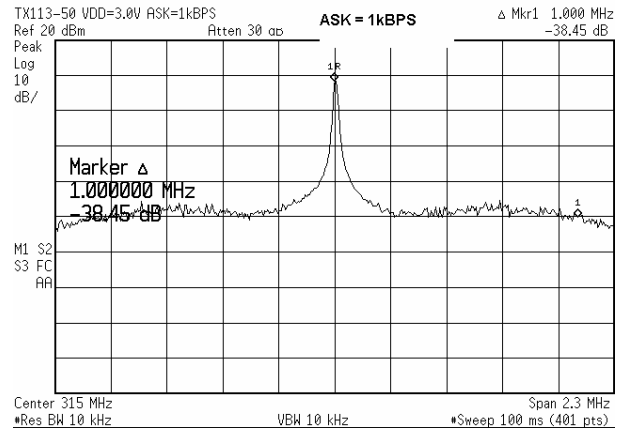
315MHz, Zero Span, ASK = 10kHz



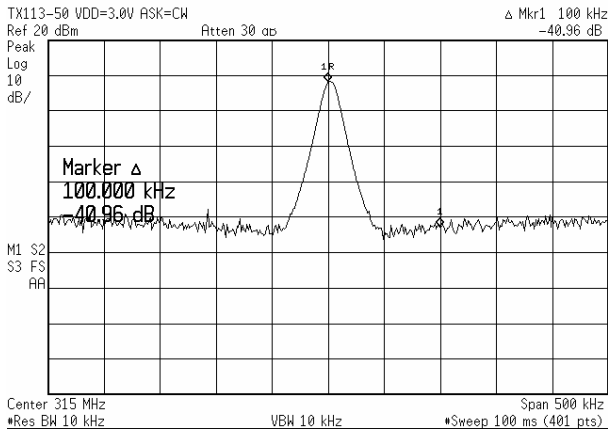
**315MHz, Phase Noise, ASK = 1kHz,
100kHz Offset, -75.59dBc/Hz**



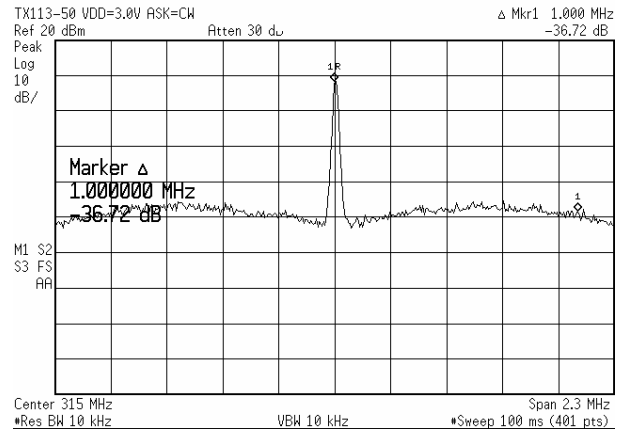
**315MHz, Phase Noise, ASK = 1kHz,
1MHz Offset, -38.45dBc/Hz**



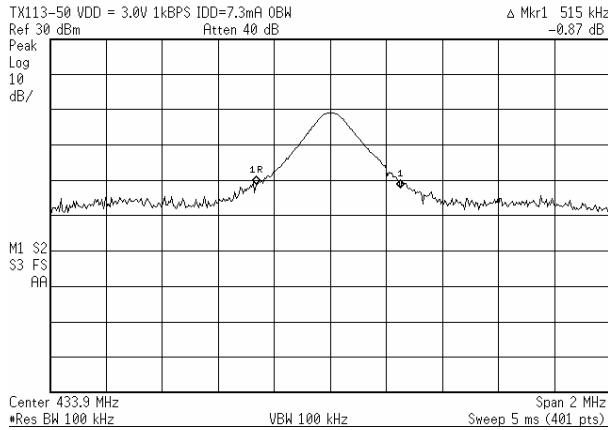
**315MHz, Phase Noise, ASK = CW,
100kHz Offset, -70.96dBc/Hz**



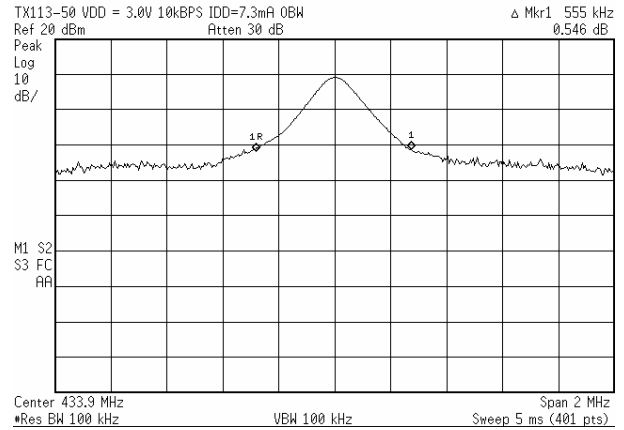
**315MHz, Phase Noise, ASK = CW,
1MHz Offset, -36.72dBc/Hz**



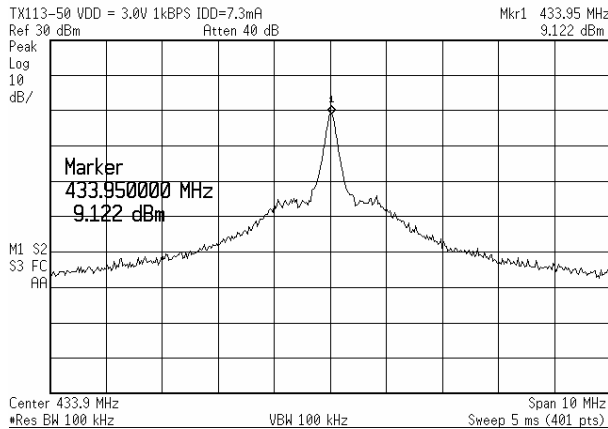
433.92MHz OBW, ASK = 1kHz



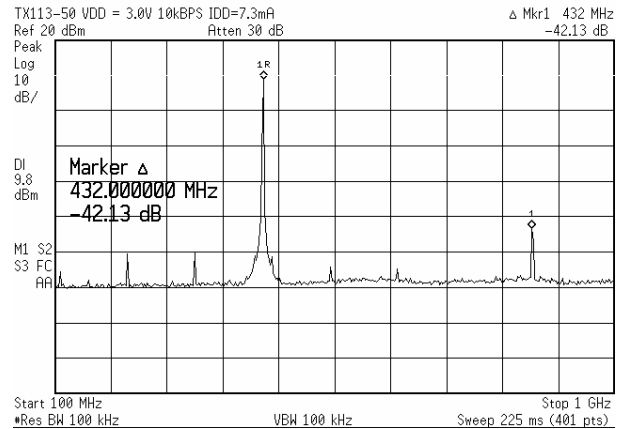
433.92MHz OBW, ASK = 10kHz



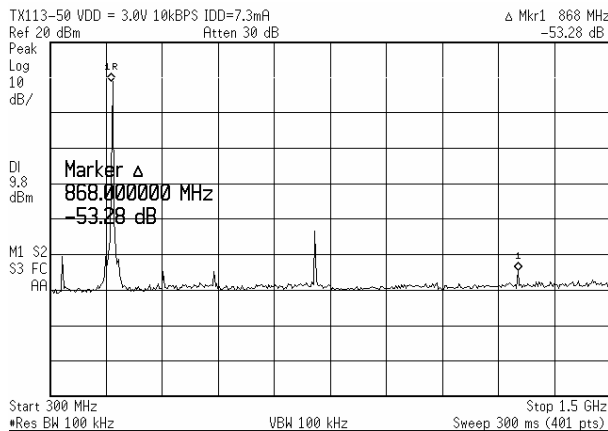
433.92MHz, CW Max Power @ 3V, ASK = 1kHz, Note 1



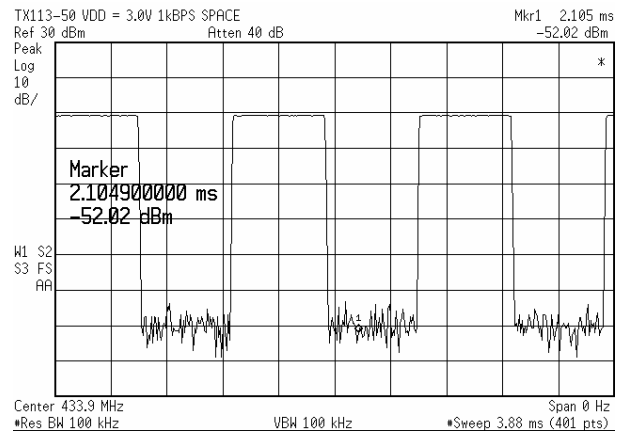
RF Spectrum 2nd Harmonic; Fundamental at 433.92 MHz



RF Spectrum 3rd Harmonic; Fundamental at 433.92 MHz

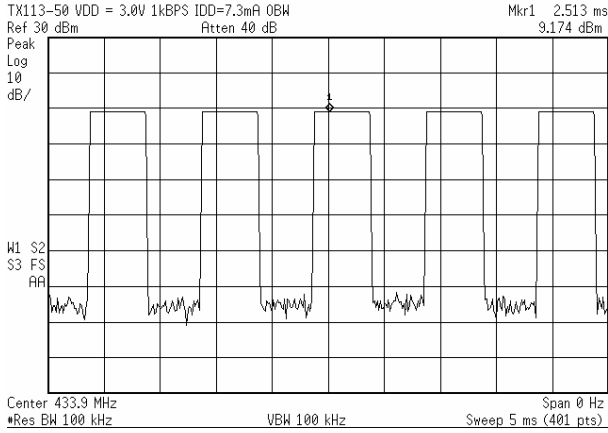


433.92MHz Power Level at Space, VDD = 3.0V, ASK = 1kHz, -52dBm

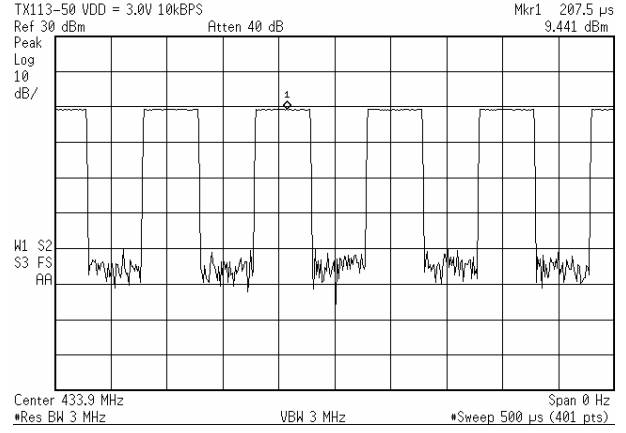


Note: 1.3dB cable loss.

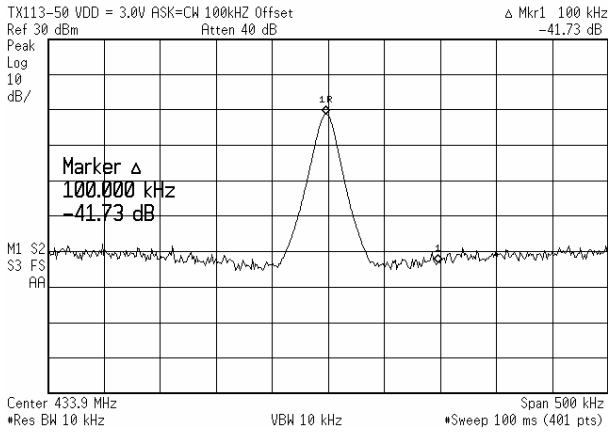
433.92MHz Zero Span, 1kHz



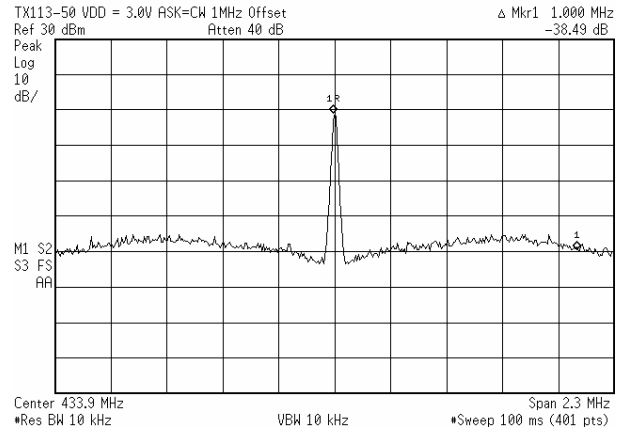
433.92ASK Zero Span at 10kHz



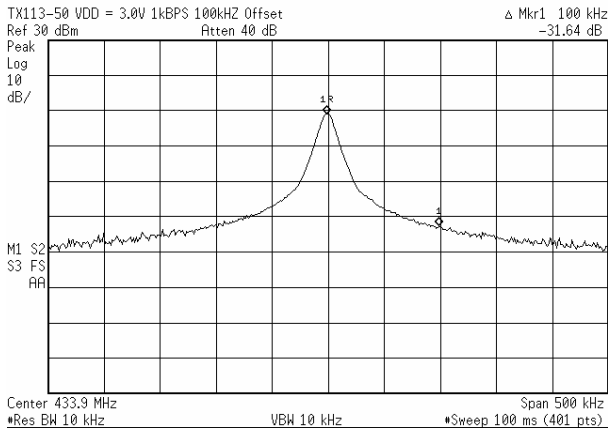
**433.92MHz Phase Noise, ASK = CW,
 100kHz Offset, -81.73dBc/Hz**



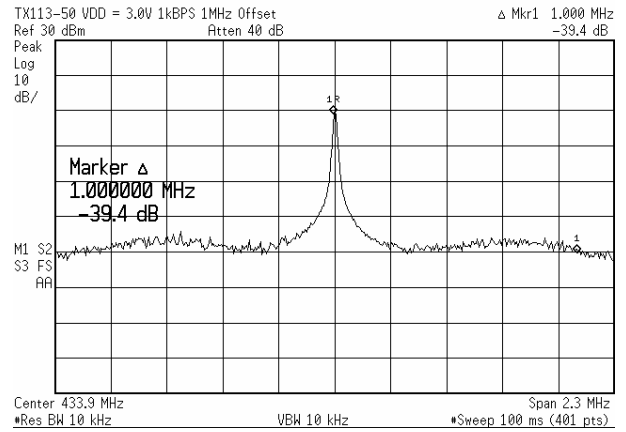
**433.92MHz Phase Noise, ASK = CW,
 1MHz Offset, -78.49dBc/Hz**



**433.92MHz Phase Noise, ASK = 1kHz,
 100kHz Offset, -71.64dBc/Hz**



**433.92MHz Phase Noise, ASK = 1kHz,
 1MHz Offset, -79.4dBc/Hz**



Functional Diagram

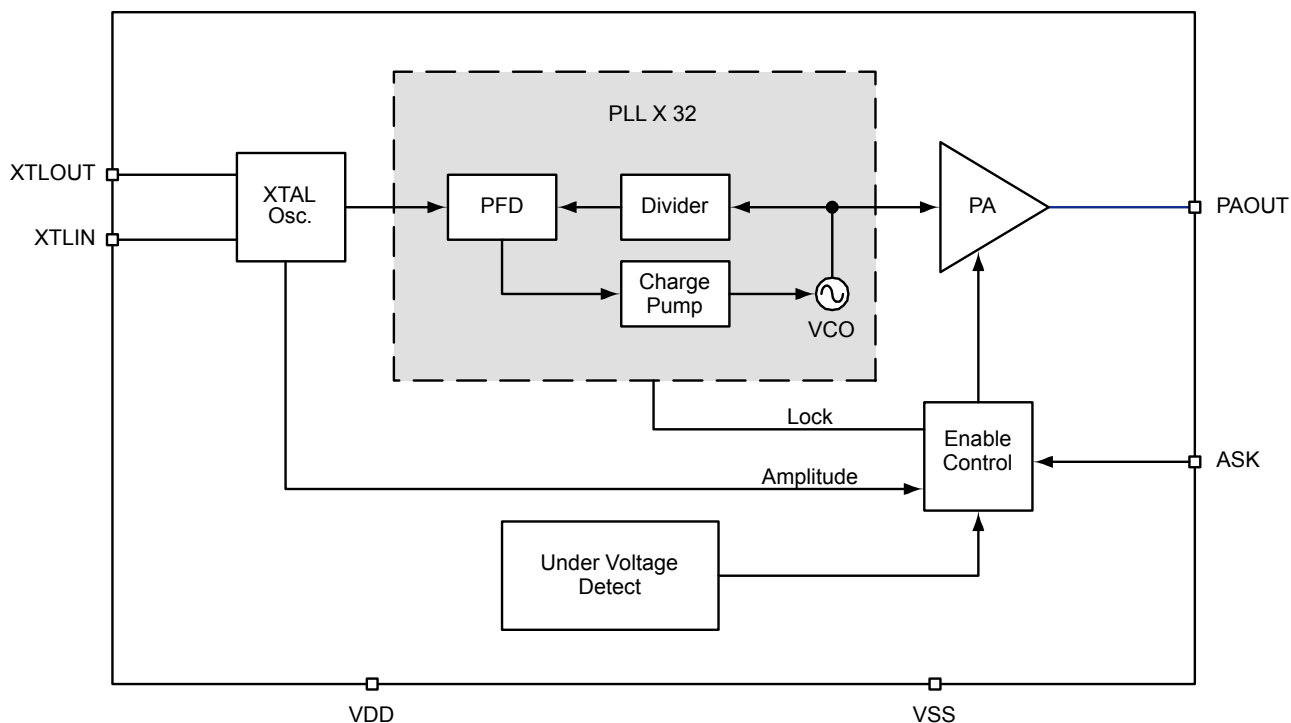


Figure 3. Functional Block Diagram MICRF113

Functional Description

Figure 3 is a functional block diagram of the MICRF113 transmitter. The MICRF113 is best described as a phase locked transmitter. The MICRF113 system is partitioned into five functional blocks:

- Crystal oscillator
- PLL×32
- Power amplifier
- Enable control
- Under voltage detection

Crystal Oscillator

The reference oscillator is crystal-based Pierce configuration, designed to accept crystals with frequency from 9.375MHz to 14.0625MHz.

Crystal Oscillator Parameters for ASK Operation

Figure 4 shows a reference oscillator circuit configuration for ASK operation. The reference oscillator is capable of driving crystals with ESR range from 20Ω to 300Ω.

When the ESR of crystal is at 20Ω, the crystal parameter limits are:

ESR 20Ω

Cpar 2 to 10pF

Cmo 10 to 40fF

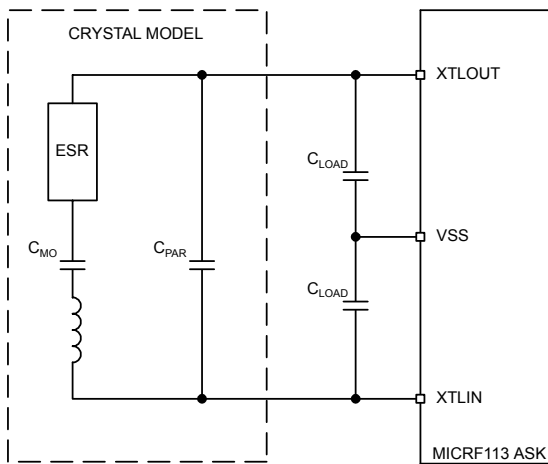


Figure 4. Reference Oscillator ASK Operation

When the ESR of crystal is at 300Ω , the crystal parameter limits are:

ESR	300Ω
C_{PAR}	2 to 5pF
C_{MO}	10 to 40fF
C_{LOAD}	10 to 30pF

PLL $\times 32$

The function of PLL $\times 32$ is to provide a stable carrier frequency for transmission. It is a “divide by 32” phase locked loop oscillator.

Power Amplifier

The power amplifier serves two purposes: 1) to buffer the VCO from external elements and 2) to amplify the phase locked signal. The power amplifier can produce +10dBm at 3V (typical).

Enable Control

Enable control gates the ASK data. It only allows transmission when Lock, Amplitude and Under Voltage Detect conditions are valid.

Under Voltage Detect

“Under voltage detect” block senses operating voltage. If the operating voltage falls below 1.6V, “under voltage detect” block will send a signal to “enable control” block to disable the PA.

Application Information

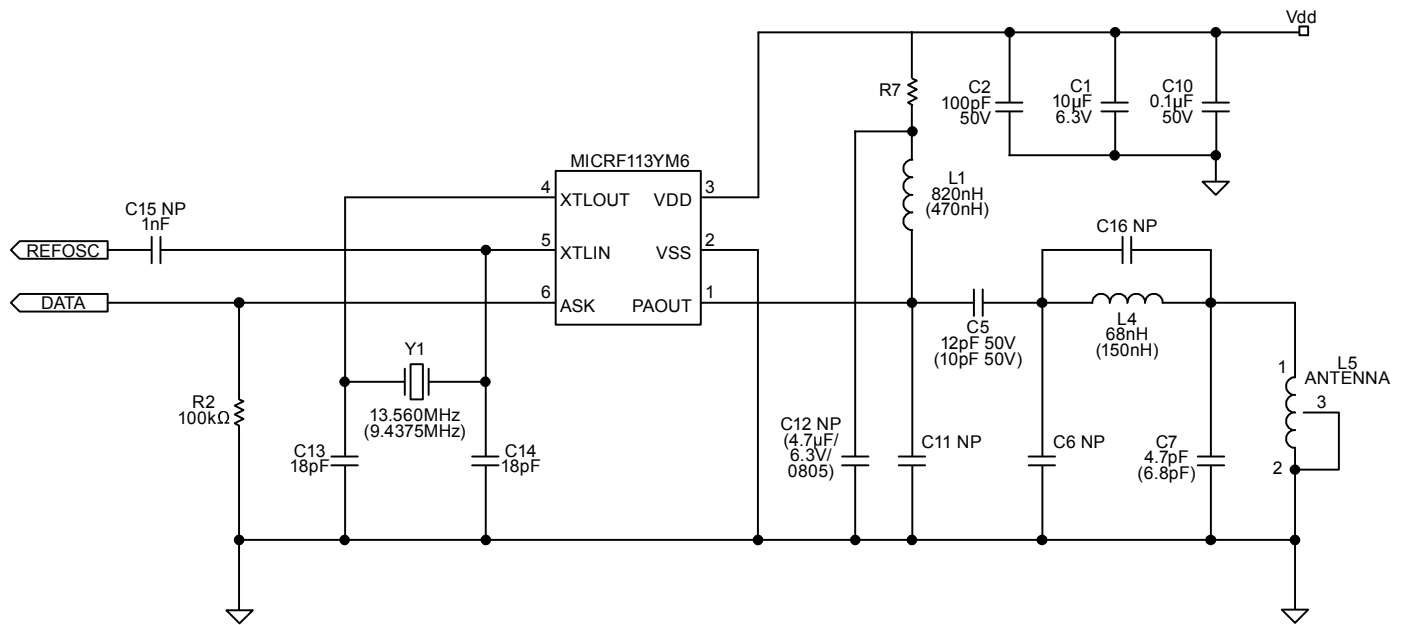


Figure 6. ASK 433.92MHz and (315MHz)

Notes:

1. Components labeled NP are not placed.
2. Values without parentheses are for 433.92 MHz and values in parentheses are for 315MHz.
3. Value of R7 is selected to vary the output power.

The MICRF113 is well suited to drive a 50-ohm source, monopole or a loop antenna. Figure 6 is an example of a loop antenna configuration. Figure 6 also shows both 315MHz and 433.92MHz ASK configurations for a loop antenna. Besides using a different crystal, Table 1 lists modified values needed for the listed frequencies.

Frequency (MHz)	L1 (nH)	C5 (pF)	L4 (nH)	C7 (pF)	Y1 (MHz)
315.0	470	10	150	6.8	9.84375
433.92	820	12	68	4.7	13.5600

Table 1

The reference design shown in Figure 6 has an antenna optimized for using the matching network as described in Table 1.

Power Amplitude Control Using External Resistor

R7 is used to adjust the RF amplitude output levels which may be needed to meet compliance regulation. As an example, the following tables list typical values of conducted RF output levels and corresponding R7 resistor values for the 50-ohm test board, as shown in Figure 2. R7 of the TX113-1C Demo board using the loop antenna can be adjusted for the appropriate radiated field allowed by FCC or ETSI compliance. Contact Micrel for suggested R7 values to meet FCC and ETSI compliances.

R7, Ω	Output Power, dBm	IDD, mA
0	10	6.7
75	8.5	6.3
100	8.0	6.2
500	1.6	4.13
1000	-3.8	4.87

Output Power Versus External Resistor at 315MHz

R7, Ω	Output Power, dBm	IDD, mA
0	8.68	7.5
75	8.34	7.33
100	8.02	7.3
500	4.34	6.3
1000	0.42	5.5

Output Power Versus External Resistor at 433.92 MHz

Output Power ON-OFF Control

There are two ways to enable the PA output power. First, by supplying the ASK signal with VDD applied continuously, resulting in a Mark and Space RF output condition. A second method involves applying both VDD and ASK synchronously. The second method allows for longer battery usage since the battery is disconnected during non-activation. Figure 7 shows the RF output time response since VDD and the ASK are applied to the MICRF113. The RF output response, as a function of VDD, is typically less than 1.25mSec. This measurement was done using the circuitry shown in Figure 2.

Note: The ASK signal should never be applied before VDD.

RF Output Response as a Function of VDD and ASK

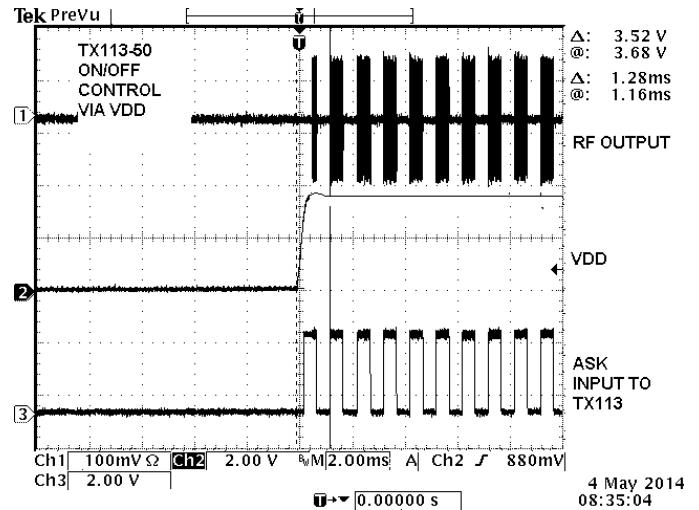


Figure 7. RF Output Response (VDD and ASK)

Output Matching Network

Part of the function of the output network is to attenuate the second and third harmonics. When matching to a transmit frequency, care must be taken both to optimize for maximum output power, and to attenuate unwanted harmonics.

Layout Issues

PCB Layout is a primary concern for achieving optimum performance and consistent manufacturing results. Care must be used with the orientation of components to ensure that they do not couple or decouple the RF signal. PCB trace length should be short to minimize parasitic inductance (1 inch ~ 20nH). For example, depending upon inductance values, a 0.5 inch trace can change the inductance by as much as 10%. To reduce parasitic inductance, the practice of using wide traces and a ground plane under the signal traces is recommended. Vias with low value inductance should be used for components requiring a connection-to-ground.

Antenna Layout

Directivity is affected by antenna trace layout. No ground plane should be under the antenna trace. For consistent performance, components should not be placed inside the loop of the antenna. Gerber formats (see Figure 8, for a suggested layout) can be obtained from the Micrel web site at: <http://www.micrel.com>.

PCB Board

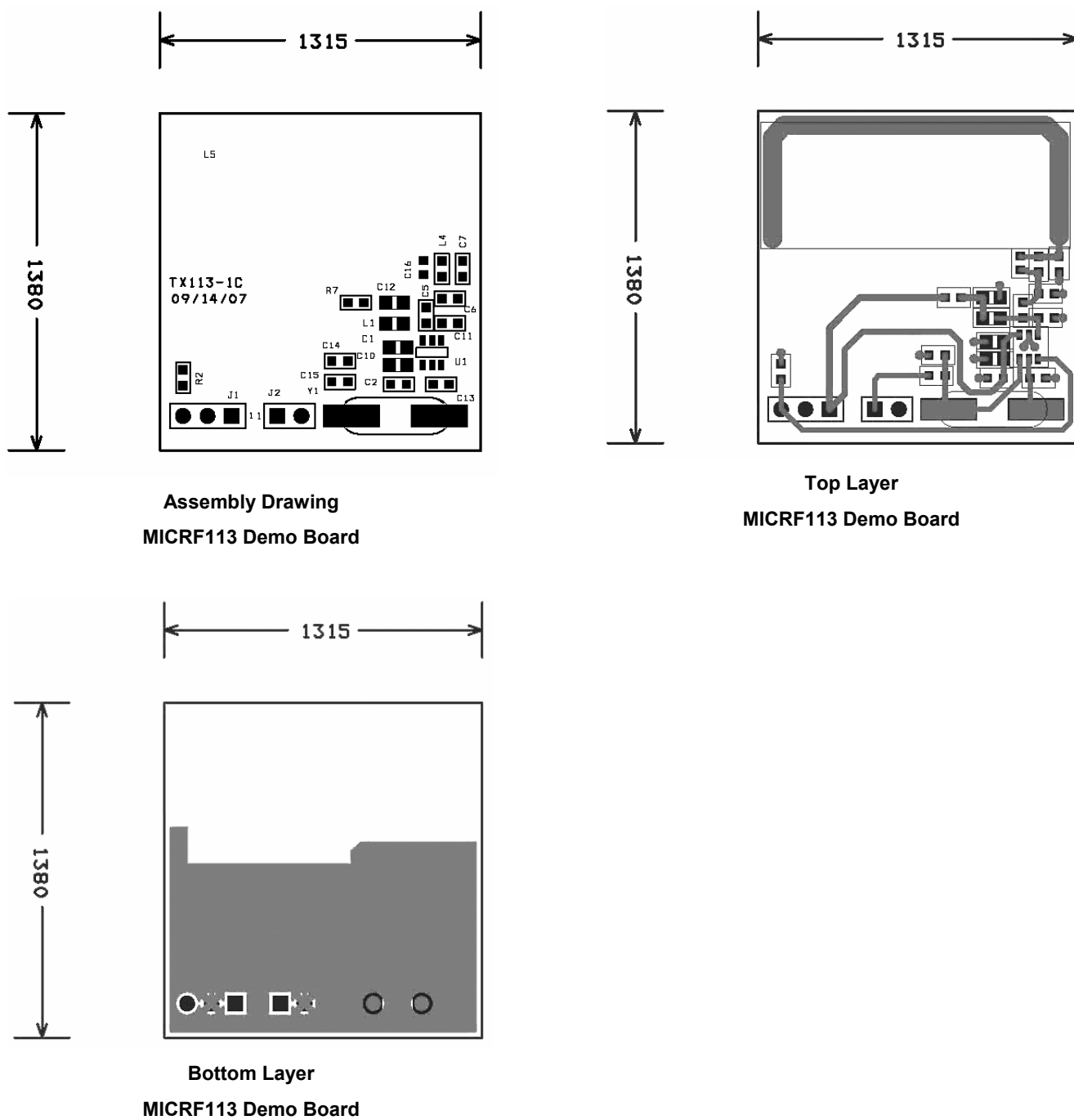


Figure 8. Demo Board PCB

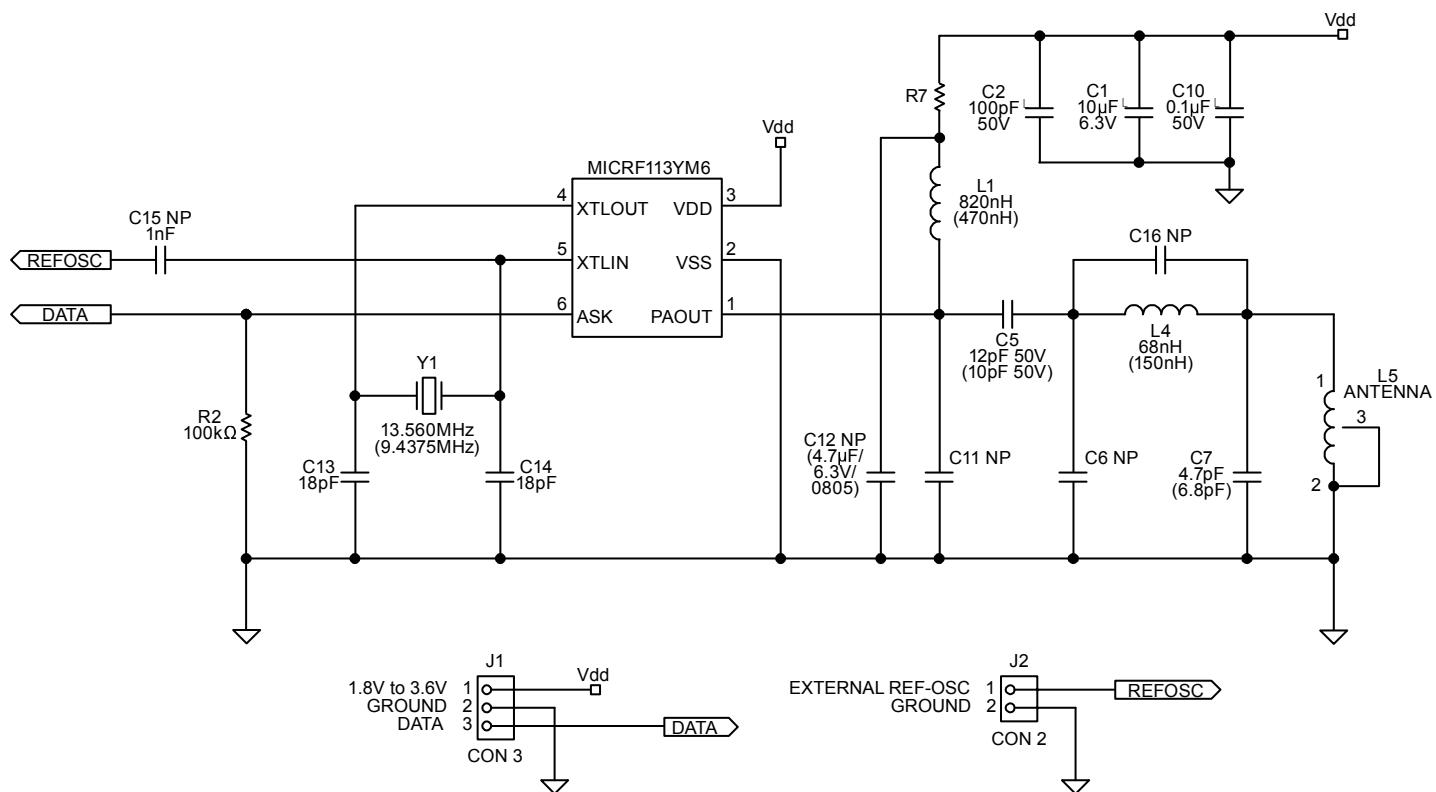


Figure 9. TX113-1c Demo Board Schematic

Notes:

1. Components labeled NP are not placed.
2. Values without parentheses are for 433.92 MHz and values in parentheses are for 315MHz.
3. Value of R7 is selected to vary the output power.

Functional Description of TX113-1 Evaluation Board.

Figure 8 shows the TX113-1c Demo Board PCB layout and assembly (Gerber format). Figure 9 is a detailed

schematic of the TX113-1c. Note that components labeled as NP (not placed) can be used to obtain different configurations. Table 2 describes each header pin connector used in the demo board.

Pin	Function Name	Functional Description
J1-1	VDD	1.8V to 3.6V input voltage
J1-2	VSS	Ground
J1-3	ASK	Modulating Data Input
J2-1	REF-OSC	External Reference Oscillator Input
J2-2	VSS	Ground

Table 2

TX113-1-433.92 ASK Bill of Materials

Item	Quantity	Ref	Part	PCB Footprint	Mfg P/N	Manufacturer
1	1	C1	10 μ F	0805	GRM21BR60J106KE01L	muRata
2	1	C2	100pF	0603	GRM1885C1H101JA01D	muRata
3	1	C5	12pF	0603	GRM1885C1H100JA01D	muRata
4						
5	3	C6,C11,C16	(NP)			
6	1	C7	4.7pF	0603	GRM1885C1H4R7JA01D	muRata
7						
8	2	C13,C14	18pF	0603	GRM1885C1H180JA01D	muRata
9	1	J1	CON3		TSHR-114-S-02-A-GT	
10	1	L1	820nH	0805	0805CS-680XJB	Coilcraft
11	1	L4	68nH	0603	0603CS-082NXJB	Coilcraft
12	1	L5	ANTENNA		ANTENNA LOOP, Part of PCB	
13	1	R2	100k Ω	0603	CRCW0603100KFKEA	Vishay
14	1	R7	0 Ω	0603	CRC06030000Z0EA	Vishay
13	1	U1	MICRF113YMM6		MICRF113YMM6	Micrel
14	1	Y1	13.560MHZ XTAL		SA-13.5600-F-10-C-3-3	HIB

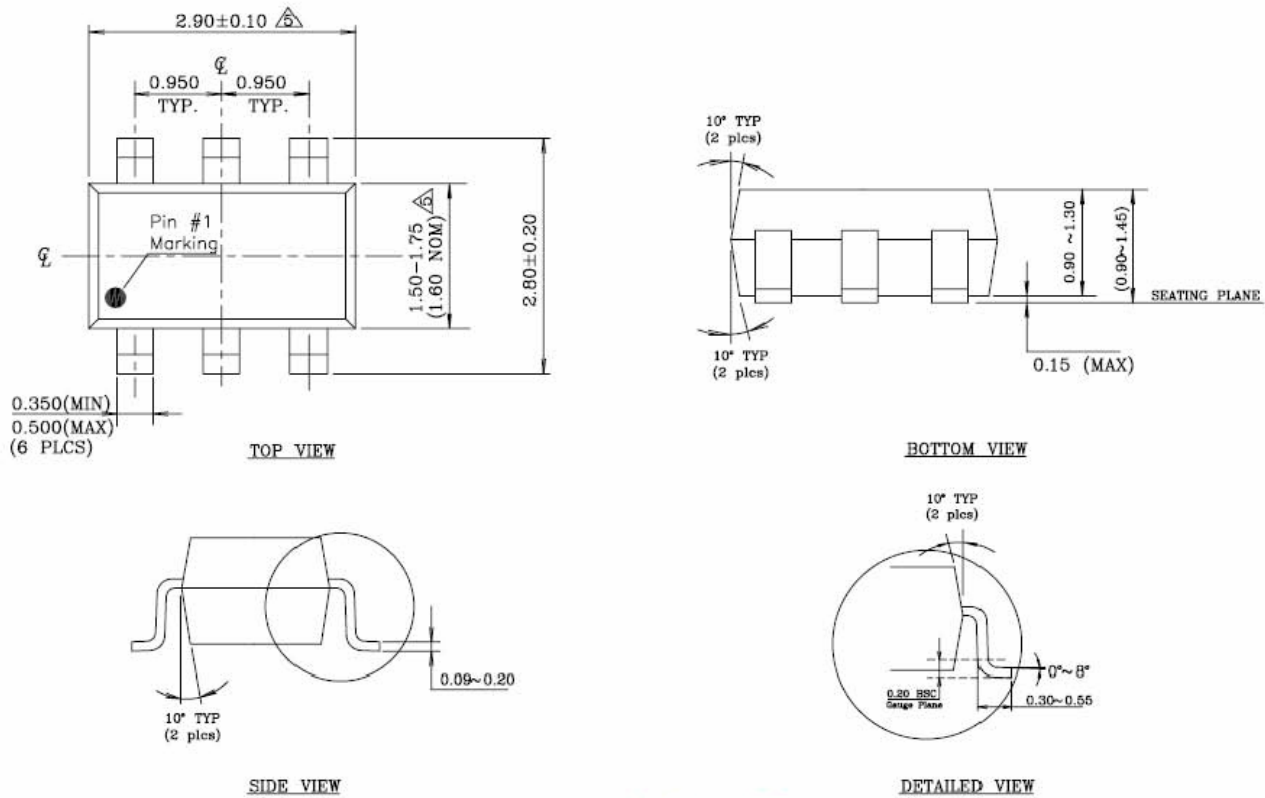
Table 3

Tx113-1-315MHz ASK Bill of Materials

Item	Quantity	Ref	Part	PCB Footprint	Mfg P/N	Manufacturer
1	1	C1	10 μ F	0805	GRM21BR60J106KE01L	muRata
2	1	C2	100pF	0603	GRM1885C1H101JA01D	muRata
3	1	C5	10pF	0603	GRM1885C1H1000JA01D	muRata
4						
5	3	C6,C11,C16	(np)			
6	1	C7	6.8pF	0603	GRM1885C1H6R8JA01D	muRata
7	1	C10	0.1 μ F	0603	GRM188F51H104ZA01D	muRata
8	2	C13,C14	18pF	0603	GRM1885C1H180JA01D	muRata
9	1	J1,J2	CON3		TSHR-114-S-02-A-GT	
10	1	L1	470nH	0805	0805CS-470XJB	Coilcraft
11	1	L4	150nH	0603	0603CS-R15XJB	Coilcraft
12	1	L5	ANTENNA		ANTENNA LOOP, Part of PCB	
13	1	R2	100k Ω	0603	CRCW0603100KFKEA	Vishay
14	1	R7	0 Ω	0603	CRC06030000Z0EA	Vishay
13	1	U1	MICRF113YMM6		MICRF113YMM6	Micrel
14	1	Y1	9.84375MHZ XTAL		SA-9.84375-F-10-C-3-3	HIB

Table 4

Package Information



6-Pin Sot Package Type (YM6)

Notes:

1. Dimensions and tolerances are in accordance with ANSI Y14.5M, 1982.
2. Package surface to be mirror finish.
3. Die is facing up for mold. Die is facing down for trim/form, that is, reverse trim/form.
4. The footlength measuring is based on the gauge plane method.

$\triangle 5$ Dimensions are exclusive of mold flash and gate burr.

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