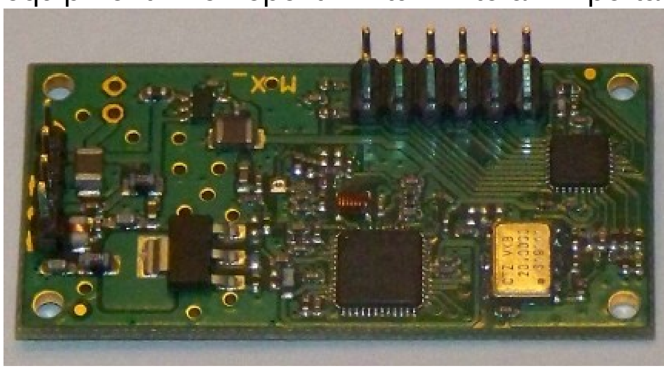
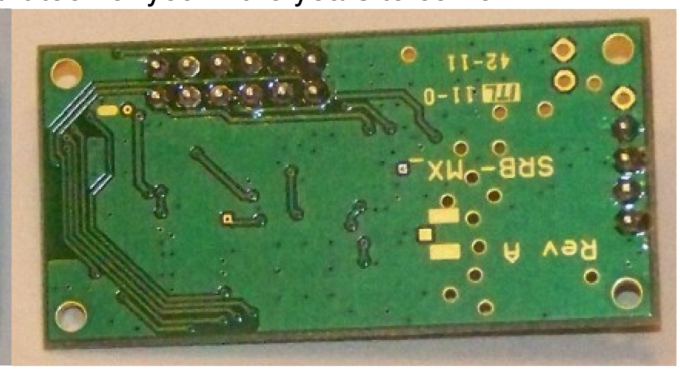
Small RF Budget
SRB-MX145

V 1.0.0

Thank you for choosing the SRB Module Transmitter as an addition to your ham radio equipment! We hope it will turn into an important tool for you in the years to come.


SRB-MX145H top


SRB-MX145H bottom

Features (for those who only read the first page):

- narrow channel spacing *), important to allow 12.5kHz channel spacing!
- 200mW output power @ 5V supply
- pre-programmed frequencies (16), can be changed by user
- precision crystal reference (+/- 10ppm max, +/- 5ppm typ)
- programmable to any frequency from 144MHz to 148MHz in narrow steps *) via bus (frequency agile)
- fast wake-up from standby mode, <25msec
- standby current less then 2.5mA
- can be modulated with more than 10kb/sec or >20kHz audio frequency (voice)
- wide loop bandwidth (~15kHz) to avoid microphonics and resist vibration

*) please see explanation below

The SRB-MX145 is a small 2m transmitter module for your APRS® tracker so you don't have to waste a complete transceiver for the occasional transmission. As an additional feature it incorporates a temperature sensor but it should only be used to monitor the board temperature as it gets heated by the surrounding components. The SRB-MX145 is a drop in replacement for both the SRB-MX146LV and SRB-MX146 with only one minor difference. The temperature sensor is no longer available.

SRB-MX145 is a 50x25mm (~2”x1”) small transmitter module. Its output power of >200+mW @ 5V supply voltage is well suited for trackers in the APRS® network. Finally a solution to build an entire APRS® unit into one very small box! You may have seen other solutions for this application but the SRB-MX145 is really different! Sure, it just transmits a signal on a certain frequency but the way how this frequency is generated and modulated is different.
The SRB-MX145 is pre-programmed for the most common APRS® frequencies in use worldwide, selectable with an external switch or it can be programmed “on-the-fly” via two popular interfaces. The SRB-MX145 can not only operate at 1200Bd, it's usable beyond 9600Bd.
To reduce unwanted spurious emission the synthesizer doesn't use the channel spacing as it's reference, it compares at a much higher frequency. Yet, the available channel spacing is <150Hz!
The usual way to modulate the signal in most ham equipment is by applying the modulation signal to the loop filter of the VCO, not so for the SRB-MX145! It uses digital injecting modulation which enhances the modulation quality and allows to have a rather wide loop bandwidth which makes it far less susceptible to vibration.
All this doesn't make for an easy design nor does it cut cost (quite the opposite) but we at Small RF Budget believe that cutting corners to make the highest possible profit isn't a method to turn customers into friends!

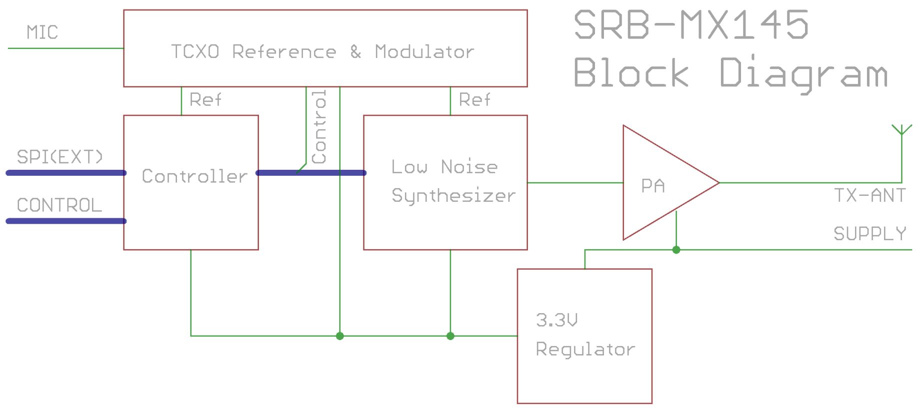
The SRB-MX145 is a module and not a complete radio which means that you will have to add some things externally to prepare it for it's use. For the originally planned use as an APRS® tracker you will have to add a tracker unit like the OpenTracker or Tinytrak. As the supply voltage range is 4.75 to 8V we also recommend that you use one of the common 5V regulators to stabilize the supply voltage. As some of the trackers have a rather poor output spectrum it is highly recommended to insert a low pass filter between the tracker output and the modulation input of the SRB-MX145!
Due to the small size the ability to get rid of heat generated during transmit is limited. This means that the SRB-MX145 is NOT intended for or capable of unlimited CW operation at 8VDC supply voltage. A 5:1 RX/TX duty cycle with TX not to exceed 5mins is recommended. At 5VDC supply CW operation is supported.

And before you ask: we believe that transmitting with more then 1W in an APRS® channel without listening first to avoid collisions isn't a way to treat others. Sure, even with a receiver you may not hear the other station but the chances are lower thus increasing the capacity significantly. In short: there won't be an SRB transmit-only solution at a power higher then 1W.

Available models:
SRB-MX145H: pin compatible with SRB-MX146. Connectors vertical to the PCB

SRB-MX145

Technical Data



Frequency range:	144MHz to 148MHz
Channel spacing:	< 150Hz (see below)
Modulation:	digital injection modulation
Modulation Bandwidth:	>20kHz
Modulation Sensitivity:	21kHz/V (typ)
Input Impedance:	~600Ω
Spurious suppression:	> 70dB
Harmonic suppression:	45dB
Frequency stability:	+/- 10ppm (-30°C ~ +85°C)
Turn On delay (after PTT):	20msec (typ)
Output power:	200 mW (nominal) into 50Ω @ 5V supply (450mW @ 8V)
Programming:	SPI® and I²C® interface or 16 pre-programmed frequencies, pin selectable. 3.3V CMOS level
Supply voltage:	+4.75VDC to 8VDC
Supply current (standby):	<2.5mA
Supply current (transmit):	<160mA & 5VDC supply
Size:	50x25x2.5mm (~2”x1”x0.1”) plug-in board (w/o connector)
Operating temperature range:	-40°C ~ +85°C
Storage temperature range:	-40°C ~ +105°C

All units are 100% tested in production:

- FLASH and EEprom programing
- frequency offset calibration
- burn serial number
- supply current (standby, TX)
- temperature sensor test
- frequency calibration DAC test
- test of all programming modes (SPI, I^2C, Fixed Frequency)
- test of all pre-programmed frequencies,
- output power vs. frequency for the entire band
- PTT delay
- FM deviation (0 – 3.3V)
- margin of VCO tuning voltage

Synthesizer step size:

The integrated synthesizer allows step sizes of <150Hz and when programmed in Hz will go to the closest possible frequency to the programmed value. This is achieved by a narrow step size fractional-N synthesizer and linear analog interpolation by tuning the reference with a DAC. It has to be noted that the absolute frequency depends on the accuracy of the crystal oscillator! Fractional spurious are successfully avoided by careful calculation of the settings of the PLL.

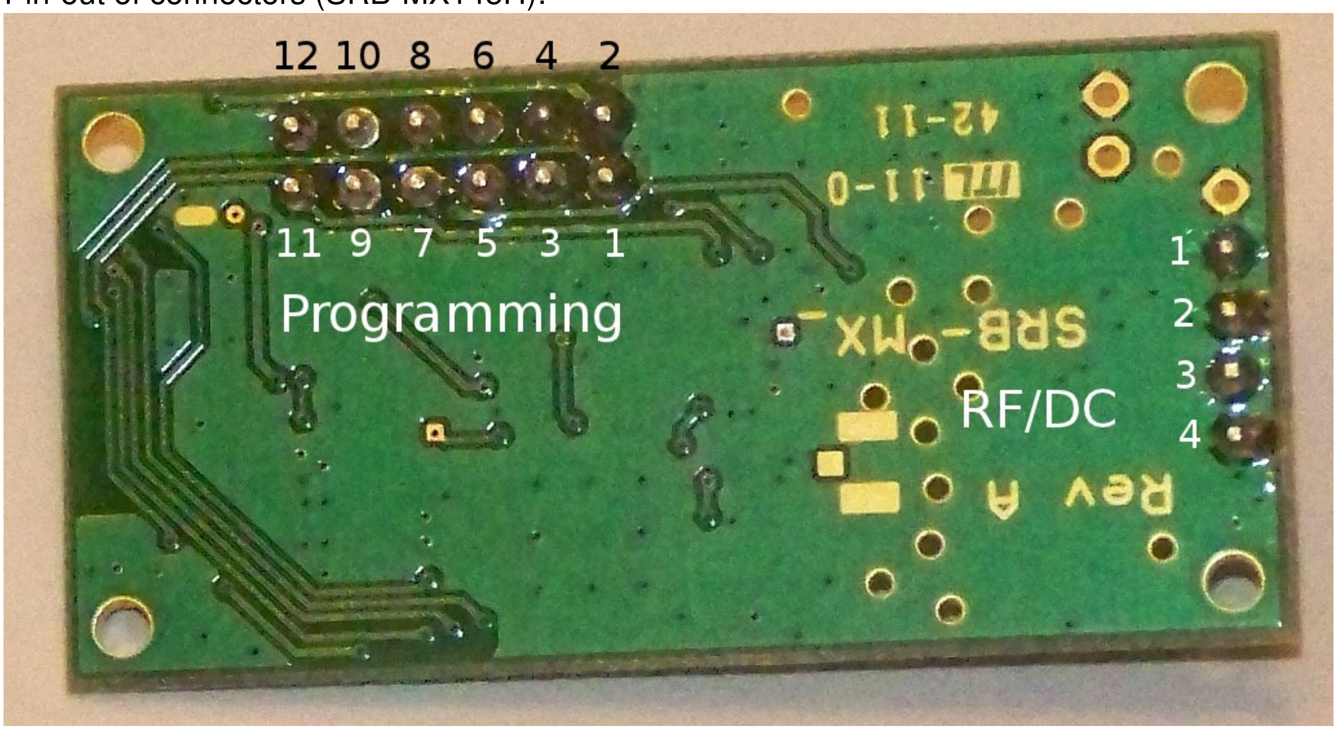
SRB-MX145

Installation

If you look onto your new SRB-MX145H you will see two connectors, a two row and a single row one. The single row is the connector for the antenna and the 5-8V power supply. The other connector is used for programming and modulation.

When handling the SRB-MX145 module make sure you observe proper ESD handling procedures! Use an anti-static surface and ground yourself! As it is a module and not a “user device” inputs and outputs on the programming connector depend on the ESD protection provided by the semiconductors only.

Pin-out of connectors (SRB-MX145H):



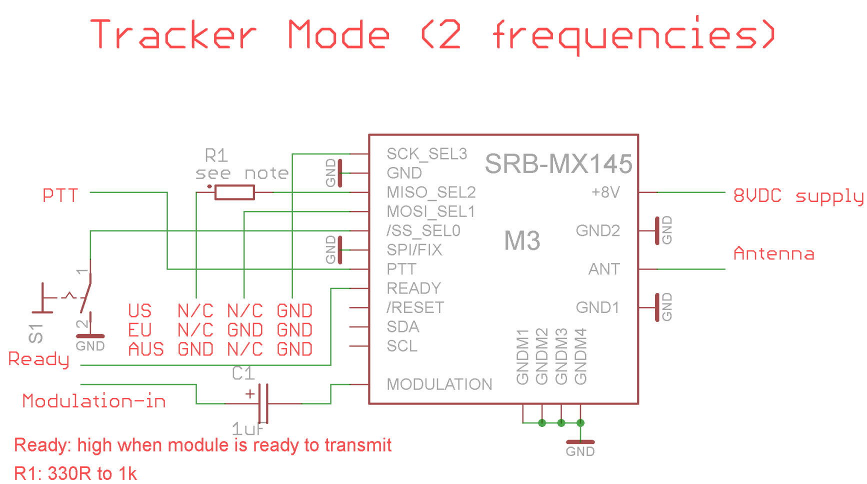
Programming connector:
1= I^2C-SCL, 2= I^2C-SDA, 3= SPI-MISO_Sel2, 4= SPI-SCK_Sel3, 5= /SS_Sel0 (/CS), 6= SPI-MOSI_Sel1, 7= SPI/FIX (Open or High -> SPI Mode, GND -> Fixed frequency mode), 8= PTT, 9= Ready to send, 10= /RESET (do not connect!), 11= Modulation, 12= Ground

Pin-out RF/DC connector (SRB-MX145H):
1= +5 to 8VDC, 2= Ground, 3= Antenna, 4= Ground

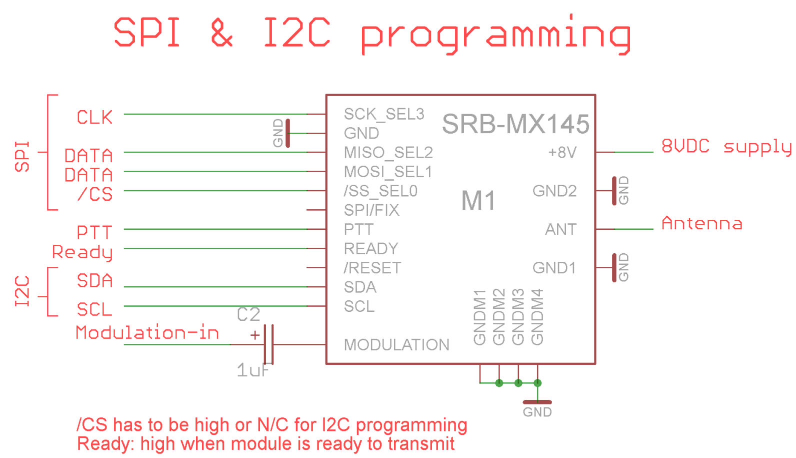
Sel0 to 3 are pins to select a pre-programmed frequency, SPI/FIX has to be ground for this mode.
Ready will go high when the module is ready to accept data (modulation). This allows you to significantly shrink the time delay before data are send.

There are several ways to integrate the transmitter into a tracker.

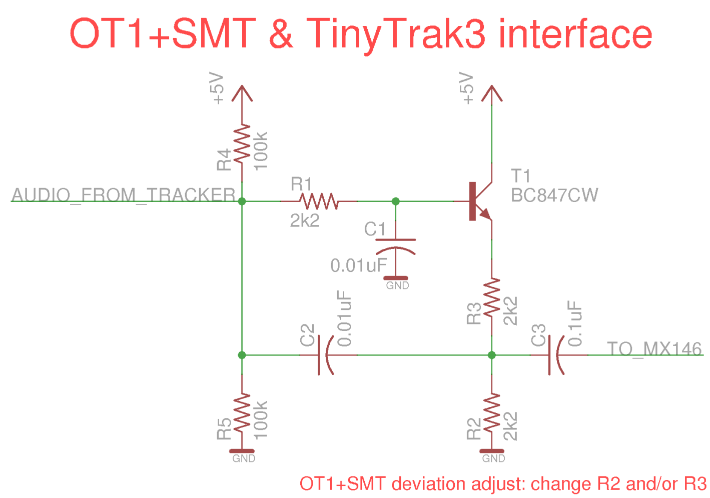
Dual selectable frequencies is the easy way where you can switch between the main and the secondary frequency in your region. This is the most common method for a tracker unit. From the schematic below please select your region, connect the correct pins to ground, an SPDT switch, the modulation and PTT output of your tracker and then connect 5VDC and an antenna cable or connector to the other connector and you are ready to go. Naturally a binary switch can be used too using all the shown data lines (SEL0 to SEL3) with the common pin connected to ground. That might be the world traveler tracker model.......



Frequency programming from a micro-controller is the more sophisticated method but usually not required for a tracker unit. If you want to use this method please wire the SRB-MX145 according to the schematic below. Please note that you can use SPI® and I²C® but only one at a time. The logic signal level is 3.3V CMOS, DO NOT try 5V levels as it will destroy the controller! The programming strings for both methods are identical, just the communication method is different.



Interface to trackers. Most trackers have high impedance outputs and the resulting signal level at the modulation input of the SRB-MX145 will not give sufficient deviation. In addition they usually have significant harmonic content which will lead to an unwanted broad spectrum of the transmitted signal.
This problem can be solved with the circuit shown below. It is an impedance converter combined with a low pass filter which has ~2.7kHz cutoff frequency. Please be aware that the output impedance of the tracker is part of the filter circuit!



This circuit can also be used for other trackers if one makes sure that the source impedance is around 5kΩ.

A suitable motherboard for the SRB-MX145H is available which accommodates an OT1+SMT and contains the above filter. Please see the datasheet for SRB-MXTRAK for further information.

Programming the SRB-MX145 is pretty straight forward. All commands start with an ASCII character followed by data. To make it easier the frequency can be send in binary, decimal and hex format. For detailed information of the data transceivers (SPI® & I^2C®) please see the data sheet for the ATmega168 (http://www.atmel.com).

Conditions:
f_{min} = 144MHz, f_{max} = 148MHz, f_{step} = <150Hz

Commands (max 22 bytes length):

Byte 0	1	2	3	....	Comment
B	LS-Byte	byte	byte	MS-Byte	frequency as 32 bit binary number in Hz (little endian)
D	char	char	char	.. [M, K]	frequency as decimal number (D145M or D144390K or D145002500)
H	hex	hex	hex	......	frequency in hex, example: H89B3770 (144.39MHz)
M	uint8				read frequency from memory location 0…15
m	uint8				write active frequency into memory location 0..15
c	uint8				Reset frequency calibration
?	.....	?			Dummy to read from SPI Port after query

Query:

Q	E		(unit8)		1 byte Error code
Q	N				Name (MX145)
Q	D				Datecode
Q	V				Software version
Q	#				Serial number
Q	F	(uint32, uint32)			Fmin, Fmax as 32 bit binary numbers

- When talking via SPI the first received Byte is always the error code.
- SPI uses mode 0.
- Next transmission after Query will send the answer back to the SPI Master or I^2C® Master.
- I^2C® has highest priority.
- I^2C® Bus address (SRB-MX145): hex 48 or 0x48

Error Code:

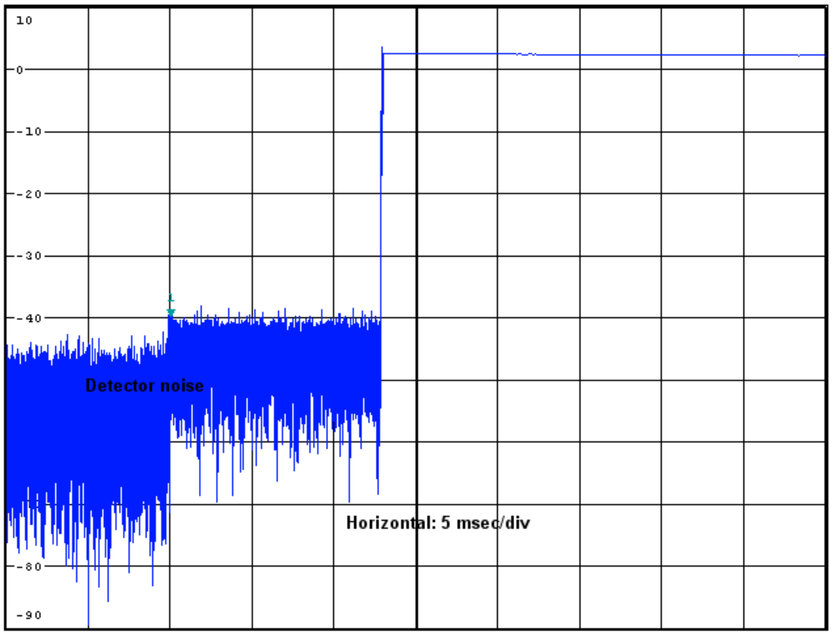
0	Frequency out of range
1	Unknown command
2	reserved
3	reserved
4	reserved
5	I^2C® error
6	reserved
7	reserved

Factory pre-programmed frequencies, can be changed by user:

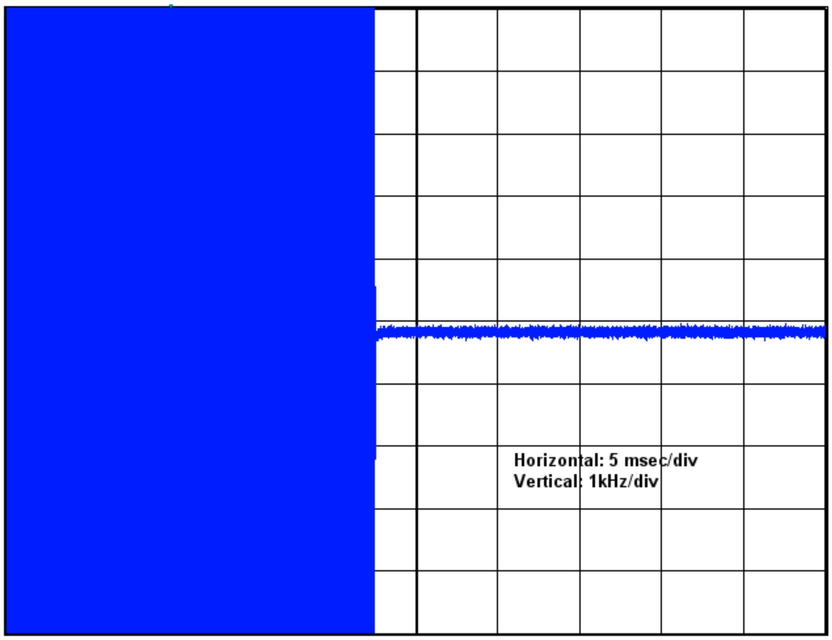
0	**0000**	144.3900	MHz
1	**0001**	144.7900	MHz
2	**0010**	144.9900	MHz
3	**0011**	144.3500	MHz
4	**0100**	144.8000	MHz
5	**0101**	145.1750	MHz
6	**0110**	144.5750	MHz
7	**0111**	144.9300	MHz
8	**1000**	144.6400	MHz
9	**1001**	144.6600	MHz
10	**1010**	147.7000	MHz
11	**1011**	144.0000	MHz
12	**1100**	145.0075	MHz
13	**1101**	146.0050	MHz
14	**1110**	147.0025	MHz
15	**1111**	148.0000	MHz

Test Data

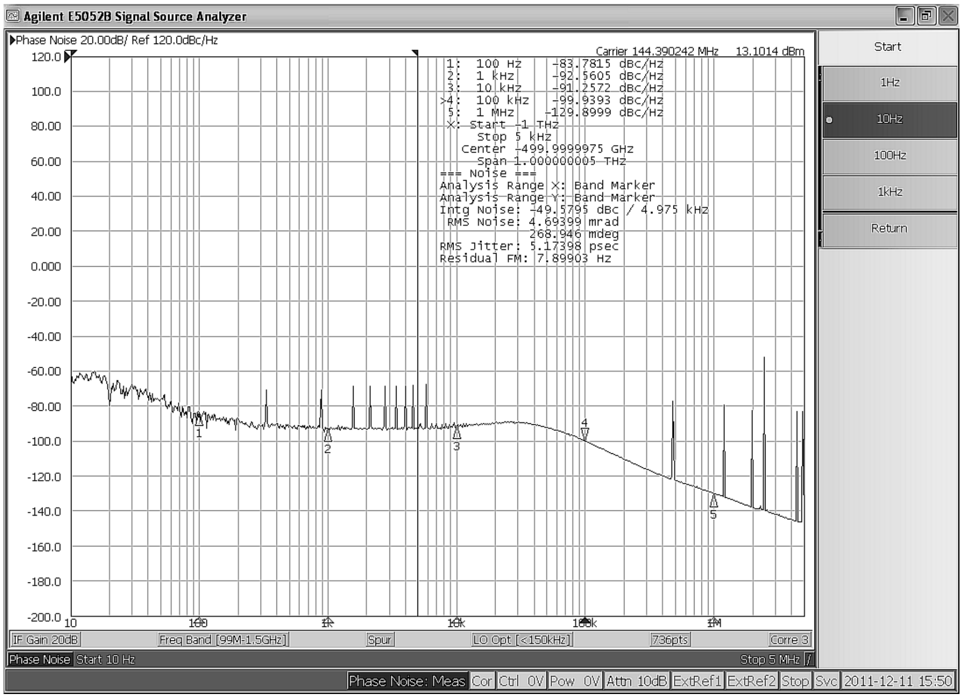
Power On delay (after PTT):



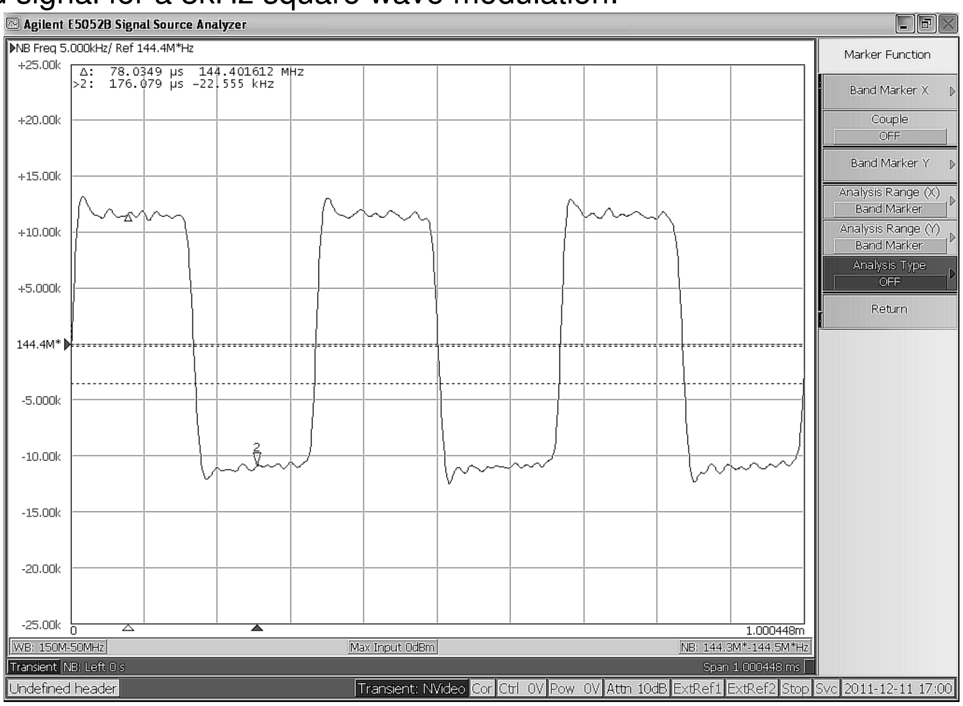
Frequency accuracy after turn on (PTT):



Spurious and Phase Noise:



Demodulated signal for a 3kHz square wave modulation:



Frequency Adjustment

In case your SRB-MX145 needs frequency adjustment there is an easy way to do it.
Set PTT low and measure the output frequency with an accurate frequency counter. Send either via SPI or I^2C® the following string: C<frequency in Hz, decimal>. Example: measured frequency is 144.37895MHz. Send “C144378950”. The SRB-MX145 will calculate the offset and store the correction value. In case you screwed it up send a “c” and then try again.