

TINYSA USER MANUAL

MARCH/2021

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1 GENERAL

1.1 Wellcome

Welcome to the tinySA™ wiki!

The tinySA is a small spectrum analyzer, primarily intended for 0.1MHz to 350MHz input but it has some nice other capabilities:

- Spectrum Analyzer with two inputs, high quality MF/HF/VHF input for 0.1MHz-350MHz, lesser quality UHF input for 240MHz-960MHz.
- Switchable resolution bandpass filters for both ranges between 2.6kHz and 640kHz
- Color display showing 290 scan points covering up to the full low or high frequency range.
- Input Step attenuator from 0dB to 31dB for the MF/HF/VHF input.
- When not used as Spectrum Analyzer it can be used as Signal Generator, MF/HF/VHF sinus output between 0.1MHz-350MHz, UHF square wave output between 240MHz-960MHz.
- A built-in calibration signal generator that is used for automatic self test and low input calibration.
- Connected to a PC via USB it becomes a PC controlled Spectrum Analyzer
- Rechargeable battery allowing a minimum of at least 2 hours portable use
- Max input level +10dBm. [Do not destroy your tinySA](#)
- Due to the low cost and very small form factor there are certain relevant [limitations](#).



Introduction and other videos

A short 7 minute video introducing the main features of the tinySA can be found [here](#). More videos in my [YouTube channel](#)

There are a number of video reviews of the tinySA by IMSAY Guy on [YouTube](#). If you go there, make sure you also watch the later videos as IMSAY Guy was still learning how to use the tinySA in his first videos

Sort of manual

For those that prefer to read a document instead of browsing a wiki, Kurt Poulson was so kind to write an extensive document explaining various aspects of the tinySA for a Danish Amateur Radio magazine. The English version can be found [here](#). Kurt describes the operation of the signal generator and spectrum analyzer functions and explains how to update the FW. The document contains many screen captures of example measurements.

Legal stuff

The name tinySA and the tinySA logo is a trademark owned by us. Nobody else is allowed to use the name tinySA for any spectrum analyzer product without written permission.

Credits

The tinySA FW is based on the NanoVNA FW created by edy555

1.2 Buying the tinySA

Be aware of bad performing illegal copy products.

The tinySA logo and the name tinySA for a spectrum analyzer are trademarked and no permission has been given to manufacture these clones so these are illegal products. The following sellers have sold at least one illegal clone:

- Navplus on eBay
- ahken-81 on eBay
- ideafoxtrot on eBay
- KKmoon on Amazon
- Shop910459103 on AliExpress
- ahken-81 on AliExpress
- Feature Tools on AliExpress
- Tool-box Store on AliExpress
- Good Home-Accessories for you Store on AliExpress
- Tools & Instruments Factory Store on AliExpress
- Tools & Meter Store on AliExpress
- Banggood

Safe places to buy an original tinySA

- [Zeenko store on Alibaba.com](#). Other sellers on Alibaba may sell bad clones. For other payment methods, such as Paypal, hit the "chat now" button and Maggie from the Zeenko store will help you. At the right top of the browser window there should be "my messages" where you will have a better overview of your messages
- [Zeenko store on AliExpress](#). Other sellers on aliexpress may sell bad clones. To be sure you get a good product only buy from Zeenko store
- [R&L Electronics](#) in the USA. When the tinySA is listed as "out of stock" R&L can still take you order and only charge your credit card when the product is available again (which should be in a few weeks).
- [Passion Radio](#) in Europe
- [Mirfield Electronics](#) in the UK
- [Switch Science](#) in Japan

If the tinySA is listed as Pre-order it means there is currently no stock but a next batch of tinySA is being manufactured and as soon as these are available (usually within one month) the pre-ordered products will be shipped in order sequence.



How to recognize a cloned tinySA

The cloners tried to copy everything, included packaging, trademarked name and logo but failed on some aspects.

The current best way to detect a clone is to run the self test. If your tinySA fails on tests 7 and 8 it probably is a clone.

The latest clone copied all visible elements except there are some errors in the sticker on the back.



and self test 7 fails like this

Post a picture of the back of your tinySA and we can tell if you have a clone.

A previous clone uses foam (instead of molded PVC) for the inside of the box and looks like this:

And the backside has no sticker with serial number but looks like this



To be even more sure, open the case and look at the PCB. If there are no shields you have a clone

1.3 Spectrum Analyzer Introduction

Just like an oscilloscope is used to measure and view an electronic signal versus time, a spectrum analyzer is used to measure and view an electronic signal versus frequency.

The main specification points for a spectrum analyzer are its frequency range, the measurement resolution in this frequency range and the signal signal levels that can be displayed.

The three important signal levels are:

- Maximum level that can be input to the spectrum analyzer without damaging the spectrum analyzer.
- Spur free maximum level is the maximum input signal to stay below for a clean, spur free display.
- Noise level is the lowest discernable signal level and this depends on the resolution bandwidth. A lower bandwidth gives a lower noise level.

The maximum input signal level for the tinySA is 10dBm. Signals below -30dBm should not generate spurs in low input mode and the noise level with an Resolution Bandwidth (RBW) of 10kHz is about -105dBm

More expensive spectrum analyzers can digitize a broad frequency range at once and, using FFT, calculate the signal over a broad frequency range. Spectrum analyzers like the tinySA use a resolution filter that is used to isolate the input power in a small frequency range. This resolution filter is swept across the desired frequency range. As the oscillator that does the sweeping and the power detector that measures the signal power require some settling time the scanning speed of the tinySA is limited. The narrower the filter the more time is needed to settle. The fastest scanning speed occurs with an RBW or 300kHz or wider and is about 2 scans per second. But with increase of the frequency span and decrease of the RBW the scanning speed decreases quickly.

A scan from 0MHz to 350MHz with an RBW of 10kHz takes about 2 minutes.

1.4 Specification

User interface:

- Display resolution 320*240 pixels
- Screen diagonal 2.8"

- 16 bits per RGB pixels
- Resistive touch control
- Jog switch control
- USB serial port control
- Optional TTL USART port (SW not yet implemented) on the internal PCB
- Linear power supply to avoid switching noise.

The input/output specification of the tinySA is split over the 4 modes

Low input mode spec:

- Input frequency range from 100kHz to 350MHz (with some limitations down to 10kHz)
- Input impedance 50 ohm when input attenuation set to 10dB or more.
- Selectable manual and automatic input attenuation between 0dB and 31dB in 1 dB steps
- Absolute maximum input level of +10dBm with 0dB internal attenuation
- Absolute maximum short term peak input power of +20dBm with 30dB internal attenuation
- Suggested maximum input power of +5dBm with internal attenuation in automatic mode
- For best measurements keep input power below -25dBm
- Input Intercept Point of third order modulation products (IIP3) of +15dBm with 0dB internal attenuation
- 1dB [compression point](#) at -1dBm with 0dB internal attenuation
- Power detector resolution of 0.5dB and linearity versus frequency of +/-1dB
- Absolute power level accuracy after power level calibration of +/- 1dB
- Lowest discernible signal using a resolution bandwidth of 30kHz of -102dBm
- Frequency accuracy equal to the selected resolution bandwidth
- Phase noise of -90dB/Hz at 100kHz offset and -115dB/Hz at 1MHz offset
- Spur free dynamic range when using a 30kHz resolution bandwidth of 70dB
- Manually selectable [resolution filters](#) of 3, 10, 30, 100, 300, 600kHz. Automatic selection of one of the 57 resolution filters.
- On screen resolution of 51, 101, 145 or 290 measurement points.
- Scanning speed of over 1000 points/second using largest resolution filters.

- Automatic optimization of actual scanning points to ensure coverage of the whole scan range regardless of the chosen resolution bandwidth
- Spur suppression option for assessing if certain signals are internally generated or actually present in the input signal
- After a small HW modification it is possible to [Listen](#) to the demodulated audio

High input mode spec:

- Input frequency range from 240MHz to 960MHz
- Input impedance is frequency dependent and deviates from 50 ohm
- As there is no input band filter, strong input signals outside the 240MHz to 960MHz range can cause distortion of the in band signals
- Absolute maximum input level without attenuation of +10dBm
- Input Intercept Point of third order modulation products (IIP3) of -5dBm with no internal attenuation
- 1dB [compression point](#) at -6dBm with no internal attenuation
- Power detector resolution of 0.5dB and linearity versus frequency of +/-1dB
- Absolute power level accuracy after power level calibration of +/- 1dB
- Lowest discernible signal using a resolution bandwidth of 30kHz of -115dBm
- Frequency accuracy equal to the selected resolution bandwidth
- Spur free dynamic range when using a 30kHz resolution bandwidth of 50dB
- Manually selectable [resolution filters](#) of 3, 10, 30, 100, 300, 600kHz. Automatic selection of one of the 57 resolution filters.
- Optional 25dB to 40dB frequency dependent input attenuator. The power level error with this attenuator activated increases to +/- 10dB
- On screen resolution of 51, 101, 145 or 290 measurement points.
- Scanning speed of over 1000 points/second using largest resolution filters.
- Automatic optimization of actual scanning points to ensure coverage of the whole scan range regardless of the chosen resolution bandwidth
- After a small HW modification it is possible to [Listen](#) to the demodulated audio

Low output mode spec:

- Sinus output with harmonics below -40dB of fundamental
- Output frequency range from 100kHz to 350MHz
- Output frequency resolution either 156Hz below 47MHz output or 312Hz above 47MHz output
- Output level selectable in 1dB steps between -76dBm and -6dBm
- Optional AM, narrow FM and wide FM modulation with frequencies between 50Hz and 6kHz or slow sweep over selectable frequency span
- Optional output level sweep over maximum the entire output level range

High output mode spec:

- Square wave output
- Output frequency range from 240MHz to 960MHz
- Output frequency resolution either 156Hz below 480MHz output or 312Hz above 480MHz output
- Output level selectable in variable increments between -38dBm and +13dBm
- Optional narrow FM and wide FM modulation with frequencies between 50Hz and 6kHz or slow sweep over selectable frequency span

Reference generator spec:

- Optional square wave output with fundamental at -25dBm connected to high input/output
- Frequency can be set to 1MHz, 2MHz, 4MHz, 10MHz, 15MHz or 30MHz.

Battery spec:

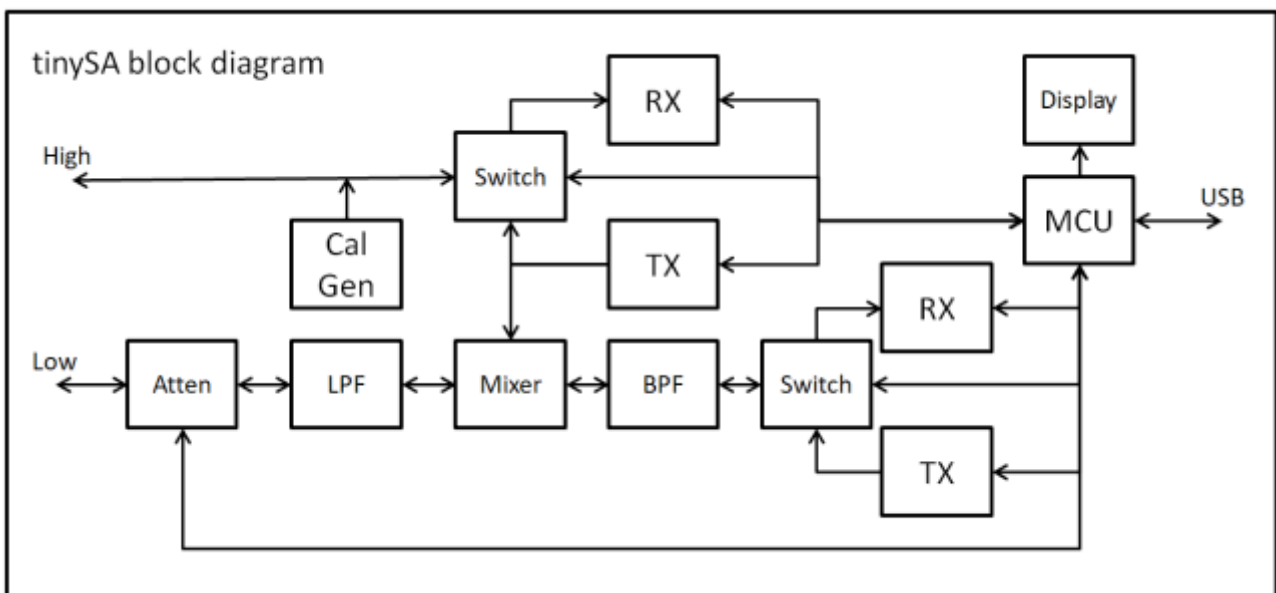
- Charging time max 1 hour on 500mA minimum USB port or USB charger
- Operation on fully charged battery for at least 2 hours

1.5 Limitations

As the internal components of the tinySA where selected with a careful balance between performance and cost there are certain limitations that experienced users of much more expensive spectrum analyzers must be aware of:

- The [internal phase noise](#) sets a clear lower limit for phase noise measurements.
- **The minimum resolution bandwidth of 2.4kHz makes it impossible to see more spectral detail**
- The high input (240MHz to 960MHz) has very limited image suppression and only one level optional built in attenuator which makes it difficult to interpret complex signals.
- The high input optional input attenuator is frequency dependent and varies between 25dB and 40dB
- **At lower resolution bandwidths (below 30kHz) the measurement time per point starts to increase due to the resolution filter implementation.** Careful use of the FAST sweeping mode may reduce this time increase
- The performance limitations of the shielding and the filters may lead to certain images and spurs being visible but certain functions like [spur suppression](#) and switching to [below IF](#) may help detect and/or reduce these spurs and images
- Below 0.1MHz the sensitivity starts to reduce.
- Below 1MHz it is recommended to disable the [AGC](#) and possibly enable the [LNA](#) to get best measurement quality
- **When using the supplied telescopic antenna or a low RBW one should be aware of the radiation from the**

tinySA MCU on 48MHz and its harmonics. See the [FAQ](#)



1.6 Technical Description

The tinySA contains all the components of a conventional heterodyne swept spectrum analyzer.

The components used in low input mode are:

- In low input mode the signal enters the tinySA through the low SMA connector
- 0-31dB settable Attenuator to protect the RX and prevent internally generated harmonics distortion
- 350MHz low pass filter to eliminate aliases
- A TX block that contains the local oscillator to do the scanning of the selected frequency range.
- The switch is used to enable the tracking output to the high output if activated
- Mixer that mixes the output from the low pass filter with the local oscillator to create the high IF.
- Band pass filter at 433.9MHz for the high IF that eliminates spurs and cleans the output from the mixer before the downconversion.
- A switch to route the output of the BPF to the RX
- And RX containing
 - Second LO and mixer to downconvert the high IF to a low IF at 870kHz.
 - Selectable resolution filters between 3kHz and 600kHz.
 - Power detector with 120dB dynamic range after the resolution filter.

The components used in high input mode are:

- In high input mode the signal enters the tinySA through the high SMA connector
- A switch to route the high input to the RX block
- An RX block containing
 - LO and mixer to downconvert the selected frequency range to a low IF at 870kHz. Mirror suppression is limited to 30dB
 - Selectable resolution filters between 3kHz and 600kHz.
 - Power detector with 120dB dynamic range after the resolution filter. Local oscillator that does the

The components used in low output mode are:

- TX block with Local oscillator generating 433.9MHz
- A switch to route the TX output to the Band Pass Filter
- Band pass filter removing the harmonics of the 433.9MHz local oscillator.
- Second TX with local oscillator that determines the output frequency.
- Mixer that mixes the output from the band pass filter with the second local oscillator to create the desired output frequency with limited harmonics
- Low pass filter for the low output to remove unwanted mixer products.
- Output attenuator connected between the low pass filter and the low output to optionally reduce the output level
- The generated signal leaves the tinySA through the low SMA connector

The components used in high output mode are:

- Local oscillator that determines the output frequency.
- A power amplifier with selectable output power between +5dBm and +20dBm
- The switch connects the power amplifier to the high SMA connector

The calibration generator:

- 30MHz temperature controlled crystal oscillator
- Selectable dividers to create 30, 15, 10, 4, 3, 2 or 1 MHz
- Fixed voltage output driver
- High accuracy attenuator to create a 30MHz fundamental of -25dBm into 50 ohm as power reference connected to the high output.

2 USER INTERFACE

2.1 First Use

The tinySA comes in a sturdy box for protection during transport



Inside the box you find the tinySA with some accessories

- two SMA cables and a barrel connector
- an antenna with an SMA connector
- a USB-C cable



After unpacking the tinySA insert the USB cable into the tinySA and connect the cable to a USB charger or computer USB port to charge the tinySA. One hour charging should be sufficient for first usage.

After charging the USB cable can remain connected or can be disconnected.

The next steps are also explained in the [video on first use](#)

Kurt Poulsen wrote a document on the tinySA that can be found through tinySA@groups.io

Execute these steps:

1. Use one of the supplied SMA cables to connect the low port to the high port.
2. Power the tinySA using the tiny power switch at the top.
3. Touch the screen to activate the menu system and select **CONFIG** and then **SELF TEST**. If navigation goes wrong use the **BACK** button or switch the tinySA Off and On to get back into a known state. If all goes well the self test will pass all tests and you can touch the screen once more to conclude.
4. Leave the high and low port connected for the next step
5. Next step is to do the power calibration of the LOW INPUT MODE. THIS has to be done only once for one frequency and it does not have to be repeated before every measurement as the level calibration is very stable and frequency independent. From the **CONFIG** menu execute **LEVEL CAL**. The red level indicators at the top and bottom should turn white to indicate the calibration has succeeded.

Optional step:

1. Doing the level calibration for the high input mode is a bit more complex but clearly explained in this [video](#)

Now the tinySA is ready to do measurements.

Connect some input signal to the low input and go back to the **INPUT** menu, you can select which input to use from the **MODE** menu, select either **LOW INPUT** or **HIGH INPUT**.

WARNING!!!. The input signal must be below +10dBm otherwise the tinySA can be damaged.

Use the **FREQ** menu to set the frequency range displayed and the **LEVEL** menu to set the displayed levels.

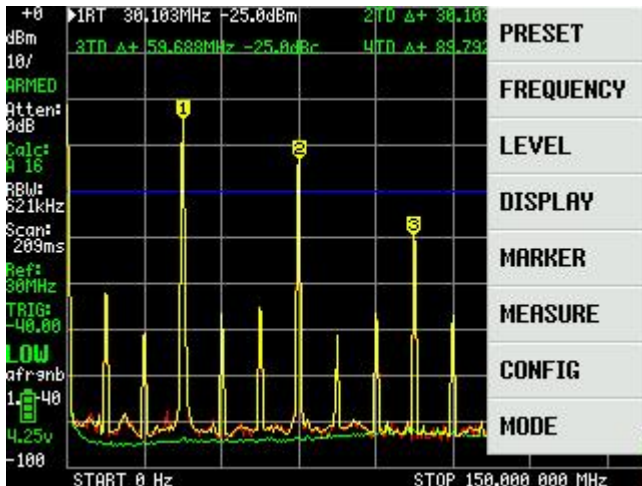
You can always go back to a defined state by clicking the **PRESET** button in the input menu and then **LOAD STARTUP**

2.2 Screen Info

The screen is divided in 5 areas.

- **Info panel** at the left
- **Marker info** at the top
- **Scan info** at the bottom
- **Measurement panel** in the middle

- Menu at the right



Info panel

From top to bottom the following info is shown (between brackets the actual info shown)

- Reference level (+0) colors green when manually set, white when automatic
- Unit (dBm)
- Scale (10dBm/) colors green when manually set, white when automatic.
- Scan status (ARMED) can be PAUSED either manually or when single sweep is done, ARMED when waiting for next trigger.
- Attenuation (0dB) colors green when manually set, white when automatic.
- Calculation (A 16 means Running average over 16 measurements), only shown when calculation active.
- RBW (612kHz) colors green when manually set, white when automatic.
- Scan time as measured (209 milliseconds), colors red when first scan after changing settings not finished yet
- Cal output frequency (30MHz), only shown when cal output active.
- Amplification of the external amplifier or attenuator, only shown when not zero.
- Trigger level set (-40dBm), colors red when waiting for trigger in NORMAL mode, colors green when SINGLE trigger completed. Only visible when not on AUTO
- Input mode (LOW) LOW is low input mode, HIGH is high input mode.
- Compact setting status (afrnbg) all lower case letters mean everything on automatic.
- FW version (1.0-40)
- Battery level and voltage

- Bottom level (-100dBm)

Marker panel

Shows info for maximum 4 active markers. Structure of the info:

- An optional arrow indicates the currently selected marker
- The type of marker is denoted with some letters. R=Reference, D=Delta marker, N=Noise marker with level normalized per Hz RBW
- The frequency of the marker, a '+' or '-' indicates a delta frequency
- Level of the marker. If no unit is indicated the level is in dBmW or in dBc in case of a delta marker.

A marker can be selected by touching its marker info. A selected marker can be positioned using the jog switch unless it is a tracking marker. Only one marker can be a Reference marker.

Scan Info

Shows the Start/Stop, Center/Span or Zero span/Scan time info.

Scan info can be selected by touching the info. Selected info is marked with a caret symbol and can be changed using the jog switch

Measurement panel

Shows maximum 3 traces.

- Yellow trace it the measurement trace, either as measured (when no calculation is active) or as calculated.
- If a calculation is active a red trace shows the info from the last scan.
- The stored info is shown in a green trace

Shows maximum 4 markers. Tracking markers are automatically positioned. Non-tracking markers can be grabbed and shifted to any location or the **MARKER SEARCH** can be used to position them

The active trigger level is indicated with a blue line

Menu

The menu is shown after touching the screen or pushing the jog button. This menu activation aborts the current sweep. After the menu setting is finished the sweep (when not in paused mode) will restart with the possibly updated settings.

2.3 MENU TREE

PRESET loads or saves configurations.

- **LOAD STARTUP** reloads the startup presets.
- **LOAD X** loads the settings from slot X
- **STORE** supports updating the stored presets
 - **STORE AS STARTUP** sets the current settings as the startup preset.
 - **STORE X** stores the current settings in slot X.
 - **FACTORY DEFAULTS** resets the startup preset to the factory defaults.

FREQ sets everything related to the frequency range to scan.

- **START** sets the scanning to start/stop mode and sets the start frequency
- **STOP** sets the scanning to start/stop mode and sets the stop frequency
- **CENTER** sets the scanning to center/span mode and sets the center frequency
- **SPAN** sets the scanning to center/span mode and sets the frequency span
- **ZERO SPAN** sets the scanning to center/span mode, sets the span to 0Hz and sets the center frequency
- **RBW** sets the resolution bandwidth. Keep in mind a low RBW may increase scanning time substantially.
- **SPUR REMOVAL** activates the two spur removal mechanisms.

LEVEL sets everything related to the level of the signals being measured.

- **REF LEVEL** sets the level in selected unit of the top of the display.
- **SCALE/DIV** sets the amount of selected unit per division of the display.
- **ATTEN** sets the amount of [attenuation](#) applied to the low input/output.
- **CALC** selects various calculation options over time such as averaging or max hold.
- **UNIT** selects the display unit. dBm, dBmV, dBuV, Volt or Watt
- **EXTERN GAIN** sets the level offset in dB caused by an external amplifier or attenuator.
- **TRIGGER** selects the trigger mode

- **AUTO** is the normal spectrum analyzer scanning mode, triggering is not active.
- **NORMAL** will display a new scan as soon as a signal in the scan causes a trigger event.
- **SINGLE** will wait for a signal to cause a trigger event and display the scan.
- **LEVEL** activates a keypad for entering the trigger level.
- **UP EDGE** generates a trigger event when the input level goes from below the set trigger level to above the set trigger level
- **DOWN EDGE** generates a trigger event when the input level goes from above the set trigger level to below the set trigger level

DISPLAY controls various aspects of how the signals are being displayed.

- **PAUSE SWEEP** pauses the scanning
- **STORE TRACE** writes the current measurement to the blue trace. Click again to store again.
- **CLEAR STORED** removes the stored trace
- **SUBTRACT STORED** subtracts the stored trace from the current measurement.
- **NORMALIZE** will store the current scan and subtract this stored scan from future measurements.
- **WATERFALL** displays the power level over time in a waterfall map.
- **SWEEP SETTINGS** menu contains various settings on how to sweep the selected frequency or time span.
 - **NORMAL** sets the default sweeping mode
 - **PRECISE** sets the precise scanning mode.
 - **FAST** sets the fast sweeping mode.
 - **SWEEP TIME** sets the target time for a complete sweep in seconds.
 - **SWEEP POINTS** allows setting the number of sweep points.
 - **FAST SPEEDUP** allows setting the acceleration factor for fast sweeping.

MARKER controls the markers on the display.

- **MODIFY MARKER** allows selecting a marker and shows a submenu to modify the [MARKER TYPE](#).

- **MARKER OPS** allows setting the frequency display range based on the active marker
- **SEARCH MARKER** allows positioning a non-tracking marker on signal maxima or minima.
- **MEASURE** helps to quickly set the tinySA for certain measurements.
 - **OFF** switches of any measurement related setting and behavior and returns the tinySA to regular operation
 - **HARMONIC** switches to a marker configuration for measuring the level of harmonics of a signal
 - **OIP3** switches to a marker configuration for measuring the Output IP3 level of a signal
 - **PHASE NOISE** switches to a marker configuration for measuring phase noise of a signal
- **BPF** enables measurement of the performance of the internal Band Pass Filter.
- **BELOW IF** switches the LO to below the IF when measuring below 190MHz.
- **HOLD TIME** sets the number of scans after which a maximum measured with **MAX DECAY** will start to decay.
- **NOISE LEVEL** sets the expected noise band in dB.
- **ACTUAL FREQUENCY** sets the measured frequency of the 10MHz CAL OUTPUT

DFU switches the tinySA to firmware upgrade mode.

MODE activates the mode switching menu.

- **LOW INPUT** activates the 0.1-350MHz input mode
- **HIGH INPUT** activates the 240MHz-960MHz input mode
- **LOW OUTPUT** activates the 0.1-350MHz output mode
- **HIGH OUTPUT** activates the 240MHz-960MHz output mode
- **CAL OUTPUT** controls the build in calibration reference generator.

CONFIG activates the configuration menu.

- **TOUCH CAL** enables the calibration of the touch panel. The results are stored in NVM.
- **TOUCH TEST** is used to verify touch calibration.
- **SELF TEST** is used after a cable is used to connect the low and high input/output.
- **LEVEL CAL** is used to calibrate the power measurement levels.
- **VERSION** shows the SW version information.
- **EXPERT CONFIG** activates the expert configuration menu
 - **LO OUTPUT** enables the output of the first LO though the high connector
 - **ACTUAL POWER** allows calibration of the dBm reading by entering the know level of the signal under marker 1.
 - **IF FREQ** allows entering the IF frequency used in low mode.
 - **SCAN SPEED** allows setting the speed of scanning.
 - **REPEATS** sets the number of repeat measurements at each frequency.
 - **MIXER DRIVE** sets the power output to the mixer.
 - **AGC** enables/disables the build in Automatic Gain Control.
 - **LNA** enables/disables the build in Low Noise Amplifier.

2.4 Preset

Load

- **LOAD STARTUP** reloads the startup presets. This startup preset is either the factory defaults or a configuration specifically saved into the startup preset.
- **LOAD X** loads the settings from slot x
- **STORE** supports updating the stored presets
- **BACK** returns to the input menu

Store

- **STORE AS STARTUP** sets the current settings as the startup preset.
- **STORE X** stores the current settings in slot X.
- **FACTORY DEFAULTS** resets the startup preset to the factory defaults.
- **BACK** returns to the Preset Load menu

2.5 Frequency Menu

There is a short [video](#) demonstrating the frequency menu

The tinySA scans its input frequency range either in start/stop mode or in center/span mode. The number of points displayed is

always 290. The number of points scanned is minimum 290 but when the [RBW](#) is too small to cover the selected frequency range with 290 points additional measurements are done and accumulated into the 290 points.

- **START** sets the scanning to start/stop mode and sets the start frequency
- **STOP** sets the scanning to start/stop mode and sets the stop frequency
- **CENTER** sets the scanning to center/span mode and sets the center frequency
- **SPAN** sets the scanning to center/span mode and sets the frequency span
- **ZERO SPAN** sets the scanning to center/span mode, sets the span to 0Hz and sets the center frequency
- **RBW** sets the resolution bandwidth. Keep in mind a low RBW may increase scanning time substantially.
- **SPUR REMOVAL** activates the two spur removal mechanisms. Below 190MHz the above and below IF are used to identify spurs and above 190MHz the IF is shifted. It is recommended to us an IF of 433.9MHz when activating spur removal
- **BACK** returns to the input menu

The scanning is limited to the frequency range of the selected [MODE](#)

2.5.1 RBW

The resolution bandwidth of the tinySA power detector can be set to match the measurement requirements.

- **AUTO** sets the resolution bandwidth selection to automatic.
- 3kHz
- 10kHz
- 30kHz
- 100kHz
- 300kHz
- 600kHz
- **BACK** returns to the **FREQ** Menu

Setting the resolution bandwidth to **AUTO** will match the resolution bandwidth with the video bandwidth determined by the frequency span. If the maximum resolution bandwidth is less then the frequency step per display point, additional steps are automatically inserted to ensure full span coverage and the measurement time will increase.

When using a fixed resolution bandwidth additional scanning steps are inserted if needed to ensure full frequency span

coverage and this may cause the measurement time to increase.

Be aware scanning a large frequency span using a low RBW can take considerable time!

The noise floor of the tinySA depends on the selected resolution bandwidth. A lower resolution bandwidth reduces the noise floor but scanning a wide span will take more time.

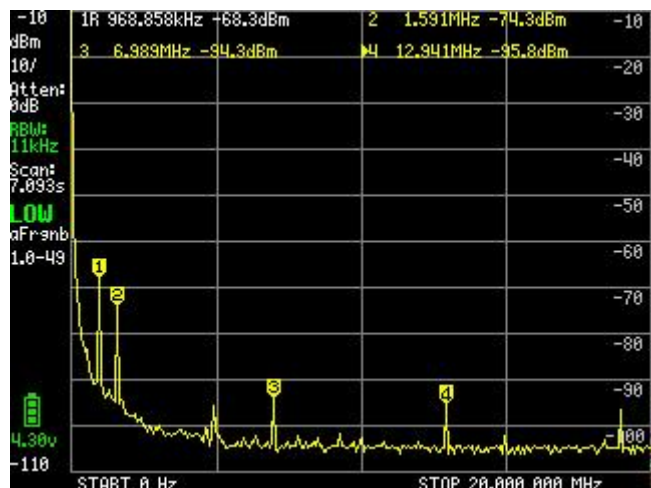
The active RBW is visible in the status panel. When the RBW is manually set the RBW status is displayed in green.

2.5.2 SPUR REMOVAL

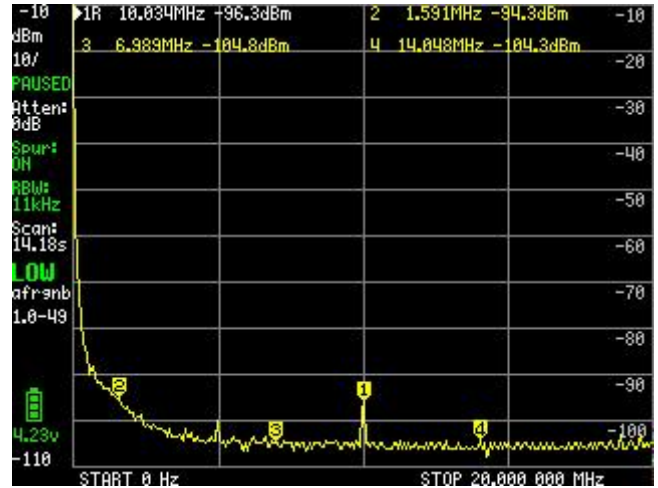
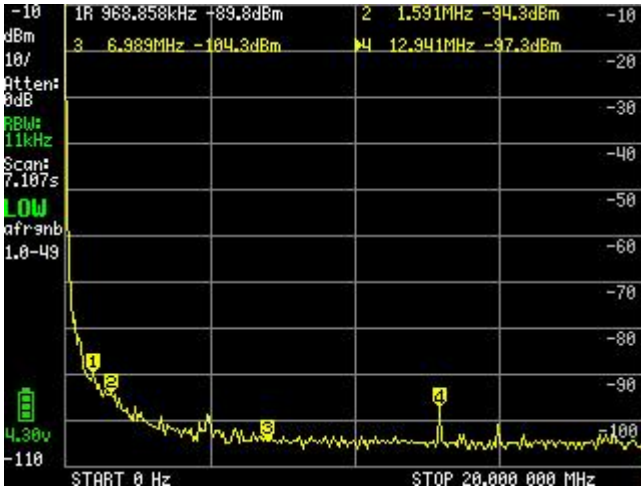
Sometimes mixing of harmonics creates artificial signals in a scan making it difficult to know what the real signals are. Spur reduction uses either wobbling the high IF frequency within the pass band of the high iF bandfilter or swapping the LO between above IF and below IF. During this wobbling or LO switching the desired signals remain at their position but all products of harmonic mixing or aliases or mirrors will move around. Spur reduction works best below 190MHz or using an [RBW](#) of 100kHz or less.

Reducing spurs

Here is the bottom 20MHz with ALL spur reduction measures switched off and the IF set to a fixed 433.8MHz



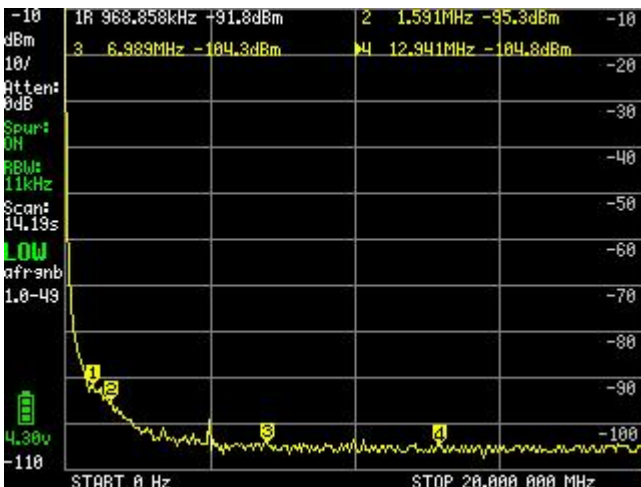
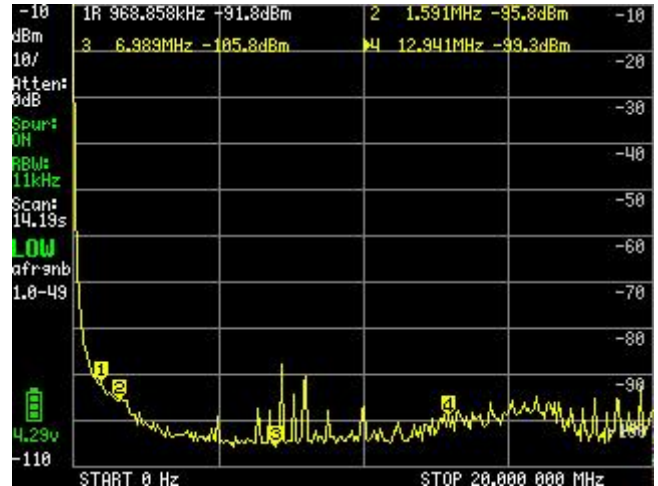
The first measure used is to shift the IF at certain scanning frequencies. The impact is clearly visible when the IF is set back to automatic.



The tinySA has an internal table recording at what frequencies the IF has to be shifted to eliminate certain spurs. This spur avoidance approach has no negative impact on performance.

Measuring such a small signal is an art in itself as can be clearly shown by what is measured when the signal generator and the tinySA where both connected to the PC using their USB interface

There are still some spurs left and these can be reduced by spur reduction techniques that do have an impact on the scanning speed and the ability to measure transients. Below scan is done with the SPUR REMOVAL enabled

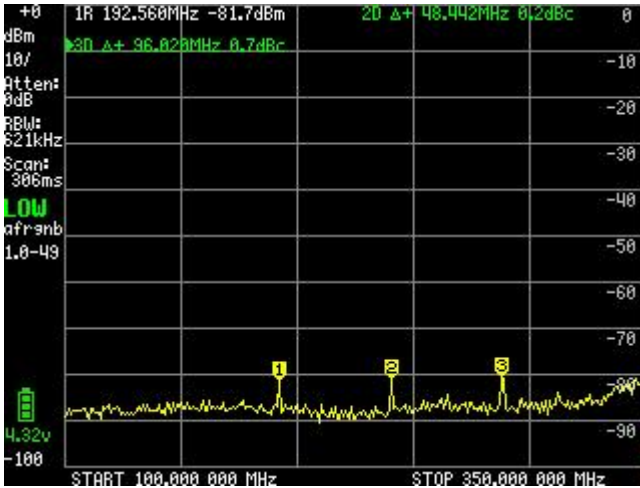


Always make sure there are no ground loops, use good quality cables and tighten SMA connectors.

Unavoidable spurs

This results in an almost clean noise floor. To check if there has been no impact on sensitivity the same scan while supplying a -95dBm signal at 10MHz

There are some spurs however that can not be eliminated because these are actually present as input signals. An example is the leakage from harmonics of the MCU clock at 48MHz that can be seen in below scan



These harmonics will become even stronger when connecting the telescopic antenna and, as they are real signals, can not be removed by spur removal.

2.6 Level Menu

There is a short [video](#) demonstrating the level menu

Various attributes of the display can be adapted

- REF LEVEL sets the level in selected unit of the top of the display. The ref level can be set to AUTOMATIC and is automatically adjusted to keep the strongest signals just below the top of the screen.
- SCALE/DIV sets the amount of selected unit per division of the display.
- ATTEN sets the amount of [attenuation](#) applied to the low input/output. The range is 0 to 31 dB. There is no settable attenuator in high mode. When set to AUTOMATIC the attenuation tries to keep the strongest signals minus the attenuation below -20dBm.
- **CALC** selects various calculation options over time such as averaging or max hold.
- UNIT selects the display unit. dBm, dBmV, dBuV, Volt or Watt
- EXTERN GAIN sets the level offset in dB caused by an external amplifier or attenuator. Default is 0. Example: For an external 20dB attenuator set to -20
- **TRIGGER** selects the trigger mode
- **BACK** returns to the input menu

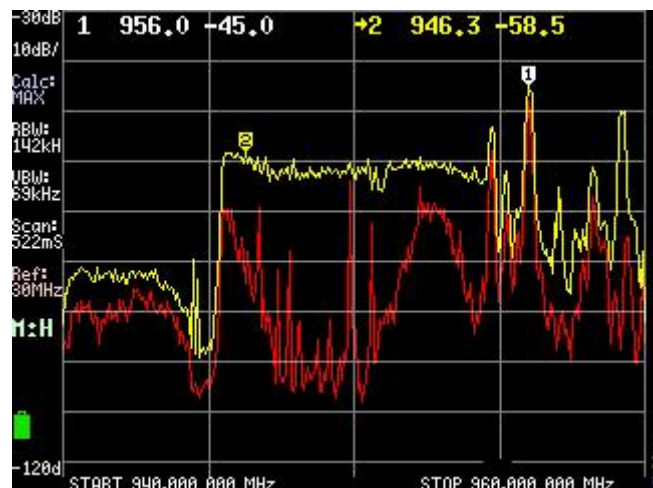
2.6.1 CALC

Combining measurements over time to allow visualization of certain aspects of the input signal or hiding of unwanted signals. All calculations can be reset by selecting the calculation mode again.

- OFF disables any calculation
- MIN HOLD sets the display to hold the minimum value measured. Reset the hold by selecting again. This setting is used to see stable signals that are within the noise
- MAX HOLD sets the display to hold the maximum value measured. Reset the hold by selecting again. This setting can be used for many measurements such as showing the power envelope of a modulated signal.
- MAX DECAY sets the display to hold the maximum value measured for a certain amount of scans after which the maximum will start to decay. The default number of scans to hold is 20. This default can be changed in the **SETTINGS** menu. This setting is used instead of MAX HOLD to reduce the impact of spurious signals
- AVER 4 sets the amount of running averaging to 4.
- AVER 16 sets the amount of running averaging to 16.
- **BACK** moves back to the LEVEL menu

As there is no VBW setting for noise reduction, it is advised to use averaging instead.

When averaging or holding is active the calculated value is displayed in a yellow trace. The latest acquired value is displayed in a red trace. Markers take their value from the calculated yellow trace.



The above picture shows the power envelope of a mobile phone base station that transmits between 945MHz and 955MHz in the yellow max hold line and the current transmit power in the red line

2.6.2 TRIGGER MODES

Triggering can be done in frequency domain (e.g. scanning a certain span) or in time domain (e.g. with zero span). Triggering in frequency domain can be slow due to the time required to scan the frequency span.

- AUTO is the normal spectrum analyzer scanning mode, triggering is not active.
- NORMAL will display a new scan as soon as a signal in the scan causes a trigger event.
- SINGLE will wait for a signal to cause a trigger event and display the scan. Restart the waiting for an event by activating SINGLE again.
- LEVEL activates a keypad for entering the trigger level. The specified trigger level will be shown in the status panel and as a blue line
- UP EDGE generates a trigger event when the input level goes from below the set trigger level to above the set trigger level
- DOWN EDGE generates a trigger event when the input level goes from above the set trigger level to below the set trigger level
- BACK returns to the Level menu

The active trigger level is shown on the screen as a blue line and in the status at the left. The trigger level in the status is shown in red when waiting for the trigger to happen and in green when a single trigger happened

2.7 Display Menu

There is a short [video](#) demonstrating the display menu

- PAUSE SWEEP pauses the scanning
- STORE TRACE writes the current measurement to the blue trace. Click again to store again.
- CLEAR STORED removes the stored trace
- SUBTRACT STORED subtracts the stored trace from the current measurement. Make sure to adjust the REF LEVEL in the LEVEL menu to make the

calculated trace visible. The current measurement is stored if there was no stored trace.

- NORMALIZE will store the current scan and subtract this stored scan from future measurements. This will show the difference in input level compared to the stored scan. NORMALIZE is the same as STORE TRACE followed by SUBTRACT STORED. Use CLEAR STORED to deactivate NORMALIZE
- WATERFALL displays the power level over time in a waterfall map. Click again to disable. The waterfall moves per scan and displays the last 40 scans.
- SWEEP SETTINGS menu contains various settings on how to sweep the selected frequency or time span.
- BACK returns to the input menu

2.8 Sweep Settings

- NORMAL sets the default sweeping mode
- PRECISE sets the precise scanning mode. Using the same RBW the amount of scan points will be doubled and the wait time after each frequency change will also be doubled to reduce noise so the total minimum sweep time will be four times higher.
- FAST sets the fast sweeping mode. This will enable offset tuning when doing frequency steps below 800kHz and as offset tuning can be done with less disturbances the wait time per measured point can be reduced. The smaller the sweep frequency span the higher the possible sweep time reduction. A disadvantage of the fast sweeping mode is an increase of the noise of about 10dB.
- SWEEP TIME sets the target time for a complete sweep in seconds. Using the 'm' button on the keypad it is possible to specify the sweep time in milliseconds. Setting the sweep time to zero enables the fastest sweep. Setting a sweep time below the fastest sweep time has no impact.
- SWEEP POINTS allows setting the number of sweep points to 145 or the default of 290. Reducing the sweep points will only lead to a reduction of sweep time if the RBW using the reduced number of sweep points is below 600kHz,

- FAST SPEEDUP allows setting the acceleration factor for fast sweeping. Default this is set to 4. The maximum acceleration is 20. The actual acceleration will depend on available and requested RBW and on the selected frequency span and can be much lower as specified. In practice acceleration with a factor 10 is possible.
- BACK returns to the display menu

As zero span sweeping does not require changing the frequency there is no impact of the sweeping mode settings on the sweeping speed or accuracy. Also the FAST SPEEDUP has no impact.

Sweep settings

- SPAN sets the span of the sweep. Set to zero to disable the sweep
- LEVEL CHANGE sets the delta to the set level at the end of the sweep. Set to zero to disable the sweep. Example: LEVEL set of -60, LEVEL SWEEP set to 50. This will start each sweep at -60dBm and increase during the sweep until reaching -10dBm at the end of each sweep. LEVEL CHANGE is only available in low output mode.
- SWEEP TIME sets the time in seconds of a sweep. Setting the time to zero sets maximum sweep speed.
- BACK moves back to the output menu

2.9 MARKER

Markers are used to display the value of signals. One marker is active and marked with an inverted number.

- MODIFY MARKER allows selecting a marker and shows a submenu to modify the MARKER TYPE or to delete the marker.
- MARKER OPS allows setting the frequency display range based on the active marker
- SEARCH MARKER allows positioning a non-tracking marker on signal maxima or minima.
- BACK returns to the input menu

Marker 1 is by default enabled and has the TRACKING attribute and is thus automatically positioned at the largest signal in the scan. The active marker can be moved with the jog switch. Any marker can be moved by dragging the marker to a new position. The active marker can also be

selected by touching the related marker info at the top of the screen.

Marker Type Menu

Each marker can have a number of attributes

- REFERENCE defines the marker used to calculate the values of the DELTA marker. There can only be one REFERENCE marker. Color white and labeled 'R'
- NOISE is a noise marker. Its level display is normalized by RBW per Hz and labeled 'N'
- DELTA gives the frequency and the signal level relative to the one REFERENCE marker. Color green and labeled 'D'. When the display unit is set to dBm this delta marker is equivalent to dBc
- TRACKING enables automatic positioning of the marker at the strongest signals. Tracking markers are labeled 'T'
- NORMAL is a marker without any of the other attributes, colored yellow.

Each marker can be set to TRACKING. The first marker with tracking active will be automatically positioned to the strongest signal. The second marker with tracking active will be positioned to the next strongest signal and so on.

A signal is only recognized as maximum if it is at least NOISE LEVEL dB above the surrounding signal minima. If no maximum is found a tracking marker is positioned at the start of the trace

Marker Operations menu

- START sets the start of the scan to the active marker.
- STOP sets the stop of the scan to the active marker.
- CENTER sets the center of the scan to the active marker.
- SPAN keeps the center frequency but sets the span to the offset of the active marker.
- BACK returns to the MARKER menu

2.10 MEASURE

First Measurement Menu

The measurement menu provides quick presets and data entering for certain type of measurements.

- OFF switches of any measurement related setting and behavior and returns the tinySA to regular operation
- HARMONIC switches to a marker configuration for measuring the level of harmonics of a signal
- OIP3 switches to a marker configuration for measuring the Output IP3 level of a signal
- PHASE NOISE switches to a marker configuration for measuring phase noise of a signal
- SNR set three markers, a tracking marker and two delta markers at the specified distance to the tracking marker
- -3dB width sets three markers, a tracking marker and two delta markers at the -3dB levels versus the tracking marker and the delta frequency of the two delta markers is calculated
- MORE moves to the second measure menu
- BACK moves back to the input menu

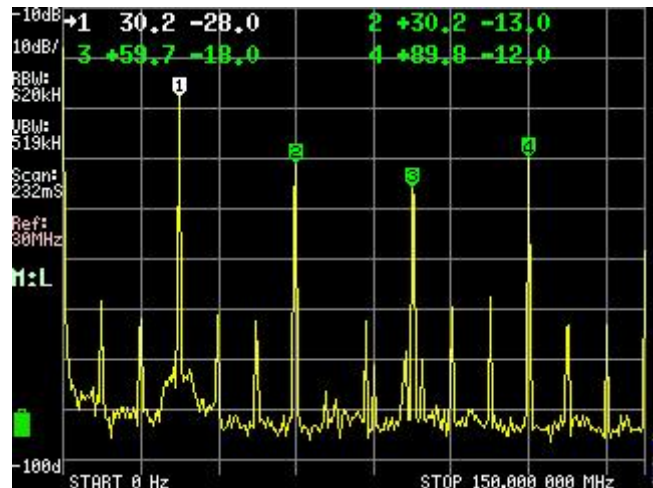
Second Measurement Menu

- AM sets various settings to optimize observations of an AM modulated signal
- FM sets various settings to optimize observations of an FM modulated signal
- THD enables the measurement of the THD defined as the percentage of energy in the harmonics versus the energy in the fundamental. The tracking marker is assumed to be at the fundamental and all harmonics in the scan are included.
- BACK moves back to the first MEASURE menu

2.10.1 MEASURING HARMONICS

After activating the harmonics measurement a keypad appears for entering the approximate frequency of the fundamental. This does not have to be an accurate number as the tinySA will search for the strongest signal

Next the IMD measurement screen appears



Four markers are activated

1. automatically finds the strongest signal and should be the fundamental and the marker is set to a tracking REFERENCE marker
2. automatically finds the second harmonic and the marker is set to a DELTA marker and level is displayed in dBc
3. automatically finds the third harmonic and the marker is set to a DELTA marker and level is displayed in dBc
4. automatically finds the fourth harmonic and the marker is set to a DELTA marker and level is displayed in dBc

The level of the fundamental should not exceed -20dBm, preferably below -30dBm. If the signal is too strong the attenuation should be increased. As harmonics could be created inside the tinySA it is advised to verify this is not the case by changing the attenuation and observe if there is no impact on the level of the harmonics. Remember the delta levels of the various harmonics and increase the attenuation with 5 or 10 dB. In high mode apply extra external attenuation. After this increase of attenuation the noise floor should go up but the fundamental and all the harmonics should stay on the same level. If the harmonics go down they were, at least partially, generated inside the tinySA. If this happens increase attenuation till you see no more change and use this level of attenuation as the starting level for the measurement.

As harmonics are at multiple of the frequency of the fundamental the measurement range of the applied input mode limits the harmonic that can be measured.

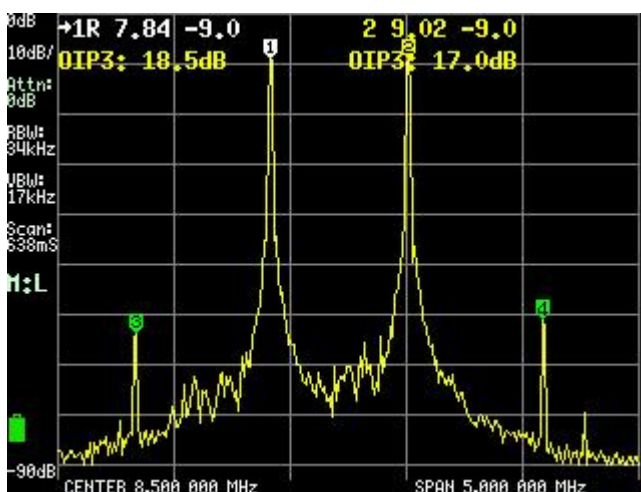
In low mode the second harmonic can be measured of fundamentals up to half the maximum low input frequency

2.10.2 OUTPUT THIRD ORDER INTERMODULATION INTERCEPT POINT

After activating the OIP3 measuring mode the tinySA asks first for the first test signal frequency and then for the second test signal frequency. The tinySA then configures itself with a span of five times the difference in frequency and the center at the average of the two frequencies. The specified frequencies do not have to be exact but within 20%. In the image below the left test signal was specified at 8MHz but it happened to be at 7.8MHz

As the phase noise of the tinySA is not very good it is important to use two test signals that are preferably at least one MHz apart

Two normal tracking markers are enabled that will be position on the two strongest signals. Marker 1 at the left signal, marker 2 at the right signal. Two delta markers are also enabled and these are automatically positioned at the calculated 3rd order intermodulation products. As can be seen in below image the regular information for markers 1 and 2 is shown but the information for markers 3 and 4 is replaced by the calculated OIP3 levels. Two numbers are given, one calculated from the left intermodulation product, the second calculated from the right intermodulation product.



The attenuator setting is extremely important. With low attenuation it is very well possible the tinySA first mixer performance is limiting the maximum OIP3

that can be measured. Changing the amount of attenuation should note change the measured OIP3. If it does you should increase the attenuation until it no longer does.

2.11 Configuration menu

The configuration menu can be used to update various settings and to test or calibrate the tinySA

- TOUCH CAL enables the calibration of the touch panel. The results are stored in NVM.
- TOUCH TEST is used to verify touch calibration.
- SELF TEST is used after a cable is used to connect the low and high input/output. The progress is displayed and you need to touch the display after each failing test and at the end of the test.
- LEVEL CAL is used to calibrate the power measurement levels. A new menu appears and you will be asked to connect the low and high input/output. After connecting the cable, activate CALIBRATE. The calibration can be reset by RESET CALIBRATION. At the end of the calibration switch of the tinySA. After switching on again the numbers indicating the power levels should be in white to indicate the power reading is calibrated. An uncalibrated state is indicated with red level indicators. The level calibration data is stored in the leveloffset configuration variable.
- VERSION shows the SW version information.
- EXPERT CONFIG activates the expert configuration menu
- DFU switches the tinySA to firmware upgrade mode.
- BACK moves back to the input menu.

2.11.1 EXPERT CONFIG MENU

Allows the setting of various internal parameters. Do not change anything unless you know what you are doing.

- LO OUTPUT enables the output of the first LO though the high connector so an external mixer and LO can be used to create a tracking generator. The LO is by default above the IF frequency
- ACTUAL POWER allows calibration of the dBm reading by entering the know

level of the signal under marker 1. The updated calibration value is stored in the `leveloffset` configuration variable. Power calibration is removed by setting the value to 100. Setting the actual power sets the `leveloffset` for all frequencies. A detailed power level correction versus frequency is available using the `correction` command

- `IF_FREQ` allows entering the IF frequency used in low mode. The default is 433.8MHz and any value below 433.6MHz or above 434.3MHz will greatly reduce sensitivity. Setting to any value other than 433.8MHz disables the built in spur avoidance and may cause spurs to appear in RBW's below 100kHz
- `SCAN_SPEED` allows setting certain parameters influencing the speed of scanning. Do not go there if you do not know what you are doing!
- `REPEATS` sets the number of repeat measurements at each frequency. Default value is 1 but a higher value can be used to average noise. Every increment of the amount of repeats will slow down scanning with about 130ms.
- `MIXER_DRIVE` sets the power output to the mixer. A high drive reduces 3rd order distortion with some dB. A lower drive may slightly reduce the noise floor. The default level of +7dBm should be good for most measurements.
- `MORE` activates the second settings menu
- `BACK` returns to the Config menu

2.11.2 POWER LEVEL CALIBRATION

The tinySA internal components do have certain manufacturing tolerances possibly causing deviations when measuring power levels in low input mode. To reduce this error it is possible to calibrate the power level display using the internal calibration generator. Without an active calibration the upper and lower power level indicators next to the display grid are displayed in red.

Before starting the calibration connect the low and high inputs using an SMA cable. The power level calibration uses a 30MHz calibration output to calibrate the low input power level display.

Once calibration is done the upper and lower power level indicators next to the display grid turn white. Directly after calibration the power level display error is expected to be below +/- 2dB

The calibration results are stored in NVM. The `RESET CALIBRATION` option in the `CALIBRATE` menu allows resetting to factory defaults in case of a failed calibration.

2.11.3 SETTINGS2

Allows even more internal settings to be changed.

- `AGC` enables/disables the built in Automatic Gain Control. The AGC helps extending the dynamic range of the tinySA but is sometimes causing artifacts. Disabling the AGC can help discovering these artifacts. Disabling of the AGC is recommended when measuring below 1.5MHz or when trying to observe AM modulation. This setting only has impact when attenuation is on manual. See the example of measuring [Low Frequencies](#)
- `LNA` enables/disables the built in Low Noise Amplifier. Should not be enabled when AGC is enabled. Enabling the LNA can cause severe signal distortion with signals above -20dBm. Switching on the LNA is recommended when measuring low level signals below 1.5MHz. This setting only has impact when attenuation is on manual.
- `BPF` enables measurement of the performance of the internal Band Pass Filter. Make sure you connect low and high input connectors with a short SMA cable. This measurement is only available in low input mode. The top of the BPF should be at close to -25dBm and have a flat passband of about 1MHz wide. The stop band of the BPF should be below -80dBm
- `BELOW_IF` switches the LO to below the IF when measuring below 190MHz. Can be used to detect spurs or mirror signals but may also cause performance degradation. This is normally in automatic mode.
- `HOLD_TIME` sets the number of scans after which a maximum measured with `MAX_DECAY` will start to decay. Decay speed is 0.5dB per scan. Default is 20. Maximum is 250

- NOISE LEVEL sets the expected noise band in dB. Used for positioning tracking markers and maximum search. A higher value will hide small signals in automatic marker search. A lower value enables automatic identification of weak signals but could also lead to more false maxima. Default is 10
- CORRECT FREQUENCY allows to enter the actual measured frequency of the 10MHz CAL OUTPUT. Make sure you have set the CAL OUTPUT to 10 MHz and measured the output with a good frequency counter.
- BACK moves back to the first settings menu

slot	frequency	value
0	10000	6.0
1	100000	2.8
2	200000	1.6
3	500000	-0.4
4	3000000	0.0
5	14000000	-0.4
6	20000000	0.4
7	30000000	3.0
8	33000000	4.0
9	35000000	8.1

The current content of the table is shown by entering correction without any arguments. The data in the table can be modified by specifying the slot number and the new values.

2.11.4 SCAN SPEED

The DSP RBW filter needs some time to charge. This time is dependent on the selected RBW. An internal table helps setting this time

- SAMPLE DELAY is used during frequency changes and is normally on automatic but for experiments it is possible to force certain sample delay. Setting the sample delay to zero sets the sample delay back to automatic. The smaller the RBW the bigger the sample delay has to be, a too low sample delay will result in a lot of noise in the measurement. Once manually set the sample delay no longer adapts automatically to a change in RBW. Do not set this value unless you know what you are doing.
- OFFSET DELAY is used during the fast mode offset tuning. The mechanisms are the same as for sample delay. Do not set this value unless you know what you are doing.
- BACK moves back to the previous menu

Example: correction 5 10000000 -0.5

This command will set slot 5 to 10MHz and a correction of -0.5dB. The frequencies specified in the table must be sorted in increasing frequency. Make sure you do a saveconfig after updating to save the new values to flash memory so they will survive reset.

There MUST be one entry for 30MHz and the correction for that frequency MUST be zero. You are free to choose which entry as long as the table is sorted in increasing frequency

Use of the correction table

All level measurements will use the frequency of the measurement to find the applicable correction.

- Any frequency below the frequency in slot 0 will use the correction from slot 0
- Any frequency above the frequency in slot 9 will use the correction from slot 9
- Any in between frequency will use a frequency based linear interpolation to calculate the applicable correction

2.11.5 USB COMMAND: CORRECTION

Correction table

There are two user controllable level correction mechanisms in the tinySA:

First is the leveloffset which is frequency independent and set by either doing a level calibration or using the ACTUAL POWER menu.

The second mechanism is the frequency dependent correction table. This table with 10 entries for frequency dependent level corrections. The default table for the V0.3 HW contains these values

2.12 Mode Menu

The mode menu allows switching to one of the four operating modes of the tinySA and to activate the calibration output. Switching mode will reset all users settings to the default values for the selected mode. Returning to a currently active mode will not change any settings.

- LOW INPUT activates the 0.1-350MHz input mode
- HIGH INPUT activates the 240MHz-960MHz input mode
- LOW OUTPUT activates the 0.1-350MHz output mode
- HIGH OUTPUT activates the 240MHz-960MHz output mode
- CAL OUTPUT controls the build in calibration reference generator. The output of the reference generator is connected to the high mode input/output. The output frequency can be 1,2,4,10,15 and 30MHz and the output level of the fundamental at 30MHz is -25dBm
- BACK returns to the current active mode.

2.12.1 HIGH INPUT

The high menu is much like the low input menu except missing options for functionality not present in high Input such as:

- Attenuator related settings
- Mixer and IF related settings
- Band pass filter measuring option
- Tracking output option
- Spur reduction related settings

There are a number of things to keep in mind when using the high input

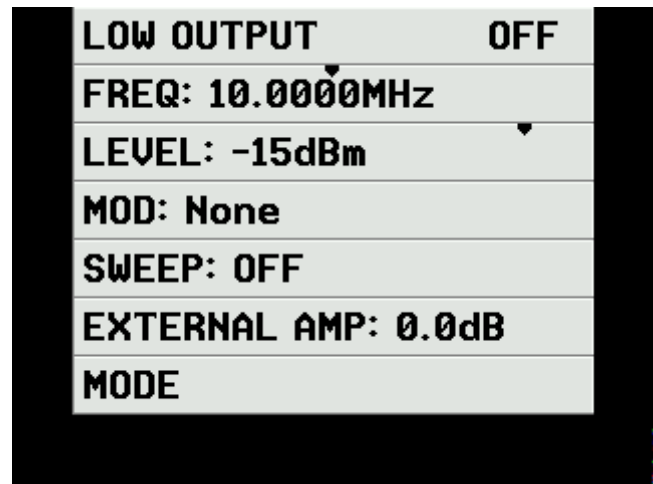
- The input IIP3 is -15dBm so VERY easily overloaded.
- The front-end is a direct IQ mixer with very limited mirror suppression (maximum 30dB)

For best use of the high input:

- Set CONFIG/EXPERT CONFIG/SCAN SPEED to "PRECISE"
- Disable the CONFIG/EXPERT CONFIG/AGC if possible.
- For low level input signals you can enable the CONFIG/EXPERT CONFIG/LNA (use only when AGC is disabled)
- Make sure input signals stay way below -20dBm to avoid overloading.

2.12.2 LOW OUTPUT

The low output mode produces a signal with reduced harmonics. Depending on the output level the harmonics vary between -35dB (highest output levels) to below -50dBm (below -35dBm output) The low output screen looks like this:



- A short tap on FREQ button activates a keypad to select the output frequency. The frequency can be set from 100kHz to 350MHz
- A short tap on the LEVEL button activates a keypad to select the output level. The output level can be set from -76dBm to -6dBm
- MODULATION allows selecting a modulation of the output
- SWEEP allows selecting a frequency span and/or level change and duration for sweeping. MODULATION and SWEEP are exclusive.
- EXTERNAL AMP activates a keypad to select the applied external amplification (positive values) or attenuation (negative values). This number will be added to the displayed output level and automatically subtracted when setting any output level thus avoiding the need for level calculations.
- MODE returns to the mode menu

The signal generator frequency resolution is about 260Hz

A long push anywhere on the LEVEL button will activate the slider mode. The slider pointer will move to the X-position of the touch and moving the touch left or right allows to quickly change the output level.

A long push on the FREQ button has two possible functions:

1. SPAN function: A long touch away from the slider indicator will put the slider in SPAN mode, indicated with the text changing to SPAN, allowing to set, by moving left or right with the touch, the SPAN range of the slider.
2. FREQ function: A long touch close to the slider indicator will put the

slider in FREQ mode with the last selected SPAN and by moving left or right with the touch the output frequency can be quickly set.

2.12.3 HIGH OUTPUTA

The high output mode works much like the low output mode with the following differences:

- The output is a square wave rich in harmonics
- The output can be set to various levels ranging from -38dBm to +13dBm
- The frequency can be set from 240MHz to 960MHz.
- There is no LEVEL CHANGE function
- There is no AM modulation

3 TUTORIALS

Here are some examples of what the tinySA can do

- Measuring [Harmonics](#)
- Measuring [Spectral Purity](#)
- Measuring [Phase Noise](#)
- Measuring [Third Order Intermodulation](#)
- Measuring [IQ Balance](#)
- Measuring [Spur Free Dynamic Range](#)
- Measuring [Low Frequencies](#)
- Capturing [ISM Transmissions](#)
- Tuning [Sweep Settings](#)
- [Coax Cable Impact](#)
- --
- Measuring [FM deviation](#)
- Measuring [AM modulation](#)
- Measuring [One dB Compression Point](#)
- Adding an [LNA](#)
- Using a Tracking Generator to measure a [Mixer](#)
- Measuring the [Noise Factor of an Amplifier](#)
- [Calibrating the low output level](#)
- Adding the [Listen](#) function

3.1 VIDEOS

All tinySA video can be found on [YouTube](#)

- * [#01 GENERAL INTRODUCTION VIDEO](#)
- * [#16 BASIC INTRODUCTION](#)
- * [#02 FIRST USE](#)
- * [#17 TOUCH CALIBRATION](#)
- * [#03 CALIBRATING THE HIGH INPUT](#)
- * [#27 CALIBRATING THE FREQUENCY](#)

- * Menu Videos
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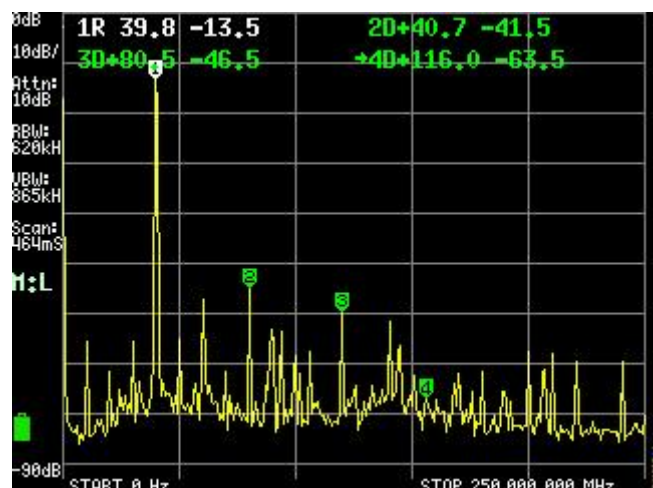
- * Internals
- * [23 INTERNALS: AGC AND LNA](#)

3.2 Measuring Harmonics

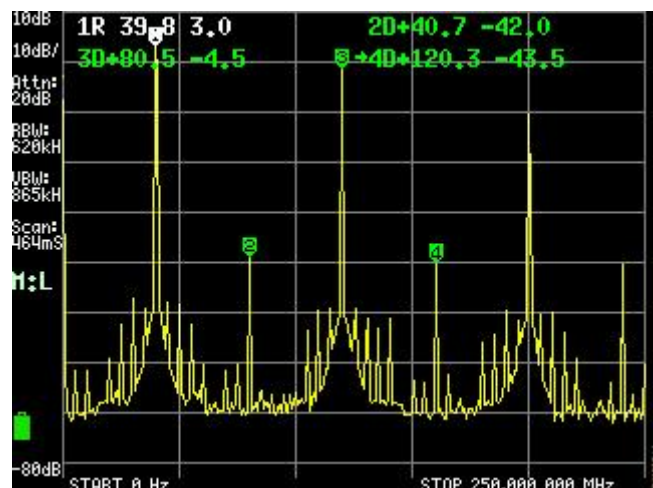
Before you start measuring harmonics, be aware you understand the [Spur Free Dynamic range](#) and avoid overloading the input, stay as low as possible, preferably below -30dBm

Here are some example measurements of a 40MHz signal from various sources

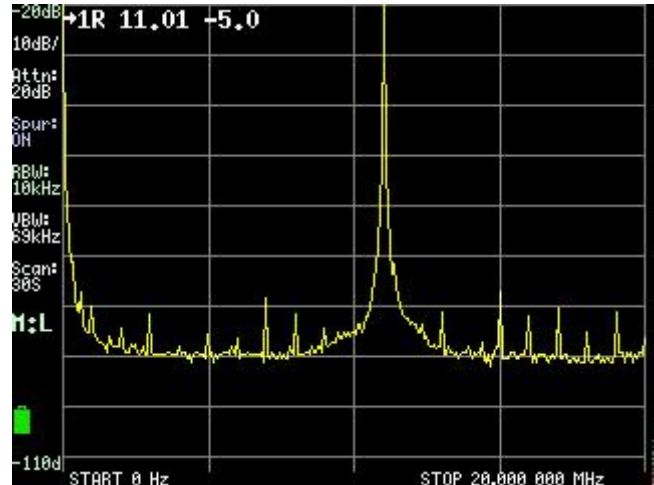
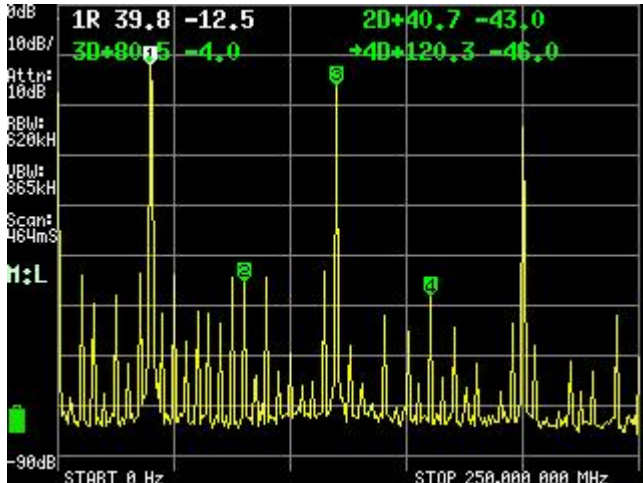
First from a DDS



Second from a SI5351



And third from a ADF4351



And third the signal from a SI5351

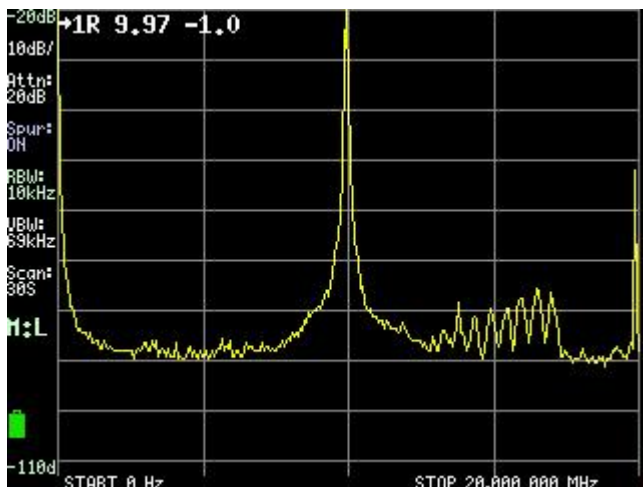
The differences in harmonics and the aliases from the DDS are clearly visible.

These measurements are done with all settings on default, only the scan stop frequency is set to 250MHz

3.3 Measuring spectral purity

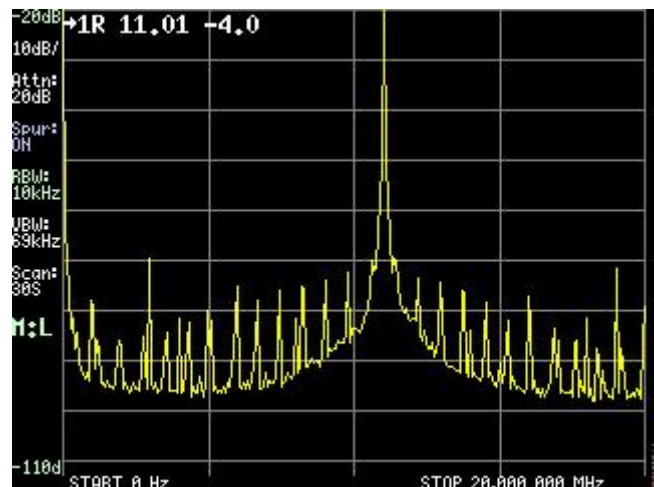
Here are 3 examples of inspecting the quality of a signal at 11MHz. For these measurements the RBW was set to 10kHz and the reflevel fixed at -20dBm to ensure the noise floor was visible. Also the SI5351 was routed through a 10dB attenuator to get all 3 signals on comparable input levels. Attenuation was kept on automatic.

First the signal from an ancient analog signal generator



The disturbance around 15MHz are caused by the signal generator.

Second the signal from a DDS



Keep in mind the baseband signal is at least 15dB above the reflevel. This shows the dynamic range of the tinySA

As you can see on the screen dump a full scan with this amount of detail (e.g. low RBW and spur reduction) does require about 30 seconds where a 250MHz wide scan with default settings requires less than 0.5 seconds. This is caused by the insertion of 13 extra scan points per display point (see ratio of RBW and VBW) and because of the time required for the RBW filter to stabilize.

3.4 Measuring Phase Noise

After activating the Phase Noise measurement the tinySA asks for the frequency of the carrier used for phase noise measurement. The specified frequency is used as center for the span. Next the offset frequency for the phase noise measurement can be entered. Typical offsets

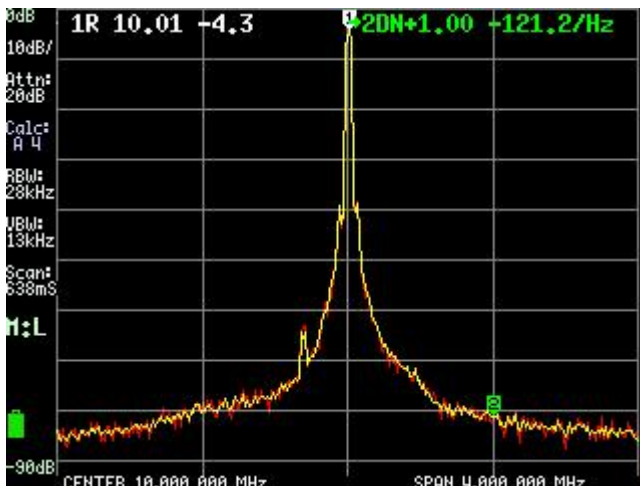
are 10kHz, 100kHz or 1MHz. The span of the tinySa is set to 4 times the offset and a two markers are activated. The first marker is a tracking marker and it is automatically positioned at the carrier. The second marker is a delta marker which is positioned in low mode at the frequency of the tracking marker plus the specified offset. In high mode the phase noise marker is positioned below the carrier to avoid the mirror of the carrier which may otherwise obscure the phase noise. The info displayed with this delta marker is in dBc/Hz to have a direct readout of the phase noise at the specified offset.

As mentioned in the limitations the Phase noise of the tinySA is not stellar. But a simple analog VCO is delivering an even worse phase noise.

First the VCO. Phase noise is given in dBc/Hz at 1MHz offset at marker 2



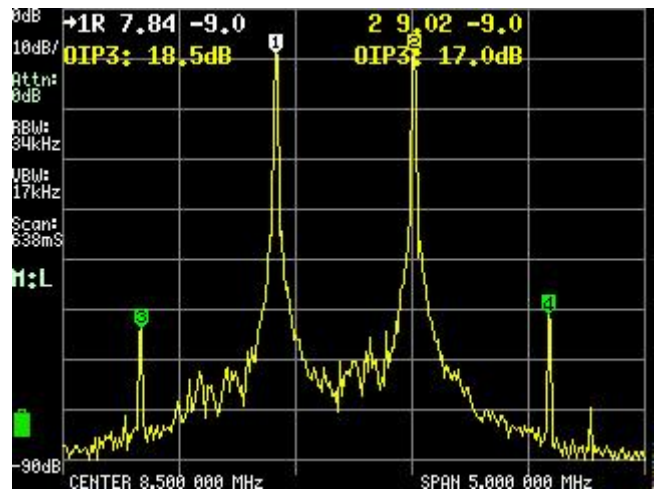
Second a DDS, which is better than the tinySA so this is the lower limit of what can be measured.



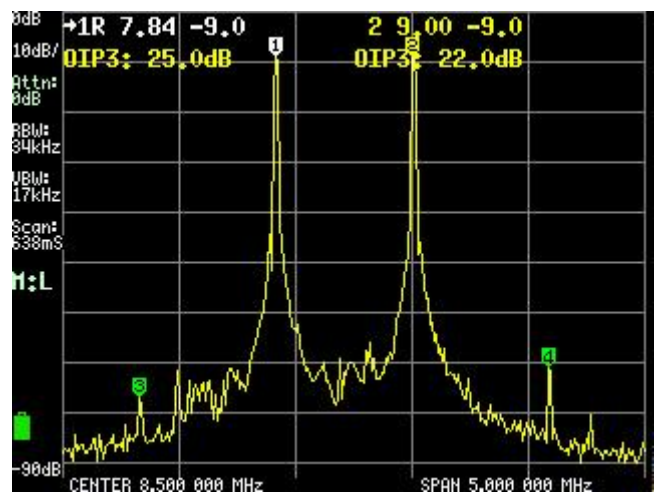
3.5 Measuring Third Order Intermodulation

The measurement function for OIP3 can also be used to measure the IIP3 of the tinySA. This IIP3 is the lower boundary of the OIP3 that can be measured by the tinySA and it is dependent on the chosen attenuation.

As input signal we use two fairly decent sinuses at 8MHz and 9MHz from two different signal generators combined through two 6dB attenuators and a resistive combiner into the low input of the tinySA. The chosen level of -9dBm is well below the 1dB compression point of the first mixer of the tinySA. Setting the LO drive at the default level, the attenuation to 0dB and using the OIP3 measurement function we measure an IIP3 of about +17dBm

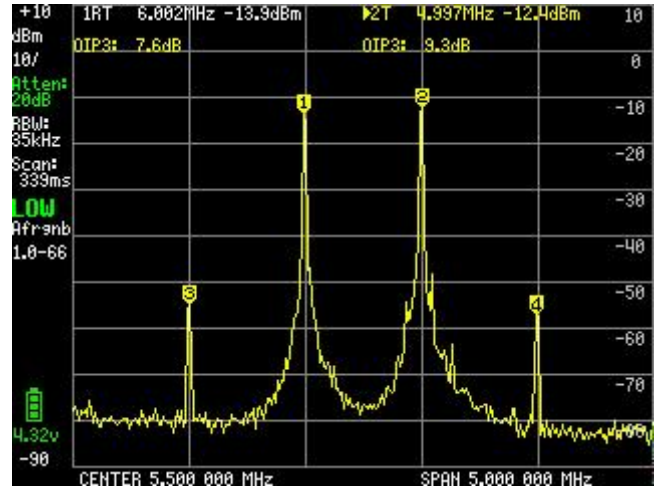
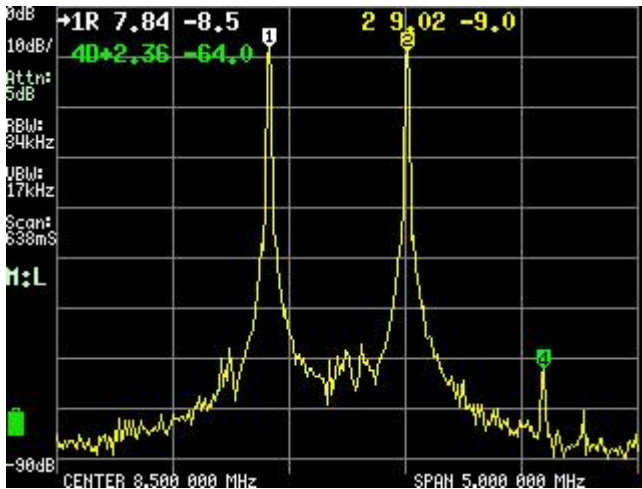


Increasing the LO drive to the maximum improves the IIP3 level to +25dBm for the left intermodulation product but the right intermodulation product remains much worse at +22dBm



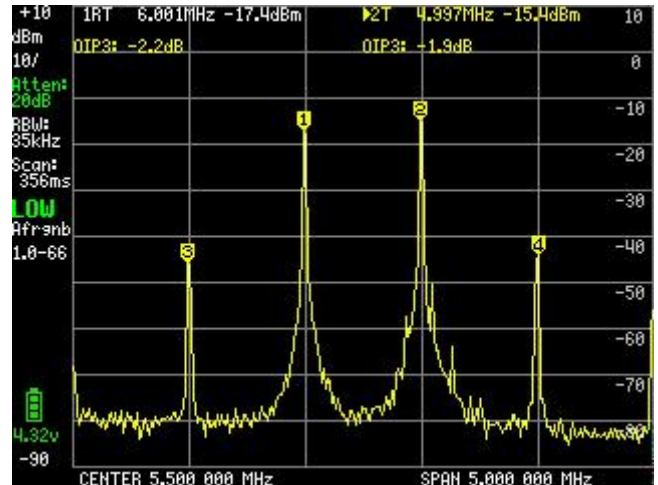
When we increase the tinySA input attenuation to 5dB the left intermodulation

product disappears so it was generated internally. The right intermodulation product does not change so it is present in the input to the tinySA



The OIP3 of the this two tone generator is around 8dB so we have to careful to create a test setup that ensure this does not hide the amplifier IIP3.

Now we know the IIP3 of the tinySA we can start measuring the IIP3 of an amplifier. First we use two tinySA to create a two tone generator. Here is the two tone output including the harmonics.



Even though there are attenuators between the tinySA generators and the passive combiner there is still some 3rd order intermodulation created as can be seen when we look close in

As the signal level we observe is 3.5dB lower as without the amp and attenuator we have to add the 3.5dB to the measured IIP3 of around -2dBm so we get an IIP3 of the amp of +1.5dBm. The is 6.5dB lower than what we measured without amp and attenuator so we can be sure we are measuring the IIP3 of the amp.

3.6 IQ Balance

In a SDR TX/RX the IQ balance of the LSB/USB TX can be inspected with the tinySA using a 2.7kHz test tone. The TX is a Softrock and the LO is set 7.1MHz, equal to the TX, to create a worst case setup. The

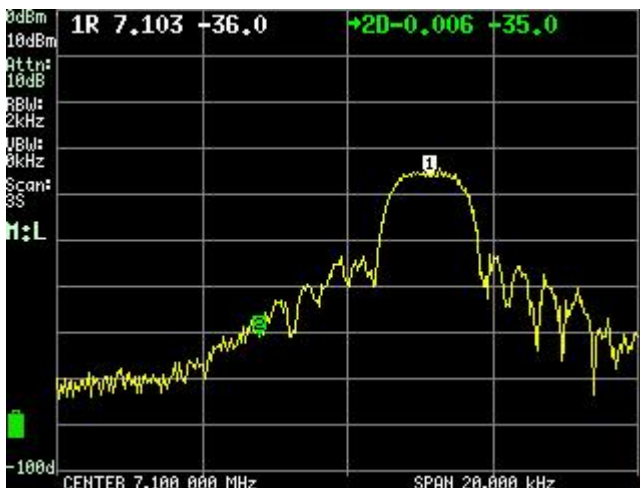
frequency span of the tinySA is set to 20kHz

Untuned this looks like this



Marker 1 is the wanted USB and marker 2 is the unwanted LSB

After a bit of tuning it already looks better



but due to the noise at the left side of the resolution filter of the tinySA it is not possible to see below -35dBc with an offset of only 5.4kHz.

This can be solved by shifting the TX frequency 5kHz from the Softrock LO and this shows we are not done yet. The span is increase to 50kHz.



Tuning the IQ balance a bit better shifts the unwanted sideband into the noise below -40dBc

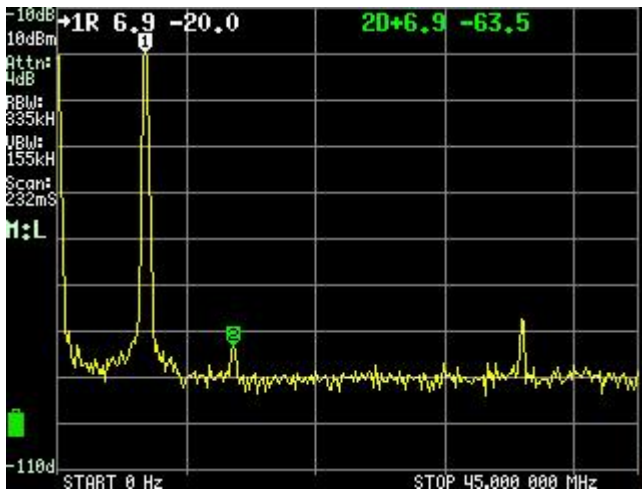


There is still a fair amount of LO leakage (marker 3) but this can not be solved with IQ balance tuning.

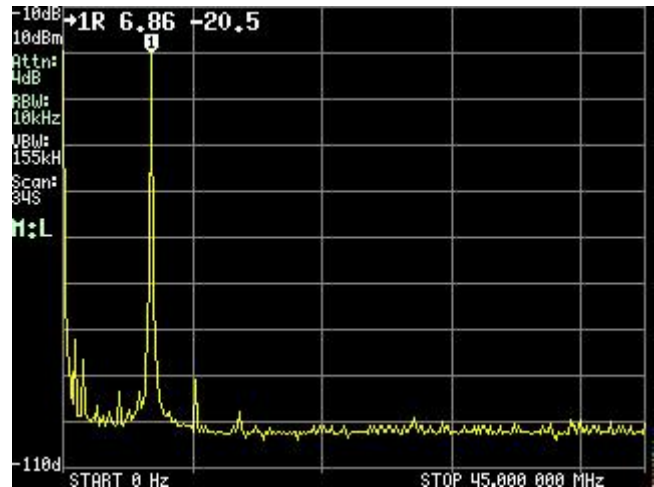
3.7 Spur Free Dynamic Range

When measuring the spectral purity of a transmitter it is important to understand the spur free dynamic range (SFDR) of the tinySA. This SFDR determines the minimum level of harmonics that can be measured with the tinySA.

Starting with a fairly clean signal around 7MHz. The 2nd harmonic is at -63dBc

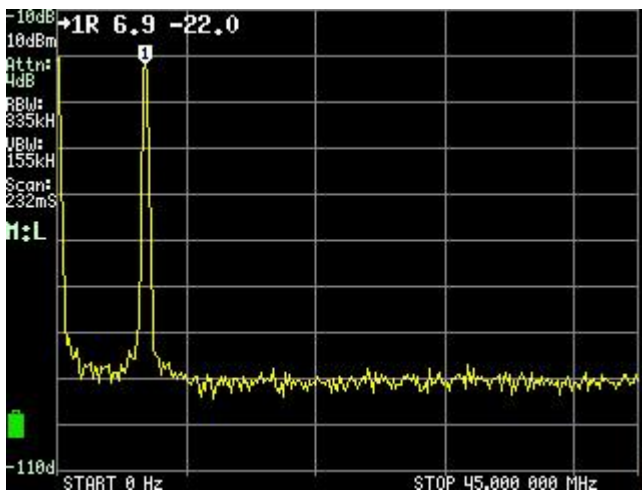


And a little attenuation is added to check if the remaining 2nd harmonic is internally generated.



A low pass filter is inserted between the transmitter and the tinySA to remove the 2nd harmonic and indeed it disappears into the noise

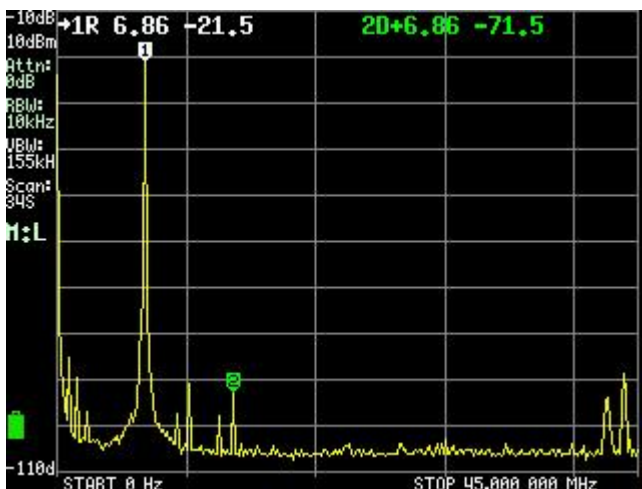
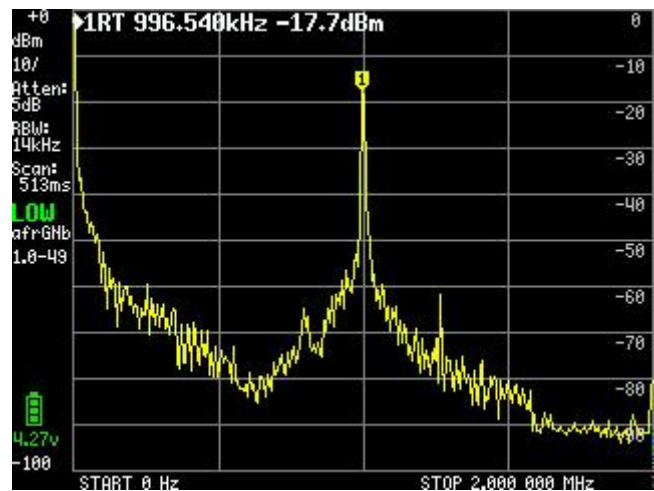
As the level of the 2nd harmonic moved down it was internally generated. With this 4dB attenuation the 2nd harmonic is now below -78dBc which is the maximum SFDR of the tinySA.



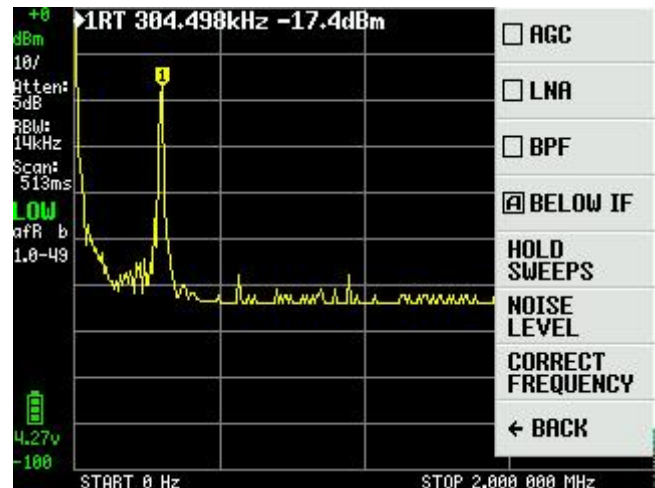
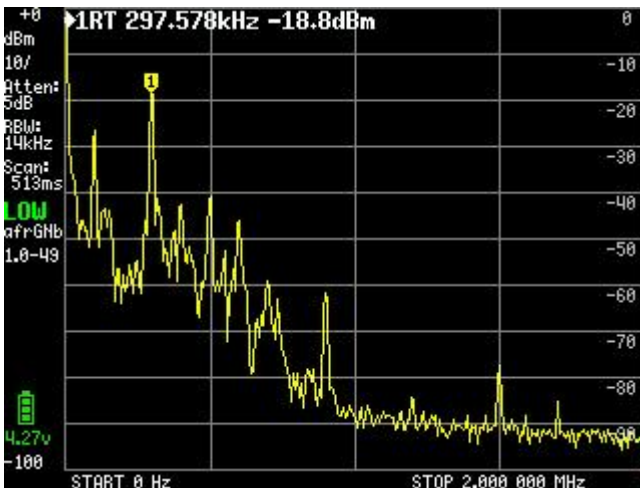
3.8 Measuring Low frequencies

When measuring signals below 1MHz some annoying artifacts can appear. First a fairly clean 1MHz signal at -15dBm

The RBW is reduced to lower the noise floor. The 2nd harmonic is now again visible at -71.5dBc



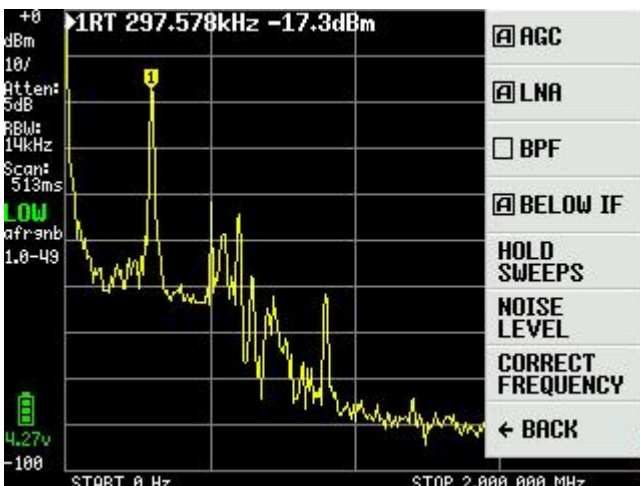
When we move the input signal to 0.3MHz at -15dBm we get a very different measurement



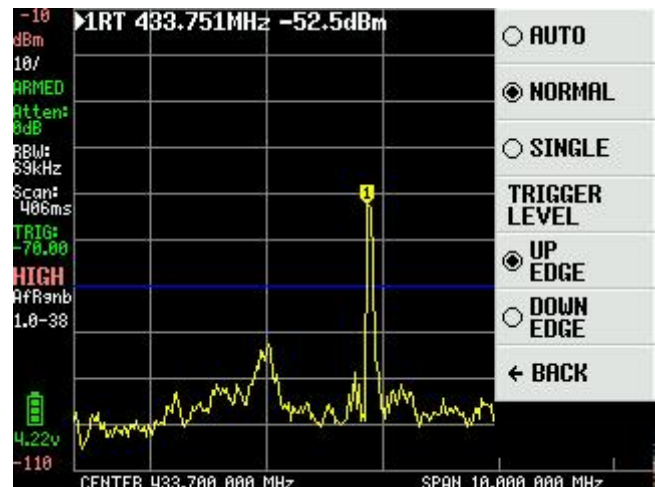
The artifacts are caused by the AGC that is misbehaving below 0.5MHz. That is why in default mode the AGC is disabled when below 0.5MHz. Setting the AGC and LNA to the default automatic settings gives some improvement.

3.9 Capturing OOK ISM Transmissions

Many On Off Keying ISM transmission are very short. Ideal to see if the trigger function of the tinySA is useful.



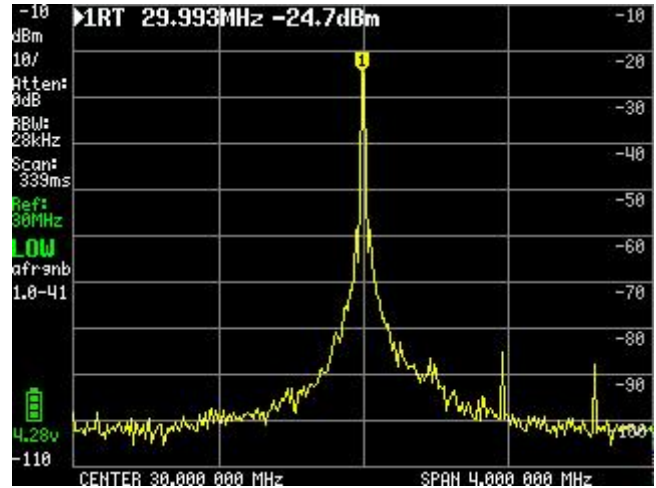
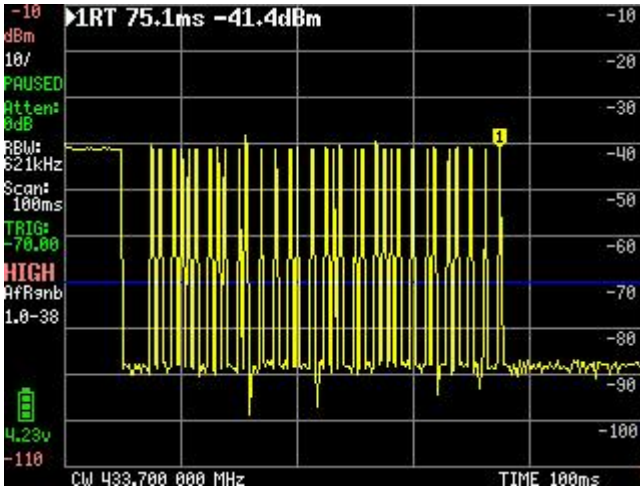
First setting a 10MHz wide scan around 433MHz to find the frequency of the transmitter. The trigger level is set to -70dBm, trigger mode to NORMAL and the signal is captured using the telescopic antenna connected to the high input



The menu shown is the second page of the EXPERT CONFIG showing everything is on default/automatic. As the signal is too strong for the LNA it is advised to also switch of the LNA

You can see in the status panel the triggering is ARMED so any new signal will be shown automatically

Now the frequency is known we set the tinySA to zero span mode and try to capture the whole transmission using single trigger and a scan time of 100ms

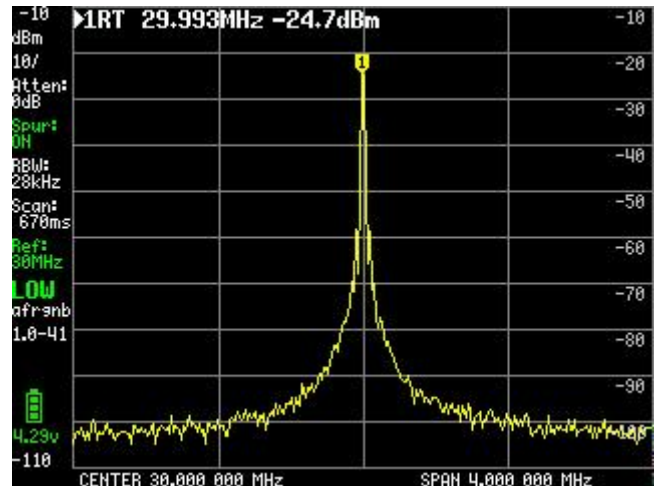
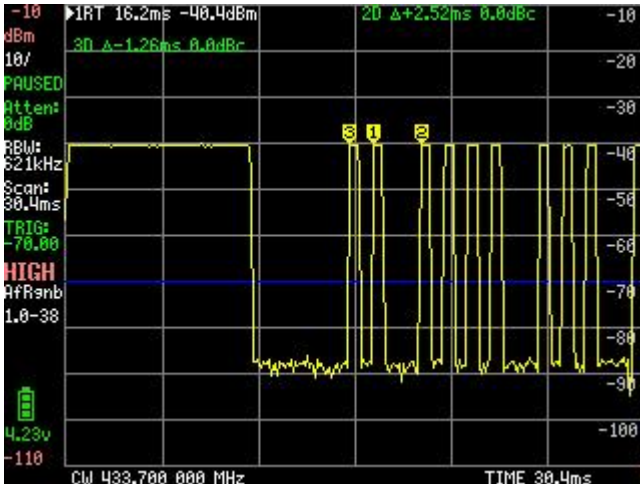


Once the single trigger happened the status display changes from ARMED to PAUSED

The important number to notice is the indicated scan time. In this case it is 339 milliseconds

To get some insight in the bit timing the scan time is reduce to 30ms

Sometimes small signals are visible and enabling the SPUR REMOVAL will help identifying if these are real signals



Using the markers in delta mode the bit timing is found to be 1.25ms

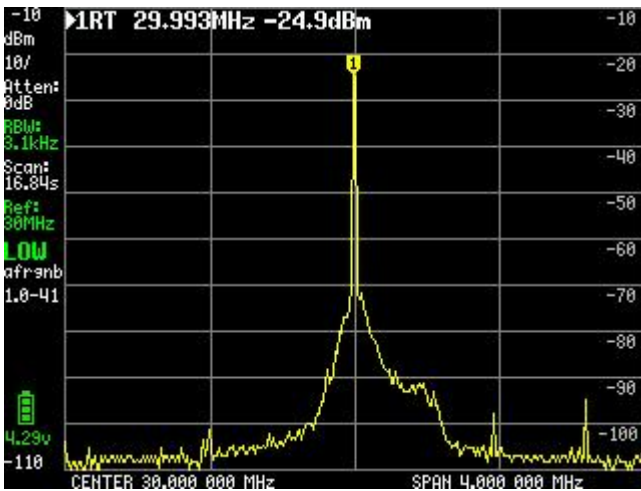
As the small signals are no longer visible these where internally generated artifacts. Notice the SPUR REMOVAL doubles the scan time.

3.10 Tuning Sweep Settings

Depending on the various tinySA settings the time to do one scan can vary between below 20 milliseconds and above 100 seconds. Here are some measurements with different settings to demonstrate their impact on scan time

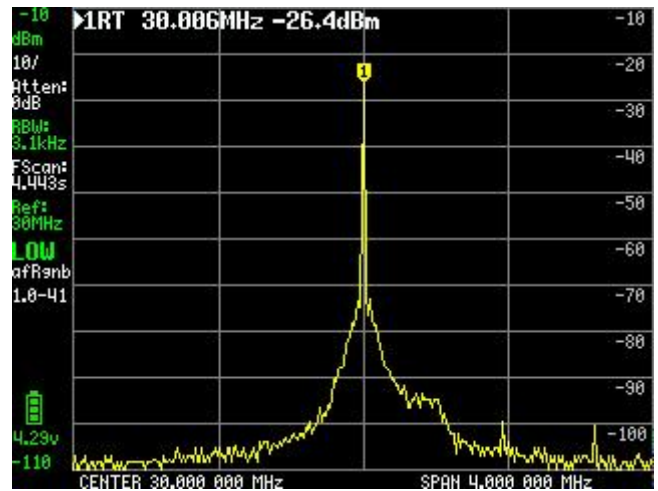
In case the noise level is too high it is possible to manually select an RBW, for example selecting 3kHz will reduce the noise level almost 10dB

First a measurement of the fundamental of the 30MHz cal output with a span of 4MHz and all other settings on default.



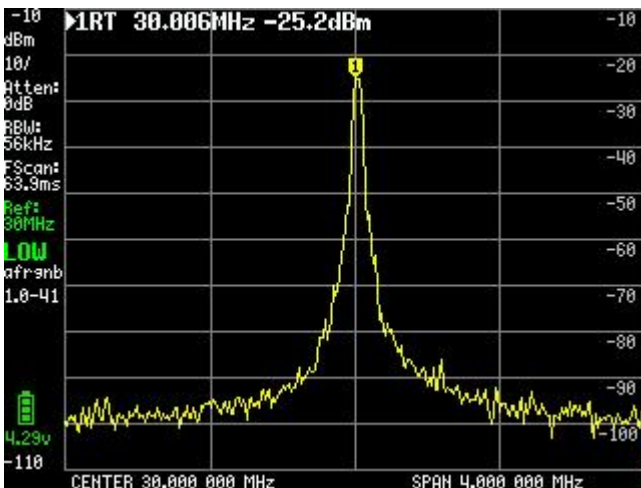
Notice the scan time increases to 16.8 seconds as a small RBW requires more frequencies to be measured and the time per measurement is longer.

One of the ways to reduce scan time is by selecting the FAST sweep mode. This gives some more noise



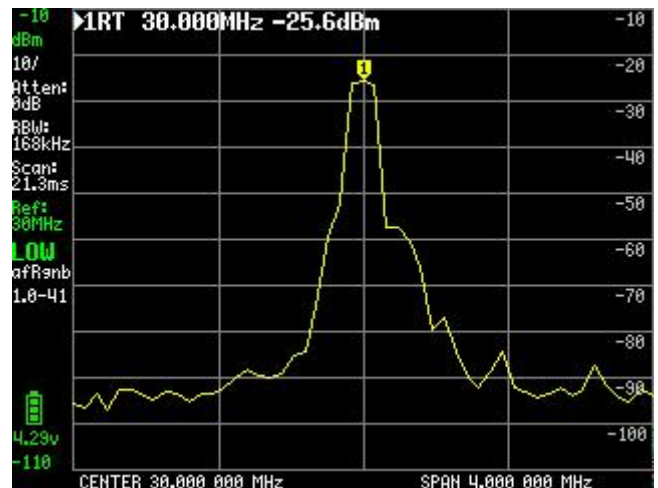
Again about 4 times faster as a normal scan with 3kHz RBW

Another way to reduce the measurement time on a small frequency span is by reducing the number of measurement points. As an example a measurement with only 51 point.



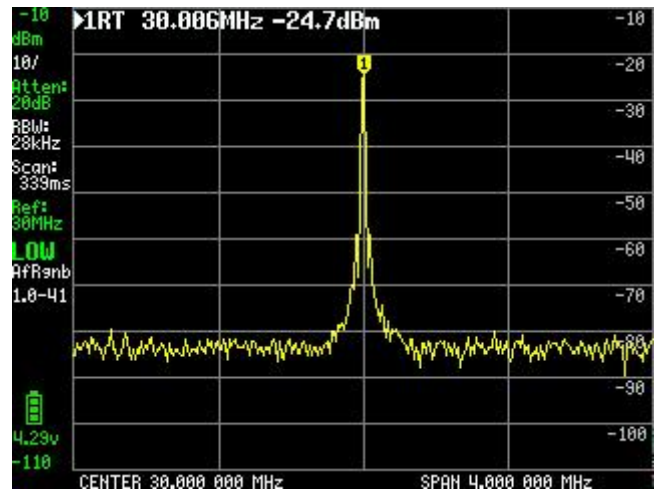
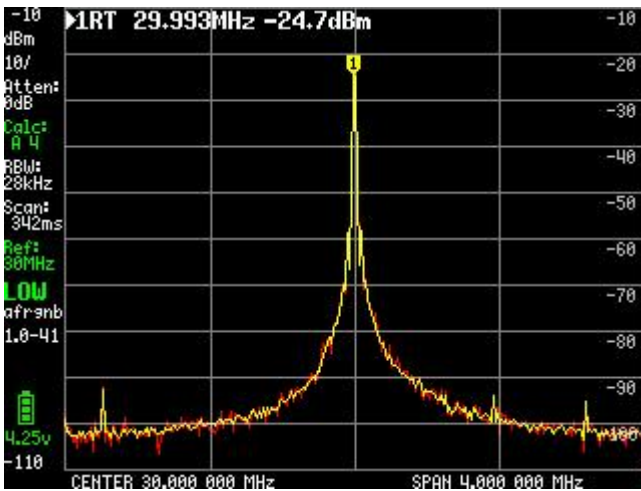
This fast scan is only taking 63 milliseconds, roughly 4 times faster compared to default settings. Another disadvantage of the FAST scan is the reduce accuracy of the level measurement as you can see in all FAST measurements on this page.

Especially when selecting a small RBW the scan time reduction is relevant.



Notice reducing the number of points increases the automatic RBW selection from 28kHz to 168kHz but reduced the scan time to only 21ms. Ideal for tuning some circuit or filter

Reducing noise is possible by averaging. This can be done on a per sweep basis showing both the actual sweep and the averaged sweep using the AVER 4 option

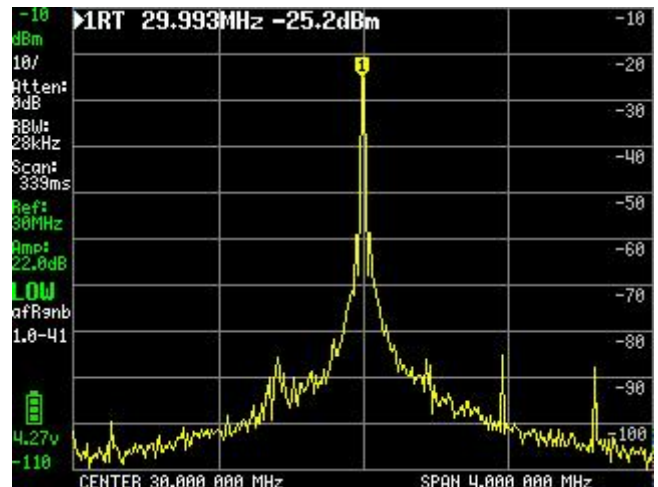
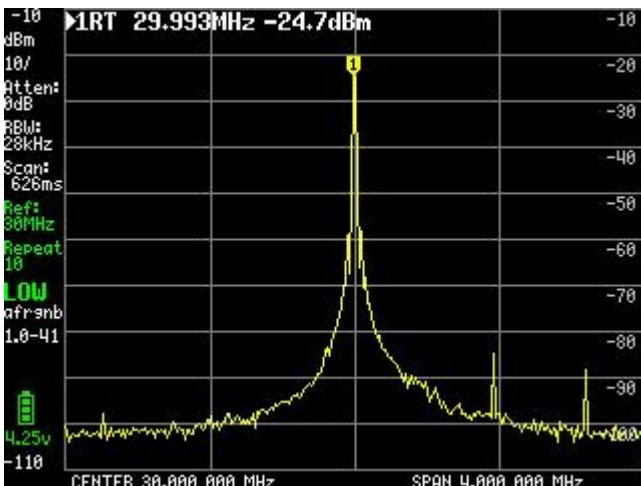


This setting does not impact scan time but it may take some sweeps before a change in level is reflected in the calculated yellow trace.

As a consequence the noise floor has moved up with 20dB but the signal level measurement has not changed

Another way to reduce noise is by setting the SAMPLE REPEAT to above 1. Setting the sample repeat to 10 give almost the same improvement compared to the AVER 4

As there is sufficient headroom it is possible add a low noise amplifier (LNA) before the tinySA. Using a 22dB LNA the noise floor should drop considerably but due to the phase noise of the PLL and the noise generated by the CAL OUTPUT this noise reduction does not happen

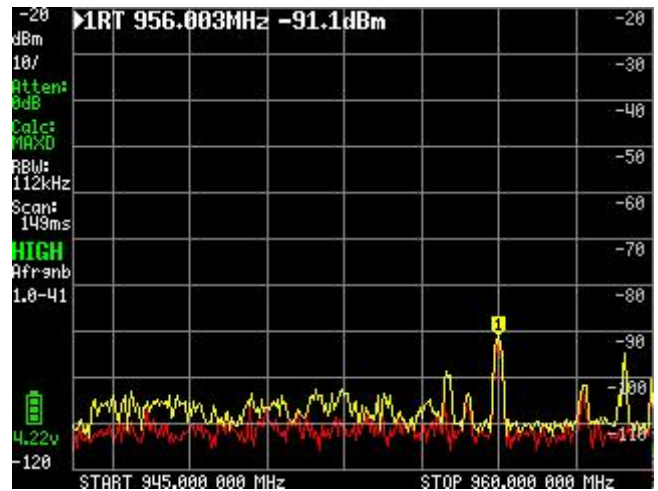
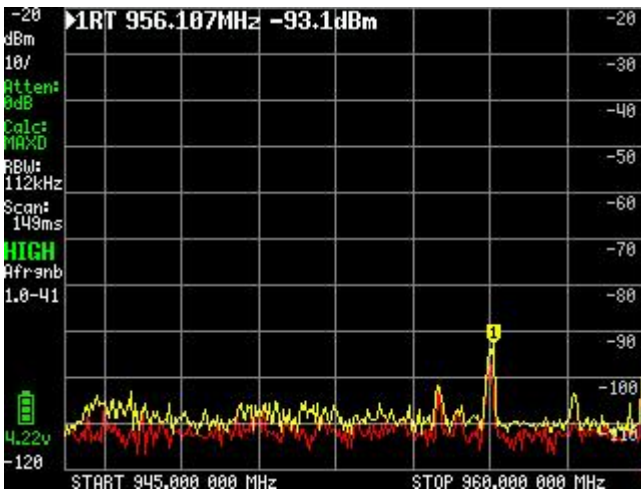


As the sample repeat measures each point multiple times with some in between delay the scan time will increase

3.11 Coax Cable Impact

The selected signal at -25dBm is far below the maximum input level and the automatic attenuation has selected 0dB attenuation. For much stronger signal the level of attenuation will be automatically increased. The impact of this increase in attenuation can be seen by manually setting the attenuation to a higher level such as 20dB

Without a coax cable attached to the high input the power envelope of a close by Mobile Phone Base Station is just visible using MAX DECAY

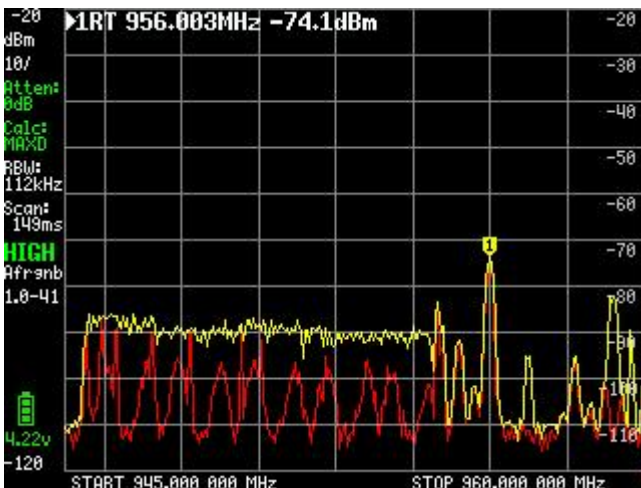


The signal under marker 1 also is from the mobile phone base station.

So be aware many coax cables are far from perfect.

As soon as you connect one of the supplied coax cables to the high input and leave the other side open this changes

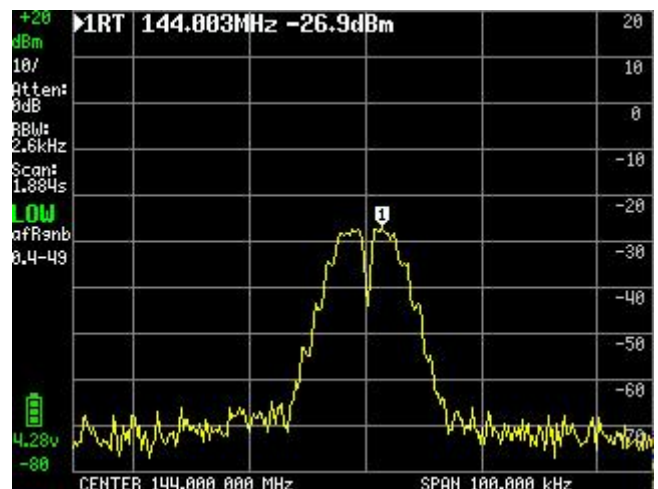
3.12 FM deviation measurement



Using a 2kHz tone it is possible to see the carrier dip with a deviation of 2.4, 5.52 and 8.66 times the 2kHz tone.

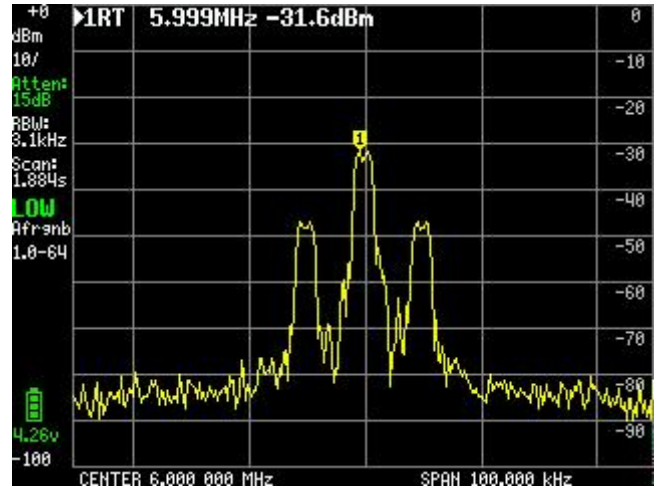
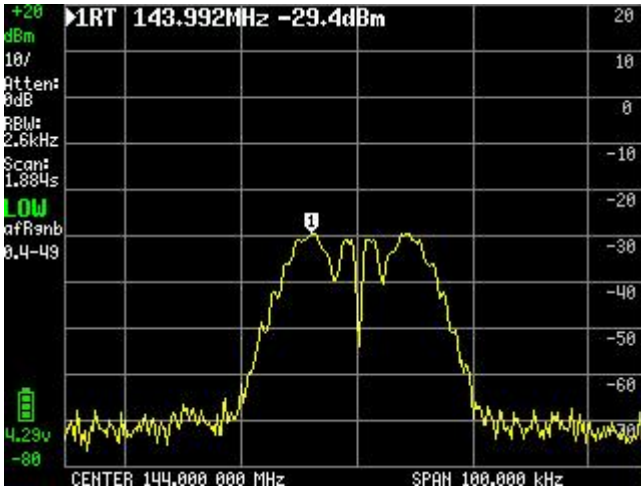
Using a 2M transmitter, a 2kHz tone and a deviation of 5kHz you get the sharp dip at the carrier frequency

The power envelope and the signal under the marker increase with almost 20dB



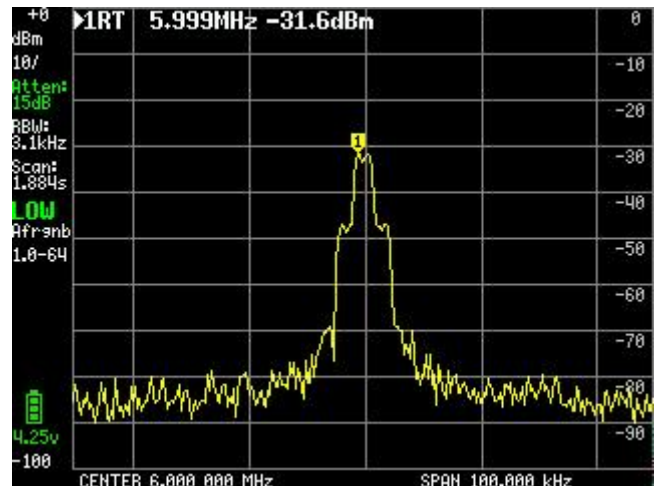
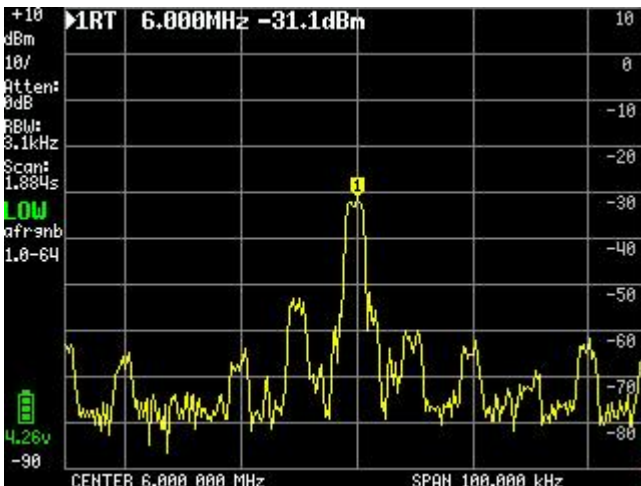
Replacing the supplied coax with a double shielded coax, costing more than the tinySA, shows the shielding of the supplied coax is not perfect as the power envelope reduces to (almost) the level without coax cable attached.

Using a deviation of 11kHz you get the next Bessel zero



3.13 Measuring AM modulation

The tinySA has some problems when measuring AM modulation. This is clearly visible in below 100kHz wide scan of a 10kHz and 50% depth AM modulated 6MHz signal.

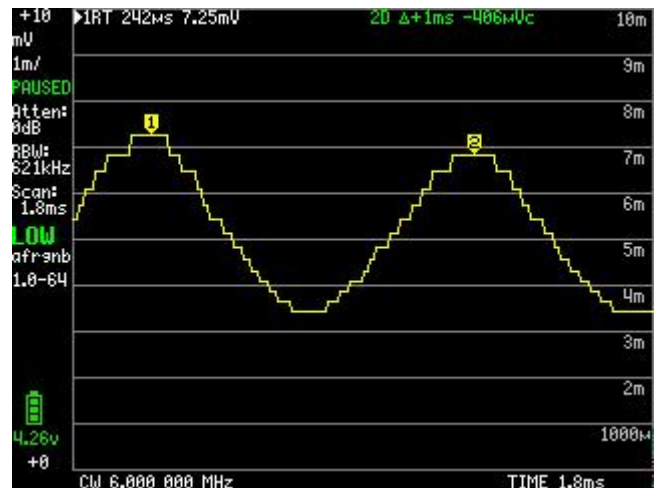


With a minimum RBW of 3kHz the lower limit of modulation that can be observed in frequency mode is indeed 3kHz

This weird effect of the many signals is caused by the internal AGC that completely fails. You either have to ensure the carrier of input signal is below -50dBm by manually increasing attenuation or you have to disable the [AGC](#)

For even lower modulation frequencies it is advised to go to zero span mode (time mode) and a linear unit to show the signal strength versus time where the modulation depth of 50% can clearly be observed

Increasing the manual attenuation creates a better picture



3.14 Measuring the one dB compression point of an amplifier

To avoid oversteering an amplifier it is nice to know the 1dB compression point. That is the input level at which the amplifiers output is 1dB below the level it should be.

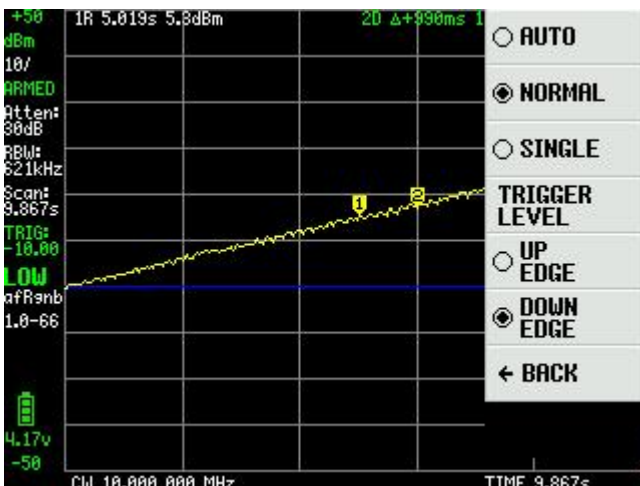
Measuring this normally required many measurements at various signal levels. This is a nice challenge for the tinySA.

First part of the setup is the signal generator providing the level sweep. The tinySA setup is below



The frequency is 10MHz and the output level is changing from -40dBm to -10dB over 10.2 seconds

The output the the generator is connected to the input of the amplifier and the output of the amplifier is connected to another tinySA. The second tinySA is in low input mode and set to a zero span mode at 10MHz, a sweep time of 10 seconds and a normal down trigger at a -10dB level as is shown below



When the signal generator jumps back to the -40dB level the second tinySA triggers and starts to record the level over a period of 10 seconds. Using two markers (one reference and one delta marker) it is easy to see the level increase per division is 6dB (5 division with in total 30dB)



Then the markers are shifted to the right to a place where the increase is no longer 3dB per half division but only 2dB.



The output 1dB compression level of the amplifier is at marker 2 at 13.8dBm, The input level to the amplifier is at that point -40dB plus 9 times 3dB (or -10 minus 3dB) equals -13dBm. Keeping the input of the amplifier below -13dBm will ensure no compression.

3.15 Adding an LNA

Sometimes you need a bit more sensitivity while still being portable. This is easily done through one small modification of the tinySA

Start with soldering a single female Dupont connector to one of the Vdd points at the edge of the PCB.

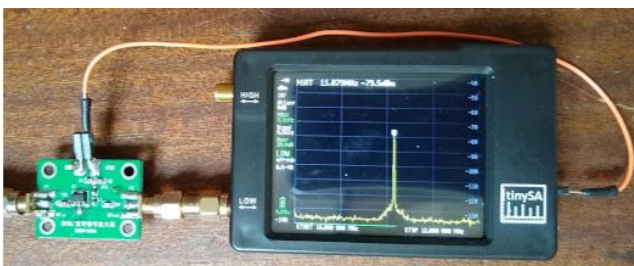


Warning: Maximum current drawn is 100mA. Monitor the temperature of the tinySA, if hot, switch off. Too much current drawn will destroy your tinySA

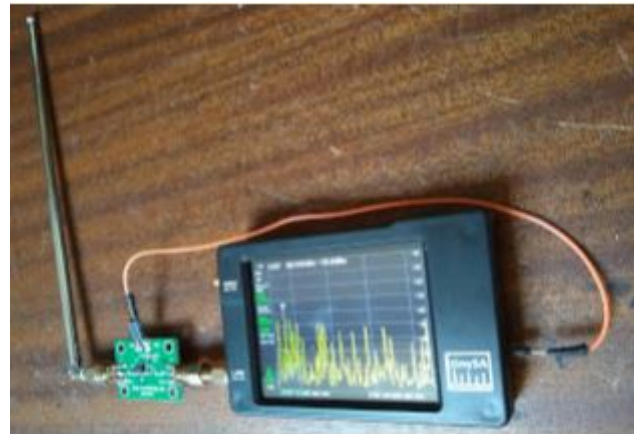
Next is to make a small hole for the Dupont connector and put the tinySA back into the housing.



After connecting a cheap LNA that gives 30dB amplification without noticeable noise and setting the RBW to 3kHz the noise floor is at a whopping -135dBm and the -80dBm signal is clearly visible. Be aware the LEVEL/EXTERNAL AMP setting is used to cater for the applied amplification so the displayed levels are still correct.



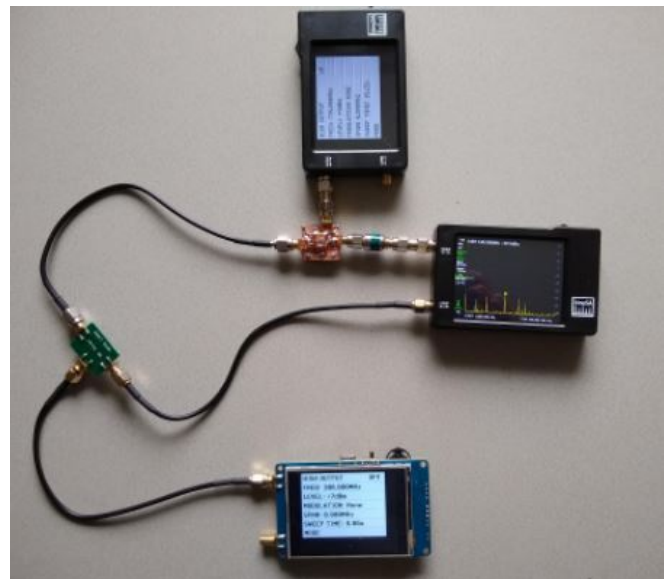
Combined with the small telescopic antenna the tinySA is ready to do some QRM hunting



3.16 Measuring a Mixer

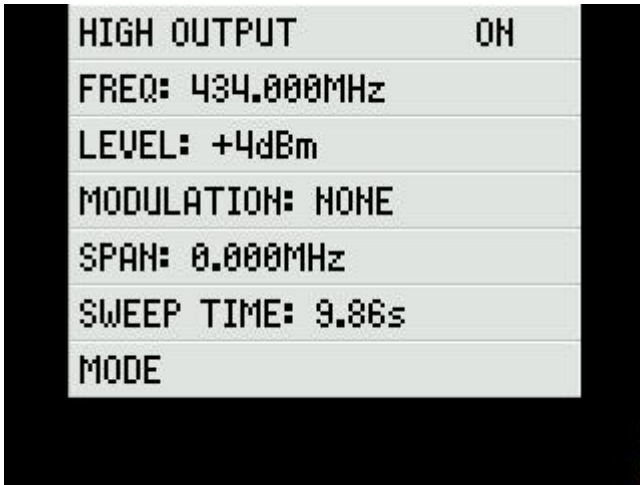
Using the LO output as input to an external Mixer, of which the LO input is driven by a generator, you get a tracking generator that can track the tinySA scanning at an offset. This makes it possible to measure frequency translation devices such as a mixer.

The total setup look like this



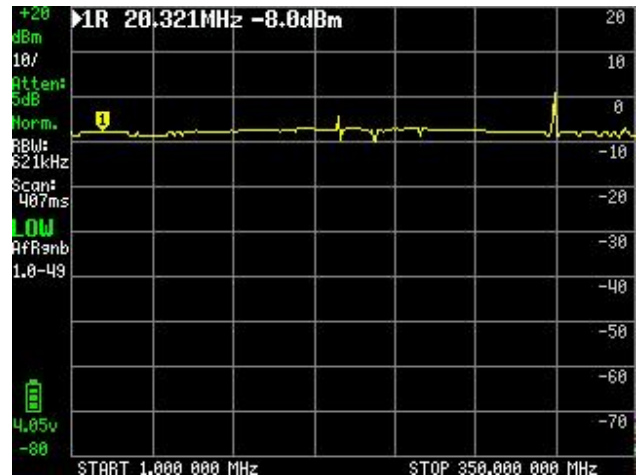
At the bottom left there is a green module containing the mixer to be tested. The LO output of the right tinySA is used as input to a copper foil cladded mixer through a 20dB attenuator to create the tracking generator. The top tinySA is the LO for the TG mixer. The bottom tinySA is the LO for the mixer being tested

First you set the tracking generator at zero Hz offset like this



and make a direct connection between the TG output and the SA input

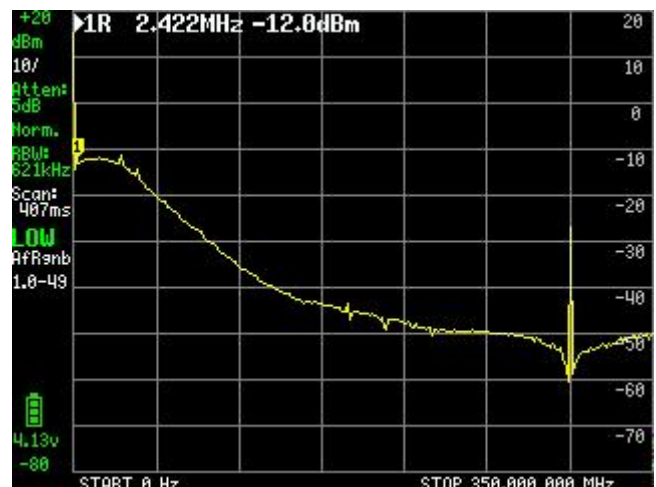
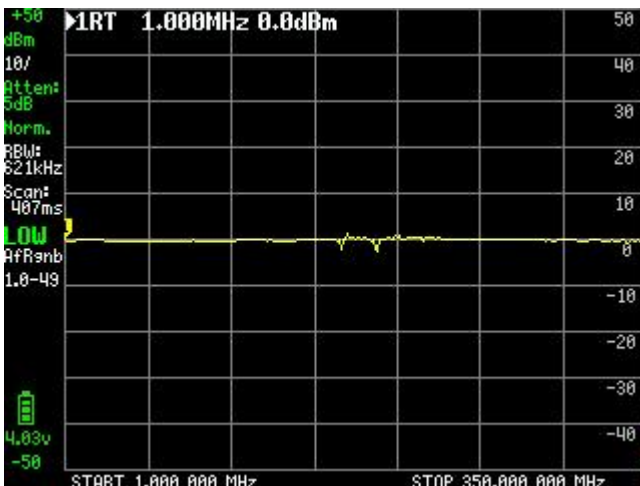
The LO of the mixer to be tested is enabled and set to 300MHz and +7dBm output and you get the conversion loss of the mixer on the SA



and you normalize

The loss is about 8dB, well within spec.

But a second mixer is showing some problems



Then the mixer to be tested is inserted as in the first picture and the TG is set to an offset to 734MHz resulting in a 300MHz offset

and it turned out there was an incorrect impedance matching in the output of the mixer being tested.

3.17 Measuring the Noise Factor of an Amplifier

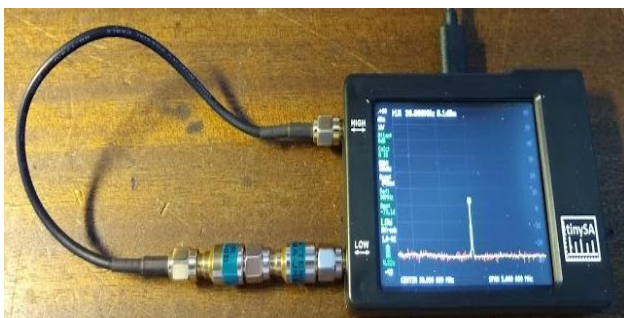
Next to the gain, OIP3 and 1dBc the Noise Factor (NF) is an important measure of an amplifier so we like to know the NF of the amplifier we are using.

The NF is the degradation in dB of the SNR after the amplifier compared to before the amplifier. This implies we have to measure noise levels.

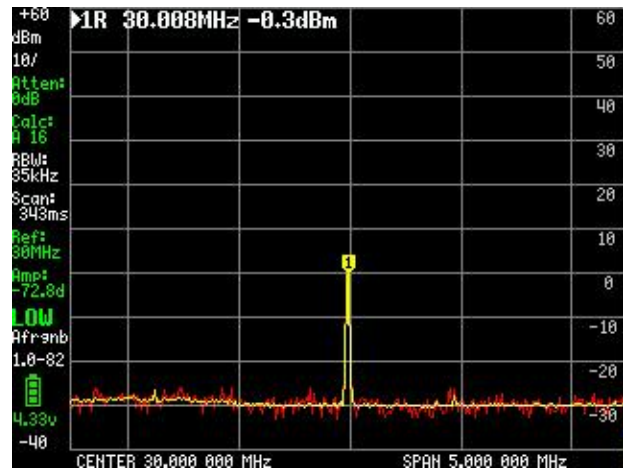
For this measurement we need some attenuators and two amplifiers, the LNA and the amplifier to be tested (DUT). The LNA is needed because the noise factor of the tinySA is too large to directly observe the noise contribution of a single amplifier.

The first step is to normalize the tinySA to the level of the test signal we want to use to measure the gain of the two amplifiers cascaded. We do this by connecting some attenuators with total attenuation approximately (+/- 10dB) equal to the total amplification of the two cascaded amplifiers to the cal output. We set the cal output to 30MHz (or any other frequency we want to use) and we observe the cal output level attenuated through the attenuators. Make sure the tinySA internal attenuation is 0dB. Then we set the EXTERNAL AMP to the same value as the observed signal level. After that the signal should read as 0dBm.

The measurement setup is like this



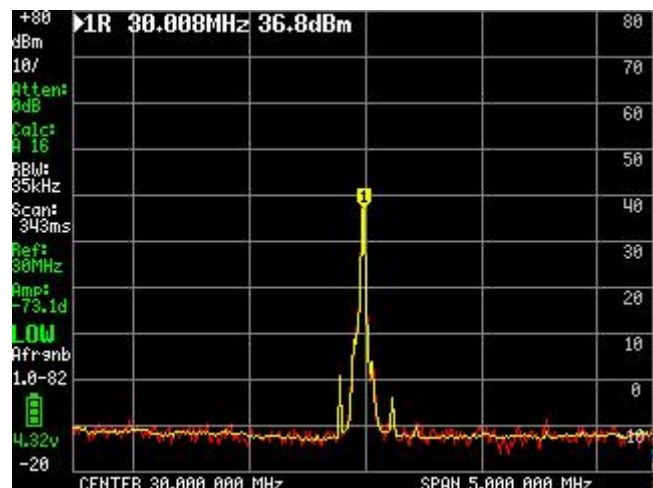
And the measured value after normalization looks like this (its +0.3dBm i.s.o. 0dBm)



Now we insert the amplifiers between the attenuators and the input of the tinySA as can be seen here



And we can directly read the amplification of the cascaded amplifiers under the marker (36.8dB)

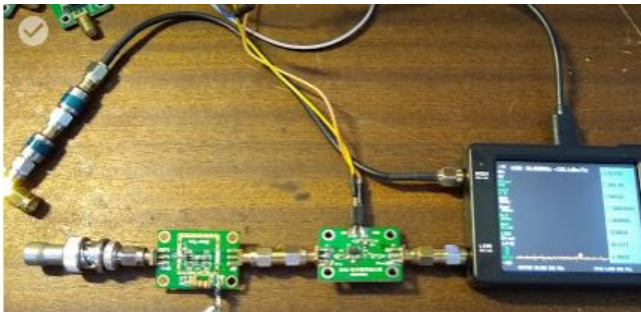


Now we make some changes

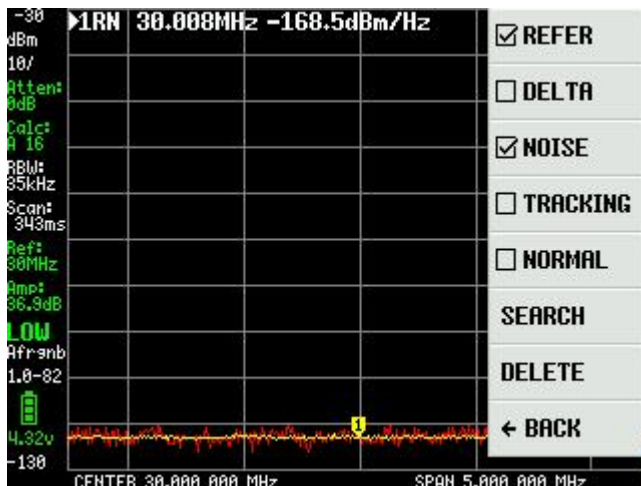
1. set the EXTERNAL AMP to the measure amplification (36.8dB)
2. decouple the the attenuators from the input and terminate the first amplifier input with 50ohm (you can also decouple the cal output from the attenuators and use the attenuators as 50ohm resistor)

3. set the noise attribute of the marker so its value is displayed in /Hz and independent of the active RBW.
4. set DISPLAY/CALC/AVER 16 to get maximum averaging

The noise measurement setup looks like this



and we can read the value of the noise marker (-168.5dBm/Hz)



To calculate the noise factor of the first amplifier we simply subtract -174dBm/Hz (the noise power per Hertz of a 50 ohm resistor at room temperature) resulting in a noise factor of 5.5dB. The spec of the first amplifier gives a NF of 4.5dB so we are close.

This measurement method assumes the gain of the first amplifier is sufficient to mask the noise of the second amplifier and the two amplifiers will mask the internal noise of the tinySA so we can safely ignore the noise of the second amplifier and the tinySA. To ensure this masking happens the total amplification of the cascaded amplifiers has to be above 30dB.

We can now also measure the noise factor of the LNA by interchanging the DUT and the LNA, put the LNA first and connects its output to the DUT. As the amplification

stay the same we can directly measure the noise level with the noise marker. The measured noise factor of the LNA is between 0.5dB and 1dB which is consistent with its specification

3.18 Calibrating the low output level

Using one of the many calculators you can find on the internet the relation between dBm and Vp-p is quick to calculate. An example calculator can be found at <https://www.random-science-tools.com/electronics/dBm-Watts-volts.htm>

For the calibration of the low output we find that an output level of -25dBm equals 35.6mVp-p in a 50ohm system and we can use this relation to calibrate the low output level using a scope.

Measurement setup

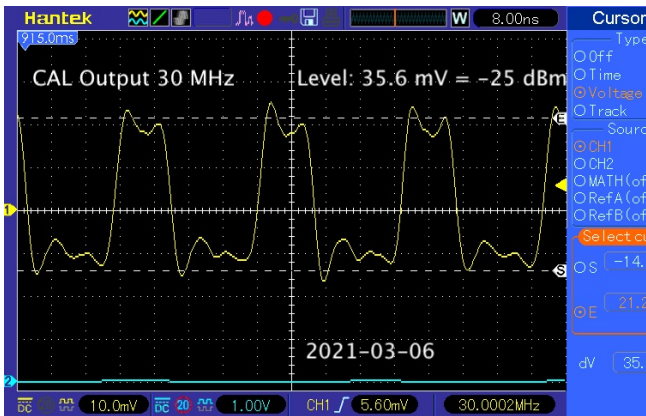
This calibration requires firmware 1.2-47 or later.

Connect the high output to the input of a scope terminated with 50ohm. This can be done using a F-F-M tee where the cable from the tinySA output connects to one side of the tee and a 50ohm load is connected to the other side of the tee. The M side of the tee is directly connected to the scope input.



Enable the tinySA CAL OUTPUT at 30MHz and set it to HIGH INPUT mode to avoid disturbances from the high connector. The cal output will provide an exact -25dBm signal. On the scope we will a somewhat

distorted square wave with an amplitude of 35mVp-p.



The small deviation can be explained by the harmonics present in the cal output. Now connect the scope to the tinySA low output and set the the tinySA in LOW OUTPUT mode, 30MHz and a level of -25dBm. Using the scope we measure (as an example) 30mVp-p

3.19 Calculating and setting the correction

Using the calculator we convert 30mVp-p to dBm and find the output level to be -26.5dBm. To correct the output level (which is -1.5dB too low) we use connect to the tinySA over USB and issue the commands

```
leveloffset low output -1.5
saveconfig 1234
```

to change the output level calibration setting and store the data so it survives a reset.

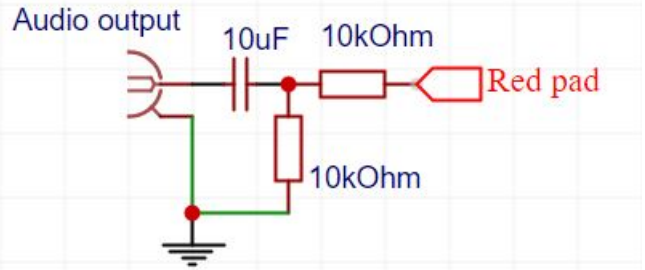
3.20 Verifying the correction

Using the scope we measure again the Vp-p of the output and now we measure 35.6mVp-p which matches perfectly an output level of -25dBm.

3.21 Listen to your tinySA

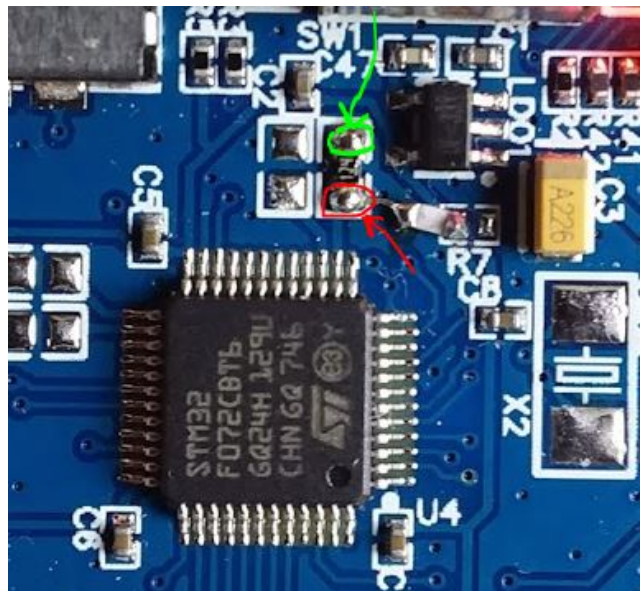
After a small HW modification it is possible to listen to AM/FM demodulated signals, both in low and high input mode.

The audio output circuit provides DC isolation and some protection of the DAC output



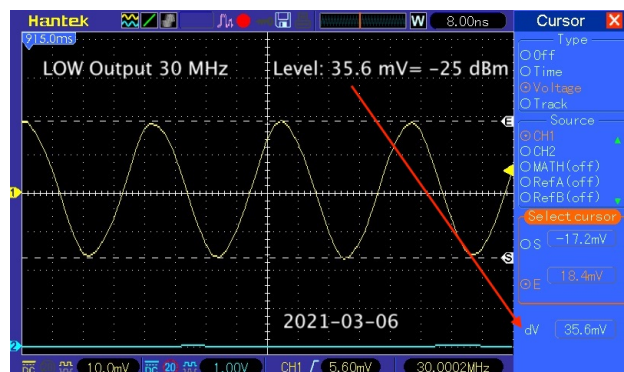
It is possible to directly connect a headphone to the audio output. If needed for volume, remove the 10k to ground and replace the remaining 10k with 4.7k

The red pad connection goes to the pad with the red circle on the tinySA PCB



The ground of the audio output circuit can be connected to the pad with the green circle or to any other GND PCB edge pin.

Output level is max 1.5Vpp

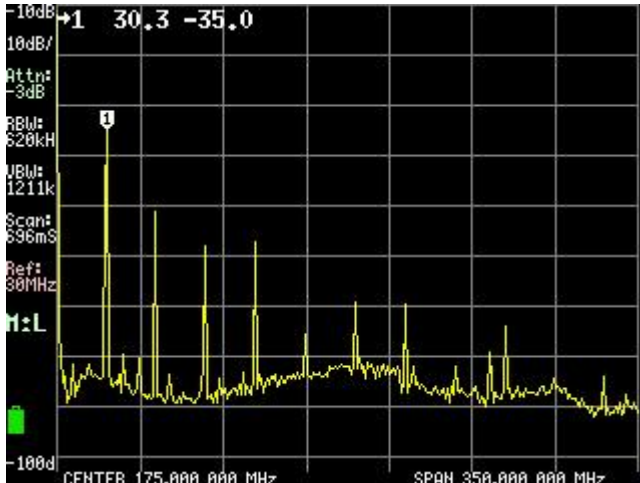


4 EXTRA

4.1 ATTENUATION

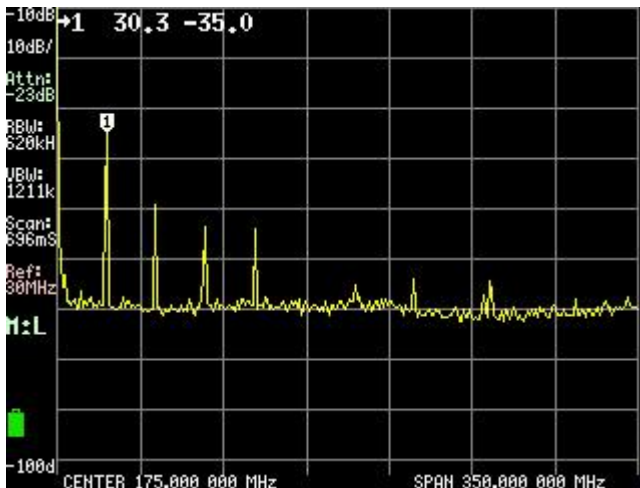
Attenuation settings and usage

To protect the tinySA from damage from strong signals or to check the possible overloading of the tinySA it is recommended to always ensure you have the correct attenuation. Internally the display data is corrected for the applied attenuation. This is the display with an attenuation of -3dB



The fundamental is at 30.3MHz with a strength of -35dBm

When increasing the attenuation the signal and all its harmonics stays at the same level but the noise floor moves up



If, as in above image, the harmonics stay at the same level when increasing the attenuation, you can be sure these are not internally generated but present in the input signal. When the harmonics decrease in strength when increasing the attenuation you have been overloading the tinySA and

the harmonics are (partially) internally generated

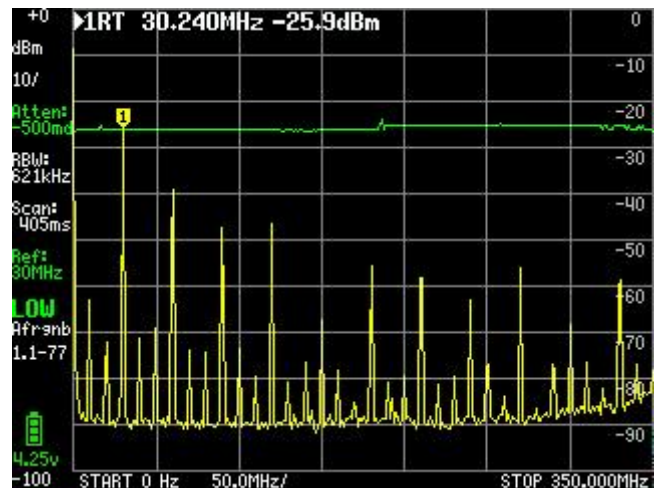
Checking the attenuator

First connect the high and low connectors using one of the supplied SMA cables

Switch on the tinySA and enable the CAL output at 30MHz using the commands MODE/Cal Output/30MHz

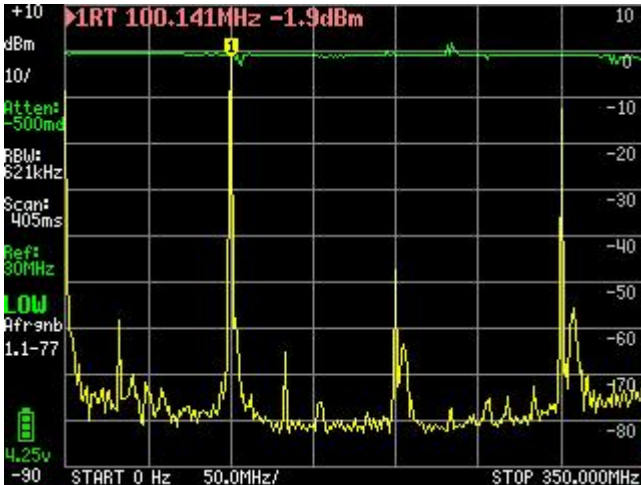
Return to low input

Activate the linearity test with MEASURE/MORE/LINEAR and this will step the built-in attenuator through all attenuation values and draw a green line on the screen at the measured signal level. If all goes well the line should be flat within +/- 1dB with an occasional measurement deviating due to interference/noise



If you observe deviations in the green line of more than +/- 1dB (excluding some noise/interference) post a readable picture or screen capture of the screen of the completed linearity test on the [tinySA support group](#)

The test also helps in getting confidence about the 1dB compression point of the tinySA. This can be measured by applying a signal of 0dBm and activating the MEASURE/MORE/LINEAR test The compression starts when attenuation is below 2dB and is just visible in the green line being curved down a bit at the right side because of the compression.

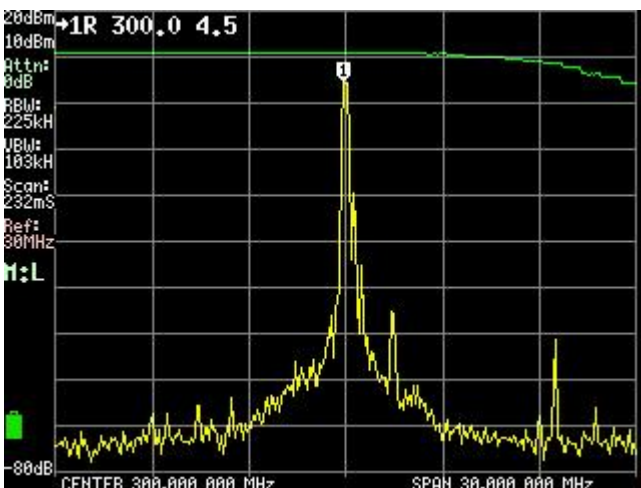
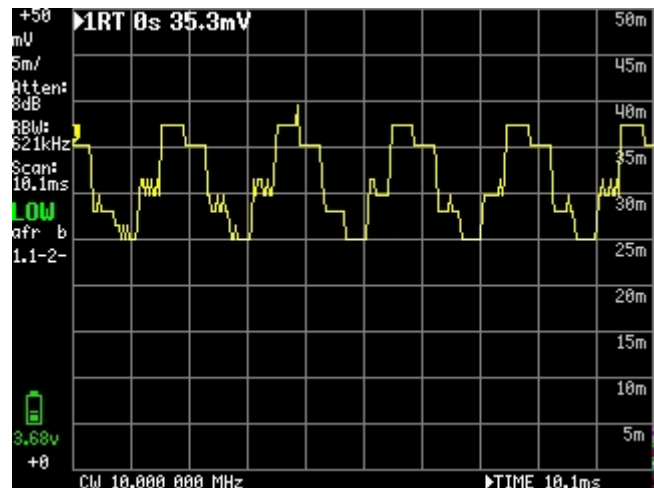


- Narrow FM sets narrow FM modulation. Width is about 3kHz.
- Wide FM sets wide FM modulation.
- EXTERNAL disables the internal LO driving the mixer and enables the high input as mixer LO input. Minimum external LO input frequency is 5MHz.
- FREQ activates a keypad to set the modulation frequency between 100Hz and 6kHz.
- BACK will move back to the previous menu

The AM and FM modulation is done using a 8 point approximation of a sinus. This limited approximation does contain harmonics and has some steep level steps as can be seen in this measurement of the AM modulation

4.2 Compression point

Using the internal attenuator and the LINEARITY measurement to step through 30 attenuation steps and plotting the peak level measured for all steps allows an easy measurement of the 1dB compression point. Here the green line plots 290 measurements of a 300MHz signal at +11dBm versus 30 attenuation steps of 1dB with the highest attenuation (29dB) at the left. The line shows the 1dB compression point to be around +3dBm. There is some variation between tinySA in this level.



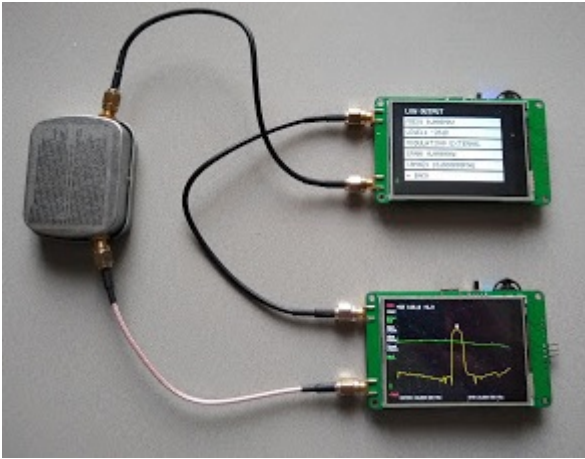
In the EXTERNAL modulation mode a second tinySA working as a spectrum analyzer in low input mode and outputting its LO from its high connector and enabled by setting the LO OUTPUT can drive the mixer of the tinySA in low output mode. By setting the frequency to zero Hz the output will follow the spectrum analyzer with zero Hz offset and can be used as a tracking generator.

4.3 MODULATION

Modulation Menu

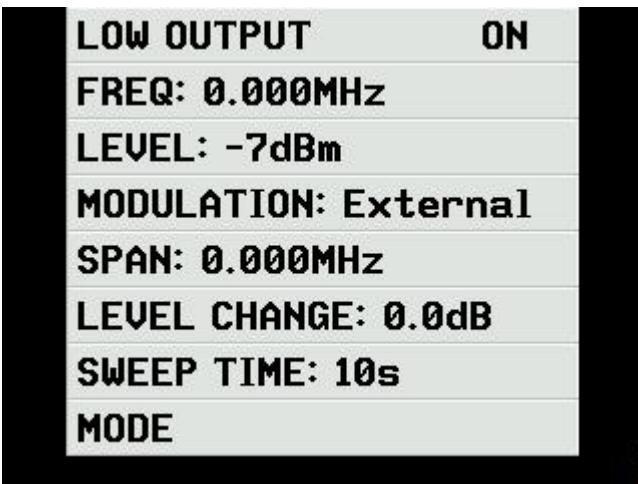
When no span for sweeping is selected the output can be modulated according to a limited set of formats.

- NONE sets no modulation
- AM sets an AM modulation. Depth is about 50%.

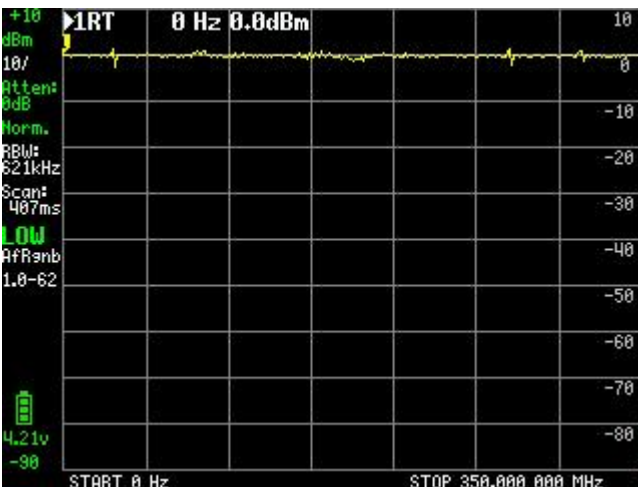


Make sure you enable the LO output in CONFIG/EXPERT CONFIG

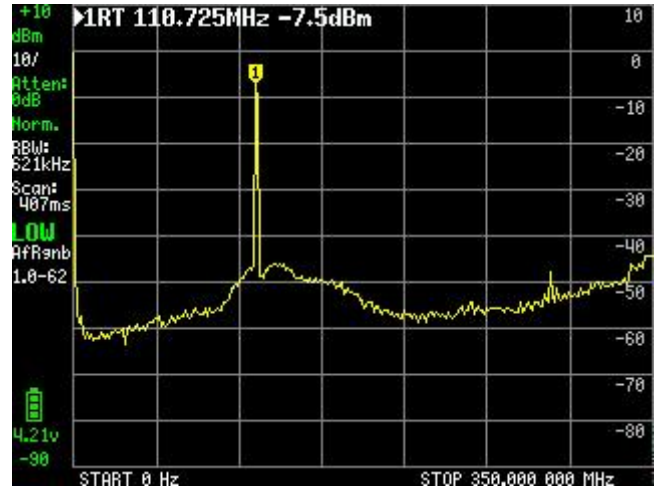
The settings for the tracking generator tinySA



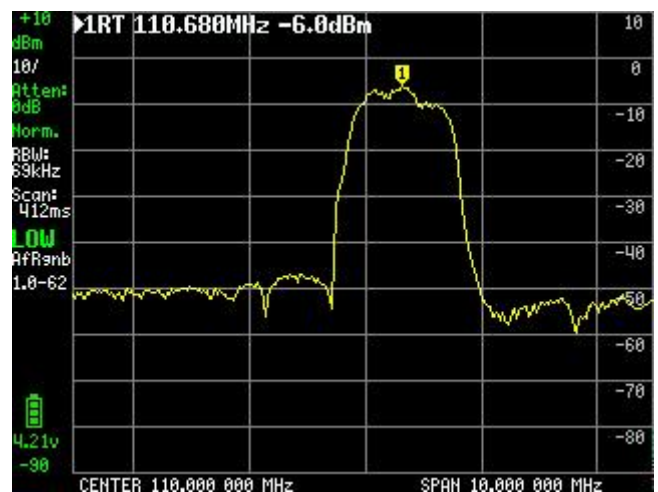
First normalize the tinySA so you have a clean 0dB level



And then you can connect a filter and do a wide scan



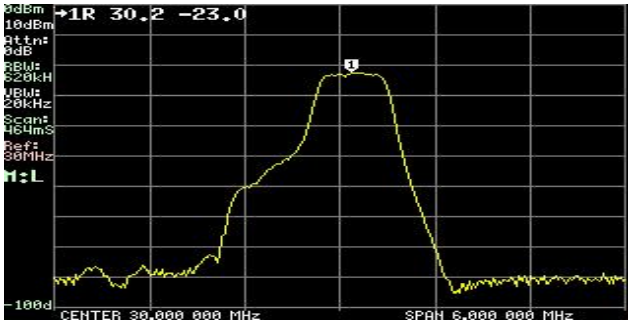
Or do a narrow scan



The dynamic range in this setup is limited due to the reverse leakage thru the mixers. Best would be to add an attenuator and amplifier between the LO output and the tracking generator input to stop the leakage. If you use an external mixer you can set the TG to an offset allowing measurement of the conversion loss of a mixer

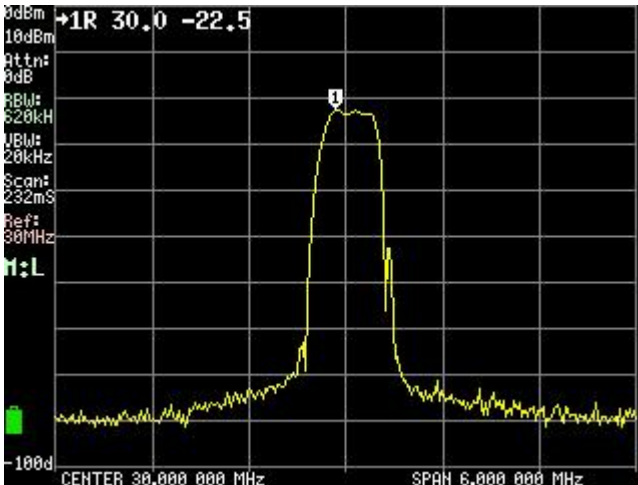
4.4 RESOLUTION FILTERS

The first filter in the tinySA is the band pass filter of the 1st IF. It has a bit of an odd shape but it does a good job in removing the image that would otherwise reduce the sensitivity of the RX SI4432. The span is 10 times the largest resolution filter



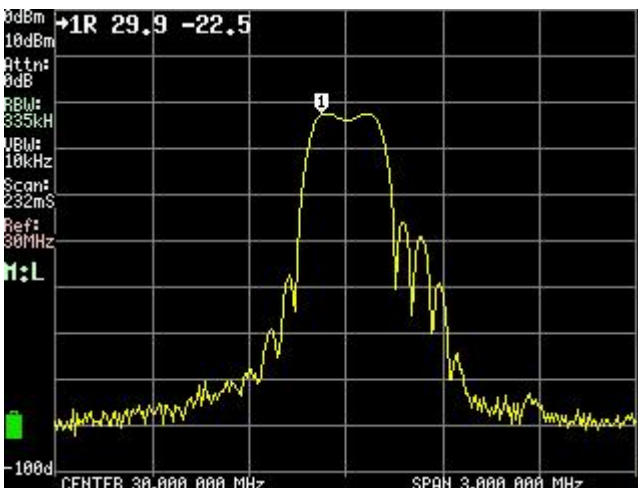
The tinySA resolution filters inside the RX SI4432 are implemented in DSP code. Here is the shape of each of the selectable resolution filters. The span is always 10 times the selected RBW. The side lobes are caused by spectral leakage in the DSP filter. The noise floor moves up with decreasing bandwidth due to the phase noise.

600kHz



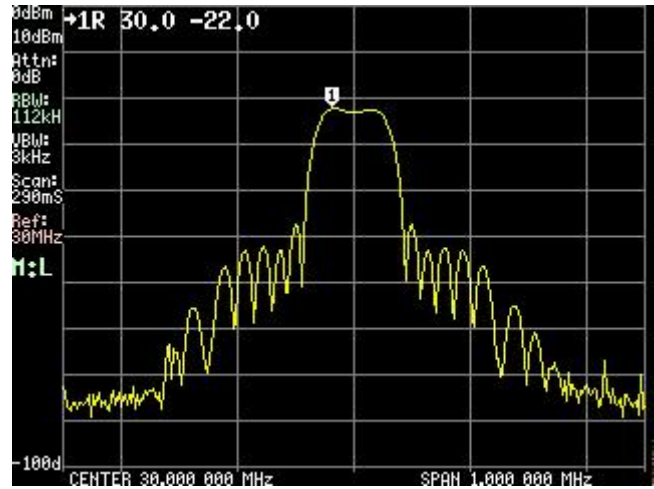
The side lobes are mostly removed by the 1st IF filter

300kHz



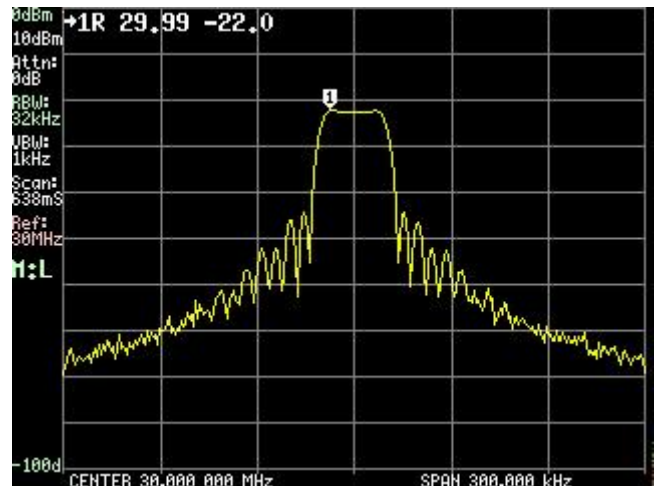
Also here the side lobes are mostly removed by the 1st IF filter.

100kHz

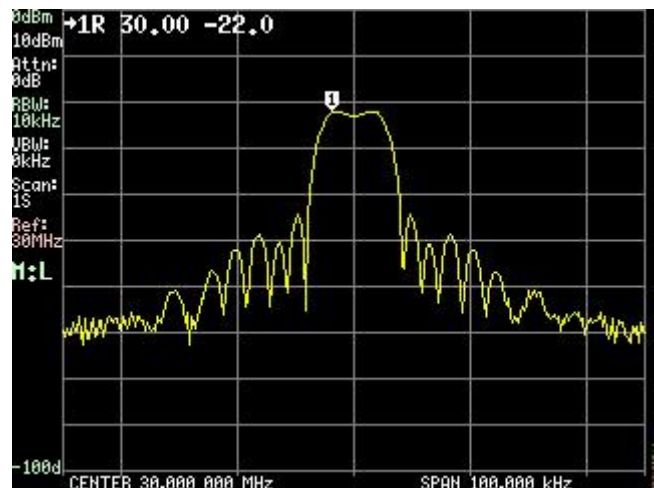


As the side lobes now fit within the passband of the 1st IF filter they become visible

30kHz

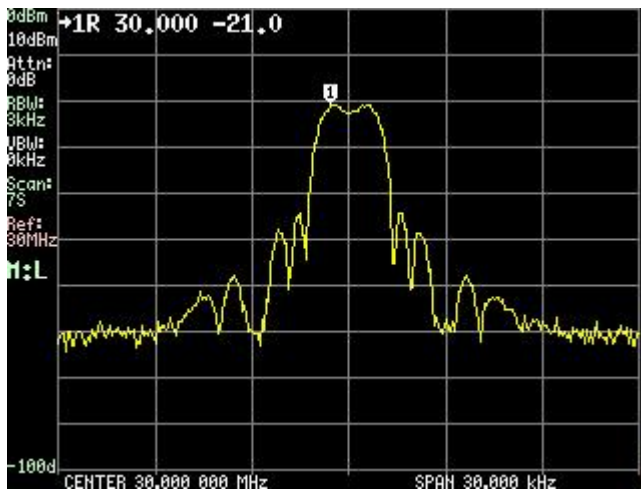


10kHz



The impact of the phase noise is visible with the noise floor moving up

3kHz



4.5 SCAN

The tinySA scans its input frequency range either in start/stop mode or in center/span mode. The number of points displayed is always 290. The number points scanned is minimum 290 but when the [RBW](#) is set to automatic the number of points scanned is increased when needed to ensure coverage of the whole frequency range

- START sets the scanning to start/stop mode and sets the start frequency
- STOP sets the scanning to start/stop mode and sets the stop frequency
- CENTER sets the scanning to center/span mode and sets the center frequency
- START sets the scanning to center/span mode and sets the frequency span
- CW FREQ sets the scanning to center/span mode, sets the span to 0Hz and sets the center frequency
- PAUSE SWEEP pauses the scanning
- BACK moves one level up in the menu structure

The scanning is limited to the frequency range of the selected MODE

4.6 Safe measurement of the output of transmitters

Calculating with dB is not too difficult. Every factor of 10 increase of the power of a signal raises the dB level with +10dB. Every factor of 10 decrease of the power of a signal reduces the dB level with -10dB.

Typical output power of a transmitter

- 100W equals +50dBm
- 10W equals +40dBm
- 1W equals +30dBm

For best measurement of harmonics in the output of transmitters the input level of the tinySA should aim between -20dBm and -10dBm

Required attenuation between transmitter and tinySA

- For 100W : between 60 and 70dB
- For 10W : between 50 and 60dB
- For 1W : between 40 and 50dB

The best approach is to use ALWAYS a 30dB attenuator directly connected to the tinySA and to use power attenuators to reduce the output of the transmitter to the target input level of this 30dB attenuator, that is +10dBm

So you will need these power attenuators

- For 100W output: 30-40dB
- For 10W output: 20-30dB
- For 1W output: 10-20dB

Another option is to use a dummy load and an inline 50dB attenuating sampler. A nice example of how to build one yourself can be found [here](#)

5 Frequently Asked Questions

Question

Will there be a 4" or larger version of the tinySA?

Answer

To reach the largest set of customers it was deliberately decided to launch the 2.8" version of the tinySA first. Next steps will depend on continued sales. A 4" version is expected to fit within the cost and affordable sales price but any communication about a 4" tinySA will only happen when there is certainty about an introduction date. Larger display's are not expected as these will have a substantial cost impact.

Question

Will there be a 2GHz (or 4GHz) version?

Answer

This is being studied but there is no plan yet

Question

Why is a wide scan with a low RBW so slow?

Answer

There are two factors that make the scan speed decrease. With a large span and a low RBW additional measurement points are inserted to avoid missing signals. Scanning 100MHz with a RBW of 10kHz requires 20000 measurements where using a 600kByte RBW would only use 290 measurements. The RBW filter is implemented in low sample rate DSP and the filter needs time to charge where the charging time is inverse proportional with the RBW. a 3kHz RBW requires more then 7 milliseconds measurement time per measurement point where a 600kHz RBW only requires 0.3 milliseconds.

Question

Why do the low and high input modes perform so different?

Answer

The low input mode has an input attenuator to avoid overloading and a good band pass filter to eliminate mirrors. The high input mode is a "for free" feature and we decided to make it available as, even with its limited performance, it could be useful.

Question

I'm not able to use touch for menu selection and I can not activate the touch calibration

Answer

Use the jog button to activate the menu and left/right/down of the jog button to select the menu option. If the touch calibration keeps failing loosen the screws of the shell a bit to reduce the pressure of the front of the shell on the touch the screen.

Question

Can I inspect the SSB modulation of my transmitter?

Answer

As the minimum RBW is 2.7kHz it is impossible to look at details inside a 2.7kHz wide SSB signal. With careful setup it is just possible to check the alternate side band rejection or see the carrier rejection.

Question

Am I limited to maximum 290 scan points?

Answer

In standalone operation the scan can use many measurement points with a large span and low RBW but the display is always using maximum 290 points. When using the tinySA in combination with a PC the amount of points is unlimited. The Windows control program supports scanning with up to 30000 measurement points.

Question

How are the additional inserted measurements consolidated into one displayed measurement?

Answer

The displayed measurement is the maximum of all the additional measurements to ensure the level of a signal falling within only one measurement is correctly displayed.

Question

Why does my signal have some unexpected weird side lobes when I zoom in?

Answer

The implementation of the [resolution filters](#) suffers from some spectral leakage due to the chosen DSP implementation.

Question

Why can't I do a screen capture of the version screen?

Answer

As long as the tinySA is in a busy wait in the UI there is insufficient memory for the execution of screen captures.

Question

In zero span mode there is a weird modulation visible, even when I apply a constant level input signal

Answer

When the input signal is very close to the zero span center frequency some yet unexplained interference occurs causing +/- 1dB variations in detected level. This can be eliminated by offsetting the zero span center frequency with 1/4 RBW.

Question

In zero span mode there are weird spikes visible in my AM modulated signal

Answer

The AGC used to extend the dynamic range of the power detector has difficulty to react to very fast level

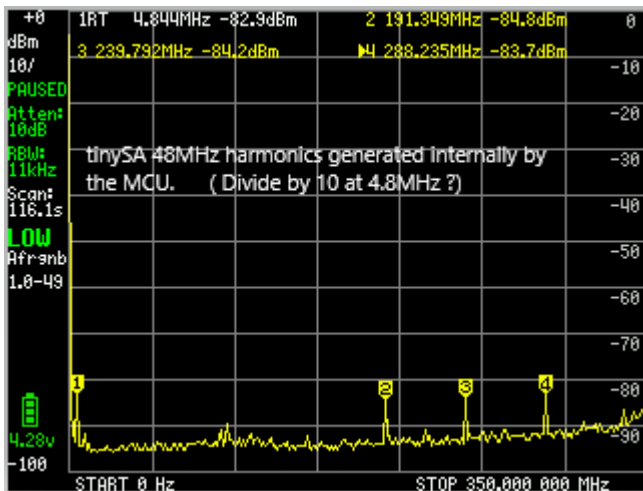
changes, as a consequence the power detector may show deviations from the actual input signal. To test if this is happening one can disable the AGC in CONFIG/EXPERT CONFIG/MORE/AGC.

Question

Even without anything connected I still see some signals

Answer

The shielding of both the high and low input can not prevent strong transmitters from entering. A nearby FM, DAB, TV or mobile phone transmitter can be visible. In high input mode the harmonics of the 30MHz TCXO generating the clock frequencies are visible over the full frequency range at or below -95dBm. The low input is susceptible to the harmonics of the 48MHz MCU clock. When doing a 0-350MHz scan with an RBW of 10kHz these are clearly visible. The latest FW version effectively eliminates these MCU clock harmonics.



Question

Is the design of the tinySA public domain?

Answer

The tinySA schematic and PCB design are not public domain. The embedded software of the tinySA is FOSS (free and open source software) according to the GPL v3 and can be found at <https://github.com/erikkaashoek/tinySA>

Question

Where is the VBW setting?

Answer

The tinySA does not have a VBW setting for noise reduction, it is advised to use the [LEVEL/CALC/AVER](#) function instead

Question

My signal was frequency X but the tinySA says it is Y?

Answer

The total scan range is divided in 290 points with equally spaced frequencies. The tinySA uses these frequencies for the markers, even when using an RBW much smaller than the

frequency step between the 290 points. Furthermore the tinySA takes steps of at least a quarter of the active RBW so any frequency reported has an uncertainty of at least that amount.

Question

I'm trying to measure AM modulation but the measurement seems completely wrong. What can be done?

Answer

When measuring AM modulation you have to carefully adjust some settings otherwise the measurement will fail. More info available in the page on [measuring AM modulation](#)

Question

Self test 3,4, 7 and 10 fail. What can be wrong?

Answer

This is happening when the observed level of the calibration output is wrong. Did you connect high and low connectors? Is the used SMA cable OK? Did a power level calibration fail? If so, redo the power level calibration and run the self test again.

Question

The Attenuator self test fails (test 10 and 12 in the latest FW). What can be wrong?

Answer

This could be caused by a faulty attenuator. Here you can find how to [check the attenuator](#)

Question

Is there an Android App for the tinySA?

Answer

Not yet, but once there is sufficient free time I will have a look.

6 COMPUTER INTERFACES

6.1 Updating the firmware

The firmware of the tinySA can be updated by the user. If your device is functioning well there is no need to upgrade the firmware. A new firmware can add new functionality or even improve performance but if your tinySA is performing well there is no need to upgrade. Saving your device specific configuration data (optional step)

If you have a new device and you did not change device specific configuration data you can skip this step

Part of the **CONFIG** data are the leveloffset for high and low mode as set by LEVEL CAL or ACTUAL LEVEL and the frequency dependent [correction](#) data. These will be reset to factory defaults when you do a clearconfig or when you install a FW with new/changed configuration or setting items. You can list the data using console mode and restore after updating and/or clearconfig. The correction table is specific for a HW version and newer or older FW's may have a different correction table or you may have improved the correction table values. These are the commands you need to enter at the console prompt and the example responses

```
ch> leveloffset
leveloffset low -3.0
leveloffset high 100.0
leveloffset low output 0.0
leveloffset high output 0.0
leveloffset switch 0.0
```

```
ch> correction
index frequency value
0 10000 6.0
1 100000 2.8
2 200000 1.6
3 500000 -0.4
4 3000000 0.0
5 14000000 -0.4
6 20000000 0.4
7 30000000 3.0
8 33000000 4.0
9 35000000 8.1
```

A leveloffset of 100.0 implies the level has not yet been calibrated. The next step is to update the firmware. This can be done either using a .dfu file or using the .bin file. Only one of these updates is needed, not both.

Getting new firmware

New versions of the firmware can be downloaded from

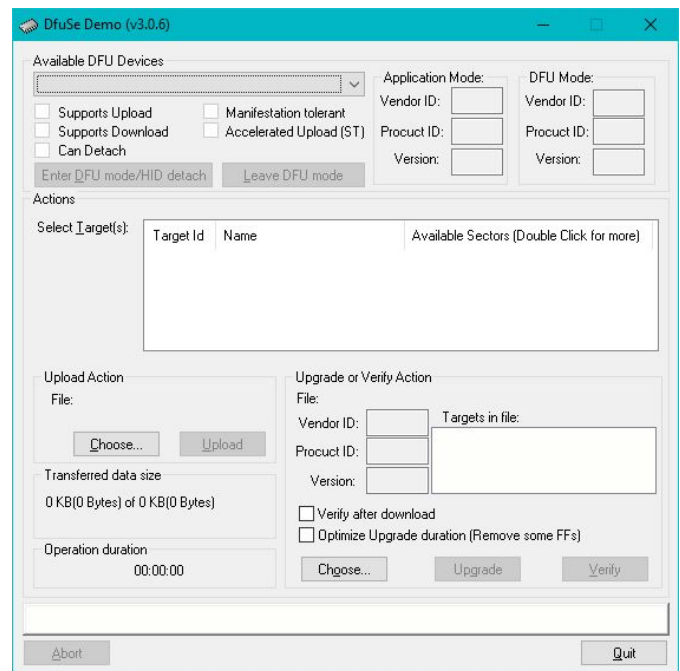
<http://athome.kaashoek.com/tinySA/DFU/>

A sub folder contains all the old FW versions so you can go back to a previous version if needed.

Download either a **tinySA_version_number.dfu** or **tinySA_version_number.bin** file to your PC

Updating the firmware using a DFU file (Windows)

To load the firmware onto the tinySA you need to download the DfuSe tools from st.com. Extract and install the tool and run DfuSeDemo



Connect the tinySA to a PC using a USB cable

Switch the tinySA on and enter **DFU** mode using the menu

The tinySA should appear under **Available Dfu Devices** as **STM Device in DFU mode** and the updating can proceed.

Start by making a backup of your current FW using the **Upload Action** function of DfuSeDemo. Use **Choose** to select a target filename for your backup and then hit **Upload** for creating the backup

Next is to update to the new FW using the **Upgrade and Verify Action** function of DfuSeDemo. Use **Choose** to select the new FW file, enable **Verify after download** and hit **Upgrade**

Updating the firmware using a BIN file (Windows, Linux and Mac)

Not needed if you have already updated using the .DFU file

Get the **tinySA_version_number.bin** file from <http://athome.kaashoek.com/tinySA/DFU/> and also download from there the files with names starting with DFU

Rename the downloaded file to tinySA.bin

Connect the tinySA with USB, switch the tinySA on and enter **DFU** mode.

Download dfu-util from <http://dfu-util.sourceforge.net/releases/> and check you can execute it.

For windows, open a command window and go to the folder with the downloaded files and run DFU_LOAD_BIN.bat. The tinySA should now be updating with the tinySA.bin file using dfu-util-static.exe

On Linux and Mac make sure dfu-util can run from the command prompt. Go to the folder where you downloaded and renamed tinySA.bin and execute

```
dfu-util -a 0 -s 0x08000000:leave -D tinySA.bin
```

If the upgrade fails and you get a white LCD screen.

If the upgrade fails for some reason (wrong file, power failure) you may get a tinySA that seems to be bricked. Luckily it is impossible to brick the tinySA. Follow these steps to unbrick:

- Switch off.
- Open the case by removing the 4 screws at the back
- Connect the two pcb edge points marked VDD and BOOT0
- Switch on.
- Lcd turns white
- You can disconnect the VDD and BOOT0 if needed
- Connect to PC using the USB cable
- Update firmware

After upgrading the firmware

Once the FW is upgraded reset the tinySA by switching off and on. The normal scanning screen should appear and the tinySA (if still connected) should appear as a **serial over USB** device in the Windows device manager or as a `/dev/tty` device under Linux. The FW maintains a checksum over the config data to detect if the structure of this data has changed with a new FW version. It is however good practice to clear the config data to be absolutely sure no old data remains possibly causing problems. Connect to your tinySA using the serial over USB port using a terminal program such as Tera and issue the clearconfig command `ch>clearconfig 1234`

After clearing the config you can reset the tinySA with the reset command `ch> reset`

tinySA Shell

```
ch>
```

Restoring your settings (if previously saved)

To restore the config, using the data recorded when saving the configuration above, issue these commands at the console prompt where the numbers are replaced by the data saved from your tinySA

```
leveloffset low -3.0
leveloffset high 100.0
leveloffset low output 0.0
leveloffset high output 0.0
leveloffset switch 0.0
correction 0 10000 6.0
correction 1 100000 2.8
correction 2 200000 1.6
correction 3 500000 -0.4
correction 4 30000000 0.0
correction 5 140000000 -0.4
correction 6 200000000 0.4
correction 7 300000000 3.0
correction 8 330000000 4.0
```

```
correction 9 350000000 8.1
saveconfig 1234
```

6.2 PC control

Connecting to a PC

The USB interface of the tinySA can operate in two modes.

- [Serial over USB](#) (console mode)
- DFU mode

During normal operation the [Serial over USB](#) mode (also called console mode) is active. Only when updating the firmware the DFU mode is used. For this see [Updating the firmware](#)

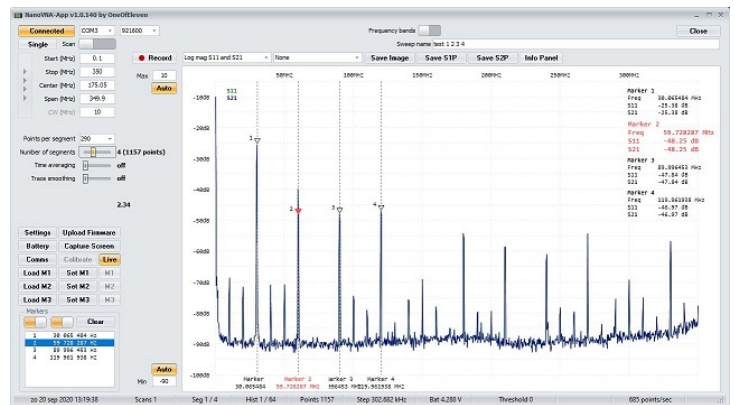
The drivers for the Serial over USB mode are built in Window and Linux so there are no drivers to install. Simply connect the tinySA to your PC using the supplied USB cable.

Once connected you can either use a terminal program (such as [Tera Term](#)) or you can use an PC application to control the tinySA

Two softwares to control the tinySA are available. All are able to capture the screen of the tinySA

Windows

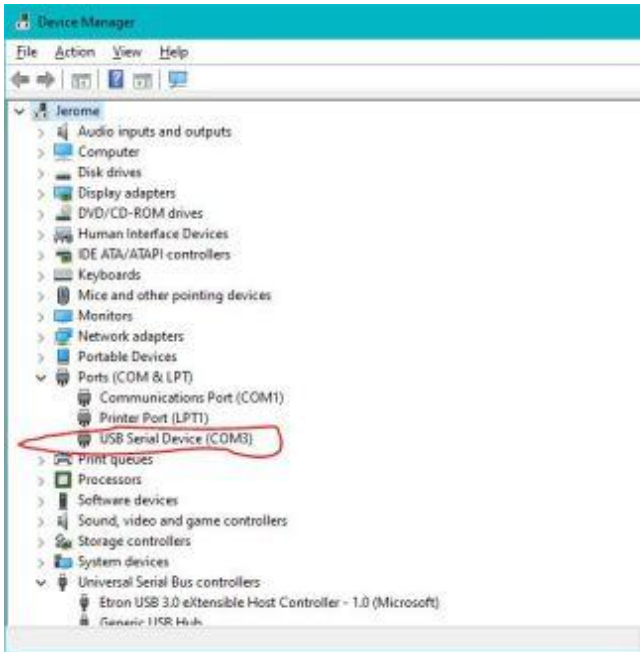
For windows there is the tinySA-App, still in its infancy



The executable can also be downloaded from here:

<http://athome.kaashoek.com/tinySA/Windows/>

In case you can not connect to the tinySA, open the Windows Device Manager and see if the "USB Serial device" device appears when you connect the tinySA. If an "Unknown Device" appears, right click on the Unknown Device and click "Uninstall Device". Switch the tinySA off and on and see if now the "USB Serial Device" appears.



Linux (and Windows (not recommended))

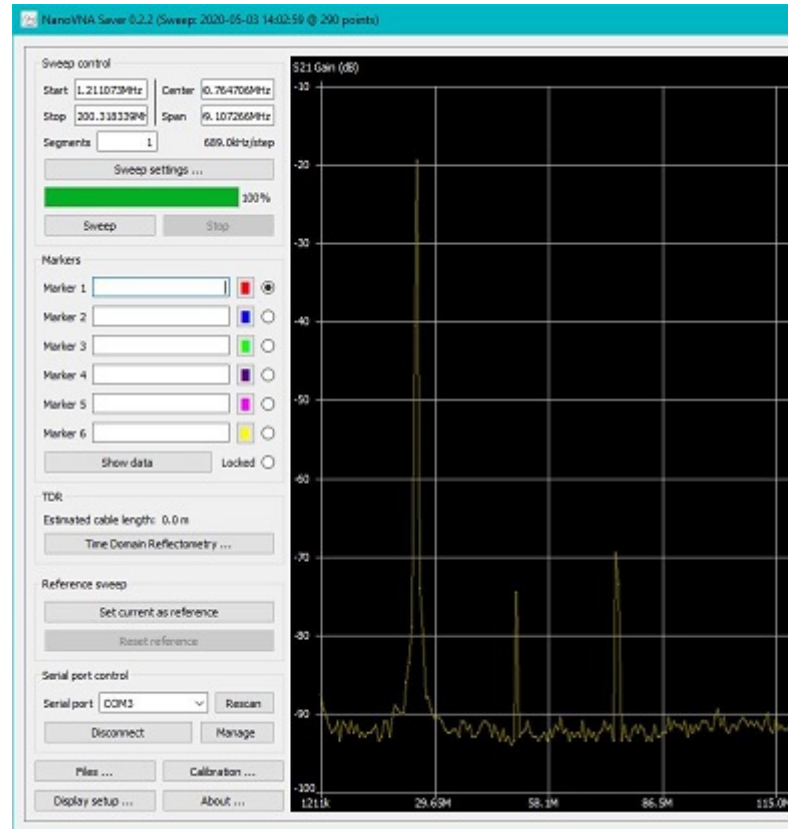
There is an early derivative of nanoVNA-saver which is still a bit rough. To run you will need to install python and a number of support libraries.

Source is available here:

<https://github.com/erikkaashoek/tinySA-saver>

Download and extract the source, go to the folder where the source is extracted and issue `python tinysa-saver.py`

This python SW is not recommended for Windows users



6.3 USB Interface PROTOCOL

After connecting the tinySA to a PC using a USB cable a serial interface will become available on the PC. Drivers for the serial interface over USB will be automatically installed on Windows and are already builtin in most Linux kernels. The serial interface supports a large set of commands. You can always use the help command to get a list of the available commands.

There is limited error checking against incorrect parameters or incorrect mode

- Frequencies can be specified using an integer optionally postfixed with the letter 'k' for kilo 'M' for Mega or 'G' for Giga. E.g. 0.1M (100kHz), 500k (0.5MHz) or 12000000 (12MHz)
- Levels are specified in dB(m) and can be specified using a floating point notation. E.g. 10 or 2.5
- Time is specified in seconds optionally postfixed with the letters 'm' for milli or 'u' for micro. E.g. 1 (1 second), 2.5 (2.5 seconds), 120m (120 milliseconds)

Commands:
attenuate

sets the internal attenuation to automatic or a specific value
usage: attenuate [auto|0-31]

bulk
send by tinySA when in auto refresh mode
format: "bulk\r\n{X}{Y}{Width}{Height}{Pixeldata}\r\n"
where all numbers are binary coded 2 bytes little endian. The Pixeldata is encoded as 2 bytes per pixel

calc
sets or cancels one of the measurement modes
usage: calc off|minh|maxh|maxd|aver4|aver16|quasip
the commands are the same as those listed in the MEASURE menu

caloutput
disables or sets the caloutput to a specified frequency in MHz
usage: caloutput off|30|15|10|4|3|2|1

capture
requests a screen dump to be send in binary format of 320x240 pixels of each 2 bytes

clearconfig
resets the configuration data to factory defaults
usage: clearconfig 1234

color
sets or dumps the colors used
usage: color [{id} {rgb24}]

correction
sets or dumps the frequency level correction table
usage: correction [0..9 {frequency} {level}]

dac
sets or dumps the dac value
usage: dac [0..4095]

data
dumps the trace data
usage: data 0..2
0=temp value, 1=stored trace, 2=measurement

deviceid
sets of dumps a user settable number that can be use to identify a specific tinySA
usage: deviceid [{number}]

fill
send by tinySA when in auto refresh mode
format: "fill\r\n{X}{Y}{Width}{Height}{Color}\r\n"
where all numbers are binary coded 2 bytes little endian.

freq
pauses the sweep and sets the measurement frequency
usage: freq {frequency}

frequencies
dumps the frequencies used by the last sweep
usage: frequencies

help
dumps a list of the available commands
usage: help

if
sets the IF to automatic or a specific value
usage: if (0 | 433M..435M)
where 0 means automatic

info
displays various SW and HW information

level
sets the output level
usage: level -76..13
Not all values in the range are available

levelchange
sets the output level delta for low output mode level sweep
usage: levelchange -70..+70

leveloffset
sets or dumps the level calibration data
usage: leveloffset low|high|switch [output] {error}
For the output corrections first ensure correct output levels at maximum output level. For the low output set the output to -50dBm and measure and correct the level with "leveloffset switch error" where
For all output leveloffset commands measure the level with the leveloffset to zero and calculate
error = measured level - specified level

load
loads a previously stored preset
usage: load 0..4
where 0 is the startup preset

marker
sets or dumps marker info
usage: marker {id} on|off|peak|{freq}|{index}
where id=1..4 index=0..num_points-1
Merker levels will use the selected unit
Marker peak will activate the marker (if not done already), position the marker on the strongest signal and display the marker info
The frequency must be within the selected sweep range

mode
sets the mode of the tinySA
usage: mode low|high input|output

modulation
sets the modulation in output mode
usage: modulation off|AM_1kHz|AM_10Hz|NFM|WFM|extern

ext_gain
sets the external attenuation/amplification
usage: ext_gain -100..100
Works in both input and output mode

output
sets the output on or off
usage: output on|off

pause
pauses the sweeping in either input or output mode
usage: pause

rbw
sets the rbw to either automatic or a specific value

```

        usage: rbw auto|3..600
        the number specifies the target rbw in
        kHz
recall
    same as load
refresh
    enables/disables the auto refresh mode
    Usage refresh on|off
release
    signals a removal of the touch
    usage: release
reset
    resets the tinySA
    usage: reset
resume
    resumes the sweeping in either input
    or output mode
    usage: resume
save
    saves the current setting to a preset
    usage: save 0..4
    where 0 is the startup preset
saveconfig
    saves the device configuration data
    usage: saveconfig
scan
    performs a scan and optionally outputs
    the measured data
    usage: scan {start(Hz)} {stop(Hz)}
    [points] [outmask]
    where the outmask is a binary OR of
    1=frequencies, 2=measured data,
    4=stored data and points is maximum
    290
scanraw
    performs a scan of unlimited amount of
    points and send the data in binary
    form
    usage: scanraw {start(Hz)} {stop(Hz)}
    [points]
    The measured data is send as '{' ('x'
    MSB LSB)*points }' where the 16 bit
    data is scaled by 32.
selftest
    performs one or all selftests
    usage: selftest 0 0..9
spur
    enables or disables spur reduction
    usage: spur on|off

sweep
    set sweep boundaries or execute a
    sweep
    usage: sweep [ ( start|stop|center|
    span|cw {frequency} ) | ( {start(Hz)}
    {stop(Hz)} [0..290] ) ]
    sweep without arguments lists the
    current sweep settings, the
    frequencies specified should be within
    the permissible range. The sweep
    commands apply both to input and
    output modes
sweeptime
    sets the sweeptime
    usage: sweep {time(Seconds)}the time
    specified may end in a letter where
    m=mili and u=micro
threads
    lists information of the threads in
    the tinySA
touch
    sends the coordinates of a touchusage:
    touch {X coordinate} {Y coordinate}
    The upper left corner of the screen is
    "0 0"
touchcal
    starts the touch calibration
touchtest
    starts the touch test
trace
    displays all or one trace information
    or sets trace related information
    usage: trace [ {0..2} | dBm|dBmV|dBuV|
    V|W |store|clear|subtract | (scale|
    refllevel) auto|{level}]
trigger
    sets the trigger type or level
    usage: trigger auto|normal|single|
    {level(dBm)}
    the trigger level is always set in dBm
vbat
    displays the battery voltage
vbat_offset
    displays or sets the battery offset
    value
    usage: vbat_offset [{0..4095}]
version
    displays the version text

```