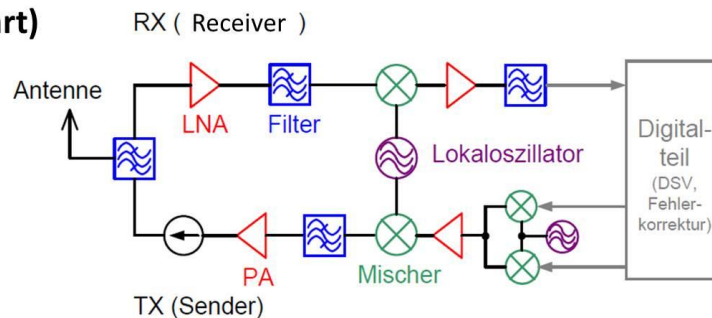# Demo / Application Guide for DSA815(-TG) / DSA1000 Series

TX1000 – Mobile Phone Frontend – Mixer –Bandpass Filter – PA

Typical Block Schematic for Mobile Phones
### (analog RF- part)

The schematic above shows a typical front end of a mobile phone. Our TX1000 RF Demo Kit shows has the same setup as the TX path of the Mobile Frontend. Mixer (Mischer) -> Band pass filter -> Power Amplifier (PA) and again a Band pass filter on the output to the antenna. Only difference is, that at the filter at the antenna of the Mobile Phone is a Diplexer which also split RX and TX frequency bands.
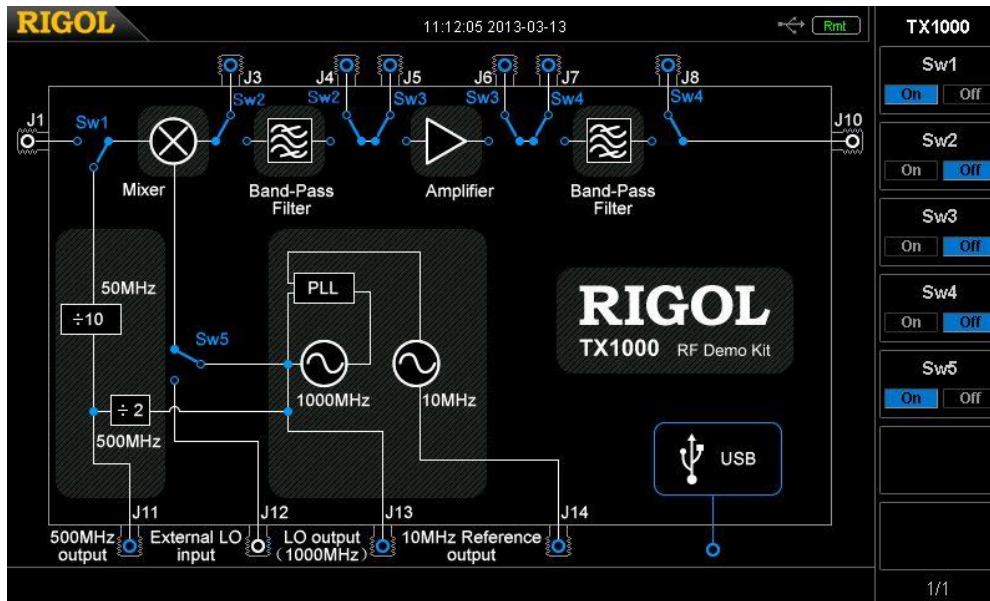
Above you see the screen shot of the TX1000 control which is built in the DSA815. To get the same picture first connect your TX1000 thru USB to your DSA815(-TG**). Press System -> *go to page2* -> TX1000** and you should see the control user interface. For the first measurements please set it as seen above and connect your DSA Input to J3 connector of your TX1000.

Press the **FREQ button and set Center Freq to 1 GHz**
Press the **SPAN button and set Span to 500MHz**

Now your screen should look like below.
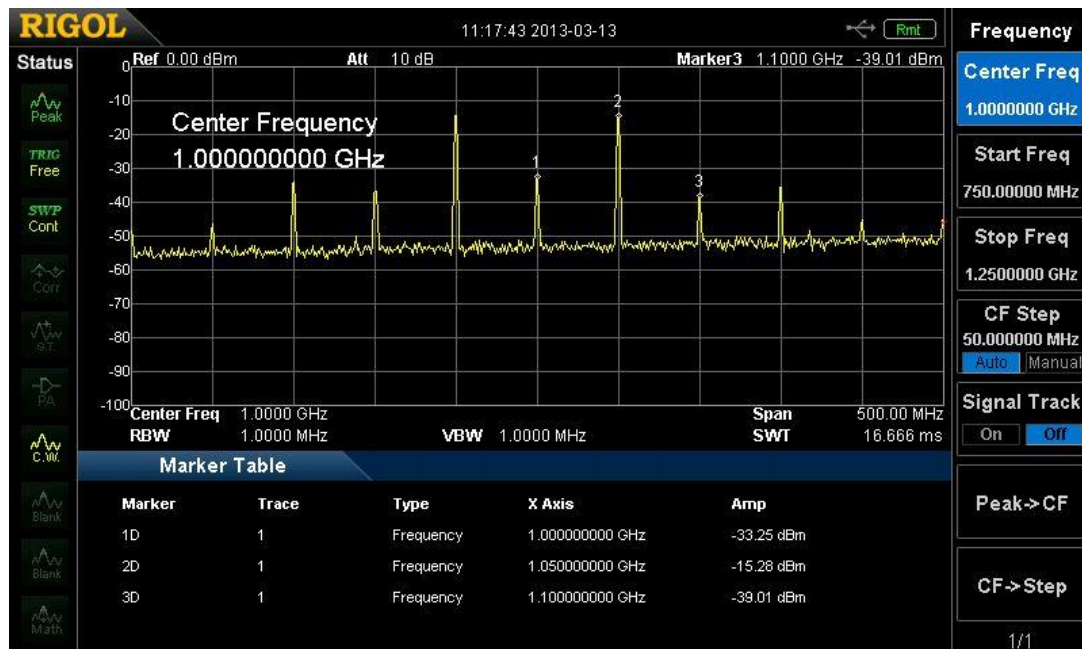
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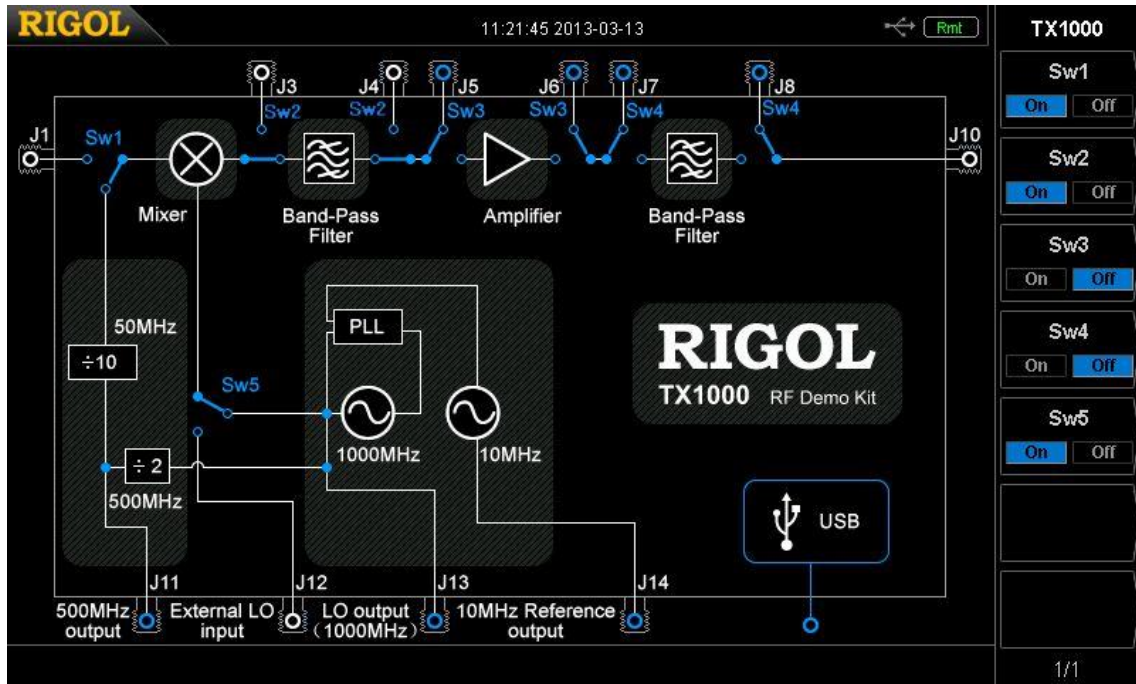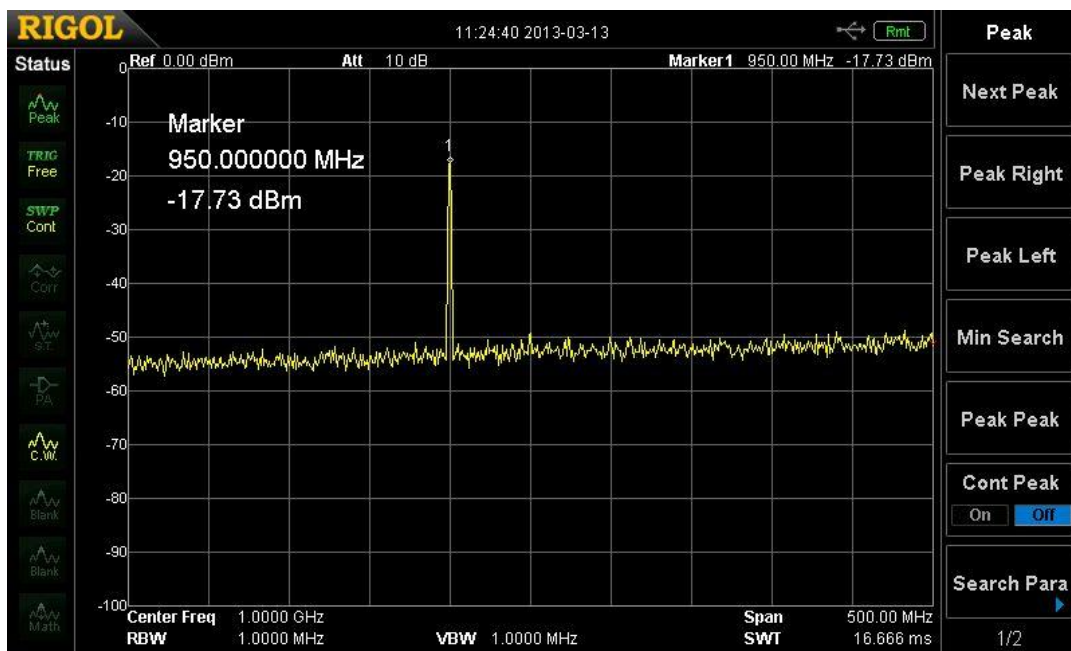
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82178 Puchheim, Germany
info-europe@rigoltech.com
Tel: 0049(0)89/8941895-0

What do we see here? The signal at the center frequency is the Local Oscillator (LO) which is supplied to the mixer. Beside you see in 50MHz distance the modulated 50MHz signal. All other peaks you see are all other mixing products. For example $F_{center} + 2x\ F_{mod}$, or $F_{center} - 2xF_{mod}$ and so on.

To avoid that all this modulated signals are available on the input of the PA we need to attach a Band pass filter in front of the PA. Go back to the TX1000 Control panel and switch as shown below. Also connect your DSA to the J5 output of the TX1000

You now should see only one frequency left. So all unwanted signals are cut off thru the filter.
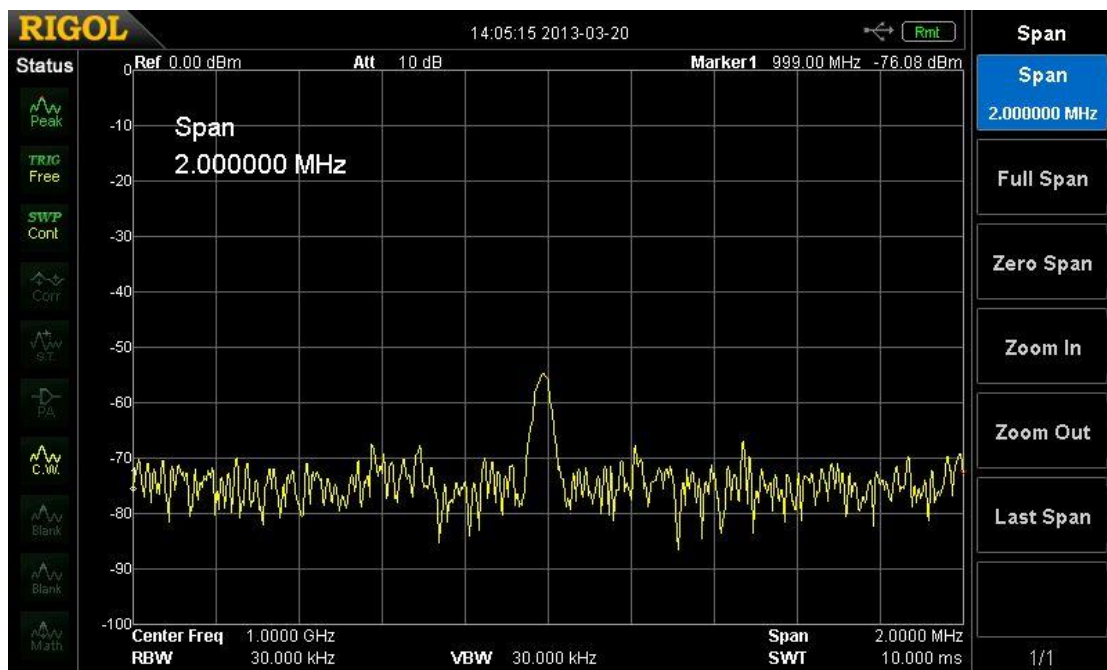
You can change the span to 2MHz. Automatically the RBW will also be changed and you can see that the noise floor goes down and the "old" 1GHz signal will appear again but much lower than before. See picture below.

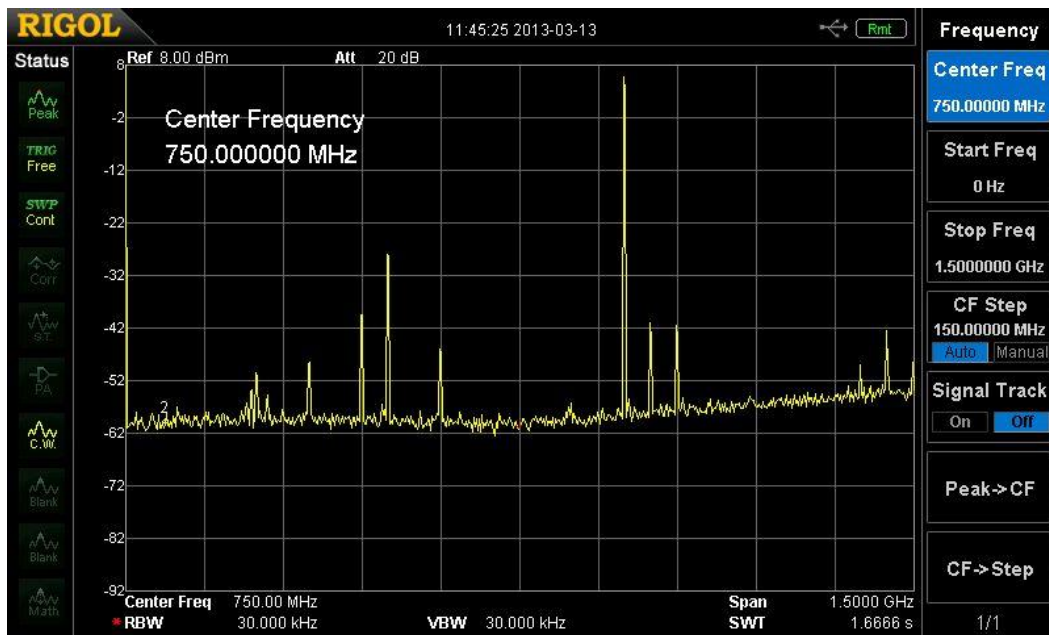The next step is to change the setup again as below and also connect J7 to the DSA.
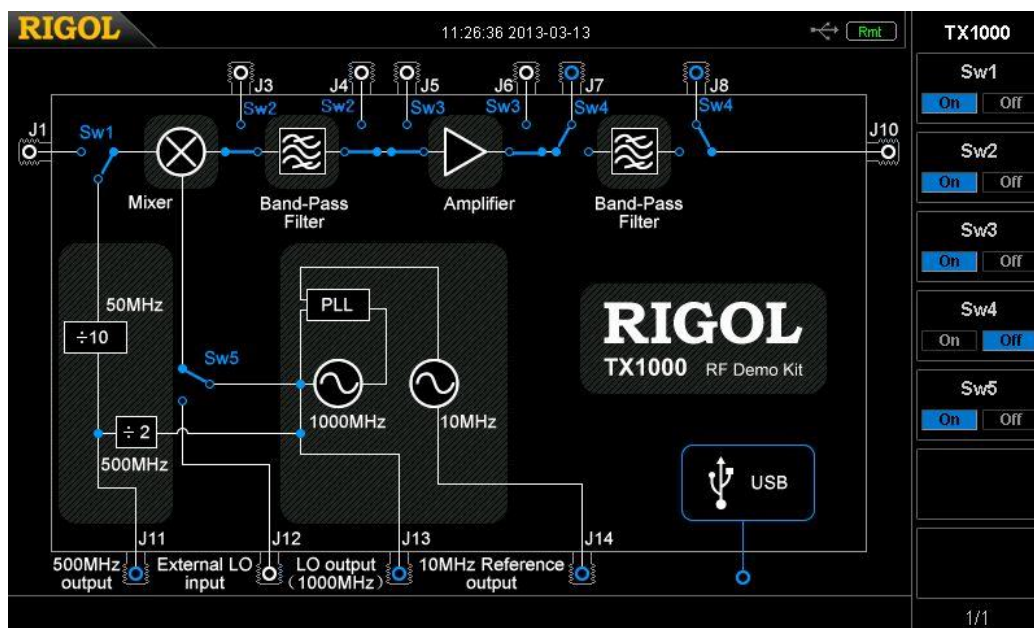
Press SPAN -> Full Span
Press BW/Det -> RBW and change the RBW to 30kHz. The screen should look like below.

You can see that there again occur a lot of unwanted frequencies. They are generated from the unlinearities of the PA and also the still existing low power peaks from the mixing stage are amplified with 20dB and arise again.

Change the center frequency to 1 GHz and change the span to 200MHz. You can see the frequencies from the mixer stage very clear.
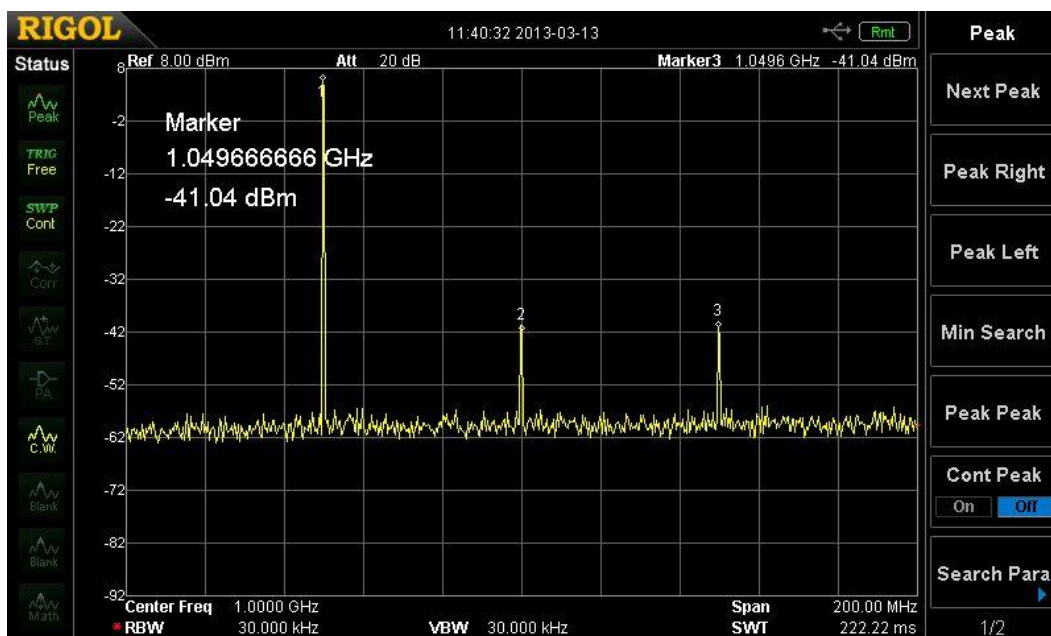
So again a Band pass filter is attached to the PA but now on the output side. Reason is of course that if you transmit these frequencies thru the antenna you will generate disturbing signals to all other RF

applications and mobile radio bands.
Go again back to the TX1000 panel and set as below

Connect the J10 to your DSA.

Back to the frequency display you can see the result.

In addition and more realistic you can change the set up and set the Switch1 ->off and attached externally an I/Q modulated signal with 50MHZ IF frequency. You can use our DG5000 series generator with the build in I/Q modulation feature.
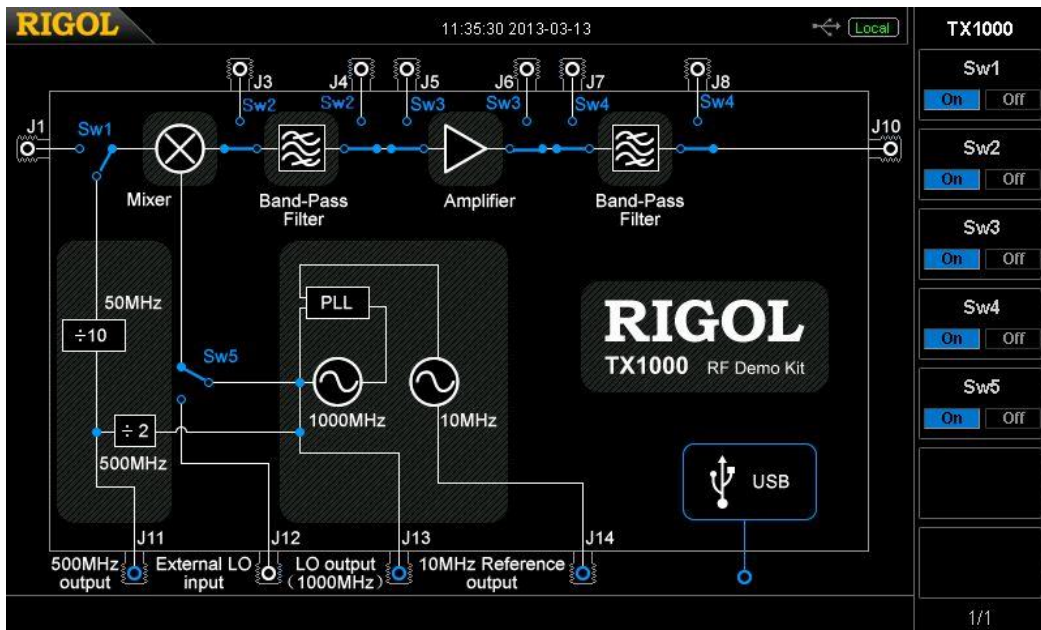
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info-europe@rigoltech.com
Tel: 0049(0)89/8941895-0

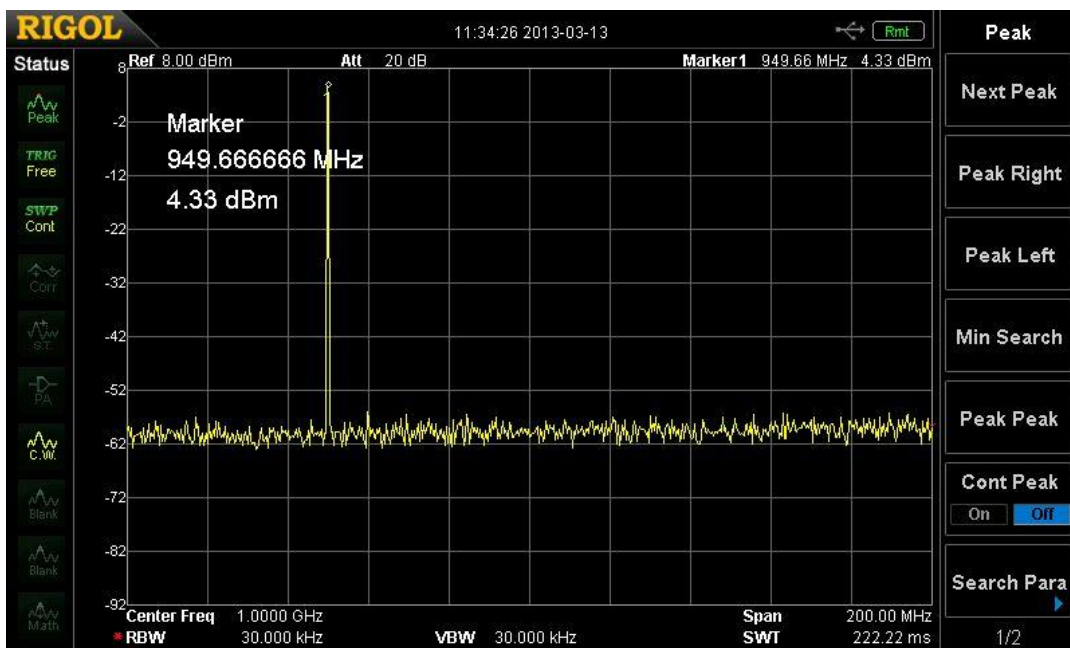# Measuring Bandpass-Filter with DSA815 –TG

For measurement of the Band pass filter characteristic you need to have a DSA with Tracking generator and also again theTX1000. Please go to the TX1000 control panel by pressing **Press System -> go to page2 -> TX1000** and set it as shown below. Additionally please connect your TG output to J6 connector of the TX1000 and the J10 to your DSA input.
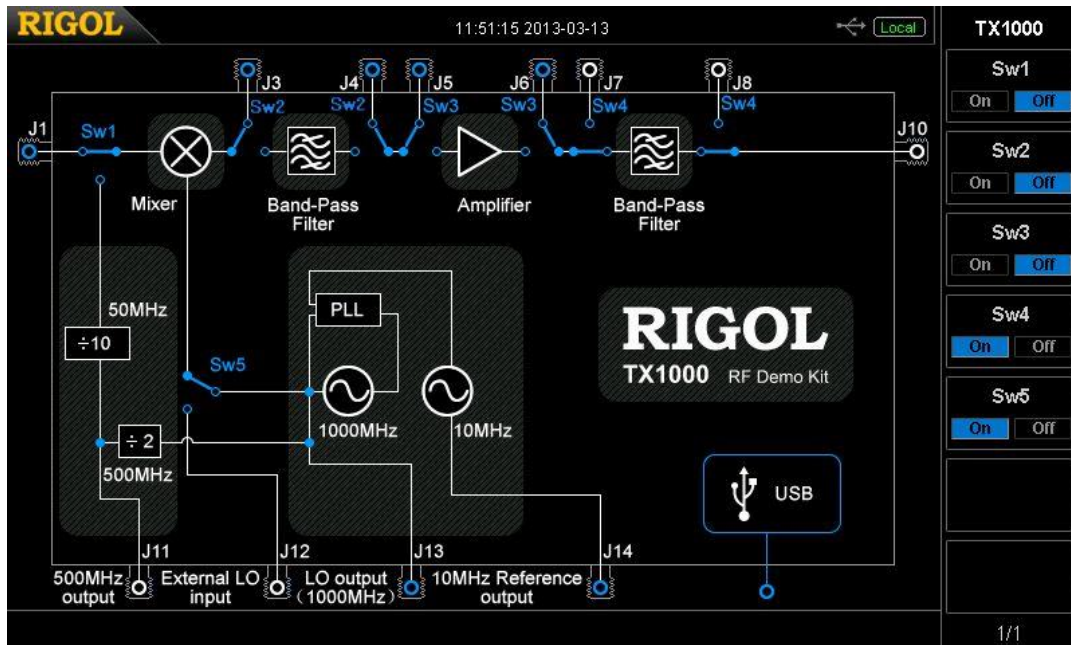
Switch TG on by **pressing TG -> TG on**
set TG level to 0dBm **Press TG Level -> 0 on the keypad and dBm on the softmenu**.
Change center frequency -> **966Mhz and Span to 145M**Hz
Press AMPT Key -> Auto Set
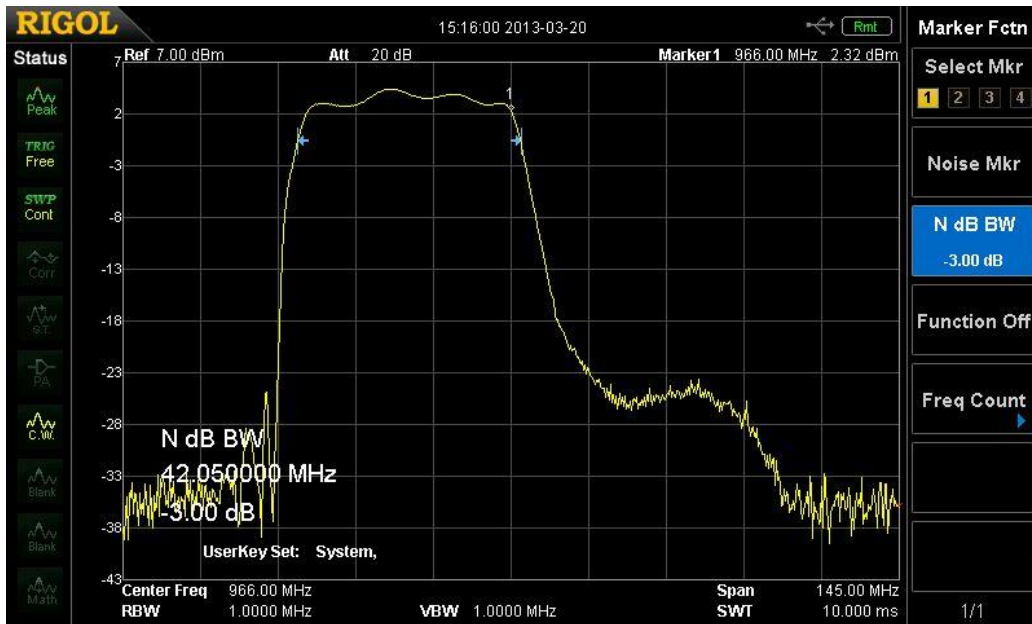**Press Marker Fctn -> N dB BW**
you should now see the following picture on your screen.

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The 3dB Bandwidth of the filter is around 42MHz. If you would like to measure the input attenuation of your filter you have to perform Normalization before starting the measurement. The Normalization can be done under TG menu structure.

Measuring compression of PA(change over from linear to non linear range)

Set your TX1000 to the following state. First make sure that the TG (TG -> TG off) is switched off, then connect your TG output to J4 connector of TX1000 and J7 connector to your DSA input.
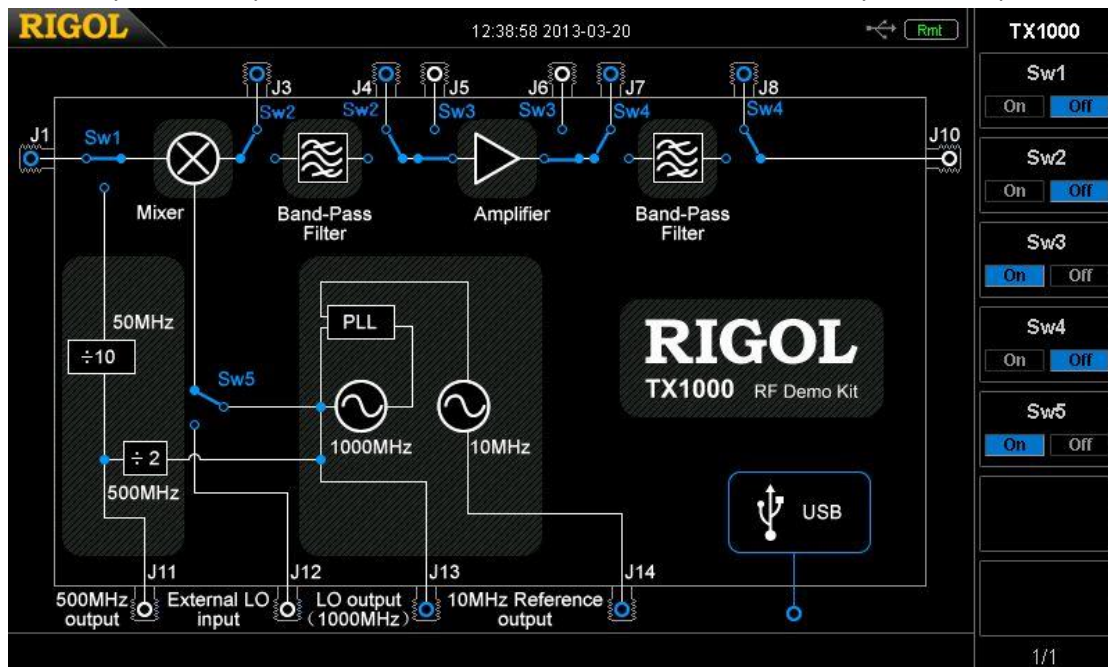
PRESET
Set Frequency to 750MHz

Set Span to 100Hz
Press TG -> TG Level -20dBm
TG on
Power Range -> 20 dB
Power Sweep on
AMPT -> Auto Scale

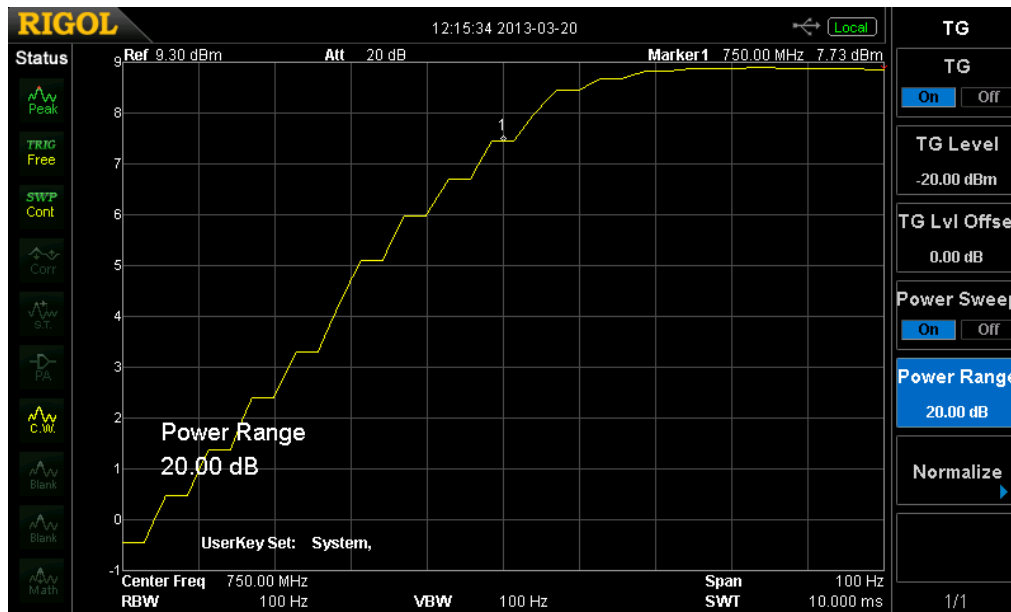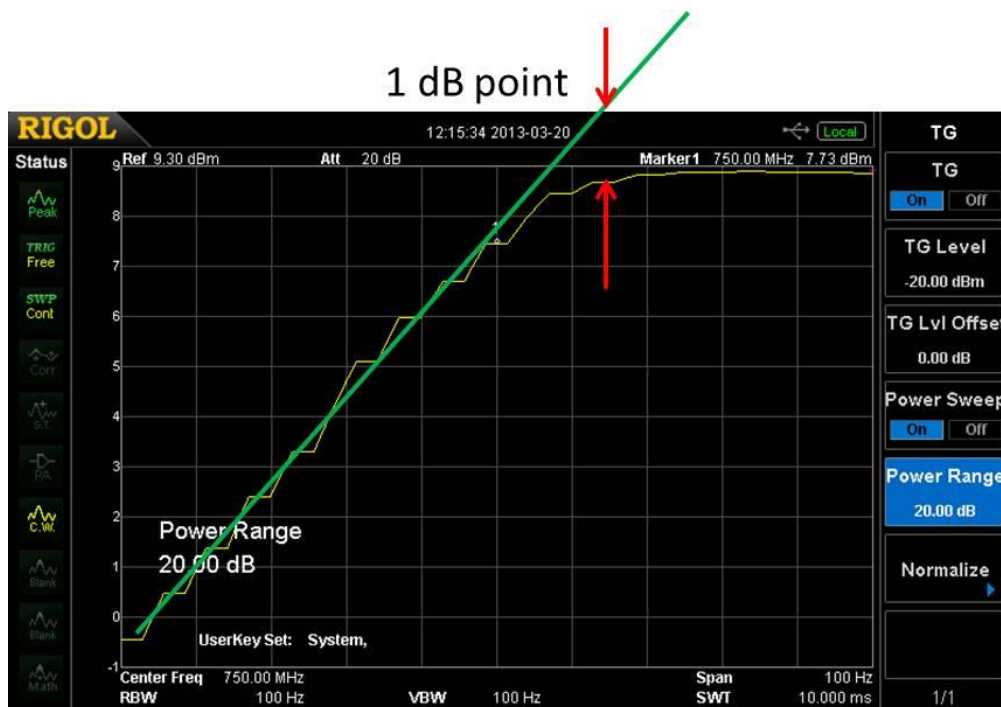We now see on the screen the change over from the linear behavior (to marker) to the non-linear range of the PA. The point when the measured power differs 1 dB from the theoretical linear extension is called the 1dB-compression point and this is a very important parameter in PA specs.

Measuring Antenna VSWR

The VSWR can be used to judge the quality of impedance matching for
cables and other passive devices. It is also mainly used to determine the efficiencyof antennas
to radiate power.
A perfectly matched antenna/cable system will have a VSWR = 1. In reality,VSWR's are
typically in the 1.1 to 1.2 range.
Higher VSWR's indicate a greater degree of impedance mismatch. For antenna user's this
indicates less efficiency.
Equipment: To measure the VSWR, you will need the following:
      1. Rigol DSA-1000 series of Spectrum Analyzer with a tracking
      generator (TG) option.
      2. Coaxial Directional Coupler with impedance match for component being tested.
      3. Antenna or other component to test.

0. Connect the VSWR Brigde to the DSA.
NOTE: Leave the input (IN) of the coupler open. This will provide 100% reflection and be
used to minimize the effects of the the cabling, adapters, and coupler.

1. Configure the DSA frequency span for the DUT by pressing the FREQ key on the DSA
display and setting the Start and Stop frequency.
• Press FREQ > Start Freq > Use Keypad to enter start frequency
and select units.
• Press FREQ > Stop Freq > Use Keypad to enter start frequency
and select units.

2. We can correct for the cabling, adapters, and coupler effects by storing the open circuit (no
DUT = Max Reflection) conditions by normalizing the current setup.
• Enable the tracking generator (Press Source > TG On)
• Store the normalized reference (Press Source > Normalize > Stor Ref)
• Enable normalized reference (Normalize > On)

3. Connect the DUT of interest to the coupler input (IN)

4. Select a marker to identify your location on the trace.
• Press Marker > Normal

You can use the scroll wheel to manually mark the minimum or you can use the Peak
Minimum function to find the lowest spot on the trace automatically.
• Press Peak > Min Search

5. The minimum value displayed on the DSA is the return loss of the DUT. Record this value
in dB

Calculations:
The VSWR can be calculated by the following
a = Return Loss (dB) measured with DSA
r = Reflection coefficient of the DUT calculated with $r = 10^{\wedge}(-0.05 * a)$

s = VSWR calculated with s = (1 + |r|) / (1- |r|)
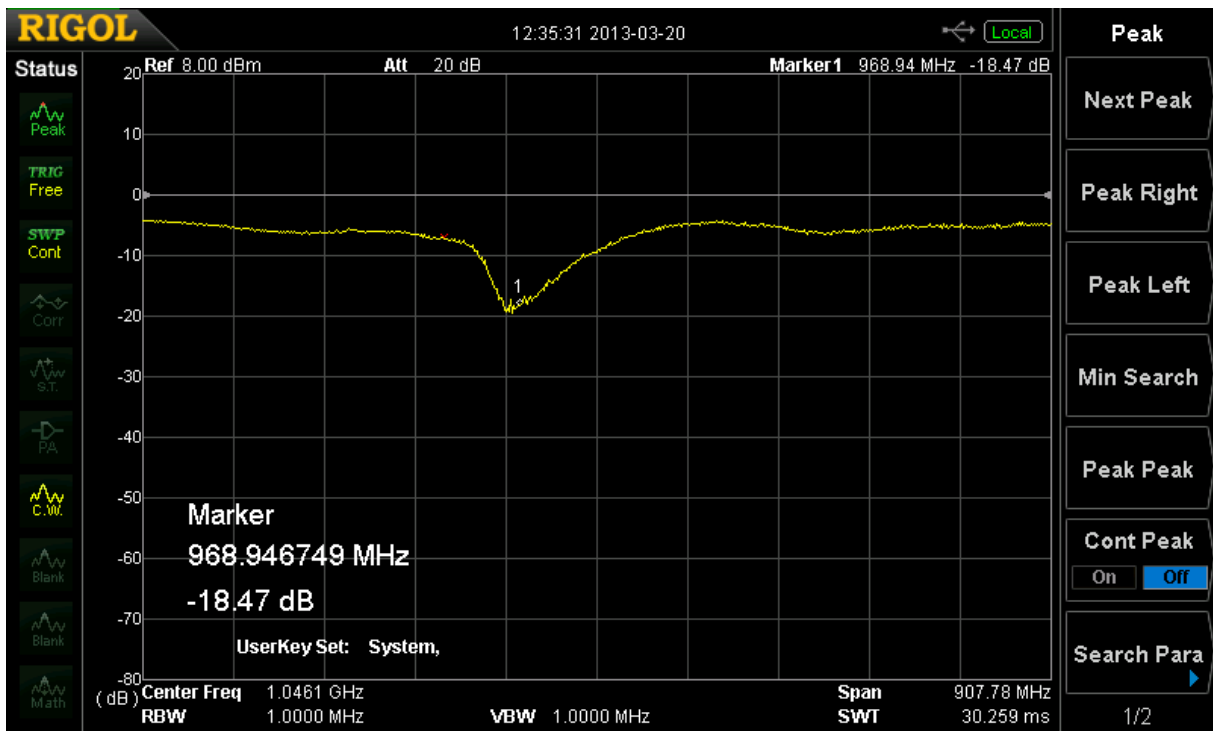
Our example test antenna delivers the following result:

r = 10^(-0.05*18.47) = 0.119 => s = (1+0.119)/(1-0119) = 1,27

As a second example we also can use the GSM-band pass filter of the TX1000. Connect the TX1000 thru USB to your instrument. Set the TX1000 as described above under Measuring Band Pass Filter with DSA815-TG and connect J6 of TX1000 to the input of the VSWR-Bridge. Attach a 50 Ohm termination to J10. Adjust the center frequency to 960MHz and the Span to 200MHz. You now should see the screen like below in the picture and on the screen shot.
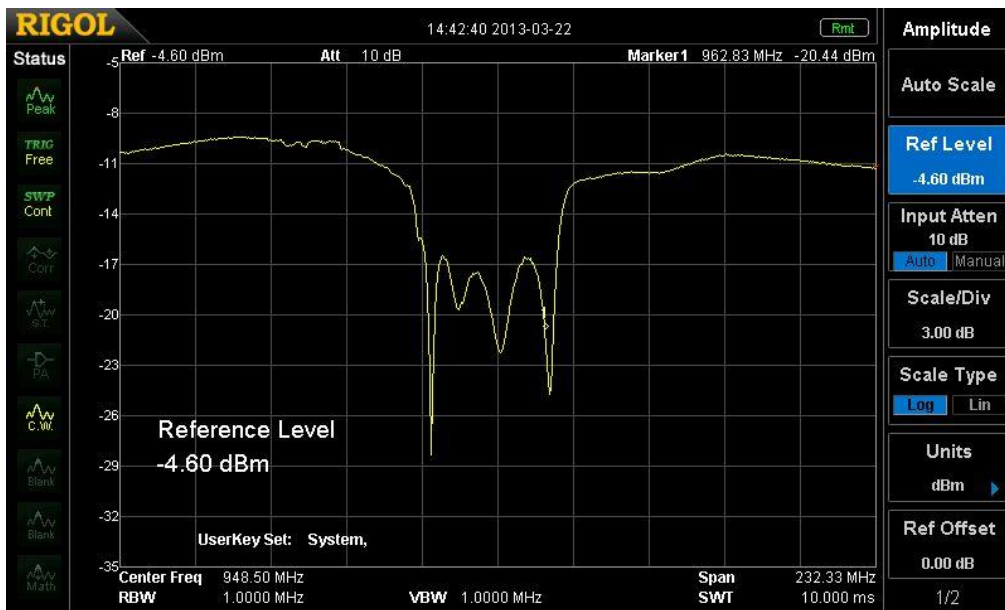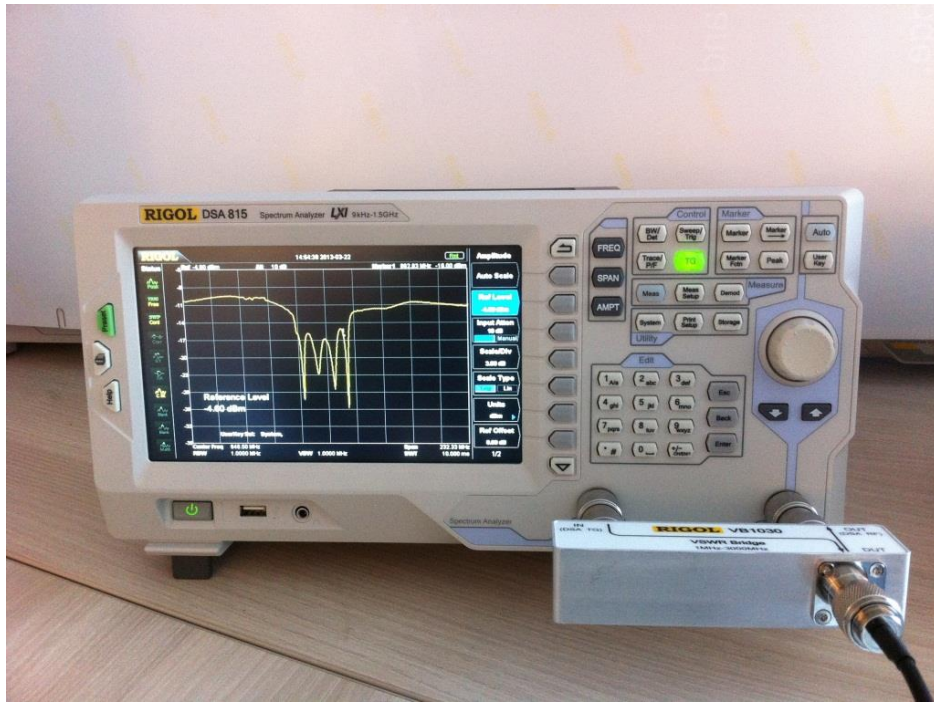
Add. Info: Why does the band pass filter looks as it look? In the pass frequency range of the filter should be maximum matching to 50 Ohms, so that all frequencies which are in this region can pass the filter without too much loss. Outside there is maximum "unmatch" so that the frequencies will be reflected. What we see on the screen is that in the pass region less signals are reflected and being measured by the DSA.

EMI Measurement with Near Field Probes

With additional options like the EMI Filter & Quasi Peak Detector and the Advanced Measurement Kit the spectrum analyzer DSA815-TG is ideal for pre compliance tests of

boards, devices and components. This allows customers to troubleshoot and test designs on their bench without having to schedule and pay for time at a full compliance lab. The pre testing helps engineers to stay within the EU-wide regulations for EMC already during the design phase and prevents from very expensive re-designs. It results in reduced development time and accelerated time-to-market.

Although the DSA815-TG does not perform exactly like a fully compliant EMC test instrument according to CISPR 16-1-1, it is ideal for all necessary pre-tests

Setup for EMI testing with near field probe.

Connect your near field probe to your DSA815. Use the DS6000 Demoboard as Device under Test. (DUT). SetUp the DSA815 as follows:

Press Preset
Set Start Frequency to 150kHz
Set Stop Frequency to 30 MHz
Press BW/DET   -> Change Filter to EMI (difference to Gauss: 6dB bandwidth definition)
                                        -> RBW to 9kHz (out of CISPR spec 16.xx)
Press AMPT   -> change Units to dBmV
Press Trace/P/F   -> Pass/Fail and switch it on
                                        -> Select Setup   -> Upper Limit
                                                               -> Switch Test ON
                                                                -> press EDIT

Set point 1 X-axis to 150kHz and Amplitude to 10dBmV
Set point 2 X-axis to 10MHz and Amplitude to 10dBmV, Connected to Yes
Set point 3 X-axis to 10.1MHz and Amplitude to 1dBmV, Connected to Yes
Set point 4 X-axis to 20MHz and Amplitude to 1dBmV, Connected to Yes
Set point 5 X-axis to 20.1MHz and Amplitude to -10dBmV, Connected to Yes
Set point 6 X-axis to 30MHz and Amplitude to -1010dBmV, Connected to Yes

Change to one menu level higher and set FAIL Stop off and on again.

If you now use the Near Field probe to the USB part of the Demo board like in the picture below.

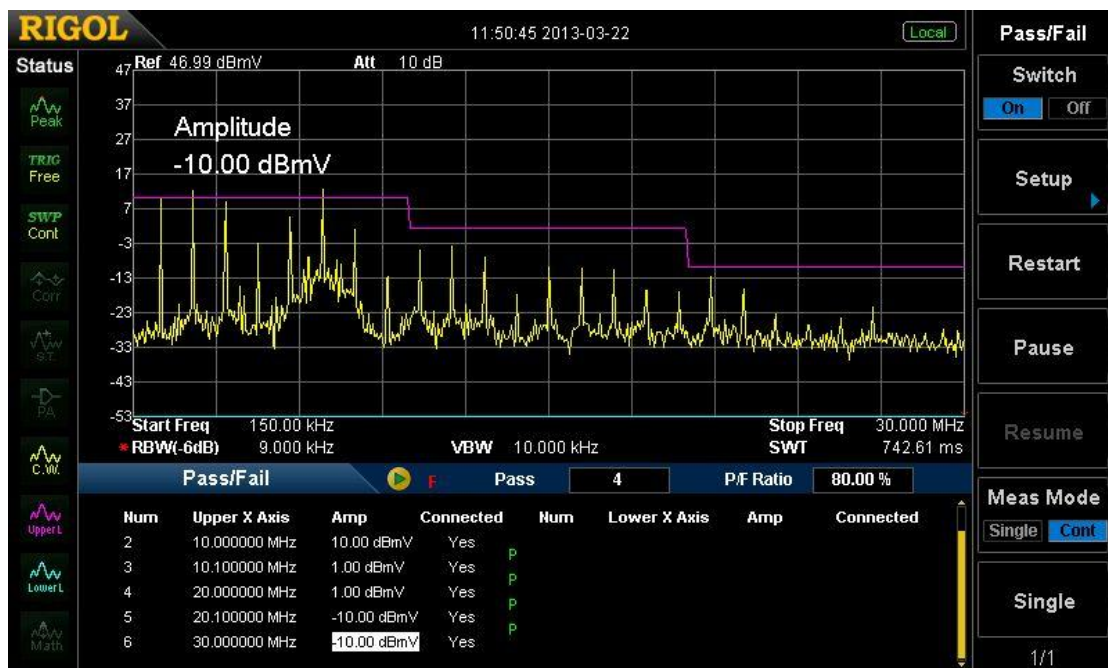www.rigoltech.eu

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82178 Puchheim, Germany
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Tel: 0049(0)89/8941895-0

Your screen should look like this

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