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RI 266
Combined 5 & 100 MHz tunable notch filters 450-2700 & 600-6000 MHz

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Background

Connected devices and mobile applications require wireless network access that is resilient, secure and able to protect individuals' privacy. For this reason, a massive number of harmonized standards and specifications have been developed by the wireless industry. Conformance to these standards and specifications is the way to accomplish resilient and secure wireless access.

More specifically, ETSI/3GPP has released an extensive conformance test specifications (TS 136 521-1 for LTE and TS 138 521-1 for 5G NR) that stipulate how and to what levels the radio properties of a mobile device should be verified in order to enable high quality wireless access. Two important objectives for the conformance test specification are to detail requirements applicable for any mobile device with respect to:

- Transmitter output spurious emissions
- Receiver blocking characteristics

(Receiver blocking characteristic is a measure of the receiver's ability to receive a wanted signal in the presence of an unwanted interferer.)

Appropriate testing and conformance to these requirements are needed to safeguard the quality of the wireless access for an individual user as well as for the overall network performance.

In some cases, the performance requirements – and hence the test levels – are so stringent that the capabilities of conventional test instruments are not enough. This is in particular the case for commercially available:

- Spectrum analyzers – that do not have the dynamic range needed to fully verify transmitter output spurious emissions
- Signal generators – that exhibit too much broadband noise to adequately verify receiver blocking characteristics

To address this, Ranatec has developed the RI 266 – a state-of-the-art, programmable notch filter. The RI 266 extends the dynamic range in spurious emission measurements with at least 30 dB by selectively suppressing the wanted transmitted signal, while leaving the spurious outputs unaffected. Similarly, the RI 266 can be set up to lower the noise level at the wanted receive frequency from any signal generator with up to the same amount, thus enabling adequate verification of receiver blocking characteristics.

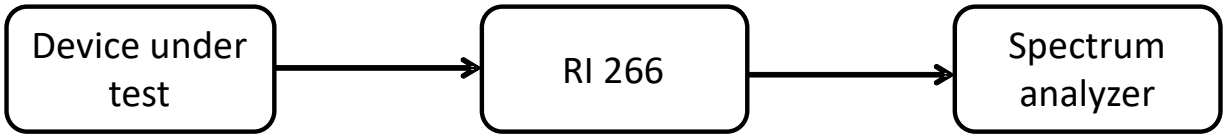
The RI 266 is intended for both formal conformance testing, performed by accredited test houses, as well internal verification by mobile device vendors.

Product description

The RI 266 is fully equipped for conformance testing across all existing mobile bands. Narrow bands (1.4, 3 and 5 MHz bandwidth channels) are defined from 450 to 2 700 MHz, and broad bands (10, 15, 20, 25, 30, 40, 50, 60, 80 and 100 MHz bandwidth channels) are defined from 600 to 5000 MHz. In addition there are 3GPP V2X channels of 10 and 20 MHz bandwidth from 5150 to 5925 MHz. Filter characteristics remain constant across the entire frequency range. A frequency extension unit (RI 4271) is available as an option, extending the pass band up to 26,5 GHz.

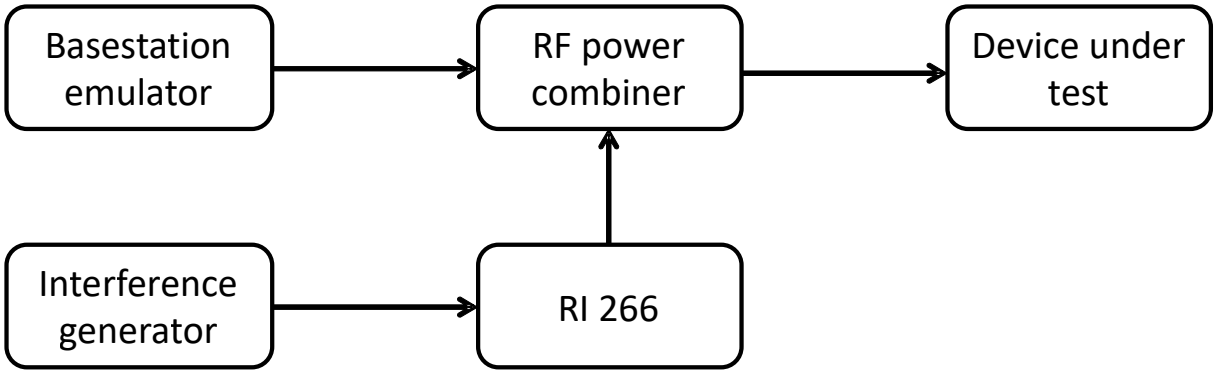
Programmable attenuators are included at both input and output of the RI 266 in order to allow signal level settings for optimum performance.

The basic test set-up for Transmitter output spurious emissions verification is shown in the figure below.



The mobile device under test can be set to transmit at any narrow band mobile channel and the RI 266 notch filter programmed to suppress the transmitted signal at least 30 dB without impacting the level of any spurious emissions from the mobile device. As a result, the problem of the limited dynamic range of the spectrum analyzer is avoided.

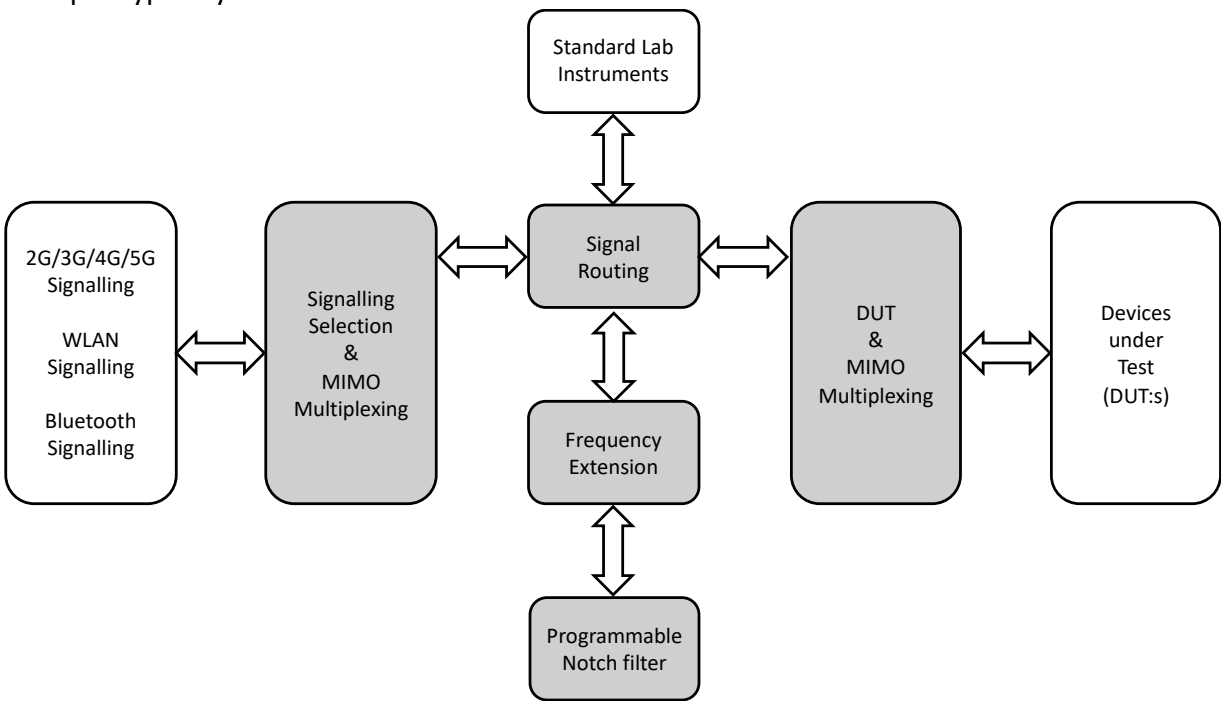
To verify the receiver blocking characteristics of the mobile device under test, the basic test set-up looks as in the figure below.



In this case, the RI 266 notch filter is centered at the channel frequency used for the link between the base station emulator and the device under test, while the interference signal is outside the rejection band of the RI 266. In doing so, any excessive noise at the channel frequency coming from the interference generator is suppressed, while the interferer itself is left unattenuated.

Typical test set-up

For the purpose of doing conformance testing of mobile devices, a generic, automated test set-up is typically established.



The Signaling units emulates the Radio Access Network base stations / access points in both downlink and uplink. A set of standard lab instruments (typically power meters, a spectrum analyzer and a signal generator) are required for calibration of the various signal paths as well performing some of the actual measurements. All these parts of the generic test set-up are typically supplied by the tier 1 players within wireless test equipment (Anritsu, Keysight or Rohde & Schwarz).

At the center of this generic test set-up sits the parts supplied by Ranatec:

a) Signalling Selection and MIMO Multiplexing contains the programmable switches, couplers and attenuators needed to accommodate the adequate signal constellation in both uplink and downlink
b) Signal Routing is the core of the test automation and provides flexible routing and level setting across the test system, by means of programmable switches, couplers and attenuators
c) Frequency Extension contains switchable high-pass and low-pass filters to allow for spurious emission measurements over the entire frequency range up to 26.5 GHz
d) Programmable Notch Filter refers to the Ranatec RI 26X family of tunable band reject filters
e) DUT and MIMO Multiplexing is the correspondence of the Signalling Selection and MIMO Multiplexing and provides and adequate signal constellation in both uplink and downlink to/from the devices under test

The actual test set-up depends on the overall ambition in terms of coverage of standards and frequency bands, type and number of DUT:s used, the selection of signaling units and lab instrumentations – as well as the ambition level in terms of level of automation. Ranatec has developed a flexible and easy to use test automation platform to support almost any ambition level, tailored to the customer demands. The key component in any such set-up is the RI26X family of programmable notch filters.

An example of such a test set-up is shown in the picture below.

Technical data for 100 MHz bandreject filter mode

Parameter	Value	Remarks
Filter Characteristics		
Band-reject center frequency range	600 ~ 1000 MHz 1400 ~ 2700 MHz 3300 ~ 4200 MHz 4400 ~ 5000 MHz 5150 ~ 5925 MHz	f_c in the figure below
Resolution of set center frequency	1 kHz	
Filter characteristics settling time when center frequency is changed	20 ms	
Pass-band when band-reject center frequency is in the range 600 ~ 1000 MHz	0 ~ 1600 MHz	
Pass-band when band-reject center frequency is in the range 1400 ~ 2000 MHz	1000 ~ 2400 MHz	
Pass-band when band-reject center frequency is in the range 2000 ~ 2700 MHz	1700 ~ 3000 MHz	
Pass-band when band-reject center frequency is in the range 3300 ~ 4200 MHz	3200 ~ 4300 MHz	
Pass-band when band-reject center frequency is in the range 4400 ~ 5000 MHz	4000 ~ 5400 MHz	
Pass-band when band-reject center frequency is in the range 5150 ~ 5925 MHz	4925 ~ 6150 MHz	
Band-width of stop-band	≥ 100 MHz	f_s in the figure below
Band-width of transition region	≤ 10 MHz	f_{t1} and f_{t2} in the figure below
Band-width of stop and transition region	≤ 120 MHz	f_b in the figure below
Stop-band rejection	≥ 30 dB	A_s in the figure below
Pass-band variation	≤ 5 dB	A_p in the figure below
RF Input and Output Characteristics		
Input return loss	>12 dB	
Output return loss	>13 dB	
Input IP3	typically +26 dBm	
Noise figure	typically 17±2 dB	
Input attenuator range	0 ~ 31.75 dB in 0.25 dB steps	
Maximum input operating power	+28 dBm	
Maximum input power without damage	+28 dBm	
Output attenuator range	0 ~ 31.75 dB in 0.25 dB steps	

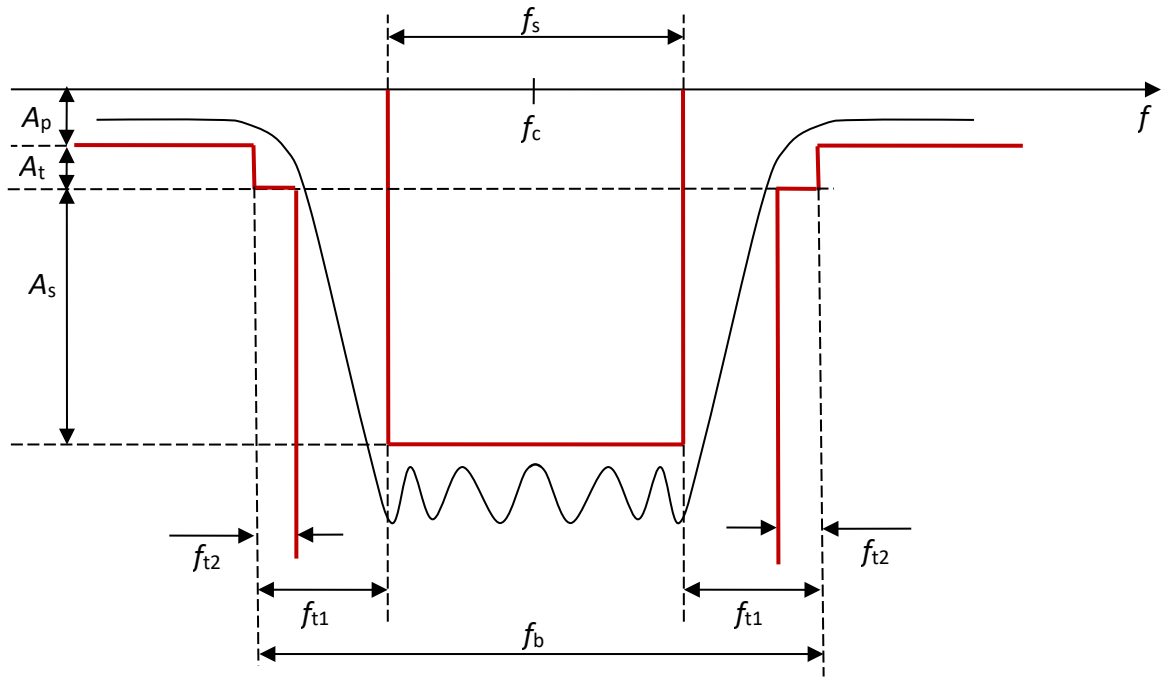
Pass-band gain from RF input to output when center frequency is in the range 600 ~ 1000 MHz	+11 ~ +15 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 1400 ~ 2000 MHz	+7 ~ +13 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 2000 ~ 2700 MHz	+2 ~ +11 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 3300 ~ 4200 MHz	-2 ~ +7 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 4400 ~ 5000 MHz	-4 ~ +5 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 5150 ~ 5925 MHz	-6 ~ +3 dB typical when Input and Output attenuator is set to 0 dB.	
Parameter	**Value**	**Remarks**
Reference Oscillator		
Internal Ref. oscillator frequency uncertainty	±2.5 ppm	
Allowed frequency uncertainty of External 10 MHz Ref. oscillator	±10 ppm	
External 10 MHz Ref. oscillator input power range	+7 ~ +13 dBm	
Power requirements		
Input mains voltage	100 ~ 253 VAC, 50 ~ 60 Hz	
Environment		
Operating temperature	0° ~ +40° C	
Storage temperature	-40° ~ +70° C	
Relative humidity	10 ~ 90 %	
Life time		
Switch cycles	>10 million	

Technical data for 5 MHz bandreject filter mode

Parameter	Value	Remarks
Filter Characteristics		
Band-reject center frequency range	450 ~ 1000 MHz 1400 ~ 2700 MHz	f_c in the figure below
Resolution of set center frequency	1 kHz	
Filter characteristics settling time when center frequency is changed	20 ms	
Pass-band when band-reject center frequency is in the range 450 ~ 1000 MHz	0 ~ 1450 MHz	
Pass-band when band-reject center frequency is in the range 1400 ~ 2000 MHz	1000 ~ 2400 MHz	
Pass-band when band-reject center frequency is in the range 2000 ~ 2700 MHz	1700 ~ 3000 MHz	
Band-width of stop-band	≥ 5 MHz	f_s in the figure below
Band-width of transition region	≤ 3.0 MHz	f_{t1} and f_{t2} in the figure below
Band-width of stop and transition region	≤ 11 MHz	f_b in the figure below
Stop-band rejection	≥ 30 dB	A_s in the figure below
Pass-band variation	≤ 3.5 dB	A_p in the figure below
RF Input and Output Characteristics		
Input return loss	>12 dB	
Output return loss	>13 dB	
Input IP3	typically +26 dBm	
Noise figure	typically 17±2 dB	
Input attenuator range	0 ~ 31.75 dB in 0.25 dB steps	
Maximum input operating power	+28 dBm	
Maximum input power without damage	+28 dBm	
Output attenuator range	0 ~ 31.75 dB in 0.25 dB steps	
Pass-band gain from RF input to output when center frequency is in the range 450 ~ 1000 MHz	+11 ~ +15 dB typical when Input and Output attenuator is set to 0 dB.	
Pass-band gain from RF input to output when center frequency is in the range 1400 ~ 2000 MHz	+7 ~ +13 dB typical when Input and Output attenuator is set to 0 dB.	

Pass-band gain from RF input to output when center frequency is in the range 2000 ~ 2700 MHz	+2 ~ +11 dB typical when Input and Output attenuator is set to 0 dB.	
Parameter	**Value**	**Remarks**
Reference Oscillator		
Internal Ref. oscillator frequency uncertainty	±2.5 ppm	
Allowed frequency uncertainty of External 10 MHz Ref. oscillator	±10 ppm	
External 10 MHz Ref. oscillator input power range	+7 ~ +13 dBm	
Power requirements		
Input mains voltage	100 ~ 253 VAC, 50 ~ 60 Hz	
Environment		
Operating temperature	0° ~ +40° C	
Storage temperature	-40° ~ +70° C	
Relative humidity	10 ~ 90 %	
Life time		
Switch cycles	>10 million	

Definition of filter parameters:



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The tunable notch filter family

Ranatec provides several different variants of tunable bandreject filters. Some represent the historical successive extension of the mobile communication frequency bands and some are to account for the different channel bandwidths. The table below gives an overview.

number	name	frequency bands for filter centre frequency [MHz]	measurement bands [MHz]	filter bandwidth [MHz]	filter slopes [MHz]
RI 260	Tunable notch filter 700-2700 MHz	698-1000 1400-2000 2000-2700	600-1200 1200-2200 1700-3000	20	10
RI 261	Tunable notch filter 700-3800 MHz	698-1000 1400-2000 2000-2700 3400-3800	600-1200 1200-2200 1700-3000 3100-4100	20	10
RI 262	Tunable notch filter 600-4200 MHz	600-700 700-1000 1400-2000 2000-2700 3300-3400 3400-3800 3800-4200	300-1100 600-1200 1200-2200 1700-3000 2700-4000 3100-4100 3500-4300	100	10
RI 263	Tunable notch filter 600-6000 MHz	600-1000 1400-2000 2000-2700 3300-4200 4400-5000 5150-5925	0-1600 1000-2400 1700-3000 3200-4300 4000-5400 4925-6150	100	10
RI 264	Tunable 5 MHz notch filter 450-2700 MHz	450-1000 1400-2000 2000-2700	0-1450 1000-2400 1700-3000	5	1.4
RI 266	Combined 5 & 100 MHz tunable notch filters 450-2700 & 600-6000 MHz	450-1000 1400-2000 2000-2700 600-1000 1400-2000 2000-2700 3300-4200 4400-5000 5150-5925	0-1450 1000-2400 1700-3000 0-1600 1000-2400 1700-3000 3200-4300 4000-5400 4925-6150	5 100	3.0* 10

*1.4 MHz slopes available on request