

# HOW TO USE EXTERNAL FRONTENDS WITH THE R&S® RTP HIGH-PERFORMANCE OSCILLOSCOPE

White paper | Version 01.01

**ROHDE & SCHWARZ**

Make ideas real



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## ROHDE & SCHWARZ PRODUCTS

### External frontends

- ▶ R&S®FE44S, 24 GHz to 44 GHz
- ▶ R&S®FE50DTR, 36 GHz to 50 GHz
- ▶ R&S®FE110SR, 70 GHz to 110 GHz
- ▶ R&S®FE170SR, 110 GHz to 170 GHz

### Oscilloscope and options

- ▶ R&S®RTP164B high-performance oscilloscope, 16 GHz
- ▶ R&S®RTP-K11 I/Q software interface
- ▶ R&S®RTP-K121 deembedding base
- ▶ R&S®RTP-K553 external frontend control

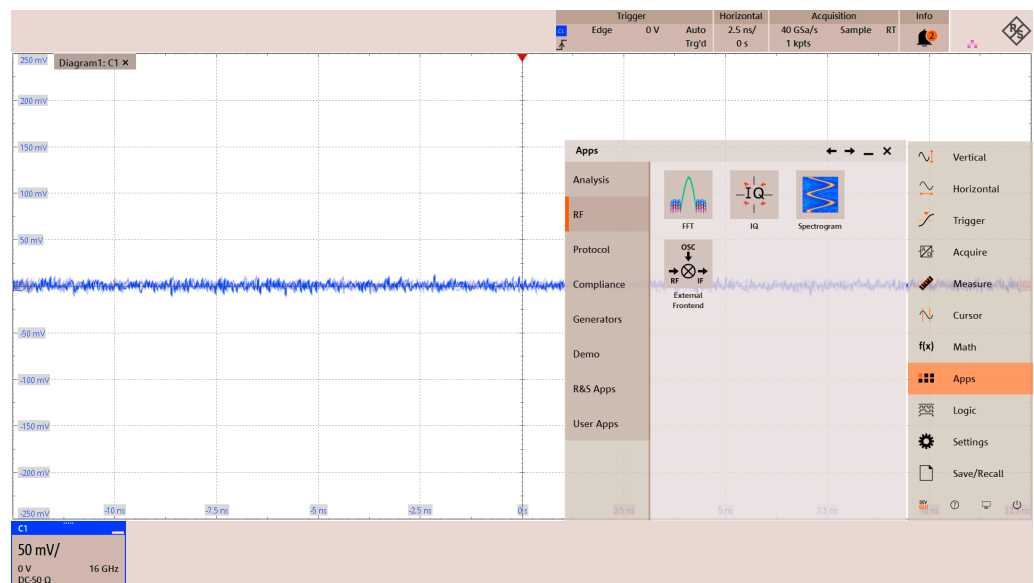
# 1 PURPOSE

External frontends (FEs) extend the frequency range of the R&S®RTP high-performance oscilloscope. The basic functionality of an FE is similar to a spectrum analyzer. Depending on the selected radio frequency (RF), an intermediate frequency (IF) is transmitted to the oscilloscope. These frequencies are typically centered roughly at 5 GHz or 10 GHz.

# 2 GENERAL

The settings for the FEs are located in the Apps menu: Apps --> RF --> External Frontend. A shortcut via the top toolbar is also possible.

**Fig. 1: External FEs can be configured via the Apps menu**



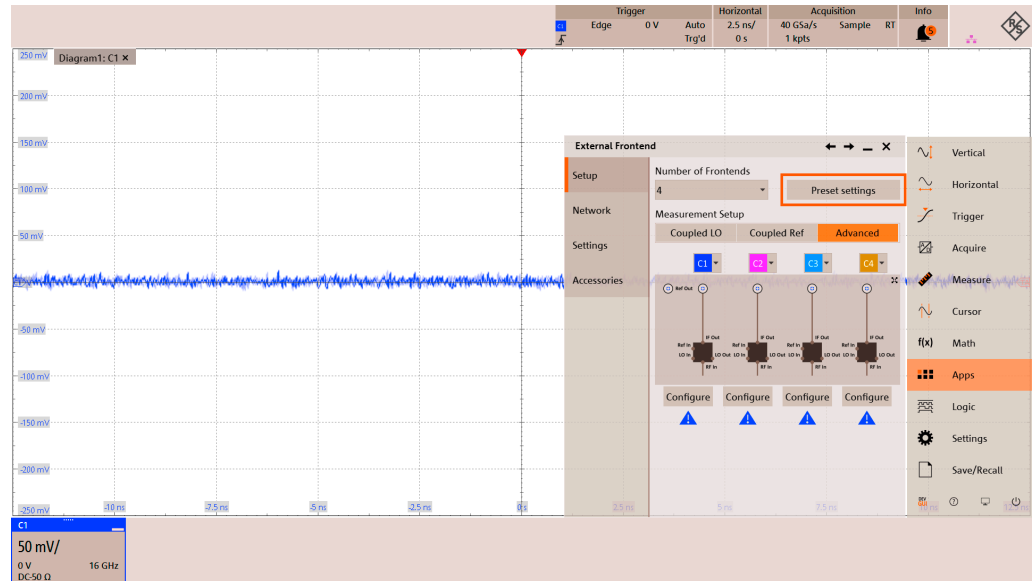
## 2.1 Preset

The FE dialog exhibits its own preset to prevent accidentally loss of settings when the Preset settings button is pressed. On regular preset, the FEs are switched off but the previously applied settings remain unchanged.

Use the dedicated preset settings of the FE to clear all settings in this application. This also frees up previously assigned network connections.

**Fig. 2: Preset condition for external FEs**

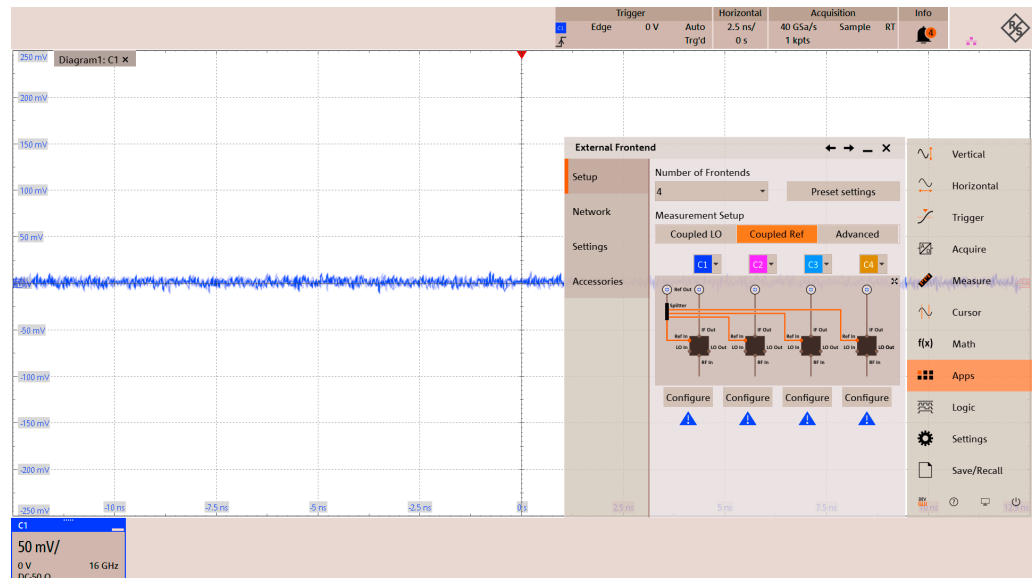
Connections can be configured with maximum freedom in the Advanced tab.



## 2.2 Setup

The Setup dialog provides easy configuration assistance for coupling local oscillators or reference frequencies. There are pre-populated flags and settings in the Settings dialog. The Advanced tab allows maximum freedom to customize of the FEs.

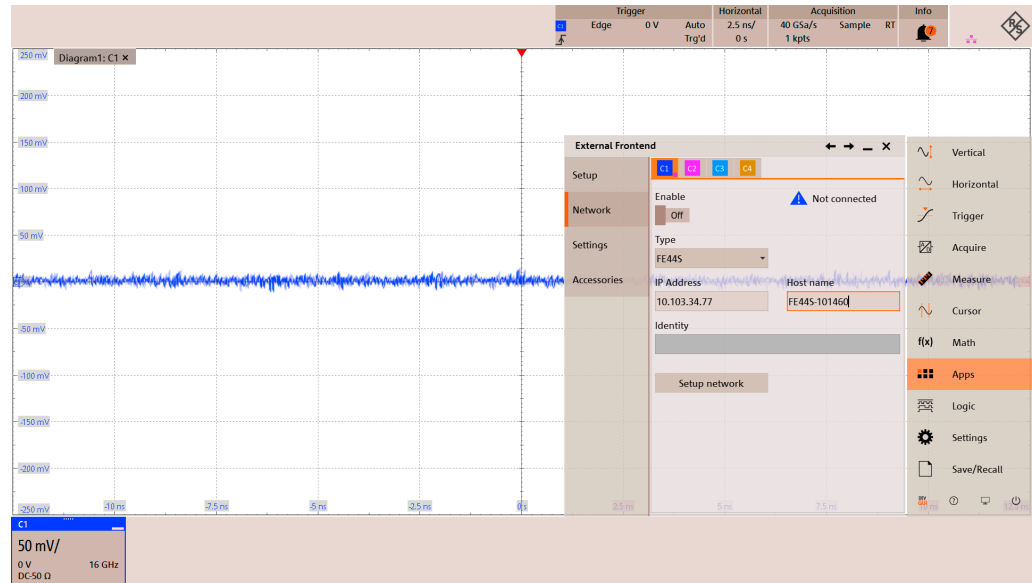
**Fig. 3: Predefined configurations are available to help setting up multiple FEs, e.g. for a coupled reference frequency**



The oscilloscope needs to create an Ethernet connection to the FE before detailed FE settings can be made. To establish the connection, enter either host name or IP address and press Enable. The initial connection to the FE may take up to 60 s as all the calibration data are read out. Once the connection is established, enabling the FE takes only a couple of seconds.

#### Fig. 4: Setting up an Ethernet connection to external FEs

The calibration data of the device is read-out once the type of FE and its network address are set.



# 3 SETTINGS

The Settings dialog is most important once a connection is established. The RF input frequency and the RF level define the incoming signal into the FE and must be adjusted accordingly.

While it is tempting to adjust vertical settings of the oscilloscope via the traditional vertical scale knob, the preferred method should be to optimize the level via the FE first. This method ensures that the oscilloscope stays at its best 50 mV/div setting.

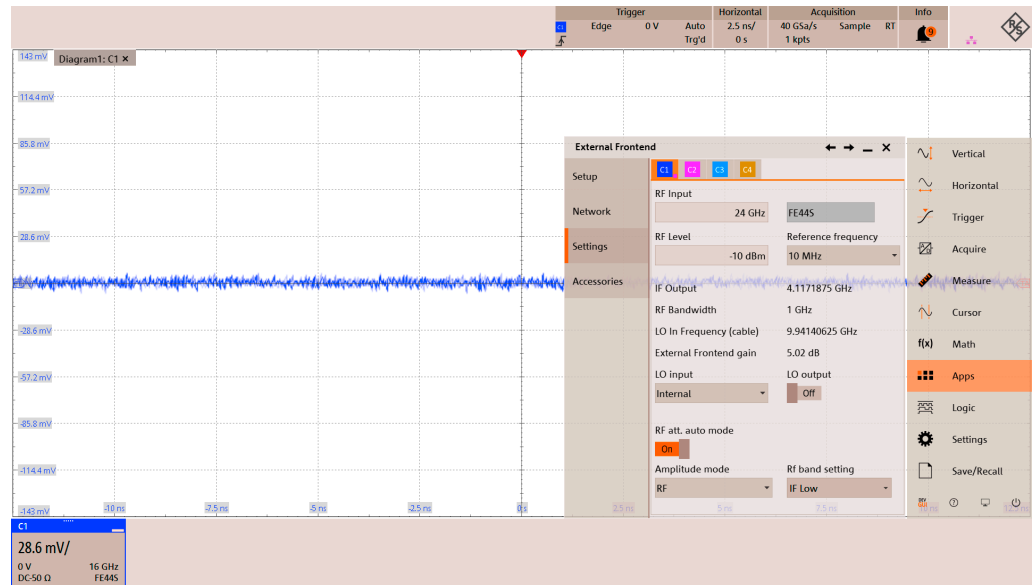
## 3.1 Amplitude mode

The vertical scale is calculated automatically via the gain settings of the RF level of the FE to provide accurate reading at the input of the FE (amplitude mode = RF, default). This is only a calculation; the default physical input vertical scale is 50 mV/div.

For debugging reasons, it is also possible to switch to an oscilloscope centric mode (amplitude mode = IF) to investigate the IF signal in detail. In this mode, the IF signal is shown with the correct vertical scale of the oscilloscope.

**Fig. 5: Main settings dialog for the FEs**

Expected RF level and input as well as reference frequency can be set. The dialog also shows additional parameters of the FE depending on the input settings. At the bottom, the amplitude mode (RF or IF) can be set.



## 3.2 LO input and output

The settings for LO input and output are either predefined from the setup dialog or can be freely selected in the advanced mode. It is also possible to select an external LO input for an FE controlled by the R&S®RTP high-performance oscilloscope, for instance. The FEs are unaware of the actual physical connection; thus, the LO input may originate from an FE controlled by a signal generator.

## 3.3 Reference frequency

If an external LO is not available, the FE needs to generate its own LO by means of an external reference frequency. The R&S®RTP high-performance oscilloscope supports 10 MHz as reference output. However, for scenarios from which the physical reference frequency originates from a signal generator it is possible to select other frequencies as well.

# 4 FREQUENCY RESPONSE CORRECTION

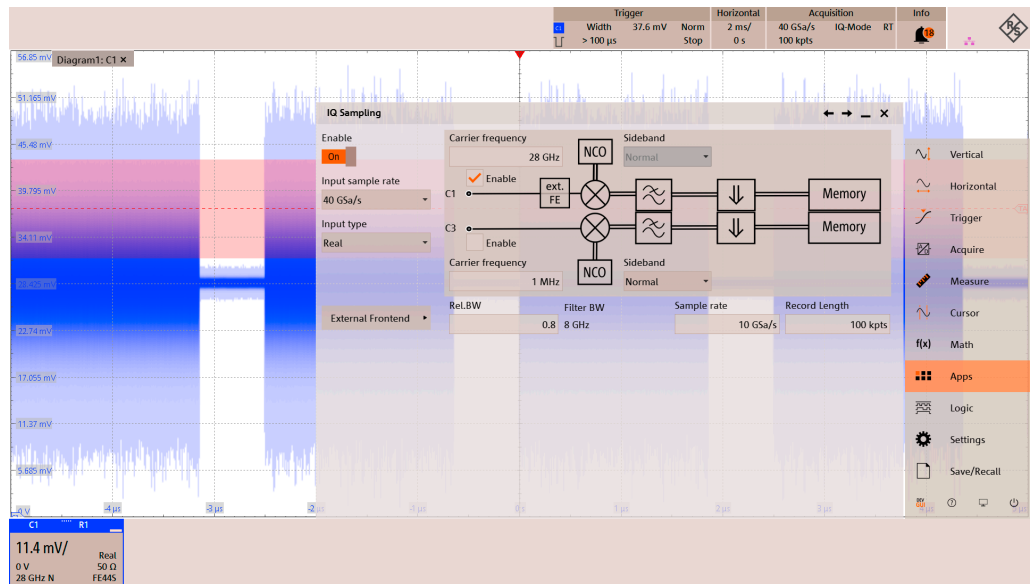
FEs are factory calibrated for amplitude, and for the R&S®FE44S and R&S®FE50DTR external frontends phase is also calibrated. To apply the correction data, either the deembedding option or the I/Q option is needed.

## 4.1 I/Q option

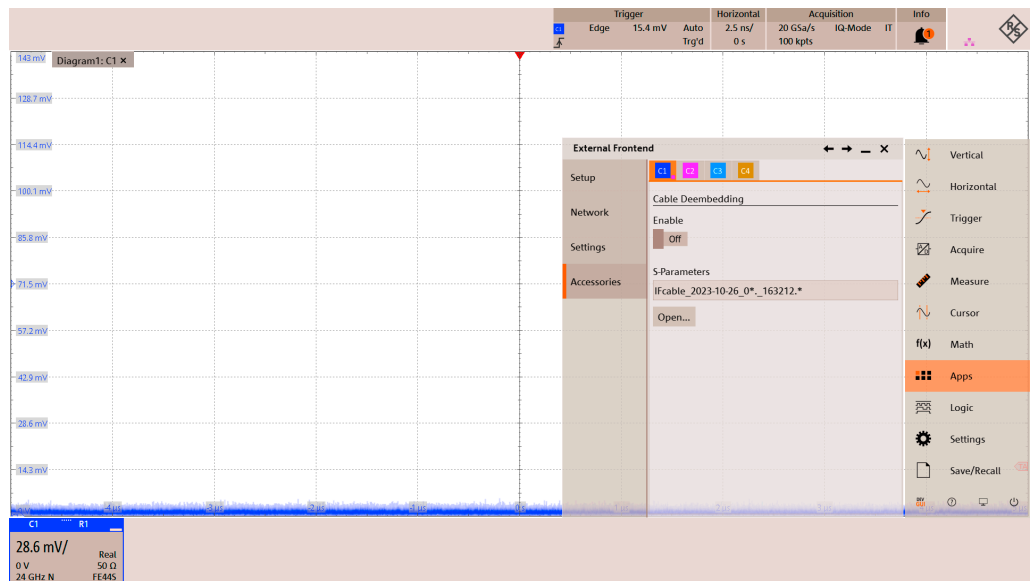
When an FE is connected and the I/Q option is selected, the corresponding channel is automatically adjusted by the calibration data of the FE.

The characteristics of an IF cable can be deembedded via the Accessories tab because the regular deembedding option is blocked when the I/Q option is active. The dialog provides general calibration data for the shipped cables.

**Fig. 6: FEs are automatically taken into account in the configuration screen of the I/Q option**



**Fig. 7: Cable deembedding can be enabled in the Accessories tab of the FE menu**



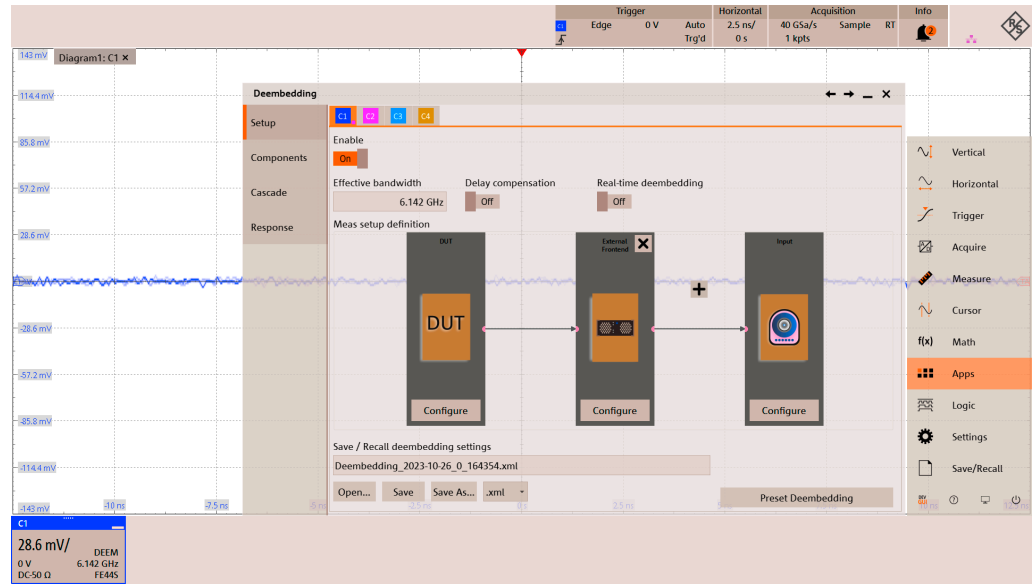
## 4.2 Deembedding

When an FE is connected, deembedding is straightforward. The dialog is prepopulated with the corresponding FE. The effective bandwidth is set automatically to the center frequency + bandwidth/2 of the FE. Additional components can only be addressed on the IF side of the FEs.

Real-time deembedding is not supported because the calibration data is too large for real-time calculation.

**Fig. 8: Deembedding dialog with external FEs**

The effective bandwidth is set automatically.





# 5 SPECTRUM ANALYSIS WITH THE R&S®RTP HIGH-PERFORMANCE OSCILLOSCOPE

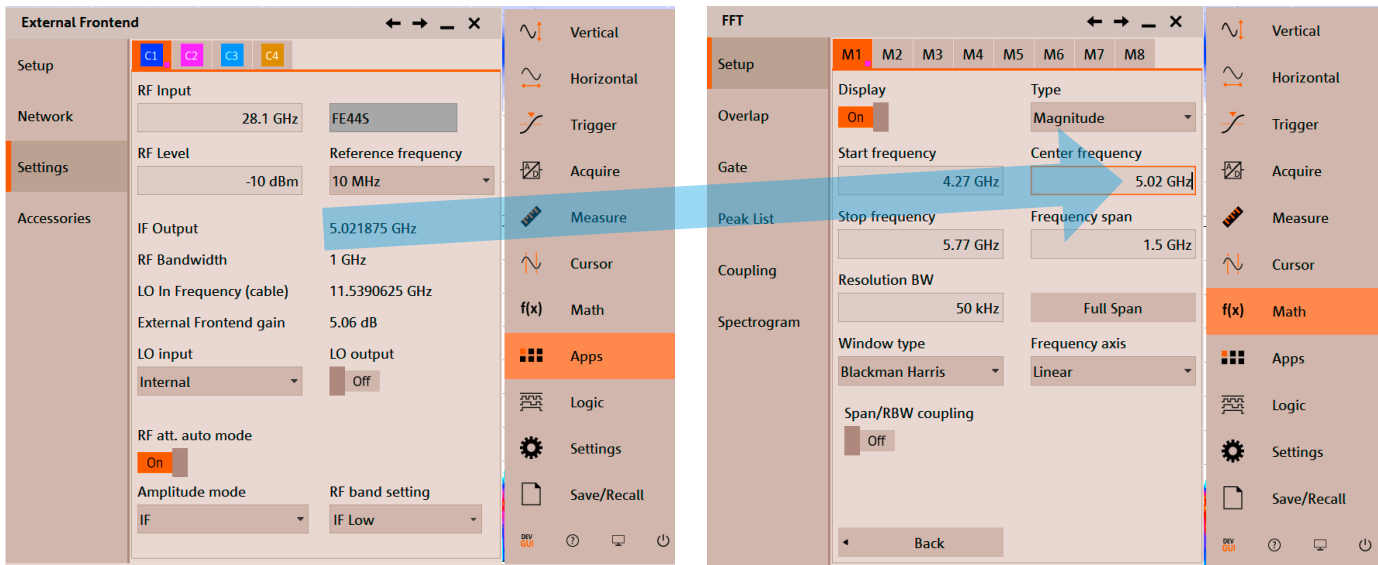
R&S®RTP oscilloscopes feature a fast and responsive FFT on up to four channels in parallel. This allows an easy start for spectrum analysis of the high frequency signals which are downconverted by the FEs.

## 5.1 Set up of an FFT

Once the signal is configured in the FE dialog (most importantly the expected RF frequency), a spectrum is easily configured.

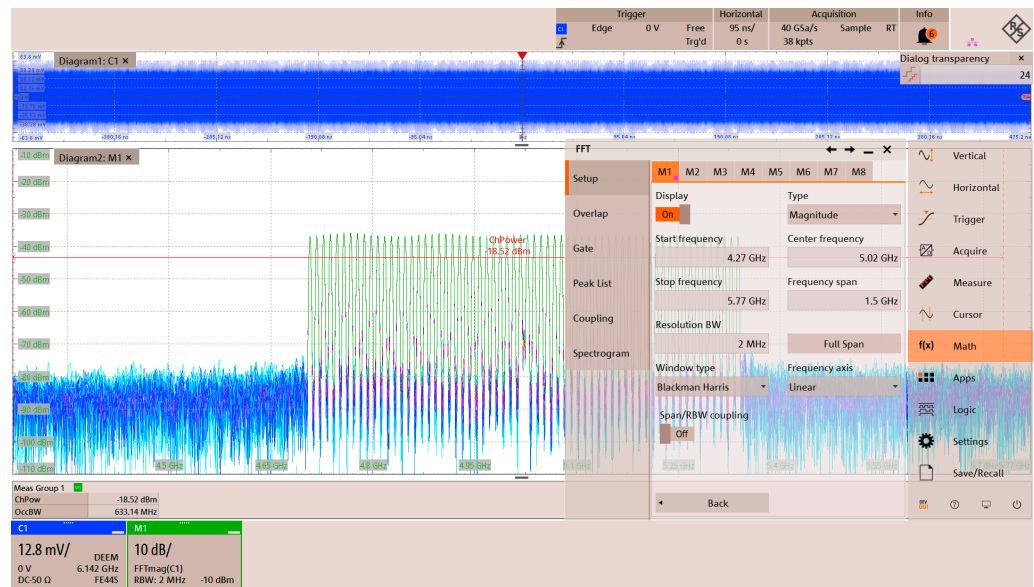
The expected IF frequency is shown in the Settings dialog of the FE. This frequency is the starting point for the center frequency of the spectrum. Frequency span can be chosen freely but because the R&S®FE44S exhibits a bandwidth of 1 GHz, a slightly higher span is recommended.

Fig. 9: At 28.1 GHz the expected IF frequency is at approximately 5.02 GHz, which is the center frequency for the spectrum.



The control of the RBW automatically updates the timebase setting. Parameters such as Window type, FFT overlap, gating and scaling parameters can be optionally configured.

**Fig. 10: FFT setup of a 28.1 GHz multi-carrier signal with R&S® FE44S external frontend**



# 6 SIGNAL ANALYSIS WITH THE R&S®VSE VECTOR SIGNAL EXPLORER SOFTWARE

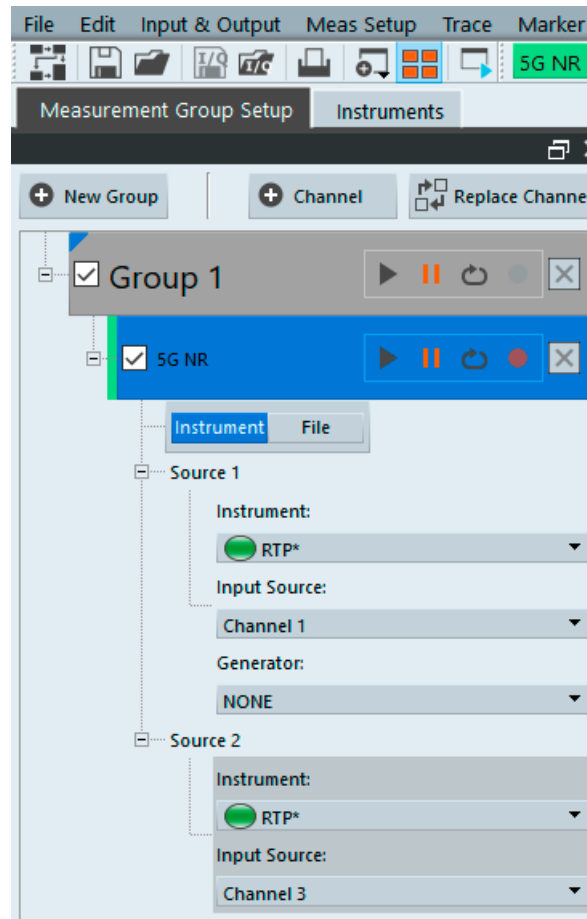
R&S®VSE application software enables powerful vector signal analysis with the R&S®RTP high-performance oscilloscope. The R&S®VSE software runs directly on the R&S®RTP or an external PC.

## 6.1 Setup of the FE

Start by configuring the FEs on the R&S®RTP as shown in previous sections. The initial settings (e.g. LO coupling) are read out by the R&S®VSE. Dedicated settings such as level and RF frequency can be changed later.

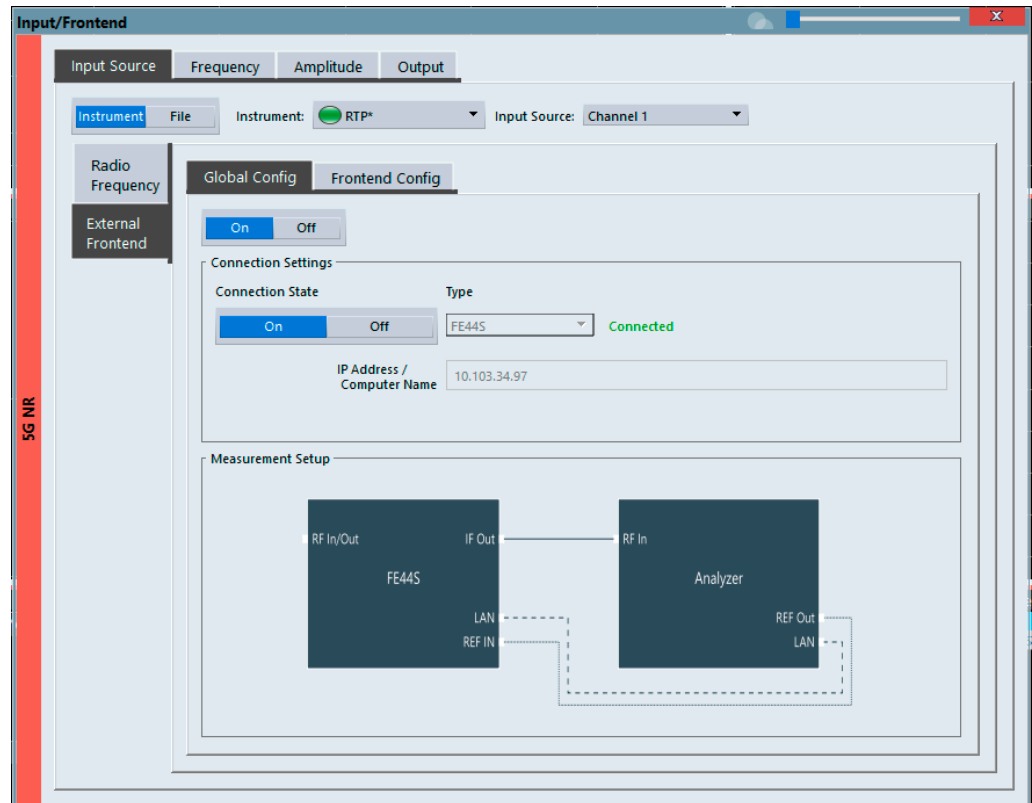
Start the R&S®VSE software from the R&S®RTP app cockpit or as standalone software on a connected PC. Connect the R&S®RTP in the Instruments tab, select a dedicated application (e.g. 5G NR) and then the respective input sources of the R&S®RTP.

**Fig. 11: Configuration of channel sources**



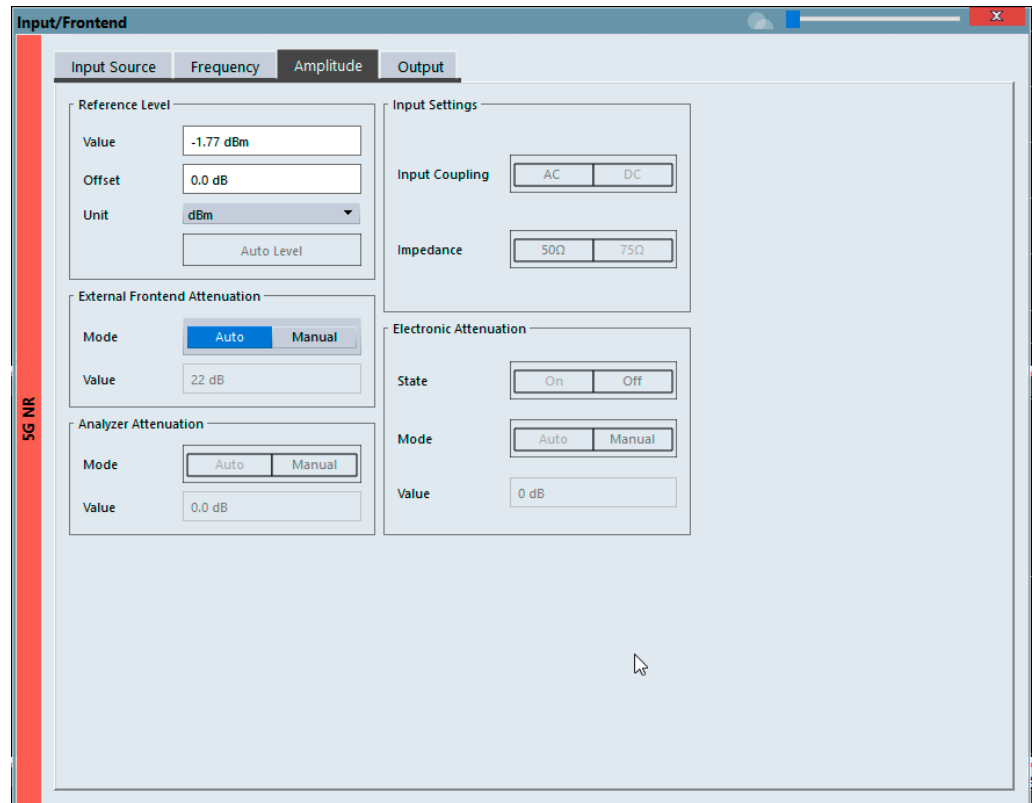
Next, configure the FEs for the selected channels. If they have already been configured in the R&S®RTP dialog, simply switching Global Config to On and Connection State to On is sufficient.

**Fig. 12: Configuration of the FEs**



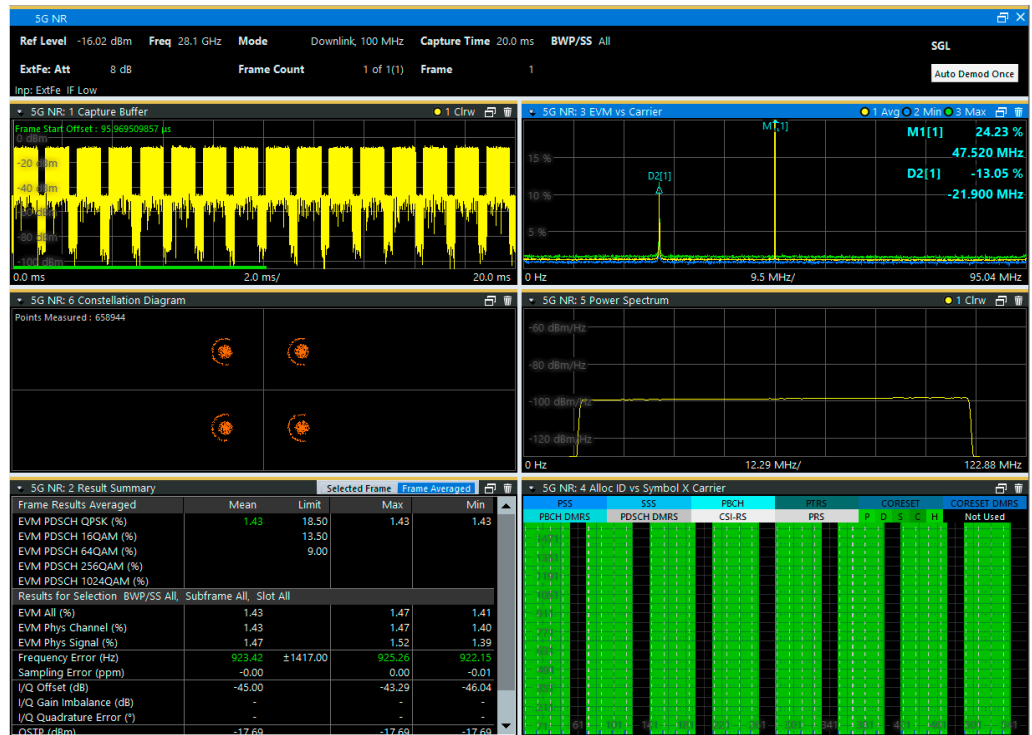
The next step is to set the center frequency and the amplitude of the channel in the corresponding tabs.

**Fig. 13: Setting the center frequency and amplitude**



Finally, start the acquisition of the waveform and perform the signal analysis. An example of a 5G signal analysis is shown below.

**Fig. 14: Example of a 5G signal analysis at 28.1 GHz with the R&S®VSE-KT144 5G uplink and downlink measurement application option**





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