Oscilloscope for complex measurement tasks and multi-domain applications

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Developers of electronic designs want to perform complex measurement tasks quickly and successfully. And they also want to do so with a powerful, highly versatile and intuitive lab oscilloscope. The new R&S RTO2000 oscilloscope gives them what they need.

Figure 1. Engineered for multi-domain challenges: the new R&S®RTO2000 oscilloscope

■ The new R&S RTO2000 oscilloscopes offer excellent signal fidelity, up to 16-bit vertical resolution and high acquisition rates in the 600 MHz to 4 GHz class. A broad range of tools along with user-friendly operation and documentation functions facilitate time-correlated analysis of the wide variety of signals found in embedded designs.

The staggering need for costefficient and powerful communications and control electronics for industry, motor vehicles and the entertainment and smart home sector is driving the integration of electronic circuits. These advanced embedded designs integrate a variety of functional units and technologies. The processor, power management, digital communications interfaces, local program memory, data memory and sensors all operate in the smallest of spaces. The next integration step is radio modules. The variety of signal waveforms is quite large, ranging from RF radio signals, analog signals from sensors or protocol-coded signals from the control interfaces (figure 2). This complexity represents a challenge for developers because highly integrated designs are significantly more prone to mutual interference. Undesirable interactions must be eliminated with an exact time reference at the system level. Therefore embedded designs, i.e. the large-scale integration of components based on a variety of technologies, represent the greatest T&M challenge in development and service today. These demanding measurement tasks require intelligent solutions such as those offered by the new oscilloscope, the all-in-one test instrument for multi-domain applications. Its comprehensive toolset includes functions for time, frequency, logic and protocol analysis – a variety that in the past required several single-purpose test instruments.

The low-noise front-ends and high-resolution A/D converters allow the analog input channels to perform highly accurate measurements in the time domain across a large dynamic range. Users benefit from reliable results, whether performing easy voltage level checks over time or specialized measurements such as jitter analyses on clock or data signals or power analyses on switched-mode power supplies. The 16 digital channels extend the oscilloscope test resources, e.g. to precisely measure the logical level (high, low) on digital interfaces over time. Even timing errors in parallel interfaces are quickly detected. The many tools for analyzing protocol-based serial interfaces provide a broad spectrum of trigger and decoding options for a variety of standards, including I2C, SPI, USB and Ethernet. The oscilloscope allows both analog and digital channels to be used for protocol decoding. And it uses its hardware-assisted protocol triggering to reliably and quickly trigger on details such as addresses or data.

Even in situations where spectrum analyzers are the first choice for precise measurements on radio interfaces, the oscilloscope is highly suitable for acquiring radio signals thanks to the high dynamic range of its analog channels. When testing at the system level, the channels deliver a precise time correlation to the other functional units in embedded designs. Figure 3 shows the variety of measurement options in an Internet of Things (IoT) application with a Wi-Fi radio module. Channel 1 (yellow) acquires the Wi-Fi signal and displays it in the time domain. However, the signal waveform is not clearly recognizable until it is viewed in the spectrum (Math4). Channel 3 (orange) shows how the radio activity affects current consumption. The timing of the USB interface control commands is also visible. A decoding option decodes the signals acquired on channels 2 and 4 (green and blue) into readable USB data.

Once the initial functional tests on the electronic design are completed, circuit optimization starts. For mobile applications, minimizing current consumption is paramount. This requires a measurement instrument that can resolve low currents down into the 1mA range while also correlating the tim-

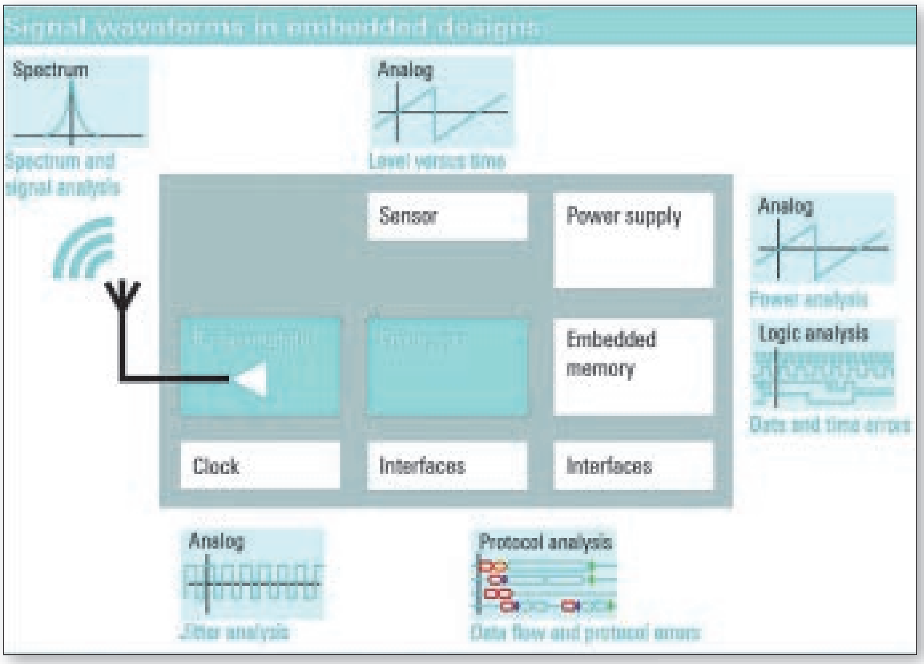

Figure 2. Example of a multi-domain application – IoT module with Wi-Fi radio module, battery-operated power supply and USB interface

Figure 3. Multi-domain application in a state-of-the-art embedded design: analog measurements in the time domain, measurements in the spectrum as well as protocol and logic analysis

ing of current changes to switching activities, e. g. when transmitting radio sequences or entering power save mode. The large dynamic range and high sensitivity of its analog input channels make this oscilloscope suited for measuring low voltages and currents. A sensitive current probe can measure currents down to 1mA at 120 MHz bandwidth. In HD mode dynamic variations as small as 100 µA can be resolved. Using an analog channel to perform current measurements provides a fixed time reference to the other measurement signals. Figure 4 shows an example of a current probe in channel 3 (orange) measuring a current of 1.7mA during a sleep sequence. The current consumption is correlated with the radio signal output on channel 1 (yellow) and the system activity at the UART interface. During the sleep sequence, the module does not transmit any radio signals, but it receives regular paging signals from the base station. The current consumption briefly increases to 105mA and the module transmits a UART-coded communications signal on the clear-to-send (CTS) line, which is acquired with a digital channel.

The powerful FFT-based spectrum analysis function on all analog input channels opens up additional possibilities, e.g. analyzing radio signals, EMI debugging to find interferers in the spectrum or spectral analysis of power supplies. In contrast to conventional

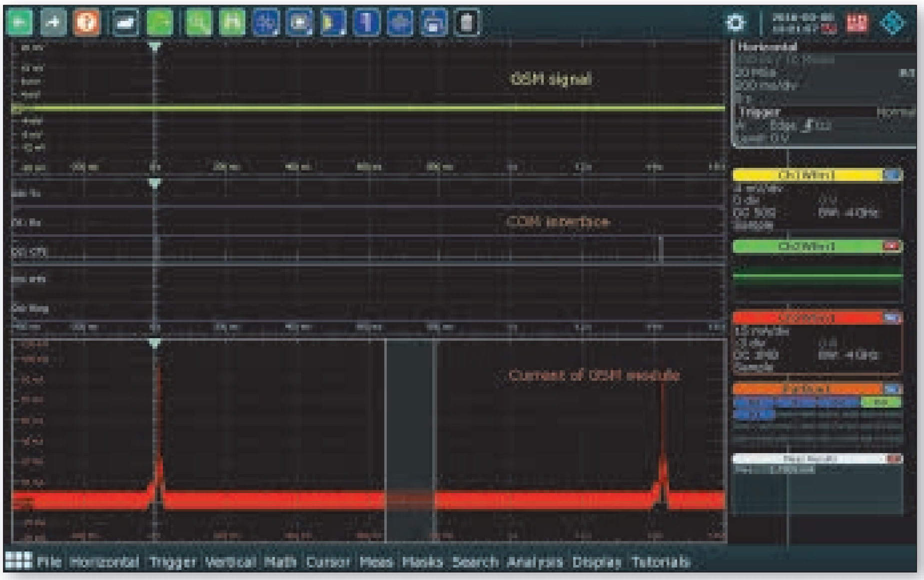

Figure 4. Measurement of the current consumption of an embedded design in sleep mode. The base station remains in contact with the GSM radio module via paging (short current pulses).

FFT implementations in oscilloscopes, the R&S RTO2000 achieves a greater resolution and display speed with its digital downconversion (DDC), in which the FFT calculation can be limited to a selected frequency range. User-friendly functions such as automated measurements, peak lists, maximum hold detectors and mask tests support debugging in the spectrum. One unique characteristic is the spectrogram, which visualizes the changes in frequency components over time.

Another unique function is the new zone trigger, which can be used to graphically differentiate between events in the time and frequency domains. Up to eight zones of any shape can be defined and logically linked as trigger conditions. A trigger is initiated when test signals intersect defined zones or when those zones are not touched. This makes it possible to detect interferers in the spectrum during EMI debugging or to separate read and write cycles in memory controllers. The example in figure 5 shows how the zone trigger is used in the spectrum to measure the current and voltage load during a GSM radio burst.

The basis for the high degree of sensitivity and dynamic range offered by the R&S RTO2000 are the low-noise frontends and the proprietary 10GHz single-core A/D converters. The minimum effective noise of <100µV, the A/D converters' more than seven effective bits (ENOB) as well as the channel-to-channel isolation of >60dB are just a few examples. Such characteristics make the analog channels ideal for analyses in the frequency domain as well as for measurements in the time domain. Investigating signal details often requires a higher vertical resolution. The oscilloscope achieves up to 16 bits in high-definition (HD) mode. In HD mode, high-quality, adjustable low-pass filters downstream of the A/D converter limit the signal bandwidth. The user can select the appropriate combination of resolution and bandwidth. Even the digital trigger system benefits from the high resolution in HD mode and can trigger on the smallest of signal details.

The oscilloscope offers not only high-performance analog signal processing. It also features powerful digital signal processing based on a proprietary ASIC. Its fast parallel signal processing is clearly superior to external PC-based postprocessing. The oscilloscope acquires, processes and displays up to 1 million waveforms per second, even when histograms, masks or cursor measurements are running. This capability, which is unique in the lab oscilloscope class, is the key to fast and successful detection of sporadic errors. The acquisition memory can be extended up to 2 Gsamples, also unique in this class. Sufficient memory is available for acquiring long pulse or protocol sequences. The history function also benefits from this memory depth because more waveforms are available for detailed analyses.

The oscilloscope is versatile enough to adapt to specific applications. 2-channel and 4-channel models are available with bandwidths of 600 MHz, 1 GHz, 2 GHz, 3 GHz and 4 GHz plus optional acquisition memory upgrades. Bandwidth upgrades are available for all models. All hardware options, including the digital channels for logic analysis and a 10 MHz OCXO reference clock, are plug-ins that can be installed on-site. For specialized tasks, software options can be enabled on the oscilloscopes at any time. Available software options include, for example, triggering and decoding options and automated compliance tests for serial interfaces, as well as options for jitter, power and spectrum analysis.

In spite of its power and functional range, the instrument remains extremely easy to use thanks to its brilliant 12.1“ touchscreen. The R&S SmartGrid function ensures that all waveforms and other information are clearly and understandably displayed. Important tools such as cursors, measurements and undo/redo are on a toolbar for quick access.

The app cockpit provides access to applications such as the triggering and decoding functions, compliance and signal integrity tests, I/Q analysis and even customer-specific development tools. The R&S RTO simplifies documentation of measurements. Screenshots, waveforms, events and instrument configurations can be stored with a simple press of a button. ■

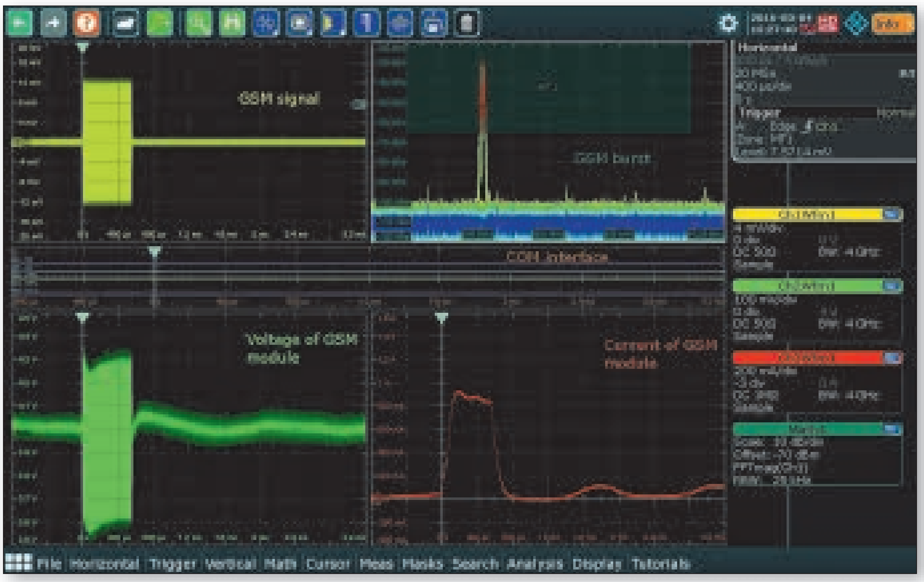

Figure 5. The zone trigger in the spectrum focuses the measurements on the GSM burst signals.