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Measurement and Monitoring Essentials

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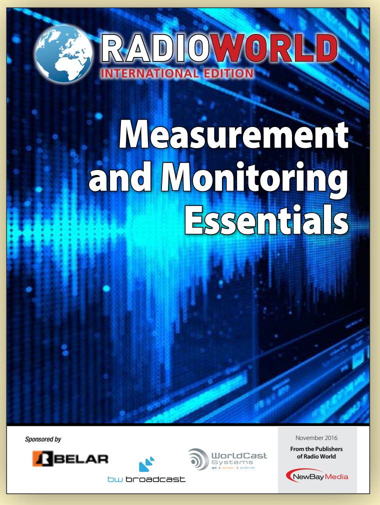

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Measurement and Monitoring Essentials

Marguerite Clark
Editor in Chief

Measurement and monitoring tools are a fundamental part of radio broadcasting. And today with an increasing number of organizations required to reduce human resources and expenses, it is more important than ever for broadcasters to be able to rely on equipment and system architecture capable of withstanding present and future challenges.

This newest Radio World eBook offers the essentials on how to maximize test, measurement and monitoring gear and procedures. It offers advice on how to best select a device appropriate to a specific requirement, provides insight on typical architectures and workflow along with explaining how quantitative assessment can raise the quality and efficiency of radio broadcasts. "Measurement and Monitoring Essentials" features information from Norway, Germany and Italy on ways in which broadcasters are implementing various techniques for FM and DAB+ networks, and more.

Radio World has published more than two dozen eBooks exploring the many facets of radio station and network operations including digital radio, sports coverage, mobile reporting, studio/transmitter links, social media and more. Find them at radioworld.com under Resources.

Let us know about how we can make these handy reference guides more useful to you.

— Marguerite Clark

The Specifics of Test, Measurement and Monitoring

Quantitative assessment raises quality, efficiency of radio broadcasts, benefitting both operator and listener

by **Davide Moro**

BERGAMO, Italy — What exactly is "test, measurement and monitoring" and how does it fit into the world of broadcasting?

For radio applications, test and measurement means assessing the performance of equipment and systems through the quantitative evaluation of key parameters.

The comparison of measurement results against specific threshold values then guides operators in determining whether the item being tested is adequately fulfilling its intended purpose. All equipment needs to comply with applicable regulations and with the broadcaster's specific requirements, including expected price versus quality ratio.

PERFORMANCE ENABLERS

After the initial acceptance test, broadcasters need to include periodic equipment checks. They also need to be able to respond in the case of a malfunction.

Fortunately today most test gear available on the market offers a high degree of accuracy in a compact size and can thus be used in the field or at the laboratory. For the most part, these new devices feature quality RF or A/D front-ends and dedicated IT-based software and allow the integration of a number of features and measurement capabilities within the same portable device.

Test and measurement devices are performance enablers. Not only do they speed up laboratory activities, field engineers now rely on a nearly universal toolbox in order to detect and assess almost any operating parameter in a single visit. Just one user interface lets operators perform various measurements and not have to worry about familiarizing themselves with different layouts, button and measurement sequences.

Monitoring is the process of iterating the quantitative performance assessment of equipment and systems at given times, or even continuously. Provided an item properly performed during the latest scheduled "test and measurement" check, a monitoring process periodically tracks and records key performance indicators of the same item under usual operating conditions.

Test and measurement devices are performance enablers. Not only do they speed up laboratory activities, field engineers now rely on a nearly universal toolbox to detect and assess almost any operating parameter in a single visit.

A basic monitoring system aggregates the alarm status messages from various equipment within a network and delivers the messages to appropriate staff.

A more refined monitoring system calculates and records performance parameters. A sudden RF power out drop by 10 percent will most likely not seriously affect the potential coverage footprint of a transmitter but it could indicate the improper operation of a power supply unit. RF power output level that decreases by 1 percent each day probably needs to be further investigated. Abnormal room temperature might indicate the need to clean air filters, for instance.

David Chambers, CTB

Field measurement activities in the Okawango Delta region of Botswana.

OPTIONS

A top-level monitoring system also comprises the collection of measurements and values from monitoring stations located within the target service area, thus assessing the quality of service. Even if a single part of one's network is performing at its best, an interfering signal could prevent an entire city from receiving the relevant broadcasts.

As a further example, an antenna system could suffer from a sudden tilting variation. No monitoring system with detectors located within the network premises will be able to detect this kind of impairment.

Finally, the advent of digital broadcasting requires broadcasters to continuously monitor parameters not applicable to analog broadcasting. A digital radio network operating in single frequency network mode, for instance, requires continuous time and frequency alignment among transmitters that cover the same portion of target locations.

SFN drifts can seriously impair or even prevent reception within large parts of the service area, and can only be measured and detected within the relevant zone. A well-designed data aggregation system will correlate the various measurement records and immediately notify users of any possible incoming impairments.

Davide Moro reports for Radio World from Bergamo, Italy. ■

SWR Strives for Standardization

The German public broadcaster tasked itself with defining unified measurement procedures and test equipment for its entire network

by **Davide Moro**

STUTTGART, Germany — Südwestrundfunk is a regional public broadcasting corporation serving the southwest of Germany, specifically the federal states of Baden-Württemberg and Rhineland-Palatinate. Part of the ARD consortium of public broadcasters in Germany, SWR produces content that is broadcast on six FM radio channels, four DAB+ multiplexes and a DTT multiplex.

Covering 55,600 square kilometers and reaching some 14.7 million people, SWR is (after Westdeutscher Rundfunk) Germany's second-largest broadcaster. It was established in 1998 through the merger of Süddeutscher Rundfunk and Südwestfunk.

Photos courtesy of SWR

SWR has headquarters in Stuttgart (pictured), Baden Baden and Mainz.

TRANSMITTERS

SWR today operates a network of about 420 FM, DAB+ and DTT transmitters. After the initial acceptance test, and apart from the usual maintenance, SWR personnel run a performance check test on each transmitter every year.

Uwe Krüger, SWR's Transmitting Systems supervisor, explains that before the digital transition, the broadcaster used Rohde & Schwarz FMAB modulation analyzers to measure its FM transmitters. SWR technicians fed each transmitter being tested with a reference MPX signal from a calibrated signal generator, which included a stereo generator and an RDS coder. Through a directional coupler and, in some cases, additional attenuating devices, they connected the FMAB to the transmitter output and subsequently performed the required measurements.

But with the analog to DTT digital switchover, which was completed in 2008 in Germany, SWR began using the Rohde & Schwarz ETL signal analyzer as its tool of reference. "Since SWR is the result of the merger of two independent broadcasters, we needed to operate all of our DTT transmitters in a standard way. For this reason, we standardized our measurement procedure so that all technicians could use the same systems and methods," Krüger added.

When SWR people began using the Rohde & Schwarz ETLs for DTT, the meters quickly became the obvious choice for FM and DAB+ measurements too. Dedicated software options (in some cases a hardware upgrade) allow the end-user to tailor each ETL to his or her specific needs.

"The FMABs were reaching the end of their operational life, many of them were more than 20 years old," he said. "We needed to find a suitable replacement for the FMABs. We valued the overall performance of the ETL and wanted to streamline our systems throughout the corporation by using a single measurement tool able to work in any standard, so we went with the ETLs for FM and DAB+ too," Krüger said.

SWR technicians still need a reference signal generator in order to test the FM transmitters, but at the same time they can use the same instrument they utilize for

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Uwe Krüger uses Rohde & Schwarz ETL signal analyzer to test the Plisch DAB+ transmitter installed at the broadcaster's Witthoh site (close to the border between Germany and Switzerland).

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testing the — often — collocated DTT ones. Once a year SWR performs a complete check on each FM transmitter, including side deviation, S/N ratio, RF power, RF quality, the presence of harmonics and the distortion of the audio signal.

SINGLE FREQUENCY NETWORK

On DAB+ transmitters, performance tests include checking for the channel power, shoulder distance, in-channel and out-channel intermodulation, the harmonic, MER and a visual check on the BER level. Each FM site is equipped with a backup transmitter, so these scheduled controls cause no service interruption on the service area.

"Our DAB+ network is growing," continued Krüger, "so our DAB+ transmitters presently adopt 'dual drive' configuration. This requires us to briefly interrupt the service to the relevant target area when we carry out measurement on our RF amplifiers."

Like SWR's DTT network, its DAB+ network is designed and operated as a single-frequency network. Digital broadcasting standards typically allow specifically designed networks to provide coverage through the "constructive interference" of two or more "contributions" (signals coming from different transmitters and broadcasting the same content on the same frequency) at almost any point within the design service area.

DAB+ is no exception, allowing for stable and higher quality reception across long distances. SFN operation requires a very effective time and frequency alignment of each transmitter, which can be received at any possible point within the considered service area.

"Before, we used to run just a complete test on each transmitter on-site," said Krüger. "But the advent of SFN networks required us to ensure the synchronization of the various transmitters covering the same portion of any target area."

Hans Schad, test and measurement engineer at SWR, tests the Witthoh DAB+ transmitter, which transmits on Channel 8D.

While skilled operators can easily check the frequency alignment of any transmitter versus a given frequency reference while at the transmitting site, the time alignment of different transmitters can typically only be detected and checked in the field, within the service area of the considered transmitters.

SWR found the R&S ETLs were fit for this purpose too. "We can easily carry them onboard our testing vehicles, and again, one can use just a single meter to perform all the necessary items within our test procedures" Krüger added.

SWR knows the importance of accurate time alignment, particularly with regards DAB+ signals, and the broadcaster continues to study the best ways in which to monitor these signals, both in its facilities and in the field. "In-building receiving stations usually use omnidirectional antennas to receive all possible signals from any transmitter. On mobile testing vehicles we use directional antennas," Krüger concluded.

SWR produces statistics on the entire volume of measurements it collects every year. The broadcaster uses the findings to enhance its network efficiency and reliability. ■

Tech Updates

WorldCast's Audemat Stays in Control

The Audemat Control is a new, IP-enabled remote facility control unit from WorldCast Systems. It is specifically designed to offer users ease of use and maintenance.

The latest addition to the range of IP-enabled remote site control products, this platform offers a large number of input and output connections in a 1RU enclosure. It provides 64 digital inputs, 64 digital outputs, 24 analog inputs, four serial ports, two Ethernet ports, four USB ports, one audio output, one audio input and one modem. The voice modem offers DTMF capabilities for traditional remote notification and control.

In addition, the Audemat Control enables SNMP monitoring of multiple devices and provides the ability to listen to audio remotely. It also offers an audio backup solution to keep you on air in difficult situations.

The IP-enabled Audemat Control unit includes ScriptEasy software as standard. ScriptEasy is a tool that enables extensive customization of a site's monitoring activities as well as defining automatic actions to be taken upon user-defined conditions. It incorporates the MasterView web-based application that allows a user to create their own customized end-user views for simple aggregation and display of all relevant data as well as presenting action buttons to initiate common actions.

www.worldcastsystems.com

BW Broadcast Offers Single-Box Monitor

BW Broadcast's latest release, the ModMon Encore, combines the technology from its award-winning receivers with lab reference-grade audio processing technology to create a single box capable of analyzing both FM and baseband signals.

According to the company, the ModMon's time-aligned twin DSP tuners allow crossfading between two different radio stations for instant and accurate signal comparison. In addition, it says the "high-performing" DSP tuners have adaptive IF filtering and stereo improvement, with antenna diversity option, and that even under difficult conditions it will pick up weak signals with the best possible sound.

The dual MPX inputs allow crossfading between two different MPX inputs for instant comparison of two processors. BW explains that zero time pop-less switching between two audio processors makes it easy to get a true evaluation between the processors. In addition, it points out that the system's reference grade stereo demodulation gives performance stereo demodulation and separation, making it easy to listen to the left-right audio from a composite MPX input signal — or even two.

The firm says that anyone working with FM or MPX signal will find this product useful and easy to use. Receiving both RF modulation as well as FM signal in one unit makes it easier to make adjustments and prevent overmodulation.

www.bwbroadcast.com

Norway Tests DAB+ on the Water

As FM switchoff nears, Norwegian radio is checking digital reception everywhere — even at sea

Gunnar Garfors, NRK advisor, tests DAB+ reception.

Photo courtesy of Gunnar Garfors

By **James Cridland**

OSLO — Norway is famous for fjords and beautiful coastlines. The Scandinavian country has 25,148 kilometers of coastline, making Norway owner of the eighth-largest coastline in the world.

Norway has a large fishing industry, and they, like everyone else, listen to the radio. Radio reception can be a matter of ensuring the safety of the crew: Few small fishing boats have internet access, and public broadcaster NRK produces a weather radio station, NRK Vær, specifically made for those who work at sea.

ALL USERS

However, early next year, Norway becomes the first country to start switching off FM transmissions in favor of terrestrial digital broadcasting via DAB+.

Any switchoff of FM transmissions needs to consider all radio users — even those in fishing boats off the coast.

So, throughout the Norwegian summer, with temperatures hitting a balmy 50 degrees F (10 degrees C), three NRK engineers packed a variety of radio monitoring equipment including a few portable DAB+ sets and took to the waves.

"We wanted to see the how far from shore it's possible to receive signals, and the quality of them: DAB reception offshore is not an official requirement for us, but we wanted to offer it anyway," NRK's Head of Distribution Øyvind Vasaasen told me via email. "We also wanted to test various receivers, and to test antenna solutions on boats."

As long as a transmitter is well-situated and not shaded by buildings or mountains, a transmitted signal should travel quite far — though the curved surface of the Earth will eventually stop reception at 190–240 MHz, the frequencies being used for DAB. "We can't find evidence that fog or rain have any practical negative effects on the

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Photo courtesy of Jørn Jensen

Michel Gascoin, NRK advisor for distribution, checks the test gear on the boat.

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reception," Vasaasen told me, further highlighting the reliability of a good radio broadcast.

NRK Advisors Gunnar Garfors, Jørn Jensen and Michel Gascoin ran a set of tests from a number of locations off the Norwegian coast — in a variety of search and rescue boats piloted by the Redningsselskapet sea rescue group.

As ever with digital reception, the quality of the antenna made all the difference. An antenna made for cars didn't perform that well, nor did a split FM/DAB antenna. However, a specific marine antenna, made for DAB reception, performed excellently.

GOOD RECEPTION

"The reception was even better than our calculations predicted," said Vasaasen. "Our aim is to offer DAB reception 50 kilometers (30 miles) from the shore, and with the external, marine antenna this was always possible within this range corresponding to the coverage map and even much further."

The hero, though, was a small, battery-powered consumer DAB+ radio with a telescopic antenna. In a trip from the working port and tourist town of Ålesund, the Sony XDR-P1DBP received signals a staggering 132 kilometers (82 miles) from land.

One further discovery. Radio engineers don't always cope well with bad weather. Seasickness isn't fun at the best of times; but two of these trips, which lasted four and a half hours, were very stormy indeed.

However, for everyone working on what's inevitably been dubbed "FMexit," this was welcome validation of the coverage plan and reception characteristics of Norwegian's DAB+ transmission network.

On Jan. 11 at 11:11 a.m., the first of many FM transmitters will go silent in Norway, appropriately in the coastal town of Bodø. Radio-loving Norwegians should relax, safe in the knowledge that even if they're out fishing, they'll still be able to tune in.

James Cridland reports on the industry for Radio World from Brisbane, Queensland. ■

Photos courtesy of Gunnar Garfors

One of the boats used for testing.

NRK Distribution Advisor Jørn Jensen tests DAB+ signal distance on the water.

The Evolving Role of the Modulation Monitor

Rise of digital breathed new life into the mod monitor's value to RF performance

by **Mark Grant**

The author is CEO of manufacturer Belar Electronics.

The modulation monitor has a reputation as an obscure component in the RF chain, and there is truth behind the statement.

For decades, engineers generally installed the box and left it alone, revisiting it for an occasional cursory glance at the front panel, along with the odd troubleshooting need around signal performance.

However, the rise and proliferation of digital media and technology in the air chain have breathed new life into how the modulation monitor can bring value to RF performance. Stations are mixing analog and digital information into the same channel streams, creating new challenges in signal separation. HD Radio technology itself brings new challenges and requirements for both compliance and performance.

As modulation monitors become more software-defined and IP-connected, both vendors and broadcast engineers are able to address these emerging needs more easily. In this article, we'll address the various emerging challenges in the RF air chain, and how the modulation monitor is evolving and adapting to these needs for the benefit of the broadcaster.

ANALOG AND DIGITAL SEPARATION

The separation of analog and digital signals at the modulation monitor quickly is becoming a common application.

Hybrid analog/digital signals containing HD Radio carriers gradually have been introduced into the RF chain. Broadcasters quickly recognized that a significant amount of self-interference was introduced into the total modulation measurement as a result.

That interference raises the modulation levels, which makes it difficult to attain an accurate total measurement in the presence of HD Radio carriers. This often forces broadcasters periodically to turn off HD Radio carriers to achieve an accurate total measurement; or, in the presence of high-level combined system that combines separate analog and HD Radio transmitter signals into a single antenna, assign analog monitors to the analog transmitter. The latter option enables the broadcaster to generate a total analog reading without an HD Radio presence.

However, there are significant detriments to both of these approaches. Shutting down the HD Radio carrier also kills the on-air audio and data, alienating the already scant HD Radio listening audience. The second option works well in theory, but is useful for only a minority of broadcasters since far more systems are low-level combined.

Low-level system configurations can natively produce both an HD Radio and analog signal presence in the same stream, making it possible for broadcasters to separate the two signals inside the mod monitor. This brings the benefit of recovering accurate total readings in the presence of the HD Radio carriers.

From monitoring mixed analog and digital signals to time-aligning digital and analog signals, the modulation monitor offers engineers more value today than ever.

This process has become much more difficult with the FCC-approved increase in HD Radio sideband power to a maximum of –10 dB. Noise and interference in the total measurement rise as the HD Radio carrier power is raised.

The evolution to a more software-defined architecture for the modulation monitors has built a foundation for incremental enhancements, including filtering and peak weighting, which improves total measurement accuracy. This is significant because there are few positions in the air chain to successfully apply filtering. The first strategy is to apply filtering on the actual RF spectrum, before being fed into the FM demodulator. This application adds a bandpass filter, which passes roughly plus or minus 100 kHz. That process suppresses the HD Radio sidebands so that the FM demodulator sees only the analog signal.

The downside is that distortion is created while

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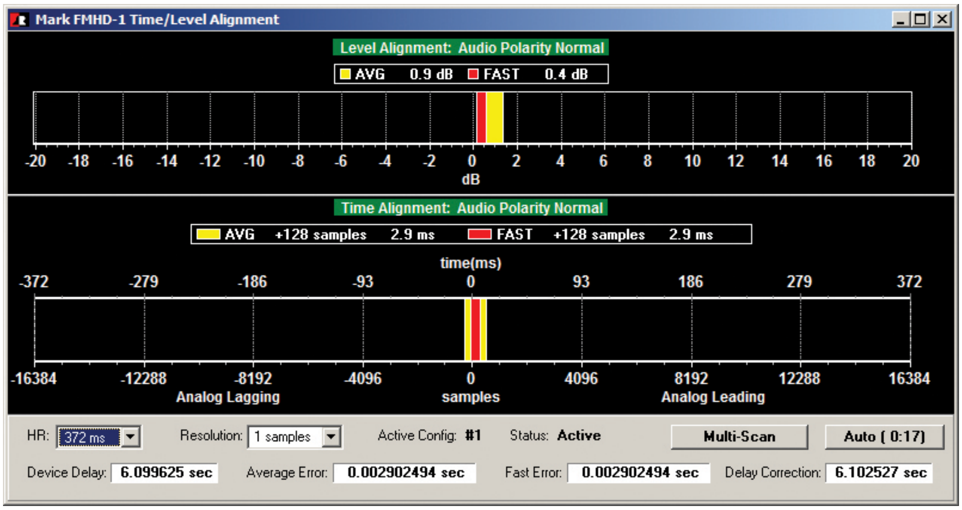

Fig. 1: The time alignment screen shows current device delay and calculated delay correction to be applied.

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band-limiting the FM signal, which causes errors in the measurement. However, those errors are usually far less significant to the total measurement compared to the HD Radio sideband-influenced modulation increases.

The second filtering point follows the FM demodulator, where the composite baseband signal exists. It is possible to band-limit the signal at this stage. In a typical analog configuration, the signal may contain SCA subcarriers, requiring a minimum 100 kHz bandwidth. Upon removing the SCA subcarriers from the air chain — which is increasingly more common — the bandwidth of the composite filter can be significantly reduced. This is achieved by bringing the 100 kHz bandwidth down to 57 kHz, which allows for passing only the RDS subcarrier. With everything but the RDS eliminated, the broadcaster wipes out as much as 50 kHz from the spectrum, along with a significant amount of noise — thus, lowering the total measurement.

An example that demonstrates how self-interference affects total readings at HD carrier power levels of –10 dB, –14 dB and –20 dB using the Belar FMCS-1 with its variable RF and composite filtering is in Table 1.

A third possibility is to apply a peak weighting algorithm on the total measurement after the RF and composite filtering. This further reduces the total measurements by eliminating some of the higher-frequency peaks. By removing those peaks, the broadcaster can bring down the total modulation. This is especially useful when monitoring signals off-the air.

Broadcasters with a sizeable noise floor can remove most of these undesirable artifacts from the HD Radio signal through an intelligent and thorough filtering strategy. By building composite filtering and peak weighting algorithms into the mod monitor, broadcast engineers more easily can make measurements in the presence of HD Radio carriers at higher power levels.

EFFECTIVE POWER MEASUREMENT

The FCC's power level increase approvals over the years (–20 dB to –14 dB, and subsequently, –10 dB) have magnified the need to effectively measure HD Radio power levels for compliance. The FCC mandates a defined ratio between analog FM signal power and HD Radio carrier sidebands.

Spectrum analyzers have traditionally been used for power ratio measurements, which communicate the power vs. frequency relationship of hybrid RF signals. In addition, the FCC and NRSC have specified an RF frequency mask for RF emission compliance. (For a fuller discussion of the measurement techniques, RF mask compliance and HD Radio carrier sideband power, refer to NRSC-G201-A and G202 documents.)

Sometimes, when HD Radio sideband power elevates interference to unacceptable levels, the RF mask needs to be adjusted based on the different upper and lower sideband power. This encompasses asymmetrical distribution. For example, the upper sideband may be at maximum power while the lower sideband may be at a reduced power. This would result in an RF mask limit of –30 dB on the upper sideband and –34.0 dB on the lower sideband, with a –4 dB reduction.

Because of the many possibilities of how carriers can now broadcast, it is more important than ever to better define measurement strategies to verify that levels are

Test Signal	No Filtering	Composite Only	RF Only	Both
Analog Only	99%	99%	99.0%	99%
Analog and –20 dB HD Radio	114%	102%	99.5%	99%
Analog and –14 dB HD Radio	131%	105%	100.0%	99%
Analog and –10 dB HD Radio	150%	114%	100.5%	99%

Table 1: Analog Test Signal: 1 kHz L+R @ 90% with 9% pilot

Fig. 2: Graph shows a delay correction applied to the audio processor by the Belar FMHD-1.

correct and unchanging. The approach to accurate measurements will be somewhat different depending on how your signals combine in the RF system.

In low-level systems, as stated above the analog and HD signals exit the transmitter fully combined. As a result, the analog and HD carrier power ratio is set and determined in the exciter. Accurate samples may be taken at the transmitter in these instances.

High-level combined systems feature two transmitters. There are variations to high-level combining — one delivers HD Radio and analog signals from each transmitter — but the traditional approach utilizes separate analog and HD Radio transmitters, each broadcasting separate carriers. The combining of the signals takes place later in the RF process, but the HD Radio and analog signals come together prior to reaching the antenna.

Space-combined or antenna-combined systems represent the greatest challenge. Like high-level combining, this approach uses separate analog and HD transmitters. The difference is that the paths run entirely separate through to the antenna. Because these signals are not combined prior to the antenna input, the only means of attaining an accurate power measurement is off the air.

To ensure the signals are combining correctly, the broadcaster must calculate the losses of both the analog and digital paths and then adjust the transmitter and sideband power. This formula will verify that the power ratio is correct based on the analog and digital path calculations.

Traditionally, broadcasters have required a dedicated spectrum analyzer for accurate mask compliance measurements. These gradually have come down in price in recent years but can still be an uncomfortable expense for most radio stations.

In contrast, the modern modulation monitor has the ability to simplify measurements greatly across all these options, particularly in the area of antenna-combined systems. However, to cover all possible HD Radio implementations, the measurement device must have two internally combined high-level RF inputs and/or a separate antenna input.

The ability to measure spectral mask in the same workflow provides an additional benefit. The spectral mask laid atop the RF spectrum ultimately determines if the station is in FCC compliance. That mask changes based on the broadcaster's upper and lower sideband power. Belar recently has integrated software to continuously measure the analog, upper HD Radio sideband and lower HD Radio sideband power. Using these measurements, the ratio between analog and HD Radio power is calculated and subsequently displayed in real-time.

Modulation monitors with an adjustable mask can address mask differences on asymmetrical sidebands without requiring an external analyzer for spectrum measurement. The mask can be adjusted to run higher on one side and lower on the other, and be set in alignment with the transmitting power. By laying the mask atop the spectrum inside the mod monitor, the broadcaster can confirm visually that the station is both in mask compliance and transmitting the appropriate sideband power.

Broadcasters interested in measurement of both power ratios and mask compliance within the modulation monitor should first confirm that the unit will provide the actual measurements. In addition, since the most accurate measurements are attained at the transmitter site, having a monitor with a remote interface is to the broadcaster's benefit.

Moving forward, enhanced IP networking within the RF chain should open additional doors to further advances. One possibility is feeding both power and mask measurements back to the exciter — similar to Belar's HD diversity delay measurement process — so that the exciter comprehends what is happening in the field. This is just one possibility on the horizon to emphasize how the modulation monitor can bring greater efficiency to problem solving in the RF chain.

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THE CHALLENGE OF DIVERSITY DELAY

Speaking of diversity delay, there is no question this is today's hottest HD Radio topic not only for mod monitors but for HD Radio in general.

The roughly eight-second delay between the analog and digital signal has long been a headache for engineers. As the digital signal strength fades in weak reception areas — on the outer market edges, and inside tunnels, buildings and congested metro areas — that signal blends with the analog FM program.

New innovations driven by mod monitor manufacturers have started to address these challenges. Some tackle the problem directly inside the modulation monitor; Belar takes the approach of communicating changes to other key components in the air chain, where continuous corrections take place. Fig. 1 (on page 1) shows an FMHD-1 display of current device delay and Fig. 2 shows the delay correction applied to the audio processor as commanded by the FMHD-1.

Whether corrections are made within the modulation monitor or elsewhere in the air chain, the mod monitor must be in communication with one of three components to achieve proper time alignment between the digital and analog program. The first option is to use a separate delay line from a company like 25-Seven Systems. This was an early innovation, before manufacturers started integrating delay lines into standard HD Radio air chain components.

These delay lines are interesting as they excel in delay adjustment through compression and time-shifting, which allows the broadcaster to speed up the program without changing the pitch. Since there is no noticeable difference to listeners, broadcasters can actually squeeze a few more ad spots into each program hour. Separate delay lines remain the most sophisticated algorithm due to its sample-accurate time adjustments in fractions of a second; and it remains a viable option for broadcasters with older HD Radio architectures.

Companies like Omnia, Orban and Wheatstone have begun to build delay lines into their on-air processors. That built-in capability enables a direct connection to a mod monitor. In the case of Belar, our Automatic Delay Correction software connects to the processor through a network interface. Analog and digital time alignment is measured continuously, with corrections fed through that interface via a closed-loop procedure. HD Radio broadcasters can also leverage an exporter for time alignment. Companies like GatesAir and Nautel offer a built-in control protocol to communicate with the mod monitor, and continuously monitor and correct delays. Fig. 3 shows examples of how the analog audio delay can be controlled, and Fig. 4 shows how the analog audio delay remains fixed while the HD-1 audio delay is controlled.

Additionally, broadcasters applying corrections through a processor can now achieve a smoother transition between analog and digital signals. Exporters and precision delay devices incorporate a ramping function to support this, but in processors the time adjustments are often jarring for the listener.

New enhancements in diversity delay software support a gradual ramping feature that delivers a smoother transition similar to the algorithm used in exporters and separate precision delays. This makes the adjustments nearly imperceptible to the listener, eliminating the obvious time jump.

Tracking the delay error requires the calculation of a correlation function using samples from the digital and

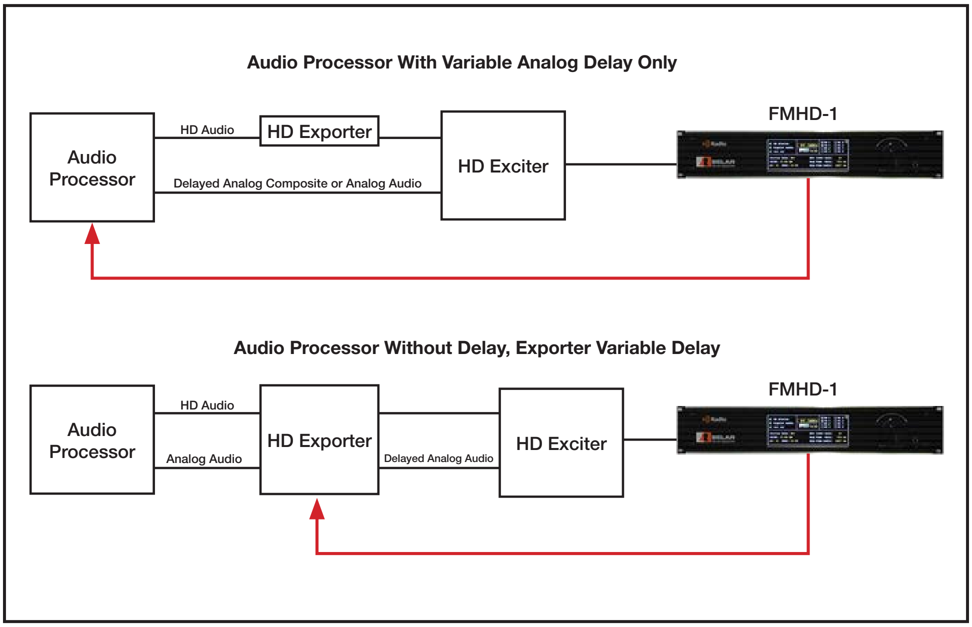


Fig. 3: Examples of analog-only delay correction.

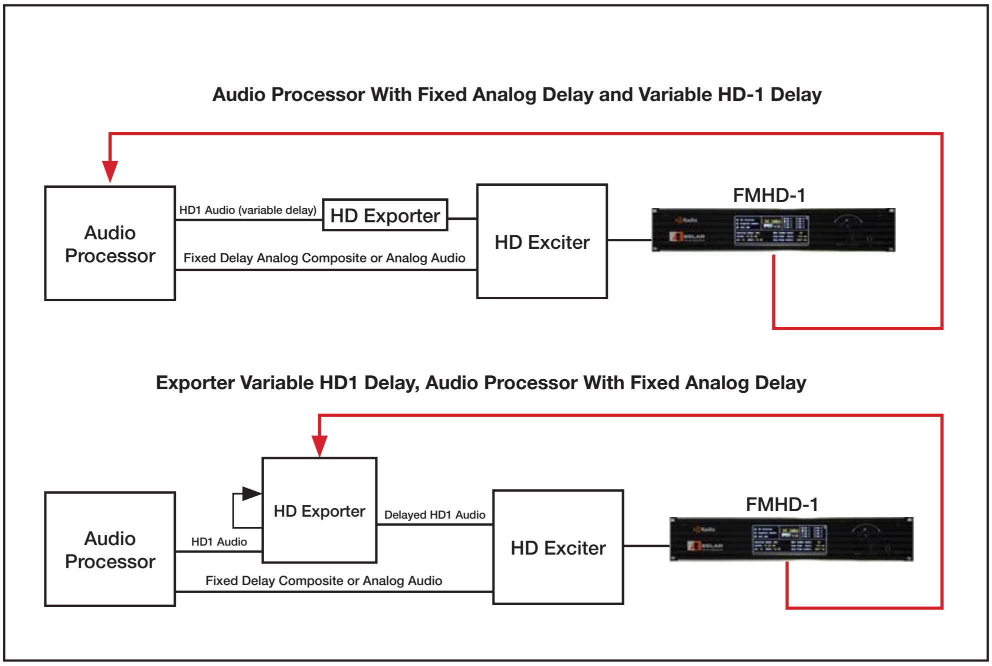


Fig. 4: Examples of fixed analog delay with correction applied to the HD-1 digital signal.

analog audio streams. The computation time of this function is dependent on the width of the time window being analyzed. At Belar, we use a variable-length time window allowing us to tailor the length of the correlation to the actual delay error. The algorithm tracks the delay and automatically adjusts the correction window if the delay creeps out of range, then contracts the window as the delay is pulled into alignment. The advantage of this approach is a faster acquisition of delay corrections, which results in a tighter overall alignment of the analog and digital audio streams.

While these three options are viable today, we see other opportunities to extend communication from the mod monitor to other air chain components — notably the transmitter. Our expectation is that this will be among the next developments in expanding the diversity delay architecture.

The integration of a scan function to correct up to six preset stations in a market is another interesting development in the past several months. This supports automatic cycling through the presets, and establishes unique IP connections to each station's delay device. The appropriate time alignment corrections are executed once the connection is made.

This provides a benefit today for stations that are monitoring multiple stations on different frequencies. Hubbard Broadcasting, for example, is using two separate inputs to service two different RF feeds, frequencies and delay devices for scanning two stations, KMQV(FM) and KRWM(FM),

The greater emergence of single-frequency networks has added a new wrinkle to the fold. These networks are becoming more common as a means to enhance coverage in challenging locations, such as mountainous terrains and congested metropolitan areas.

To achieve greater coverage, these networks use multiple transmitters — typically lower power — and lock the transmitters together over a single frequency. This is similar to how a cellular phone network works. The radio broadcaster operating a single-frequency network or SFN adds strategically positioned boosters and repeaters to strengthen coverage across that network.

The challenge: How does the broadcaster keep costs low and processes manageable when delivering HD Radio over such a complex network? The traditional model of a standalone transmitter with an exporter and processor for each location quickly adds up in an SFN configuration. Instead, engineers are architecting these networks to support multiple transmitter sites from a single exporter, with signals fed over multipoint IP networks.

As more networks like this are deployed, the need to develop a diversity delay within the transmitter grows in importance. Since there is no need to duplicate each transmitter site with dedicated exporters and/or expensive standalone processors, enabling corrections inside the transmitter represents one viable solution. The multiscan function mentioned previously could be applied in this scenario, allowing one monitor to provide alignment corrections for a group of transmitters.

Perhaps the greatest benefit of a software-defined system is the ability to tweak and improve the platform continuously without significant technical overhaul, reducing the cost burden to broadcasters over time. In addition it means the ability to do more in a single box, reducing the number of components — and associated costs and complexity — in the air chain.

One thing is certain: As the need for better diversity delay solutions grows, the technology to support it will continue to evolve and mature through more software-defined innovations. ■

Rai Way Deploys Benchmarking Network

The network operator has designed and implemented a proprietary system to assess overall network performance and to highlight QoS historical trends

By **Davide Moro**

MONZA, Italy — In 1929, state-owned Ente Italiano per le Audizioni Radiofoniche, the Italian Body for Radio Broadcasting, established its broadcasting control center in Sesto Calende, near Lake Maggiore. The center monitored the frequency occupation on the entire spectrum of medium-wave and shortwave bands on a daily basis.

After World War II, EIAR became RAI, Radio Televisione Italiana; and in the early 1950s, the rise of FM radio and TV broadcasting in Italy required the control center to develop specific infrastructures to also monitor these frequencies.

NO MAN-MADE NOISE

In 1954 the control center moved to Monza, within a natural park and far enough away from any man-made noise capable of affecting radio reception. In 2000, RAI spun off its former broadcasting division and renamed it Rai Way, which currently operates as the network provider for RAI.

The former control center in Monza is now the headquarters of Rai Way's Innovazione, Certificazione e Sperimentazione Radioelettrica (Radio Frequency Innovation, Certification and Field Testing) department.

RAI has long run a comprehensive remote control and management system to operate its transmitting sites, explains Aldo Scotti, head of ICSR at Rai Way. "In the late 1990s, we envisioned the possibility of designing and operating a field monitoring network for benchmarking purposes."

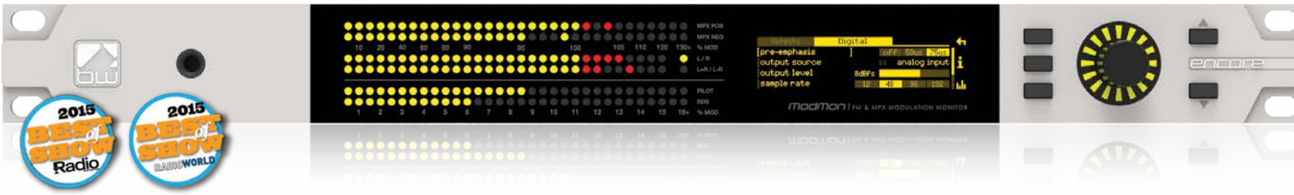
This monitoring network was not intended for everyday operational purposes. The idea was to develop a network of monitoring stations within the service area of Rai Way's transmitters that was able to carry out statistical analysis on the performance of Rai Way's broadcast networks, along with that of competing networks.

Continued on page **20**

The headquarters of Rai Way's Innovazione, Certificazione e Sperimentazione Radioelettrica in Monza, Italy.

A technician carries out RF measurements at Rai Way's Monza facilities around 1960.

Meter 4 things at the same time



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Continued from page 18

"We had the opportunity to start from scratch, so we could really develop and tailor the best solution to comply with the project's goals," Scotti said. "The monitoring network had to be accurate, reliable, fully remote-controllable and budget-minded."

The new monitoring network was named "Rete Leggera" ("Light Network"). A major requirement for these monitoring stations was the capability to be positioned almost anywhere, so they needed to be light and simple.

Aldo Scotti is head of ICSR at Rai Way.

"This compelled us to move the computational power elsewhere," Scotti said. The Rete Leggera design features three physical layers: monitoring stations (detectors, Layer III), network nodes (Layer II) and network management (Layer I).

Each monitoring station includes professional-grade receiving antennas and combiners, one or more measurement device per each broadcast standard (MW, FM, DAB+, DTT) and a local controller. Rai Way's technicians custom-designed and built the controller.

"Targeting 100 percent availability, we carefully selected a specific IT-based fanless appliance where we installed just two pieces of software — a basic OS and a proprietary package we created to manage the operational cycle of the various receivers and communication to the node level," he said.

TIME MACHINE

Depending on the location of the monitoring station, the controller adjusts each receiver to tune into a frequency from an assigned list, on a round-robin basis, then perform the required measurements, according to a specific time window.

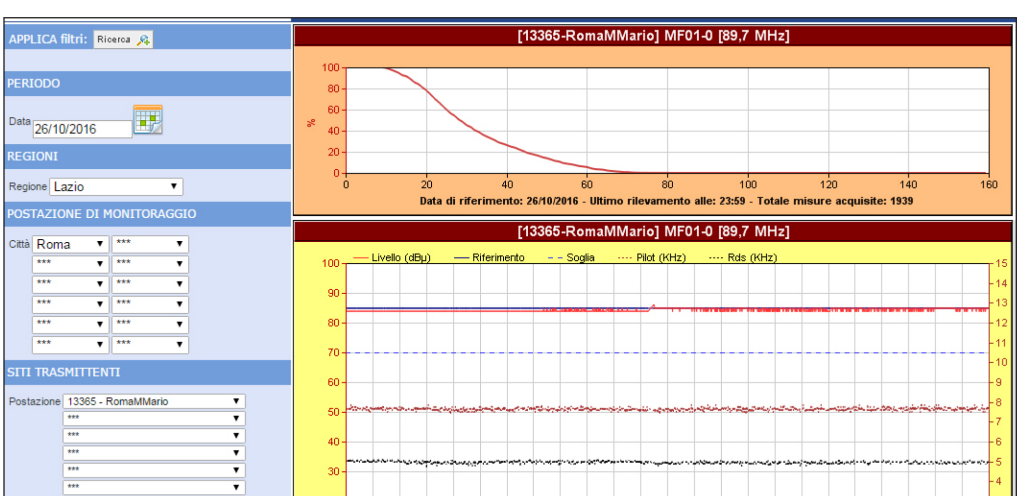
"We monitor the performance of our networks, and also of our competitors, as well as checking for possible interference from abroad [North Africa, the Balkans, etc.]." Each controller stores the resulting data from the various measurements for five minutes, then forwards a message including all the acquired data to its hierarchical network node (Layer II), in a proprietary and "lite" format to limit the bandwidth requirement and the amount of data transfer.

A specific message allows each network node to acknowledge proper message reception. When the sending controller receives confirmation, it deletes the measurement records. "We chose to implement local controllers with virtually no local storage, to keep them simple and to speed up each data transmission" Scotti added.

Rete Leggera controllers are connected to the network nodes (Layer II) via a proprietary VPN. Each network node compares every measurement set with specific thresholds, with the corresponding previous set and with the resulting mid-term trend from the same monitoring station. The node subsequently deletes the data situated within the relevant limits, while it stores each measurement record not matching with the expected figures.

The nodes also build graphics for each monitored value at any measurement station. If nothing "out-of-spec" is registered within 24 hours, each node stores one measurement set per day from each monitoring station.

"The network nodes store data corresponding to a specific moment when something went out of the expected figure at a specific location," said Scotti. "Rete Leggera is a sort of time machine capable of reverting us to the very moment when something happened."



Statistics from Rai Way's "Rete Leggera" regarding broadcasts from the Roma Monte Mario transmitting site in Rome.

A map of Italy showing Rai Way's "Rete Leggera" monitoring stations. The image highlights two event notifications in red.

KEY PERFORMANCE

On a daily basis, each network node forwards the recorded events to the network management (Layer I) of Rete Leggera. Network nodes generate alarms and triggers as the consequence of a detected status change of the monitored parameters. The network management aggregates all the data from the entire territory and maps each measurement event to a specific transmitter and to a specific service.

Even if broadcasts from a given transmitter are clearly receivable in one measurement location, interference or other impairments can affect the quality of service for the same broadcast at a different location.

Rete Leggera's advanced graphic interface provides mid- and high-level managers with key performance indicators on the entire broadcasting network. Any kind of drill-down is then allowed. Operators can compare the performance of a specific Rai Way service versus the performance of a different service, either from Rai Way or its competitors.

Rete Leggera can produce historical reports for both nationwide or regional services, as well as for a given transmitter. Transmitting sites with similar equipment but different configuration can be compared from the point of view of their reliability and overall availability. The same applies to nominally identical transmitting sites that are using equipment from different manufacturers.

Today, the Rete Leggera network comprises 50 monitoring stations, covering about 70 percent of the potential nationwide audience. Rai Way intends to deploy 10 additional monitoring stations in the future. ■

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