A Practical Guide To RF In Broadcast :

Part 3 - Planning, Tuning & Monitoring

A Themed Content Collection from The Broadcast Bridge

Themed Content Collection

Contents

Introduction

By Tony Orme. Editor at The Broadcast Bridge.

This is the third of a multi-part series which serves as a reference resource for broadcast engineers. It covers the science and practical applications of RF technology in broadcast.

Broadcasting has encountered more technology change over the past thirty years than many of us care to think about. Analog has changed to digital delivery, SD has changed to HD and 4K, and sound is transitioning to deliver higher levels of immersive experience through object and surround sound. But the one consistent technology that has stood the test of time is RF.

RF differs from most other broadcast technology as it's fundamentally analog. As the laws of physics haven't changed in the past hundred years, then the underlying rules that govern all RF systems haven't changed either. But what has changed is how we use RF in the context of modern broadcasting along with our understanding of how waves propagate through the universe.

Broadcasting has always driven technology to its limits, and this is certainly the case with RF. Morse devised the first channel coding system ninety years before Shannon formalized his achievements through information theory. And this in turn led to the development of the highly efficient coding systems that we use in modern broadcasting such as CODFM and 5G-NS.

Our RF understanding is sure to improve for as long as users continue to use mobile devices.

A Practical Guide To RF In Broadcast is a four part series with three articles per part.

Available now:

Part 1. History, Modulation & Regulation

Part 2. Bands, Designs & Radiation

Part 3. Planning, Tuning & Monitoring

Future parts due in 2023:

Part 4. Codecs, Facilities & The Future

- Codecs and Encoding
- Other Radios in TV Stations
- The future of OTA TV

Transmitter Plant Planning

By Ned Soseman. The Broadcast Bridge.

Broadcast transmitter facility planning, design and construction... and what an engineering consultant can help with.

Of all the systems in a TV station, the transmitter RF system provides the most opportunities for hardware mishaps that can put a station's reputation and license at risk in the blink of an eye. The tower could fall. The transmitter could catch fire or drift off-frequency. A RF filter could fail and cause interference with another station or a data carrier. Broadcasting is a trouble magnet, attracting the most unlikely random technical issues occurring at the worst possible moments.

TV transmitter planning, upgrades, and operations usually begin and end with the designated chief operator and acting chief operator because if anything breaks, they must identify the problem and fix it. Significant changes usually involve engineering consultants and contractors and must be approved by a corporate committee and sometimes the FCC, before work can begin. Nearly all RF system changes are initiated by need, by FCC direction, or new technology like ATSC 3.0.

FCC Rule 47 CFR § 73.1580 Transmission System Inspections states: "Each AM, FM, TV and Class A TV station licensee or permittee must conduct periodic complete inspections of the transmitting system and all required monitors to ensure proper station operation." TV transmitter engineers, chief operators, and chief engineers are expected to be skilled RF technicians and technical FCC rules experts while maintaining 24/7 compliance with federal rules and regulations.

Each TV station is different, and every station RF system is a unique combination of brands, transmission line lengths and sizes, towers, guy wires, antennas, transmitter buildings, HVAC systems, installations, and terrains. This chapter discusses the ubiquitous active and passive hardware devices in the signal flow from the studio to the signal radiated by the antenna on the tower. More specific details as to what exactly will work best in your station's scenario are best determined by a professional broadcast engineering consultant and manufacturers of items you may need. You may also want a communications attorney to assist with FCC filings. Engineering design and construction of RF facilities is necessarily detail oriented.

Upgrade or New?

Are you building a new facility or upgrading an existing facility? If you are building a new RF facility literally from the ground up, you will need to identify a practical location, negotiate a property lease, design and build a building or buy a pre-fab unit with redundant HVAC systems, add electrical service and a backup generator with a transfer switch, add internet service, and install the RF system from the Studio Transmitter Link (STL) to the tower and transmitting antenna.

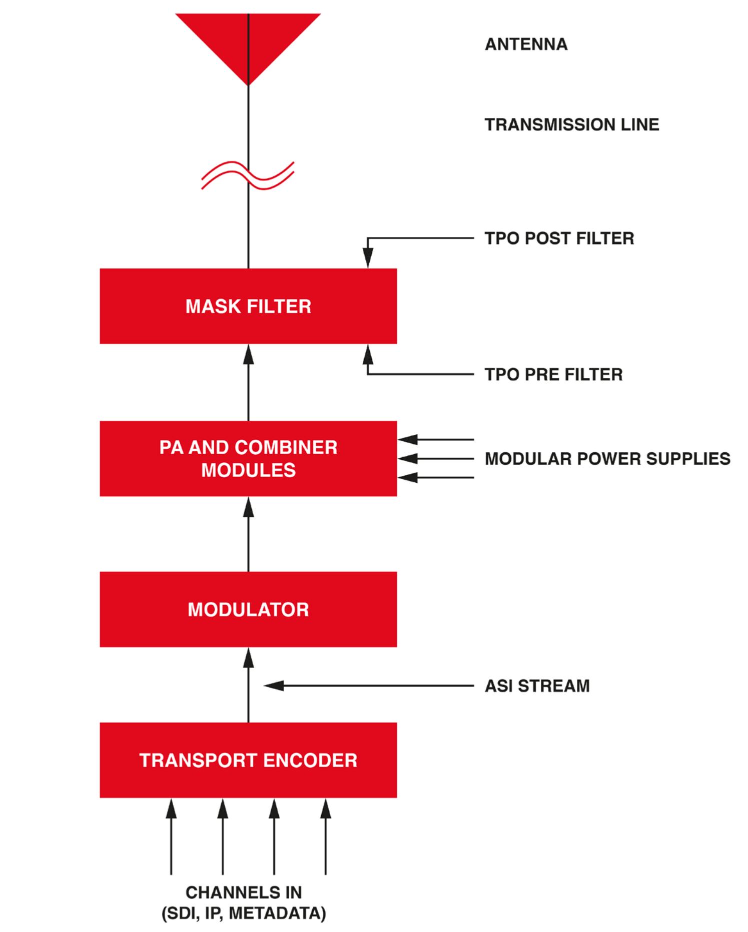


Figure 1 – The seven elements of DTV transmission are the STL, exciter, transmitter, filter, transmission line, tower structure and antenna.

Coordination of delivery and order lead times is critical. You'll need a tower first, then the antenna, transmission line, power, emergency power and a building before you are ready for a transmitter. If you're upgrading or remodeling, control of the dust and the mess of demolition can be crucial, particularly when keeping a transmitter on the air in the same space. Every TV station RF project faces similar challenges, and most stations handle them differently due to individual circumstances.

If you are upgrading an existing facility, can you do the work without disturbing on-air operations, or will you need a standby RF system available elsewhere while the upgrade is in progress? Every project begins with a unique set of circumstances and specifications. In the case of TV transmission, many of the key specifications such as location, antenna height above average terrain, and effective radiated power (ERP) are enumerated in each station's license. The project plan should identify every action, anticipated expense, and source related to the project, along with an estimated timeline.

Next Step: ATSC 3.0

In 2020, nearly 1000 US TV stations completed repacking to new channels. The smart ones built in as many ATSC 3.0 upgrade abilities as possible into their new RF systems and paid for the upgrades during implementation. Today, in the USA the TV RF focus is on ATSC 3.0 and the transition from ATSC 1.0. ATSC 3.0 uses software-based encoding and has peak power levels 10 dB above the average power of the transmitter output. ATSC 3.0 also has a wider bandwidth than

ATSC 1.0. It uses 97% of the allocated spectrum compared to 90% for ATSC 1.0.

The STL connects the output of the studio or master control to the transmitter exciter via IP-based WANs or microwave. The Broadcast Auxiliary Microwave Service (BAS) 2 GHz band was created by the FCC specifically for broadcast STLs and point-to-point transmission. Newer STLs can use either the BAS microwave band or a UDP-based data transfer protocol (UDT) for IP-based content data and metadata over wire, microwave, or fiber, typically using Secure Reliable Transport (SRT) protocol. With a good connection, there's little reason not to go with the UDT solution. However, not all internet service is perfect and there will always be a few remote locations where UDT will not function properly. Otherwise, UDT is a proven, stable component of STLs and exciter inputs.

ATSC 1.0 and 3.0 exciters need an Asynchronous Serial Interface (ASI) input to simultaneously carry all the channels, subchannels and metadata. ASI carries MPEG data serially as a continuous stream with a constant rate at or less than the SDI rate of 270 megabits per second. The only purpose of ASI is the transmission of an MPEG Transport Stream (MPEG-TS). MPEG-TS is the universal standard protocol universally used for real-time transport of broadcast audio and video media. When a composite data transmission signal of asynchronous but formatted data is transmitted as RF, it is typically called DVB-S, DVB-T, or ATSC. When carried unmodulated on coaxial cable it's called ASI.

Secret For Better Signals

FCC ERP measurement is based on horizontally polarized (H-Pol) radiated power. Double the transmitter power output (TPO) can be used to feed a Circular Polarized (CP) antenna. Adding a vertical component adds to the H-Pol signal and can increase overall signal strength compared to H-Pol only, depending on the position of the receiving antenna. CP also minimizes signal dead spots.

To take full advantage of ATSC 3.0, stations should investigate antennas that use either CP (50% H-Pol/50% V-Pol) or Elliptical Polarization (70% H-Pol/30% V-Pol or similar). Adding a vertical component to the transmitting antenna aids mobile service and improves deep indoor signal penetration. Most FM stations use circular polarization to minimize multipath reception issues in autos and homes.

SFNs Ahead?

I built and operated one of the first commercial single frequency networks (SFNs) in the US, KRBK-TV in Springfield MO. We had five identical but independent transmitters operating on Channel 49 across a geographically large DMA consisting primarily of fields, woods, and cows. The ATSC 1.0 SFN only worked in the narrow geographic area it was tuned work in. The transmitter installer tuned all the delays to 'exactly between SFN transmitters.' That didn't work if the town you want to cover is near one of the transmitters. We learned how to tune SFN delays for the best signals where viewers were. The station was sold and changed channels during repack, moved to a 2000' tower, and abandoned the Channel 49 SFN.

ATSC 3.0 SFNs are fully automatic by design. NextGen TV tuners sense multiple signals and build the best display signal from all of them. In the world of SFNs, ATSC 3.0 SFNs are quite powerful. In addition, extreme local transmitters can offer extreme local news, alerts, promotions, and advertising, as well as neighborhood school closings and other important public information targeted by zip code.

SFNs follow the highly localized cellular data RF model: Low power from a network of short towers. ATSC 3.0 SFNs similarly covering rural interstate highways with repeaters may be the future of ATSC 3.0 Broadcast Internet datacasting.

Tuning & Monitoring TV Transmitters

By Ned Soseman. *The Broadcast Bridge.*

How to tune for legal &standards compliance and performance, during installation and daily operations.

Amateur radio is one of the safest and most efficient hobbies to learn the critical fundamentals and characteristics of RF systems and signal propagation while having fun and not being responsible to anyone but the FCC.

At the time I learned about TV transmitters, I was a young amateur radio operator (ham) and knew the fundamentals of transmitters. Most TV stations signed off at midnight for transmitter maintenance. My early TV years were spent on a 7pm – 3am transmitter maintenance shift working with the long-time station transmitter engineer. In those days, we signed off at midnight and the union required two transmitter maintenance engineers, one to do the work and the other for safety when working with dangerously high voltages during the wee hours of the morning.

The first TV station that paid me to watch prime-time and late-night TV as an engineer was WDAF-TV. The station owned a RCA TT5-A analog TV transmitter, with 8 huge rack cabinets and dedicated RF Amplifier cabinets for the aural and visual signals feeding a combiner. The cabinets were filled with dangerously high voltages, big capacitors, heavy transformers, and glowing vacuum tubes. All the cabinets included a mechanical interlock to cut off rack power if the door was opened, which was regularly defeated by necessity during maintenance. For this reason, every cabinet also included a built-in, copper capacitor discharge stick, aka a ‘stick’ with several descriptive names preceding the word ‘stick.’.

Dangerous Capacitors And Grounding

The first thing the long-time transmitter engineer taught me was the purpose and safe use of the capacitor discharge stick hook. His words, “You could save my life,” burned into my mind the moment he said them. The ‘discharge stick’ and hook was attached to the grounded rack chassis with 000-gauge insulated wire on one end with thick fiberglass insulation rated at 4KV covering up to a big bare copper hook on the other end. Its primary purpose was to discharge high-voltage capacitors. The hook feature was to pull fellow engineers away from electrocution. Muscles fully contract when electrocuted, and the hook was meant to pull a tight hand or hands away from an energized wire or connection. I never used the hook to save anyone or knew anyone who did, but every engineer I ever worked with knew what it was for. It was part of ‘the fun’ of working with high voltages capable of high current.

The transmitter racks were connected by a solid 4” copper ground strap running from rack to rack to station ground, which was a buried 4” copper strap surrounding the building perimeter. The station TV transmitter was fed by its own private electrical substation on a different service than the rest of the station. In terms of TV facilities and TV transmitters, grounding is everything. Sledgehammering a single 5-foot copper-coated steel spike from a box hardware store randomly into the ground is not a good RF ground. An efficient RF ground covers lots of territory and can easily discharge a direct lightning strike to the building.

There are two ways to discharge a capacitor. One is to use a screwdriver or an alligator clip jumper wire to short the capacitor’s terminals and possibly create sparks. The more professional method is to use a discharge stick. It’s not unusual to find a discharge stick at an electronics workbench because it’s safe and directly connected to the station ground like a transmitter discharge stick.

Always verify complete capacitor discharge with a voltmeter. Some engineers leave alligator jumpers connected to each end to ensure capacitors remain discharged during maintenance. Most transmitter power circuits contain “bleeder resistors” in parallel with the output of a high-voltage power supply to automatically discharge big capacitors when gear is turned off, but many transmitter maintenance engineers don’t necessarily trust them. Large capacitors can build up a residual charge without an external power source, which bleeder resistors are supposed to drain. However, bad bleeder resistors may or may not cause a transmitter warning indication. Most power supply circuits don’t depend on them to operate normally.

Fortunately, in 2023 vacuum tubes, the inductive output tube (IOT), and high voltage power supplies in broadcast transmitters have become virtually extinct. Today’s DTV transmitters have eliminated the dangers and risks associated with high voltage power supplies. Most modern solid-state DTV transmitters use off-the-shelf, commodity, 50VDC modular power supplies that plug into a mother chassis. There are no hard rules for what point a voltage becomes dangerous nor consistent definitions of the ‘low voltage’ dividing line, but the term ‘low voltage’ has clearly become electrical industry slang for 50 VDC or less.

TV transmitter power supply troubleshooting has been replaced by hot-swapping, and most modular 50 VDC power supplies are cheaper to replace than fix. Power supply modules are usually accessed in the front of the transmitter cabinet. Modern DTV power amplifiers are similarly modular, hot-swappable, and accessible from the front of the transmitter cabinet. A PA may be fixable on a workbench, but a spare PA can keep a station on the air at full power seamlessly as a faulty PA is repaired or replaced.

Transmitter Tuning

When analog TV transmitters were the only TV transmitters, the experienced engineer who trained me showed me some "tricks they don't teach you at transmitter school." One of those tricks was to increase the filament voltage of weak tubes to compensate for lower output. Other tricks were similar, and they were all meant to compensate for drifting circuitry and aging active components before necessary replacement.

The fact is that a TV transmitter is simply a series of tuned circuits and amplifiers optimized for the transmitter's licensed frequency and power output. In the old days, TV transmitters were two separate transmitters. One was the visual transmitter (AM modulated) the other was the aural transmitter (FM modulated), and they were mixed in a combiner before the mask filter. Analog transmitter tube performance and component values drifted, and TV transmitters required constant monitoring and manual compensation adjustments as parts and circuits aged. Manual transmitter readings with clip boards and typewriters were logged hourly not only to meet FCC requirements, but for maintenance engineers to note and identify clues and trends prescribing the need for preventative maintenance intervention.

Digital transmitters are different to their analog predecessors in many respects other than simply being digital. One is the ubiquitous 50 VDC PA power supplies. Another is that the TV broadcast frequency band is significantly narrower than it once was. Transmitters are either VHF low-band (44-88MHz), VHF high-band (174-216 MHz), or UHF (470-614 MHz). Most importantly, solid state digital transmitters don't drift because most are locked to GPS.

When the FCC adopted the NTSC's recommendations of the original black & white TV legal standard in 1941, the technical details of the NTSC standard were defined by the National Television Standards Committee (NTSC). In 2011, when the FCC announced the DTV broadcast standard, it followed how the FCC adopted the NTSC's recommendations of the original black & white TV legal standard in 1941. The technical details of the DTV broadcast standard were and primarily are defined by ATSC A/52, ATSC A/53, and ATSC A/54A, and in FCC rules 47 CFR § 73.682 - TV transmission standards.

The Loss Of US TV Spectrum

Year	Channels	Bandwidth	Reason
1983	UHF Ch 70-83	84 MHz	Unused
2009	UHF Ch 52-69	108 MHz	DTV Transition
2020	UHF Ch 38-51	84MHz	Spectrum Auction
Total Initial TV Spectrum		446 MHz	
Total Lost TV Spectrum		276 MHz	
Total 2023 TV Spectrum		170 MHz	38% of what TV was in 1982

The RF bandwidth allocated to US TV broadcasters is 38% of what it was before 1983, yet broadcasters remain restricted to 6 MHz channels when needing more bandwidth than ever for UHD and other services.

Transmitter Monitoring

Monitoring requirements in 2023 are less about legal compliance and more about eliminating complaints. For example, the FCC does not specify a frequency tolerance for digital TV (ATSC 1 or 3.0) transmissions except in relation to lower adjacent analog TV stations. If required by the ATSC 3.0 transmitter and filter, the overall occupied bandwidth can be reduced from 5.832844 MHz to as little as 5.508844 MHz. Details are explained in the ATSC A/327 Physical Layer Recommended Practice section 4.2.2.

Also, according to FCC 47 CFR 73.1560 (h), "The power level of emissions on frequencies outside the authorized channel of operation must be attenuated no less than the following amounts below the average transmitted power within the authorized channel. In the first 500 kHz from the channel edge the emissions must be attenuated no less than 47 dB. More than 6 MHz from the channel edge, emissions must be attenuated no less than 110 dB. At any frequency between 0.5 and 6 MHz from the channel edge, emissions must be attenuated no less than the value determined by the following formula: Attenuation in dB = $-11.5(\Delta f + 3.6)$; Where: Δf = frequency difference in MHz from the edge of the channel." Such critical measurements require a professional spectrum analyzer.

In fact, monitoring in 2023 is crucial, but don't depend on the FCC or your government RF regulatory agency to tell you when you are out of bounds. Most of the 276 MHz of lost TV spectrum is now used for Wi-Fi and paid Cellular customer connections. Those providers are managing and monitoring their spectrum more closely than the FCC ever could. The point is to not get a complaint, respond and act quickly if you do, and keep government regulators out of the loop. Things break. I once had a mask filter develop a mysterious, random issue that began interfering with the cell system on the same tower. They complained to us, we immediately returned the filter to the manufacturer for repair and retuning, and the problem was resolved without FCC intervention in about a week.

Monitoring RF Systems

By Ned Soseman. The Broadcast Bridge.

Studio Transmitter Links, remote monitoring, QoS probes, and other OTA signal monitoring solutions... and verifying signal coverage stability.

In addition to their broadcast channel, TV studios and stations have become a jungle of RF signals. The best way to identify, sort and manage all the active RF sources in a facility and find new signals is with a spectrum analyzer.

Monitoring RF systems can be divided into five specific categories;

- RF compliance with government regulations, such as transmitter power limits and potential interference, including ATSC and ATSC 3.0 standards and signaling compliance.
- Audio compliance, loud commercials and aircheck archiving.
- Baseband video, typically measured and monitored by a waveform monitor and vectorscope and adjusted by gain, pedestal, chroma and phase controls and sometimes the camera iris on the source device.
- IP and network monitoring, including streaming video on the internet.
- Monitoring and being aware of what kind of RF signals are active in or around a facility or remote site that might cause interference. Monitoring the whole spectrum calls for a spectrum analyzer.

Over the TV years from analog to today, Test & Measurement gear for operators in many TV stations mainly consisted of baseband analog waveform monitors and vectorscopes, VU meters, and a couple of general-purpose oscilloscopes. Waveform monitors and vectorscopes are important tools for content creation, post-production and ingest preparation.

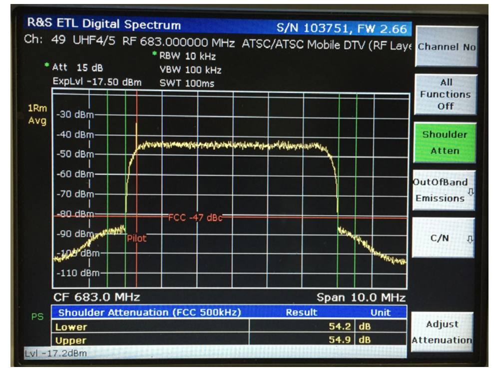
Live production and limited table space call for floor-mounted, knee top-level monitoring of video levels using a familiar WFM fed by a HD HDMI-to-SD analog converter.

These 'dashboard' tools help the operator properly set levels and colors in scenes within industry limits on a calibrated display and they are particularly useful with color bars for reference. They are like a speedometer and tachometer on a auto dashboard, displaying to the driver objective safe operating limits for the vehicle and engine. The best time to set video and audio levels is as the original content is captured. Once content has been captured and digitized to calibrated industry standards, new issues can be attributed to IP, which requires different types of monitoring gear more common in a maintenance shop or bench.

RF & Visual Compliance

RF output compliance is usually measured with a pair of wattmeters, one measuring the input power to the mask filter, the other measuring the mask filter output power to the antenna transmission line. Visual transmission compliance ensures the integrity and standards conformity of the video and data signals, including ATSC 1.0 diginet channels and all things in ATSC 3. T&M gear specific to examining streams and pipes is important to verify full signal compliance with ATSC A/52, ATSC A/53, and ATSC A/54A, and FCC rules 47 CFR § 73.682 - TV transmission standards. Accurately measuring ATSC 3.0 signals requires a good RF signal. The FCC defines the edge of a UHF DTV signal contour at 41 dBµ. A 40 dBµ (0.1 mV/m) signal is generally considered the minimum strength a station can be received with acceptable quality on most receivers.

ATSC 3.0 is a highly sophisticated scheme that compresses more data bandwidth onto an RF signal than the bandwidth of the actual RF signal. This is accomplished digitally using Physical Layer Pipes (PLPs). A PLP is a logical channel carrying one or more services,



Commissioning a new Channel 49 transmitter that couldn't wait until repack with a TV analyzer revealed key installation and antenna performance details that all became a learning experience after repacking to Channel 22.

with modulation and robustness unique to that individual pipe. There are books covering the myriad details of PLPs but suffice it to say that every PLP needs a Bit Error Ratio (BER) and a Modulation Error Ratio (MER) sufficient for required modulation and reception quality.

The ATSC recently published "ATSC Recommended Practice: ATSC 3.0 Field Test Plan," available at A/326, "Field Test Plan" (atsc.org), which precisely explains how to test and measure an OTA ATSC signal.

Audio Compliance

Loud ads annoy TV viewers, and the FCC responds to viewer complaints. The Commercial Advertisement Loudness Mitigation Act (CALM Act), meant to eliminate loud TV ads, began enforcement in 2012. The CALM Act calls for maintaining a target level of -24 LKFS. The acronym LKFS stands for "Loudness, K-weighted, relative to nominal Full-Scale." LKFS represents the amplitude level that is communicated to viewing audience in decibels (dB), but it focuses on the audio elements that viewers recognize the most.

LKFS is significant because it provides an integrated measurement over time. Achieving the -24 LKFS target level often requires increasing high frequencies and dropping lower frequencies across all 5.1 channels, with additional calculations around power averages for each audio file. If all content sources universally used the 'dialnorm' standard, dialog levels would be consistent and uniform from channel to channel. The -24 LKFS level is considered 'dialnorm,' meaning the dialog level is normalized.

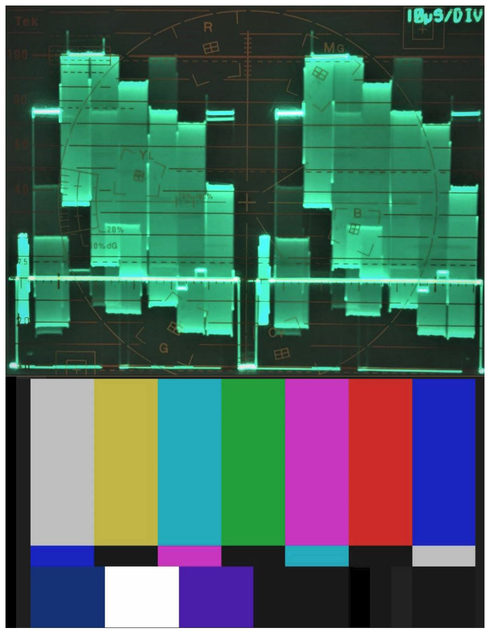
Many products will log, measure, and display LKFS values. Some CALM Act monitoring gear includes aircheck auto-logging that reproduces technically accurate audio levels and can be used to prove LKFS values over time. Accurate CALM Act logging and archiving is the best possible protection from 'loud commerical' complaints and FCC loudness investigations.

Baseband Video

TV monitor displays are subjective. Waveform monitors and vectorscopes are scientifically objective measurement instruments and therefore valuable production tools. At one time, a primary use for a waveform monitor was to measure the timing of sync pulses and the width of the burst signal, because in the vacuum tube days, these values could drift and make it impossible to switch inputs without a glitch. Digital TV automatically takes care of the sync pulse timing, but it takes a human to make artistic decisions such as how to use the full dynamic range of a video image for maximum effect.

Waveform monitors graphically display a 1 volt p-p video signal waveform. Top to bottom range is divided into 140 IRE. The bottom 40 IRE is vertical sync, the upper 100 above the vertical sync measured in 0-100 IRE. Zero IRE represents the blackest legal black, 100 IRE represents the brightest legal white. In the analog days, legal black was 7.5 IRE, and the dynamic range was only 92.5% of todays 0-100 IRE dynamic range.

Not every camera shot needs to include fully black or the brightest white images. It needs to look natural, but content creation and 'the look' is the director's decision. From an engineering perspective, objects in a scene that are compressed into the whiteness or darkness when captured usually can't be uncompressed from a captured file. It can be compensated for in post, but it's better to capture everything live and realistically using all the dynamic range available. Encourage the director to use their creative visual magic in post and set the camera iris and pedestal levels for the best possible image for capture.



A 1080i HDMI color bar signal converted to SD analog shows zero pedestal, as HDTV should.

Vectorscopes display calibrated color markers on a simple scale for hue and color control adjustments. They work best to calibrate with color bars at the beginning and to monitor for illegal colors in content. Typically, in the analog TV days violations of any of these defined level limits would cause a home TV receiver sound to 'buzz' and overload transmitters.

IP & Network Monitoring

RF monitoring in IP and networks includes lots of Wi-Fi and perhaps BAS. Both are most easily discovered and identified with a spectrum analyzer. RF IP and network monitoring include dedicated solutions such as remote QoS probes for remote IP broadcasting. Some remote TV receiver probes are available or adaptable to a PC or blade, but most TV signal verification is done as prescribed in official FCC signal strength measurement techniques, such as height above terrain (20' above ground level for single story structures). Cluster measurements "should be 9.84 feet apart, if possible." Take the first measurement with the antenna on a 20' mast above ground level at the center of the square. Take four more measurements with the same antenna on the same mast facing the strongest signal from the transmitter in each corner of the 9.84 x 9.84-foot square. The FCC allows a use of a horizontally polarized half-wave dipole or multi-element antenna with gain.

Tracking RF Sources

In 2023, nearly every remote device is connected by RF, from garage door openers, auto smart keys and smartphones to Bluetooth, Wi-Fi, and 2 GHz Broadcast Auxiliary Service (BAS). Additionally, some people who may have used Wi-Fi on their phones while at stations and remote sites can cause IP havoc if their cellphone trying to log on to the production system Wi-Fi is set to dynamic IP.

Sweeping the RF spectrum with a spectrum analyzer is the best way to learn what devices are transmitting on airwaves near you and monitor the active spectrum for new transmitters in mere seconds. Spectrum analyzers are available as software with a USB probe for an antenna connection, some offer optional software with templates for FCC measurements. Others are standalone TV analyzers, specifically designed for broadcast engineering RF system commissioning, monitoring and maintenance. A modern TV analyzer combines a TV signal analyzer, a video and MPEG TS analyzer and a spectrum analyzer in one unit and typically cover from 500 kHz to 3 GHz. Some may require an optional digital demodulator for a single DTV carrier.