



FM HD Radio Combiner Guide

FM HD Radio™ implementation has become a lot like that popular game show in which hopeful contestants must choose one of the doors.

Behind door number one is common amplification (also known as low-level combined), a proven implementation plan for lower powered stations but not a practical option for high-powered FMs.

Behind door number two is separate antennas, which will fit the bill for some Class B and Class C stations but only if they have antenna infrastructure to spare. This methodology may include an entirely separate antenna, interleaved bays, or antennas that are dual fed.

Behind door number three is high-level combining, a prevalent option for powerhouses that lack the wherewithal for a separate HD Radio antenna. There's also door number four, a back door approach to high-level combining known as mid-level combining. This is yet another possibility for a few Class B or C stations that have late-model transmitters not able to high-level combine HD Radio and FM.

So, contestant, which one of these doors is the right one for your station(s)?

Determining how and where to introduce HD Radio in the transmission chain is an important first step. There's simply no way around it: You will have to crack open one of these doors in order to take part in all the new opportunities opening up as a result of HD Radio.

The key is to choose the most cost-effective, operationally-efficient system that will give you a reliable foothold on HD Radio now, plus unlock all the potential it has to offer, such as multicasting and text data functions.

We suggest you start with the basic considerations:

1. operating power
2. availability of tower and transmitter space
3. cooling capacity
4. desired redundancy
5. implementation cost
6. operating costs
7. existing equipment compatibility with HD Radio
8. system complexity
9. whether to upgrade a single station or a cluster of stations

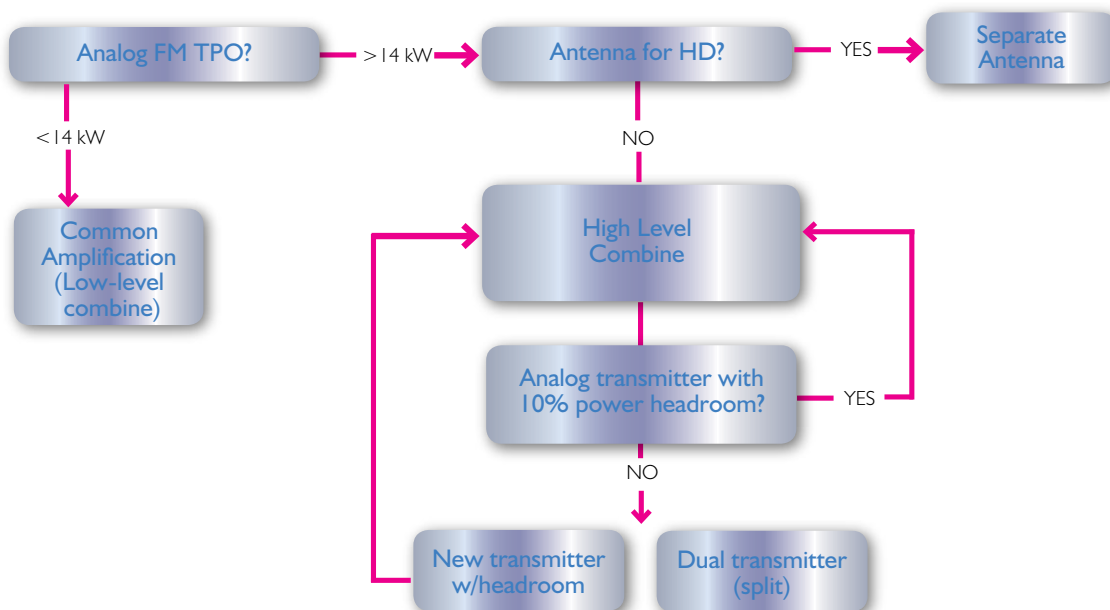
It doesn't hurt to add flexibility into the equation:

10. readiness for multicasting
11. readiness for HD Radio text; Ethernet connectivity from the studio

Then, review what you know about combiner methods ... and bone up on what you might not know about those methods. What follows is a closer look at what's behind each door.

FM HD Radio Implementation Decision Tree

Go to www.bdcast.com/HDRadio and click on "HD Radio Power Calculator" to determine power requirements



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Low-Level Combined

Common amplification. HD Radio is combined with FM analog in the exciter for common amplification through one transmitter and one antenna in a low-level common amplification configuration.

Consider low-level common amplification if:

- Have less than 14 kW TPO analog FM (transmitter costs increase with power)
- Existing transmitter does not have the additional 10% power headroom needed to cover the combiner losses of high-level combining
- Plan to purchase a new transmitter for analog FM anyway
- Do not have the site space for an additional transmitter

What you'll keep:

- Existing antenna

What you'll need:

- One FXi 60/250 BE exciter for dual HD Radio and FM operation, a BE XPi 10 for signal generation at the studio or the transmitter site, and a solid-state transmitter such as BE's FMi series for HD Radio and analog FM
- New audio processor for HD Radio

One other thing to consider:

- BE's FXi 60/250 exciter combines HD Radio and analog FM at the output of the exciter, so both can share a common transmitter. BE's FXi exciter offers this option inside the exciter, in DSP, so what comes out of the exciter is essentially one RF spigot with HD Radio and analog that'll feed the transmitter

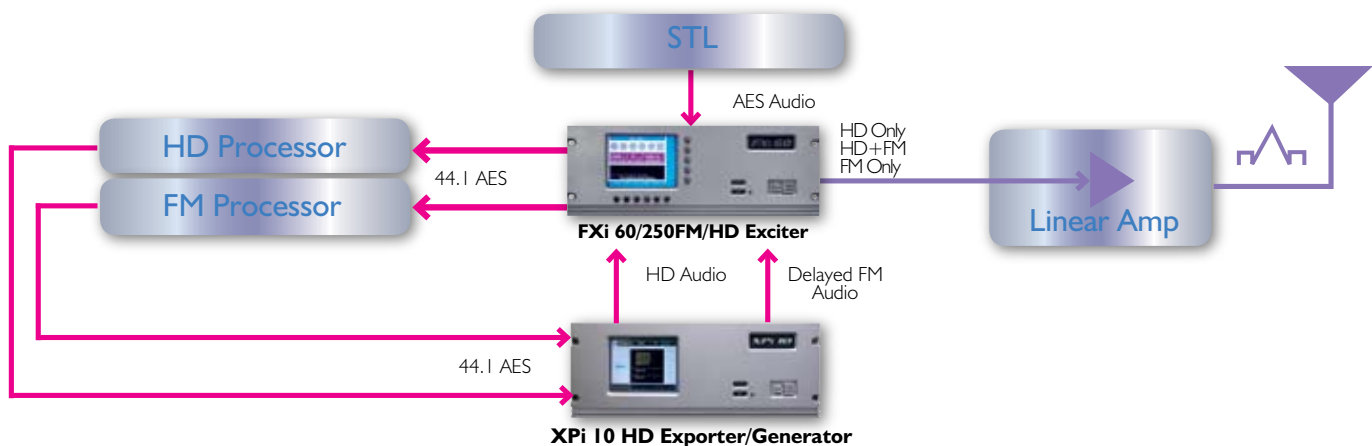
Pros and cons:

Low-Level Pros

- Less space required
- Less power consumed
- Less heat in building
- Easy installation
- Peak-to-average ratio is approximately 1.3 dB. (This means the transmitter is more efficient in this mode of operation over HD Radio only.)
- HD Radio and FM are transmitted through the same antenna, ensuring HD Radio to FM power ratios are maintained throughout antenna pattern

Low-Level Cons

- Single point of failure for both analog and HD Radio
- Requires replacement of analog transmitter



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Separate antenna

Separate HD Radio transmitter and antenna. HD Radio is amplified separately and run through a separate feed line and possibly antenna. The HD Radio antenna can be new, a backup not in regular service, an existing antenna that has been converted to HD Radio by interleaving additional bays, or a dual feed antenna. The antenna also can be a master community antenna that has been back-fed HD Radio through an isolator for HD Radio/FM analog signal radiation at opposite polarities.

Consider separate antenna if:

- Have more than 14 kW TPO analog FM
- Have the antenna infrastructure to add HD Radio (existing master or backup antenna) or the site space to mount an additional antenna
- Have an antenna that can be modified for dual-feed
- Have a late-model analog FM transmitter that has years of service left

What you'll keep:

- Existing antenna, transmitter and exciter for analog FM

What you'll need:

- New BE FXi 60/250 digital FM exciter, an XPi 10 for HD Radio only signal generation at the studio or the transmitter, and a solid-state transmitter such as BE's FMI series operating in linear Class AB mode for HD Radio
- New antenna, bays or an isolator if the isolation between analog and HD Radio is less than 40 dB
- Optional separate power meter to monitor the power ratio between analog and digital transmitter outputs
- New audio processor for HD Radio

Pros and cons:

Separate Antenna Pros

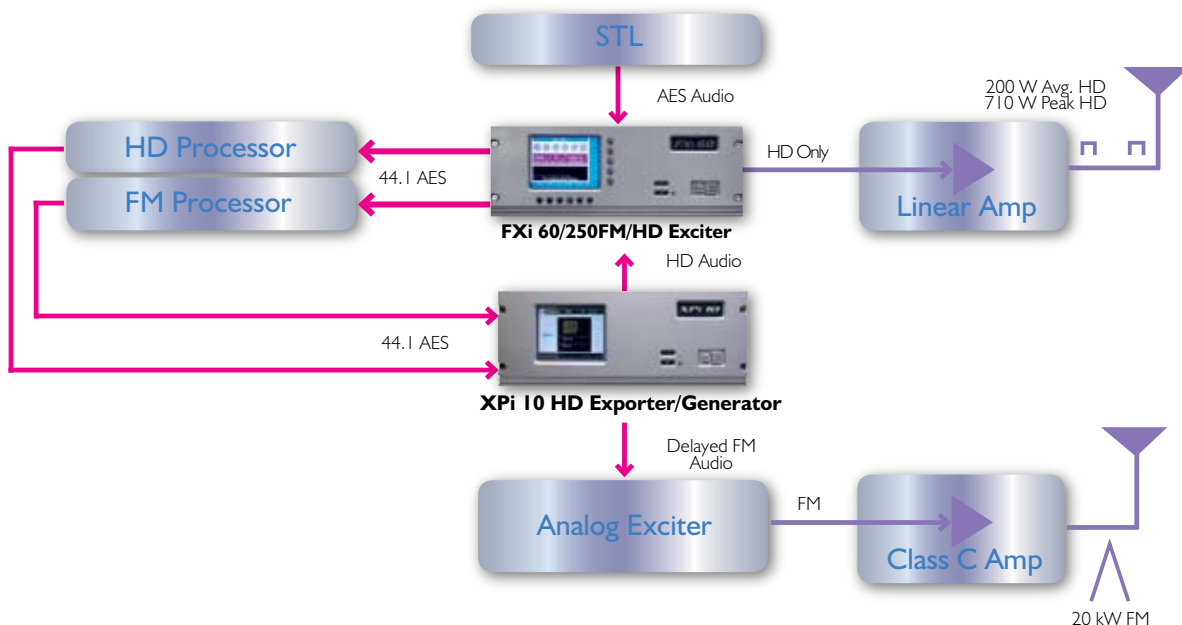
- Low powered transmitter for HD Radio (20 dB below main TPO)
- No combiner or combiner losses
- Lowest startup costs
- Simplified transmitter installation
- Keep existing analog transmitter with no additional power overhead required
- Most efficient operation of existing transmitter
- Have separate HD Radio and analog FM operation in case of failure

Plus, BE's Total Radio Guarantee

- BE products can switch on-the-fly between HD Radio and analog FM operation. This provides the ability to backup your existing analog transmitter
- BE HD Radio and analog FM transmitters share PA, IPA and exciter components for easy maintenance of both products

Separate Antenna Cons

- May need to account for gain differences (if any) between analog and HD Radio antennas
- HD Radio pattern may not be exactly the same as analog FM particularly if the antennas are not the same gain
- If dual-fed, must excite all elements or apply for STA
- Separate antennas require an STA (must maintain 70–100% HAAT and 3 seconds of latitude and longitude of main antenna; isolator may be required)



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High-level combined

HD Radio is combined with analog FM at the input to antenna. HD Radio is amplified separately and combined with FM analog amplification via a 10 dB coupler at the input to an antenna; both analog FM and HD Radio share the same antenna.

Consider high-level configuration if:

- Have more than 14 kW TPO analog FM
- Existing transmitter or a transmitter you're planning to buy soon has enough headroom, about 10% more output power, to cover combiner losses
- Have available site space for separate transmitter

What you'll keep:

- Existing antenna, transmitter and exciter for analog

What you'll need:

- New BE FXi 60/250 digital FM exciter, an XPi 10 for HD Radio only signal generation at the studio or the transmitter site, and BE solid-state FMi transmitter operating in linear Class AB mode
- 10dB hybrid combiner, plus line and reject load, to produce the final mixed signal to the antenna
- Relocation of HVAC and/or additional capacity to handle combiner heat load
- New audio processor for HD Radio path
- Optional separate power meter to monitor the power ratio between analog and digital transmitter outputs

Pros and cons:

High-Level Pros

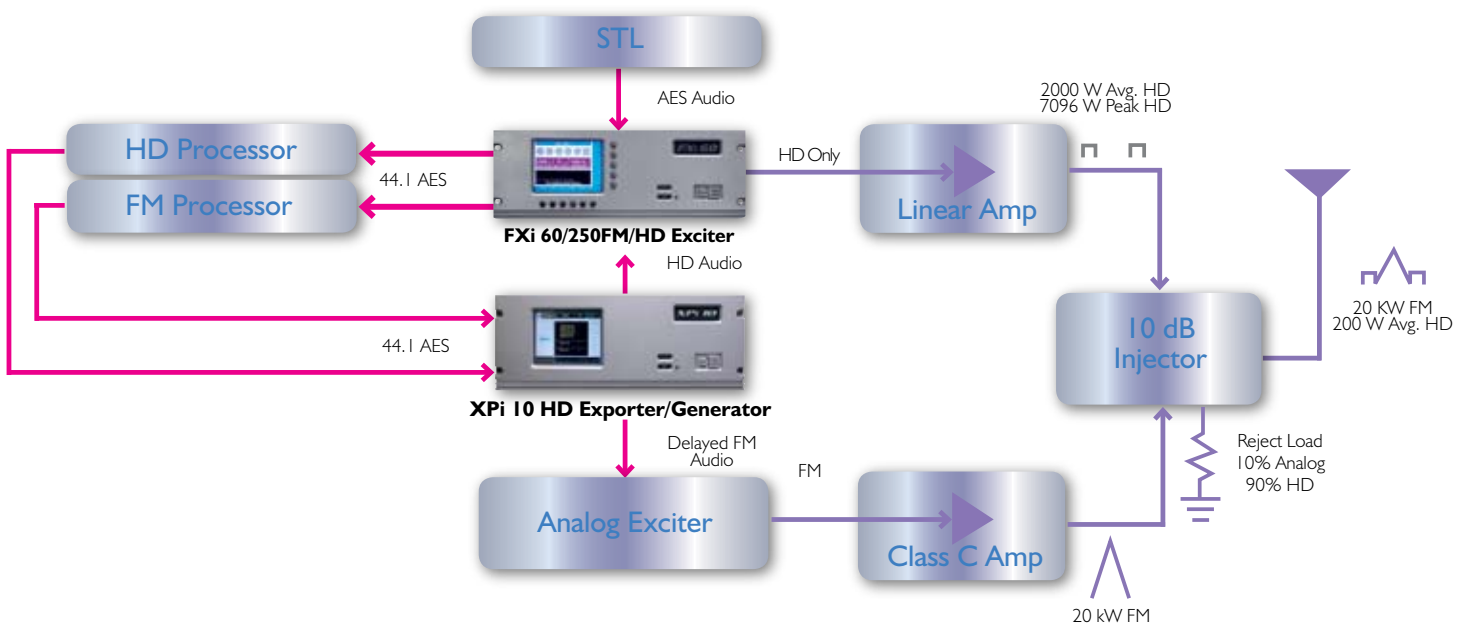
- Keep existing analog transmitter
- Analog FM and HD Radio operate separately in case of failure

Plus, BE's Total Radio Guarantee

- BE products can switch on-the-fly between HD Radio and analog FM operation. This provides the ability to backup your existing analog transmitter
- BE HD Radio and analog FM transmitters share PA, IPA and exciter components for easy maintenance of both products

High-Level Cons

- Existing transmitter for analog FM requires additional 10% TPO headroom
- Large reject load (90% of HD Radio and 10% of analog) due to injector loss
- Peak-to-average of HD Radio is 5.5 dB. This means the transmitter is less efficient than a low-level combined transmitter
- External coupler required (typically 10 dB)



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Mid-level combined

Split configuration of main FM into two transmitters and combined with HD Radio into an existing antenna.

Main FM analog is split between an HD Radio transmitter and a late-model analog FM transmitter, which is operating at full nameplate power and lacks the additional headroom needed for high-level combining. The HD Radio transmitter amplifies HD Radio and a portion of the FM analog signal that has been phased to add at the output combiner with the signal generated by the main transmitter. The HD Radio transmitter is of higher power than that used in high-level combining in order to meet the HD Radio power requirement of 20 dB below main TPO plus any additional power needed for injector loss.

Consider mid-level configuration if:

- Have more than 14 kW TPO analog FM
- Late-model, existing main transmitter does not have enough headroom to handle 10% more output, to account for high-level combiner loss
- A separate HD Radio antenna is not an option due to tower space or structural limitations (or increased operational costs if tower space is leased)
- A dual feed antenna is not an option

What you'll keep:

- Existing antenna, transmitter and exciter for analog FM

What you'll need:

- New exciter
- New solid-state transmitter operating in linear Class AB mode of sufficient power to handle HD Radio power at 20 dB of main TPO plus part of the main TPO
- External coupler, typically 3 to 6 dB

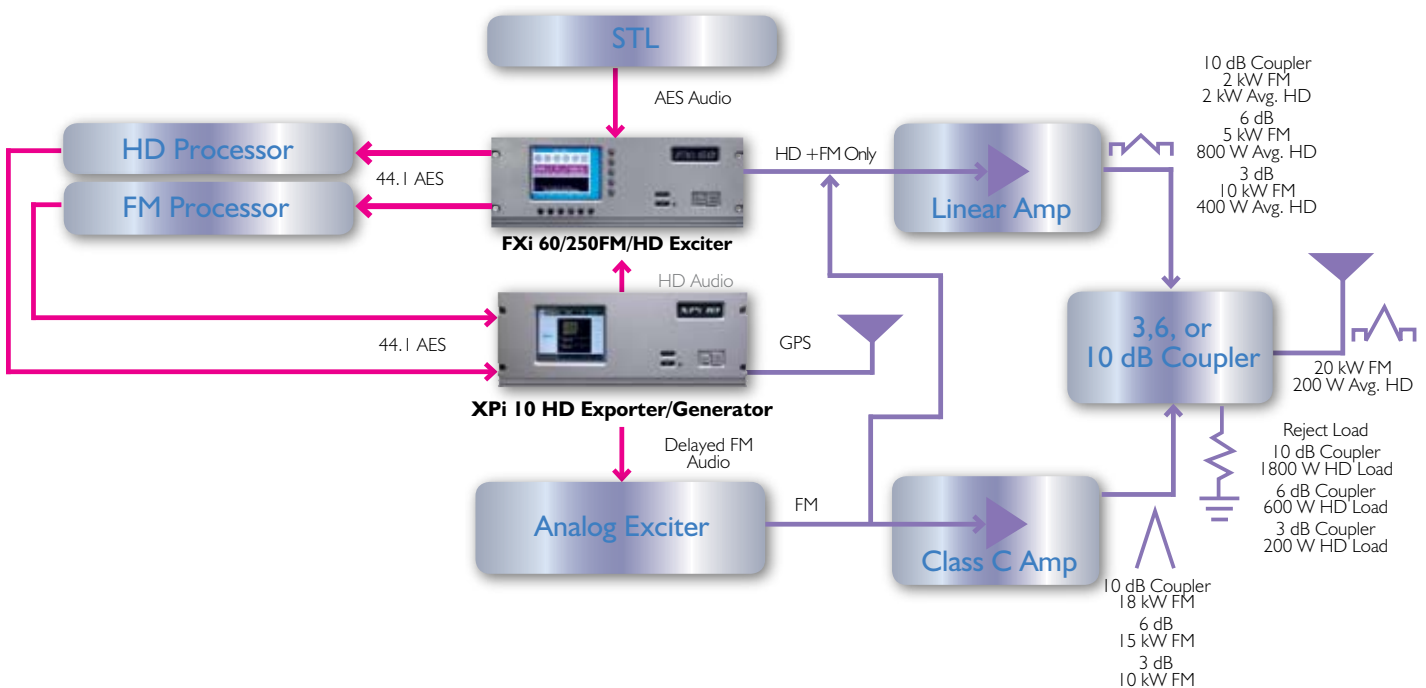
Pros and cons:

Mid-Level Pros

- Last resort for a Class B or Class C station with a late-model FM analog transmitter that doesn't qualify for high-level combining (lacks additional 10% headroom needed for injector loss) and a separate HD Radio antenna is not possible (no possibility of adding interleaved bays onto an existing antenna; no backup antenna available or antenna site won't allow for an additional structure.)

Mid-Level Cons

- Technically complex split combiner method with more failure points requiring regular adjustment of two dissimilar transmitters
- Need a higher powered HD Radio transmitter to amplify both the new HD Radio signal and the split off portion of analog FM
- The 1–5% efficiency gain over high-level combined is offset by the added cooling costs needed to dissipate combiner heat from the transmitter (high-level injector losses go directly to the reject load outside)
- The heat exhausted and energy consumed by the HD Radio transmitter is significantly greater
- Combiner is fixed; no on-the-fly backup operation allowed
- If the HD Radio transmitter fails, a large portion of the analog is diverted to the reject load. Depending on the coupling coefficient used, as much as 40% of the analog power will be dumped, leaving only 60% of the analog TPO into the antenna. In a high-level system, 100% of the analog TPO is still delivered to the antenna
- If the analog transmitter fails, as much as 75% of the analog FM developed in the HD Radio transmitter is now diverted to the reject load, leaving as little as 6% of the remaining analog power to exit the combiner to the antenna



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Put flexibility behind your HD Radio plans

The HD Radio products you purchase today will determine what surprises, if any, you'll find on the other side of whatever door you choose. The key to any HD Radio system is operational flexibility—redundancy now and an upgrade path to new services later. A system cast in stone can compromise analog FM today, and lock you out of opportunities in text services and secondary audio services later. Enter Broadcast Electronics HD Radio solutions.

- BE delivers a choice in where you generate HD Radio, at the studio or at the transmitter.
- BE delivers a solution for point-to-multipoint distribution of HD Radio to station clusters in order to avoid unnecessary bit-rate reduction coding in the audio chain
- BE delivers a PC-free zone at the transmitter with Ethernet connectivity from the studio to the transmitter

BE HD Radio flexibility for redundancy:

All BE solid-state FM transmitters currently shipping are capable of operating in Class C FM, Class AB FM only, Class AB linear HD Radio only, or low-level FM+HD Radio linear hybrid mode. The FMi 703 and FMi 1405 models for HD Radio, which are based on the BE "S" series chassis, can be re-biased on-the-fly via a remote command to operate in Class C or AB linear. Other FMi transmitters based on BE's "C" series transmitters (chassis sizes from 500 watts to 5 kW) are capable of switching to Class AB linear with internal jumper changes, thus protecting your investment if HD Radio is contemplated as a future upgrade.

In a high-level combined system, an FMi HD Radio transmitter typically operating in digital mode can be switched into hybrid HD Radio/analog mode during an emergency, capable of delivering adequate analog power while maintaining HD Radio operation at the proper 20 dB ratio. Although 90% of both analog and HD Radio power would be dissipated in the reject load, a motorized RF transfer switch could instantly put the full output of the hybrid solid-state transmitter into the transmission line. This operation could continue until the analog FM transmitter was restored to service. If HD Radio operation was not deemed essential, the FMi transmitter could be hot-switched to Class C with the press of a remote button, thus increasing to the full rated power of the FM transmitter in Class C mode.

In common amplification configurations, Broadcast Electronics uses one direct-to-channel digital exciter to combine the analog and HD Radio signals in a single hybrid RF chain. The FM and HD Radio signals are combined at low-level and the single RF output from the exciter contains both FM and HD Radio carriers. There is no need for a second exciter or combining of two RF outputs, one digital and the other analog.

BE's FXi 60/250 FM digital exciter is the only exciter on the market that can be used for analog-only, HD Radio-only or for both HD Radio and analog FM. It can be used in all digital configuration schemes, whether it's high-level, separate or common amplification. The FXi:

- Provides emergency backup in case of main transmitter failure
- Provides fill-in for a main/alternate system during switchover
- Allows power output to increase to maximum allowable in common amplification mode
- Can be controlled from the front panel or remotely with a relay closure
- Maintains FM and HD Radio ratios

BE HD Radio flexibility at the studio for multicasting and Messagecasting:

BE HD Radio systems are capable of HD Radio signal generation at the studio for multiplexing data, main and secondary audio into one data stream that can be carried over STL to the transmitter. This flexibility is made possible by the unique design of Broadcast Electronics' XPi 10 Exporter/Generator and FXi 60/250 digital FM exciter.

The XPi 10 HD Exporter/Generator and FXi exciter with Exgine plug-in option will be critical for getting multicast channels from the studio to the transmitter site without adding another cycle of bit-rate reduction to get data and audio through the typical STL system.

BE HD Radio flexibility for station clusters:

BE HD Radio systems offer a cost-effective, easy solution for point-to-multipoint HD Radio distribution to two or more transmitters in a cluster. BE's XPi 10 codes audio at the studio using the standard HD Radio coding algorithm and bit rate, which fits the transport rate required to send the program through a low bit-rate terrestrial STL or satellite channel to all transmitters in the cluster.

What about new HD Radio capabilities as they come along?

Good question. Choosing how, where and with what to implement HD Radio is merely the first step. Gaining traction in the digital world of HD Radio, with new potential in text services and multicasting, will require equipment—and a company—that can go the distance.

BE's approach to HD Radio operation extends from the studio to the transmitter for unsurpassed reliability without the risks of rapid obsolescence or unpredictable expenses.



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