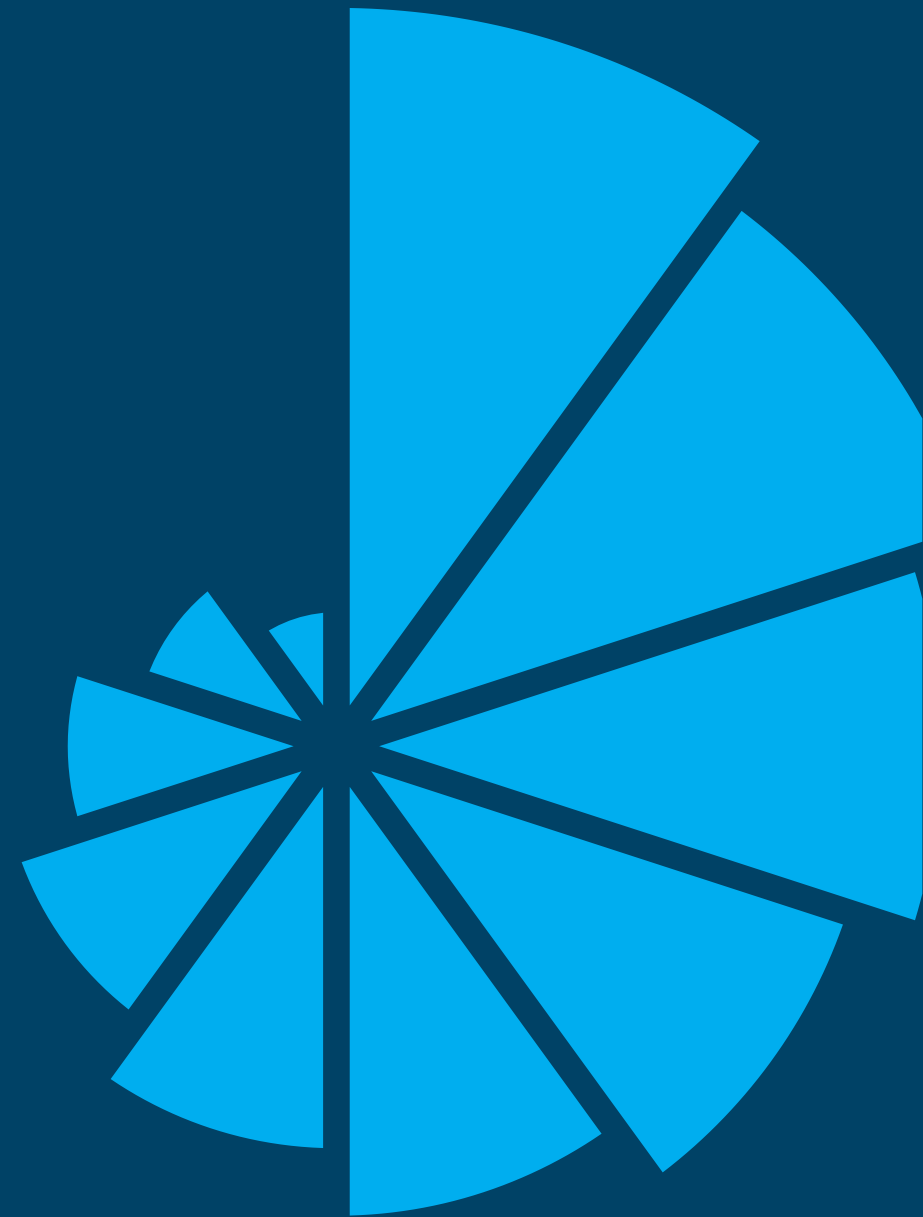


# BE HD Radio<sup>3</sup> Solutions

May 19, 2020



# BE HD Radio Solutions

- The Million Dollar Question
- The history of HD Radio
- The current state of HD Radio
- Where we are today
- What makes the BE solution unique?
  - Embedded components
  - Advanced Adaptive Precorrection
  - ATSC3 STL interface
  - Integrated audio and RF spectrum analysis tools
- Your questions



Your host:  
Chuck Kelly  
VP Market Development



Special Guest:  
Perry Priestley  
COO / CSO Broadcast Electronics



Special Guest:  
Morten Simonson  
CTO – Elenos Group



# The Million Dollar Question



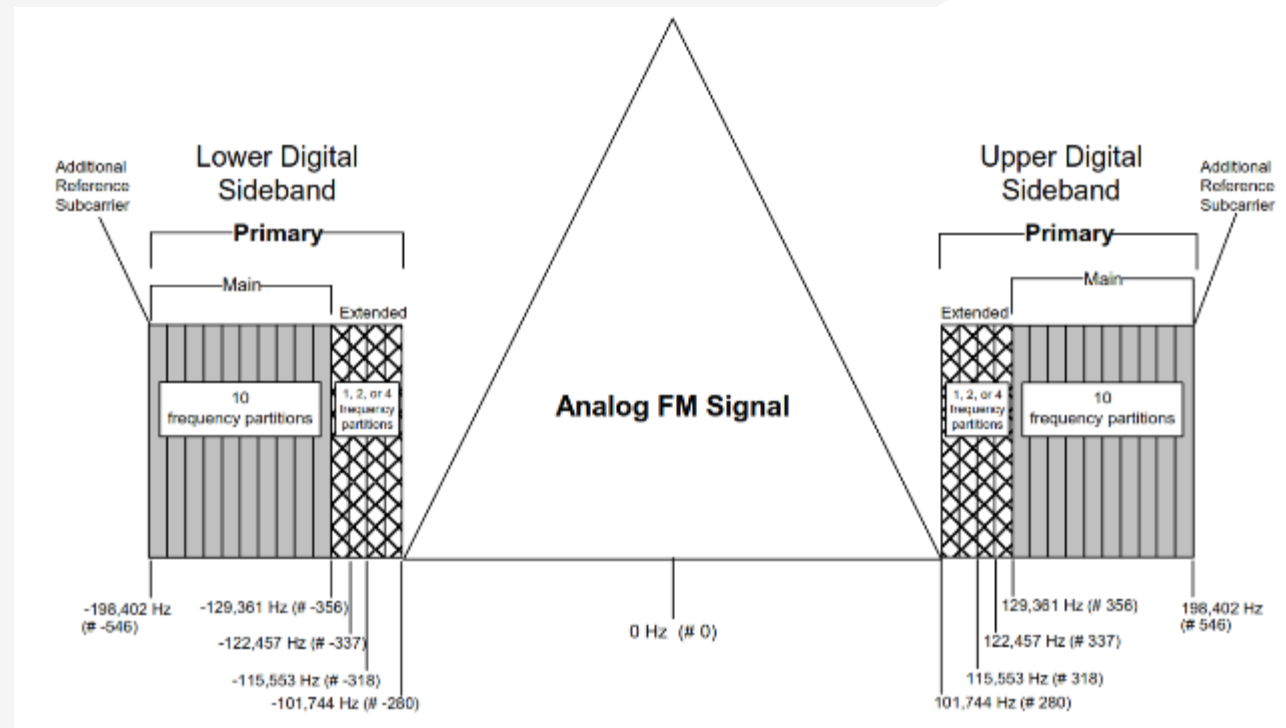
## A brief history of FM Radio®

- In 2002, the US FCC endorsed HD Radio as the digital system for the US, and in 2007 added multicasting and datacasting services.
- HD Radio is a transitory technology, allowing stations to continue to broadcast their normal programming in analog, while adding new digital signals which offer better audio quality, and additional services.
- Today, there are 2,450 FM broadcasters offering HD Radio in the US, Canada and Mexico.
- HD Radio is the digital radio standard for the US, Mexico, Panama and the Philippines. It's also on the air in Canada and in India.
- Over 70 million HD Radio receivers have been sold worldwide, with 65 million of them in vehicles.
- Broadcast Electronics has been a leader in HD Radio transmitters since the beginning.



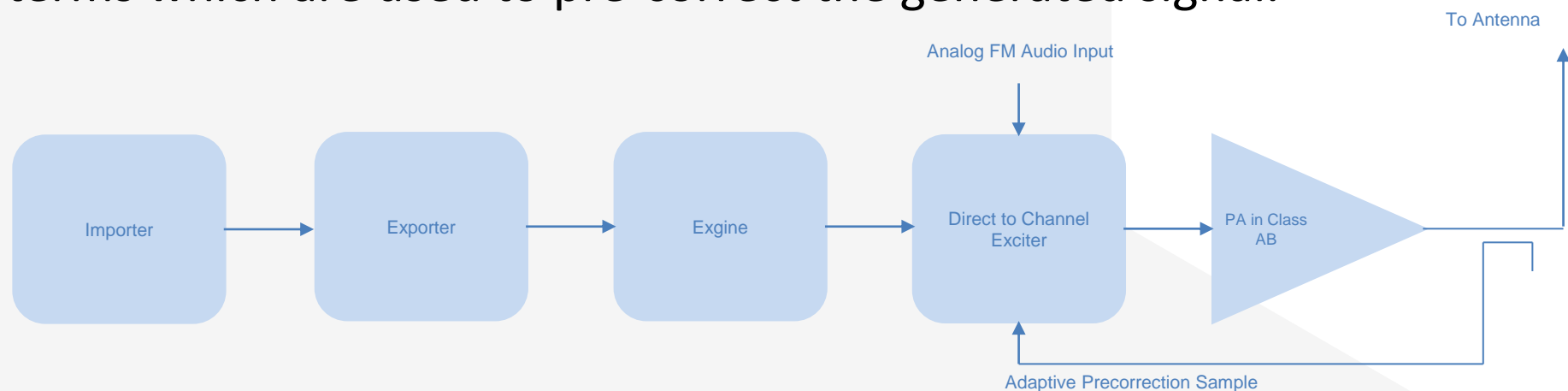
# FM HD Radio Basics: composition

- Hundreds of digital carriers are added both above and below the FM analog signal.
- The combined power level of these digital carriers is between -20dB and -10dB below the unmodulated FM carrier, so for a 10kW FM, the digital power is between 100W and 1kW.
- There are several methods of transmitting an FM HD Radio signal, but today the most common is an exciter capable of simultaneously creating the analog and digital components and following it with a PA in Class AB linear mode.
- Since any non-linearities in the PA stages can cause spectral regrowth, adaptive precorrection techniques are used to correct the non-linearities.



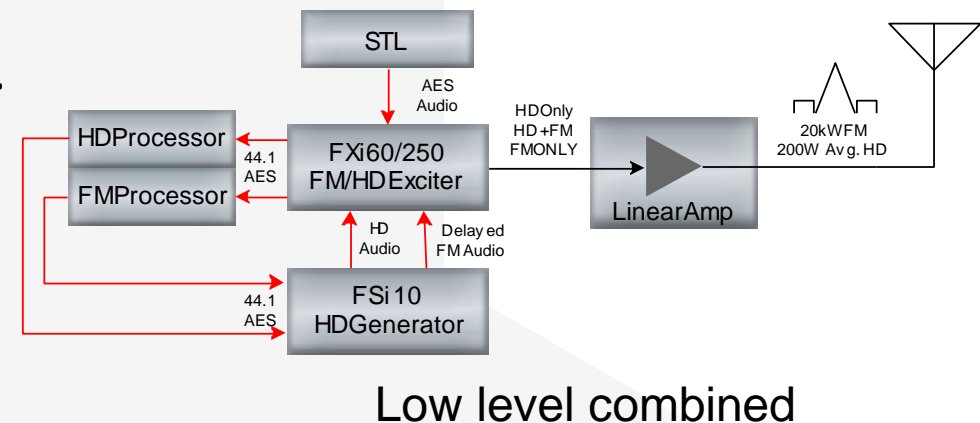
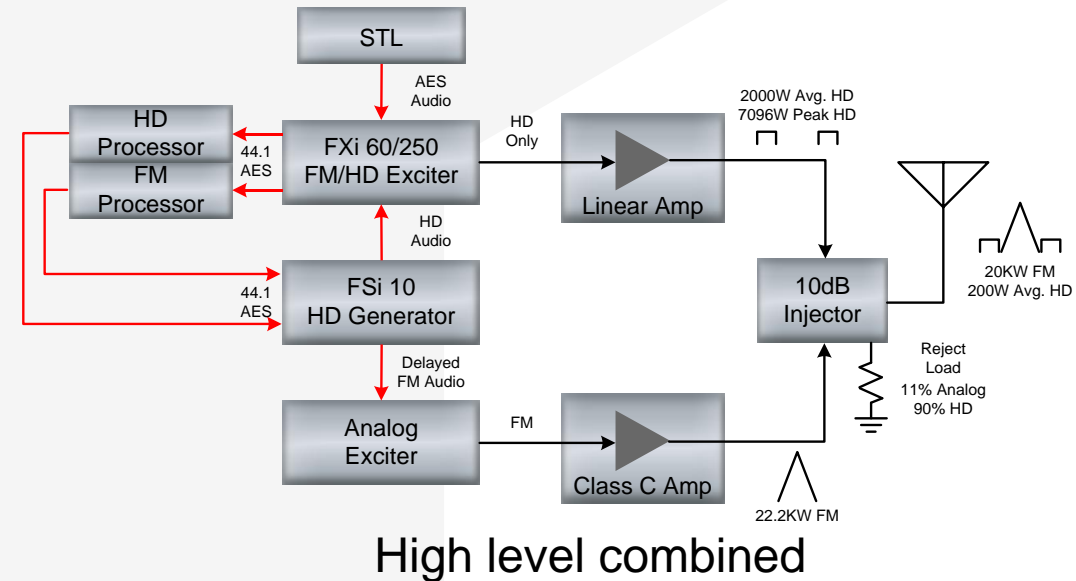
# What does it take to transmit HD Radio on FM?

- **Importer:** Multiplexes the audio content channels into a single stream.
- **Exporter:** Creates the HD Radio signal in E2X form.
- **Exgine:** Creates an IQ signal from the E2X data which is fed directly to the Direct to Channel Exciter.
- **Direct to channel Exciter:** Digitally synthesizes both the analog FM content as well as the HD Radio carriers and creates the total waveform on the RF frequency. Receives a directional sample of the signal being fed to the antenna, compares it with the mathematical ideal signal, and creates error terms which are used to pre-correct the generated signal.



# Early amplification alternatives

- High level combined: Loses 10% of analog and 90% of digital power.
- Separate Antennas: Efficient, but received ratio changes leading to degraded reception.
- Split level combined: Proprietary system which offered increased efficiency over high level combined.
- Low level combined: Both analog and digital signals are amplified in a single class AB amp.



# Injection level changes

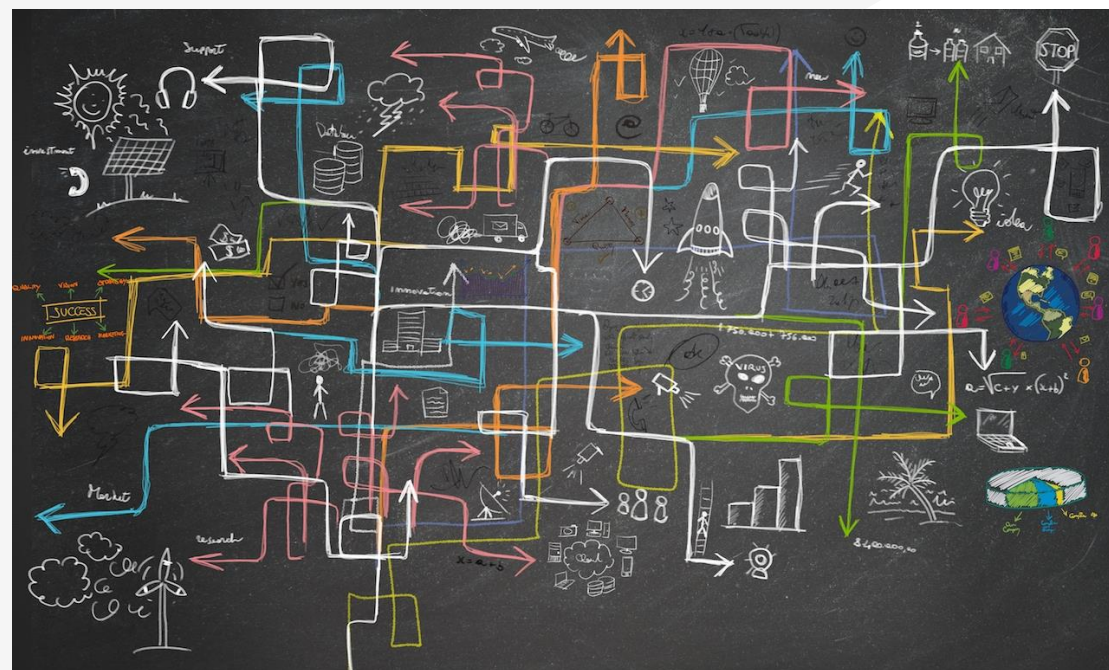
- Early adopters of FM HD Radio faced challenges with digital coverage being less than average analog coverage especially indoors where increased noise levels caused digital dropouts.
- In 2008, the FCC allowed increased digital injection levels from -20dBc up to -14dBc for all stations, and up to -10dBc for stations without adjacent channel interference issues.
- Asymmetrical sideband power was also allowed, allowing stations to increase the power on just one sideband and stay with -14dBc on the sideband with adjacent channel interference issues.
- The increase in digital sideband power of 4X in the case of -14dBc, and 10X for -10dBc effectively eliminated the use of High level combined and Split level combined systems. Efforts by manufacturers focused on improving the efficiency of Low level combined systems.

Total Digital/Analog Power Ratio (dBc)	dB Increase	Power Multiplier	Total Digital/Analog Power Ratio (linear)
-20	0	0	1/100
-18.5	1.5dB	1.4	
-18	2dB	1.6	
-17	3dB	2	1/50
-15	5dB	3	
-14	6dB	4	1/25
-13	7dB	5	
-10	10dB	10	1/10



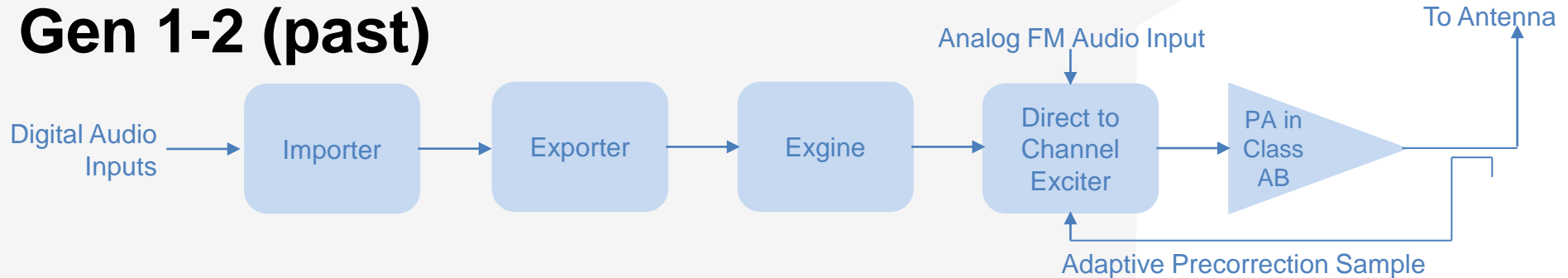
## Simplifying the install

- Early installations of HD Radio were complex, I mean *REALLY* complex.
- Many different boxes, many UI's, lots of IP addresses, routers, it was anything but intuitive.
- As the technology has evolved and improved things have gotten marginally better, but it still can be a daunting task.
- Now with the integration of components, the installation of an HD Radio system has become much easier.
- Having the importer and exporter in the same box, reduces the wiring and the configuration, and the same for the engine and advanced HD Radio exciter.
- Eventually, we will get to the point where all the components are in a single box, and you'll have all the audio inputs on one side (via IP) and RF out on the other. This will be cheaper, more reliable, and far easier to install and maintain via a single UI.

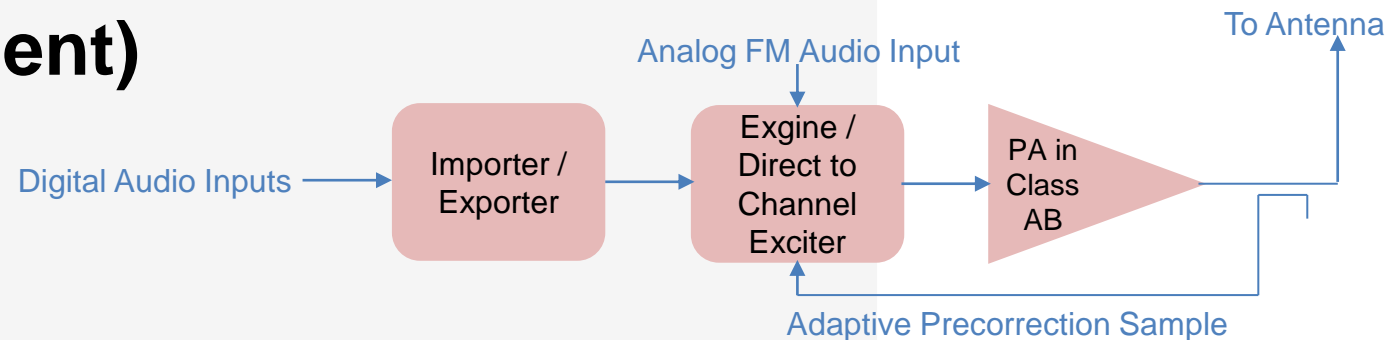


# What makes the BE solution unique: Integration of the building blocks

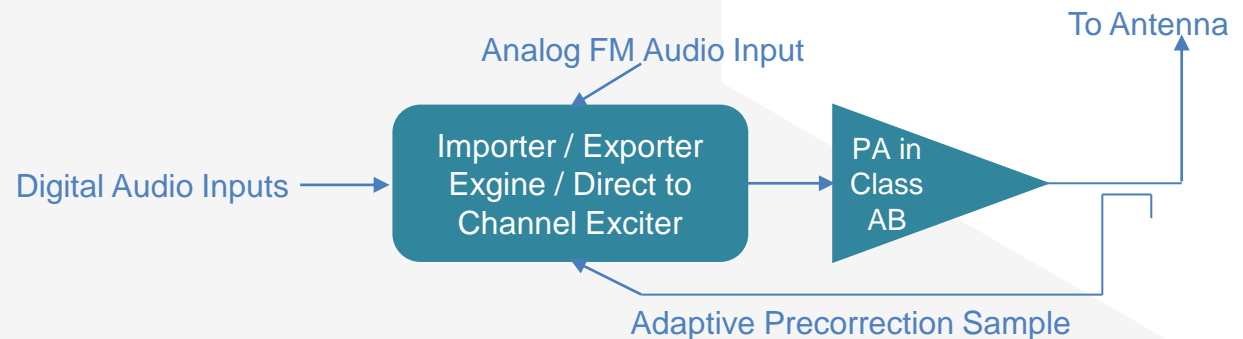
## Gen 1-2 (past)



## Gen 3-4 (present)



## Gen 5 (future)



# What makes the BE solution unique: Integration of the building blocks



BE Importer-Exporter

- Fourth generation importer/exporter in a single box solution
- Embedded solution for maximum reliability
- Analog / HD diversity delay
- Simple
- Cost-effective
- Provides dynamic time, level, and phase correction



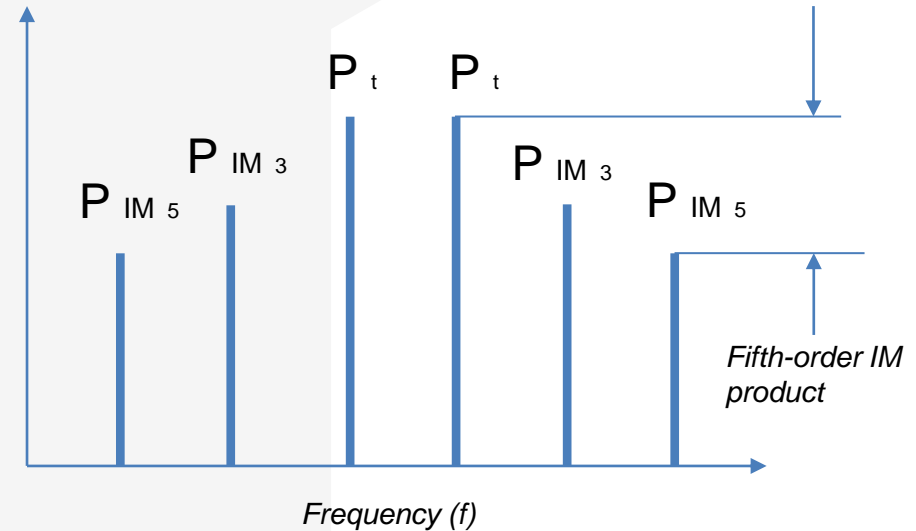
BE Engine / DTC exciter

- 4<sup>th</sup> generation engine with direct to channel modulator/exciter
- Software defined HD Radio modulator
- Adaptive / automatic linear and non-linear correction
- Web browser with graphical user interface



# What makes the BE solution unique: Advanced Adaptive Pre-correction

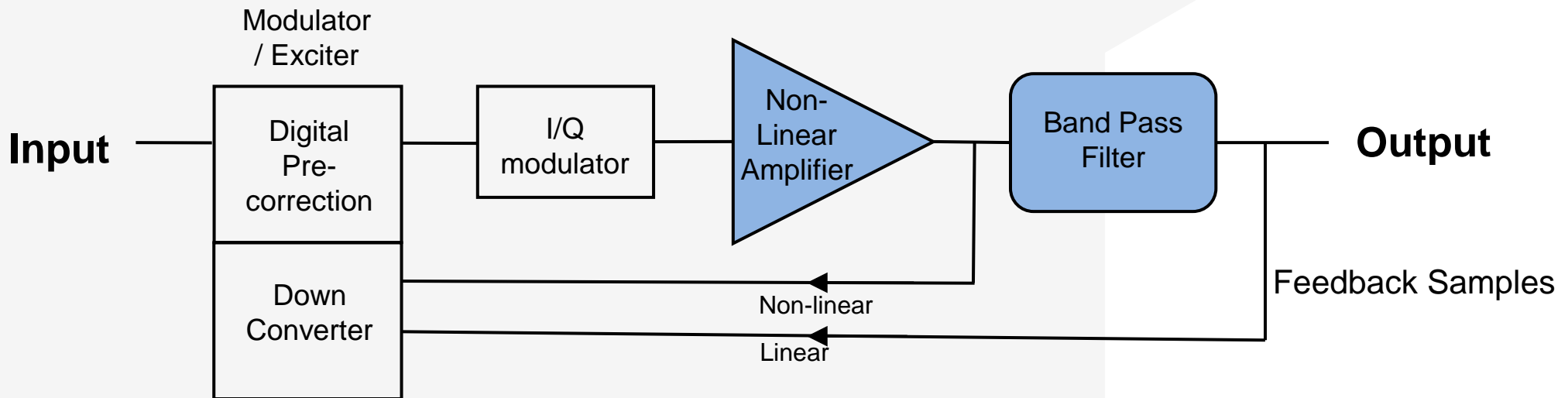
- Any distortion to the amplified signal  $P_t$  (dB) linearity causes IMD products which can affect adjacent frequencies.
- The higher average power output of a given amplifier can result in higher efficiency, however at the cost of increased IMD.
- The solution is adaptive pre-correction, where the signal output from the power amplifier is dynamically analyzed and a correction term representing the distortion is applied out of phase in the modulator, effectively cancelling the distortion.
- Thus pre-correction allows higher average power from an amplifier, and higher efficiency, while preserving spectral purity.
- All digital radio transmitter manufacturers employ adaptive precorrection, however the system BE and the Elenos Group has developed is far more advanced.



*Two-tone test for the fifth order intermodulation levels*



# What makes the BE solution unique: Advanced Adaptive Pre-correction

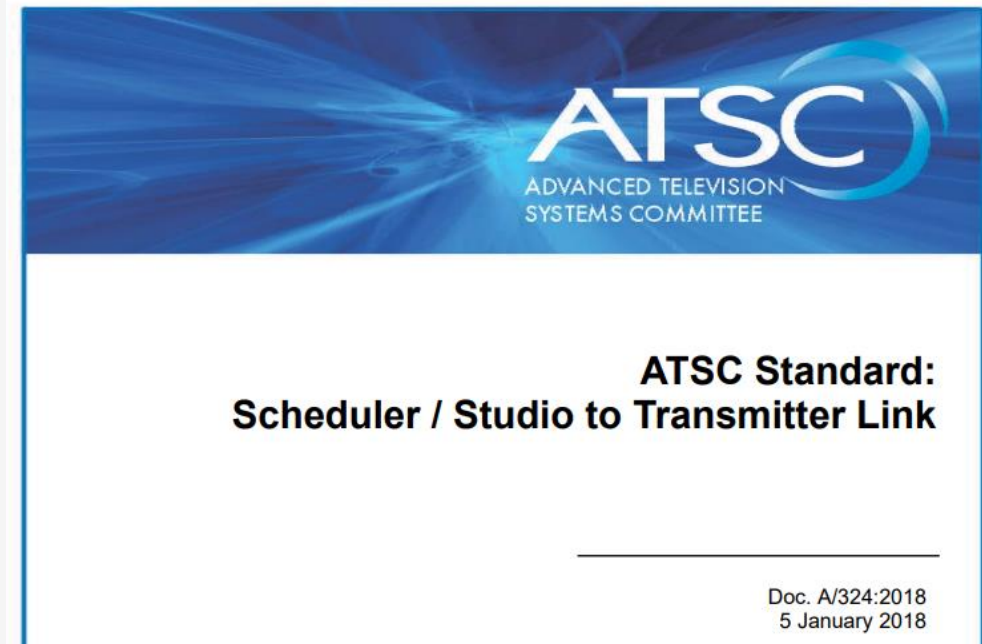


- Most manufacturers implement only non-linear pre-correction, but we include both linear and non-linear feedback to correct for more types of distortion in the PA and output networks and combiners.
- In addition, the new BE solution provides correction for memory effect, a sophisticated form of distortion. Our correction can significantly improve both efficiency and MER while staying within the spectral mask.



# What makes the BE solution unique: ATSC-3 A/324 STL protocol

- The Advanced Television Systems Committee has developed a standard IP interface protocol for the STL function for ATSC 3 installations. It has a number of important features which are valuable to HD Radio installations:
  - Configurable to carry multiple audio and data streams.
  - Includes provisions for precise timing both for SFN applications and to minimize dynamic changes in the analog / digital timing.
  - End to end IP security provisions to minimize the chance of having the STL hacked.
  - Allows for redundancy of the content.
- As ProTelevision is already implementing this standard in our ATSC-3 modulator, it is being implemented as well in the HD Radio exciter.



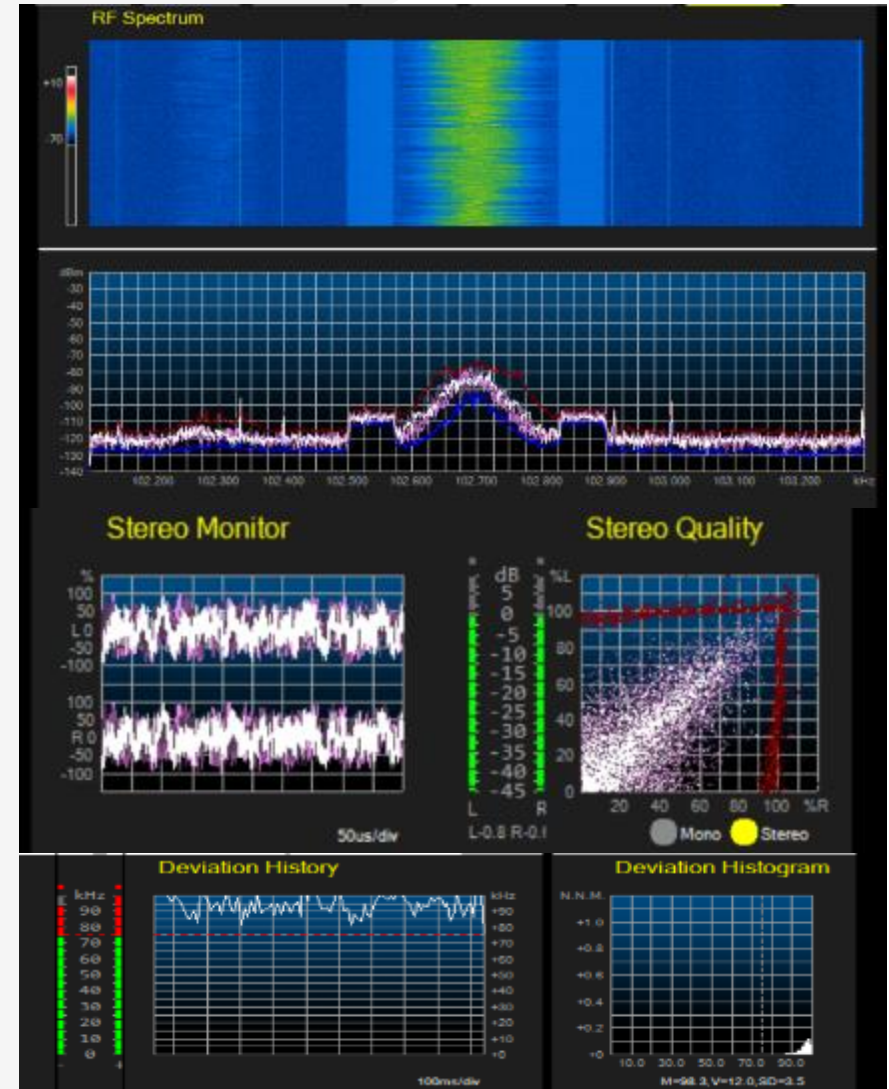


# The RF Supercomputer

- A programmable hard real-time processor
- A programmable Linux real-time, multi-threaded processor
- A programmable DSP
- A large programmable FPGA
- One integrated board of programmable power
- 16-layer printed circuit board with 2200+ parts
- RF out from 30MHz to 760MHz in 1Hz steps
- Four Ethernet ports with individual MAC addresses
- Build-in GNSS (optional: GPS, Glonass, Galileo & BeiDou)
- Single supply voltage (5 to 50 V)
- Totally software defined with remote firmware upgrade
- Onboard webserver control / monitoring (no FLASH Or Java)
- 3 different levels of Reference Oscillator (holdover duration)
- Currently supports: DVB-T/H/T2, ATSC legacy/3.0, ISDB-T/Tbb, Analog PAL/NTSC, DAB/TDMB/DAB+, ..)



# What makes the BE solution unique: Integrated audio and RF spectrum analysis tools





# Summary

- Our HD Radio solutions are the latest in a long line of reliable, efficient and performance-leading digital technology from Broadcast Electronics.
- The Elenos Group with 90 years corporate experience, 60,000 installations and some exciting new products for all radio stations is here to be of assistance.
- Contact your BE representative to find out how cost effective our HD Radio solutions can be!
- Register for our schedule of upcoming free webinars at:  
<https://www.elenosgroup.com/webinar/>



# Your Questions?

*We'll try to answer them all here, but if we can't we'll email you.*



# Thank You



Radio & Television  
Broadcast Equipment  
and Solutions Worldwide

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We know how valuable your time is, and we are honored that you chose to spend time with us.

For further information, contact your regional Elenos Group sales professional

Register for our schedule of upcoming free webinars at:

<https://www.elenosgroup.com/webinar/>

