Field Reconfigurable HD Radio Combiner Provides a Path Forward.

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Abstract

The road to HD Radio has met and conquered many challenges along the way. The most recent "speed bump" stems from the original digital sideband power level and its inadequacy in some situations. While testing and discussions are ongoing to update these power levels, it appears clear that no universal hardware solution currently exists to meet the needs of every group involved. This paper proposes a novel system architecture that not only offers a possible solution to solve these issues for early adopters, but also creates a best-in-class solution for those in the initial planning stages. The discussion will offer a path to accommodate multiple sideband power levels while also addressing the critical space requirements faced in many transmitter facilities. This adaptability, both electrical and mechanical, will be examined in this paper in order to demonstrate that this current challenge may be conquered, just as others have before it.

Introduction

The future of HD Radio is certain since "Failure is not an Option". In order to compete with the continually evolving media being brought to bear from numerous sources, terrestrial radio has to make the quantum leap to digital in order to remain competitive. Over the past few years of the initial "roll out", there are a number of parameters which have been considered as critical when building an HD Radio system, efficiency, space, isolation, coverage, to name but a few. However, most recently, the -20 dBc digital power level has been called into question as being insufficient in some areas, primarily due to lack of building penetration. As the discussions rage on with respect to raising the power level, the question has to be asked, "What of the early adopters"? Many broadcasters have already made the leap to deploy HD Radio, only to find themselves "out of pocket" with a potentially less than optimum system. This paper discusses possible modular system integration approaches which may offer a way forward by allowing the broadcaster to utilize what is already in place through adding additional modules to achieve increased digital power levels without having to incur the huge increase in losses, which would be associated with their current system.

The proposed approach, naturally, is not without cost and additional losses will be incurred. However, the magnitude of these losses may be limited. In addition, the adjustability of the digital level alone provides a very important degree of freedom which is currently unavailable. This paper discusses ground level combiner systems and how they may be added to in order to achieve the desired analog to digital ratio.

High Level Systems

Much of the initial development work involving In Band On Channel radio utilized a 10 dB coupler as the mechanism to combine analog and digital signals in order to achieve the -20dBc signal levels envisaged for HD Radio transmission. This was certainly not a very efficient method since 10% of the analog transmitter power and 90% of the digital transmitter power was subsequently dumped into a waster load. It was believed at the time that much more efficient methods would be developed to obtain the necessary analog/digital power ratio and to a large extent, they have. During the initial deployment phase, however, this inefficient method became one of the popular methods utilized by early adopters due to the inexpensive installation costs. Given the current move to raise the digital power level, these early adopters undoubtedly feel that they have no way forward. By utilizing the modular approach described here it is possible to increase the digital power level without losing any more analog power than was previously discarded.

Typical high level combiner systems necessitated that the analog transmitter have enough headroom such that the power could be raised in order to allow 10% to be dumped into the waster load of the combiner, while still providing full analog power to the antenna. For a 20 kW system the analog transmitter power required is 22.22 kW, which allows for 2.22 kW to be dumped. At the same time a 2 kW digital transmitter is utilized to obtain the necessary 200 watts directed to the antenna, the other 1800 watts being dumped into the waster load

Split Level Systems

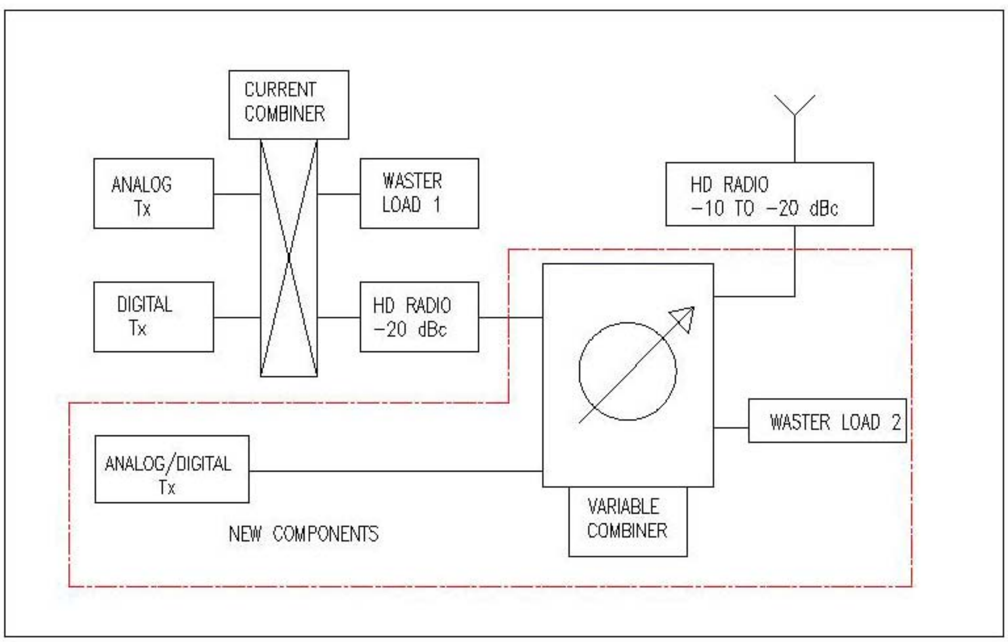
A second system widely in use is the split level system, as introduced by Harris Corporation. This system makes use of the existing analog transmitter and a hybrid transmitter providing a combined analog/digital signal. The two signals are fed into a fixed coupler, which has a coupling value proportionate to the ratio of the two analog signals. In addition, the two analog signals are manipulated to be 90 degrees out of phase and, as a result, they combine within the coupler to be directed to the antenna with minimal or no analog loss. The digital signal on the other hand, is only fed into one port and is subjected to a loss proportional to the coupler value. The split level system is substantially lower loss than the high level system.

Typical systems utilize either a 4.77 dB or a 6.2 dB coupler. In the case of the 4.77 dB coupler, 66% of the digital power is lost and for the 6.2 dB coupler 75% is lost. However, in either case the digital loss is less than that of the high level system and with no analog loss, the overall loss is typically reduced by over 60%.

Modular Building Approach.

A new modular approach, as shown below, has been developed which provides a way forward for the broadcaster with such systems already in place. This approach will allow systems in place to ” bolt on” other equipment in a modular fashion in order to increase the digital power level from the current -20 dBc level up to as high as -10dBc. There are a number of different scenarios which may be explored and the possibility also exists of completely re-configuring the system in place in order to obtain the most optimum performance. The proposed modular system requires the addition of a low power hybrid transmitter and an “add on” combiner system to provide a variable digital output to 10 dB. In the case of a 20 kW high level combined system, one possible scenario is described.

For this example, the existing analog transmitter may be throttled back from 22.2 kW to 20 kW such that the high level combiner system output is set at 18 kW analog, 200 watts digital. As such the analog power dumped
into the existing waster load is reduced from 2.22 kW to 2.0 kW. A new hybrid transmitter with 2 kW of



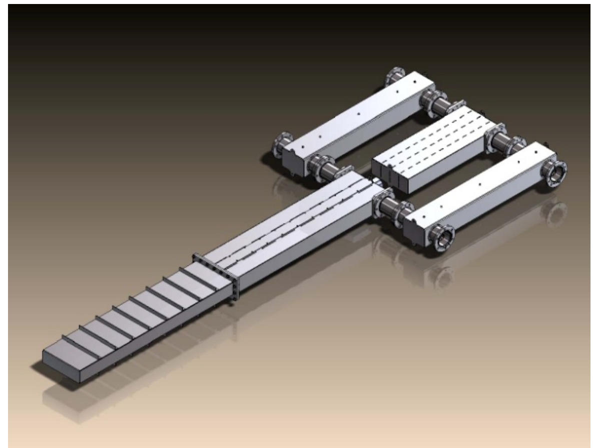
analog power and a variable digital power range is then added into the system along with a versatile combiner to allow the desired analog and digital levels to be achieved. By adjusting the new combiner, the two signals are combined to provide an analog output of 20 kW and a variable digital level. One example of the losses of the old and new systems is as follows.

	High Level System	New System	
Analog Tx	22.2 kW	20.00	kW
Digital Tx	2.0 kW	2.00	kW
Hybrid Tx An	-------	2.00	kW
Hybrid Tx Dig	-------	2.00	kW
Output	20 kW Analog	20.00	kW Analog
	200 W Digital	0.75	kW Digital
Waster Load 1	2.22 kW Analog	2.00	kW Analog
	1.80 kW Digital	1.80	kW Digital
Waster Load 2	------	0.00	kW Analog
	-------	1.45	kW Digital

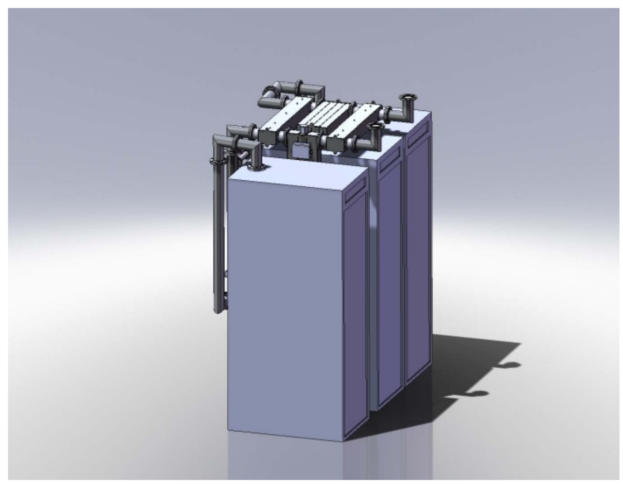
As can be seen here, the overall analog loss is actually decreased from 2.2 kW to 2.0 kW. The digital loss, however, increases from 1.8 kW to 3.25 kW in order to achieve a -14.3 dB analog to digital ratio. By sacrificing more analog signal it is possible to raise the digital signal level closer to the -10 dBc level.

Combiner Module

The key component of the new system is a highly versatile combiner module, which may be oriented in a number of ways in order to optimize space requirements. Similar devices have been utilized for decades in the military communications field where signal combination/selection is required. In this instance, one of the critical design parameters has been to design a frameless device which may be mounted in a number of different configurations in order to best utilize the available space in the transmitter room. The base design, shown here, is a flat-pack device.



The unit may be mounted horizontally or vertically such that it may be wall or ceiling mounted. Alternatively, the device may be reconfigured to fit around the transmitters, one example being shown here.



The use of swivel flanges provides much of the mechanical versatility required to fit into even the tightest spaces.

In essence this is a 4-port device with 2 inputs and 2 outputs, one of which is connected to a waster load. One input accepts the current HD signal, which is set at the -20 dBc ratio. The second input accepts a signal from a new hybrid analog/digital transmitter. A motorized tuning mechanism allows the much needed variability between the signals to be controlled, remotely if desired.

The two inputs are combined together such that two internal lines within the device contain equal magnitude analog and digital signals. The relative phasing of the two is such that it is not feasible to completely re-combine both of these signals such that they can both be directed towards the antenna. The balancing is accomplished through the use of a stepper motor-driven phase shifter assembly, which can be positioned to provide optimum performance. In addition, the magnitude and phase of the various transmitters may be utilized to further optimize the system.

Key Considerations

As with all of the HD Radio solutions proposed to date, this is not an all- encompassing solution designed to fit every unique situation. However, the versatility of this approach, both mechanically and electrically, allows each system to be optimized, through reconfiguration if necessary. The new module includes a hybrid transmitter and a combiner module. In the case of existing split level systems it may be possible to re-use the existing hybrid transmitter and only buy a new "digital only" transmitter in order to minimize costs. After a thorough engineering review of the existing components with respect to the desired analog to digital ratio, a determination can be quickly formulated as to what new components are required.

Conclusions

Considering the historic path towards HD Radio, one would have to say that it has been somewhat less than ideal. At this point in the process, manufacturers have met and conquered many unique challenges and it has to be said that no all encompassing solution has been presented to the broadcaster. The obvious choice from a technical standpoint is a high power transmitter which can provide the necessary analog and digital power levels. Where such a device is not readily available, a number of various combination schemes have been developed, some as part of the RF circuit on the ground and others as part of the RF circuit in the antenna. None of these solutions has proved to be optimum for numerous reasons, mostly revolving around cost! Given the latest challenge involving the need to raise the digital signal power level, the majority of what has come before has quite simply just become obsolete! The proposed solution is one way to try to contain costs on the path forward to higher digital power levels while also offering a method to deal with the possible interference issues that could occur when the digital power level is raised. All of the components utilized to build the new circuit are tried and tested components which have been utilized in systems for over 50 years.

While additional losses will indeed be incurred, it is believed that the incremental cost of adding the new modules will be substantially less than going back to the drawing board and starting from scratch.