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Common Amplification of FM IBOC at Elevated Power Levels

The proposal to allow broadcasters to increase the power in the digital portion of an FM IBOC signal has been of great interest lately, and raises a number of issues not the least of which is how this can best be implemented. A session at the upcoming NAB Broadcast Engineering Conference (BEC, April 18-23, 2009, Las Vegas, NV – see below for additional information) entitled "*HD Radio Implementations and Improvements Part I*" includes a paper, excerpted here, which focuses on a new solution for more efficient common amplification of high power digital FM IBOC and analog signals in the 10 kW to 40 kW RF power output range.

INTRODUCTION – this paper traces the process of selecting the technology and developing a new high power, VHF transmitter for the common amplification of high power digital FM IBOC and analog signals. This paper also explains the application of new, high power, RF amplifier and power supply technologies to elevated HD Radio sideband transmission. The desired transmitter solution is focused on optimizing these key parameters: minimum purchase and operating cost, maximum power output and operating efficiency, and environmentally "green." The transmitter should be capable of at least 40 kW analog FM power, 30 kW FM+HD @ -20 dBc digital sideband level, and at least 15 kW FM+HD @ -10 dBc digital sideband level.

THE LINEARITY CHALLENGE – the proposed 10 dB increase in HD Radio digital sideband levels presents a significant linearity challenge to common amplification of FM and HD Radio signals through a single transmitter. The common amplification linearity must be improved by 20 dB to accommodate a 10 dB increase in HD Radio digital sidebands while still meeting the original NRSC-5-B RF emission mask.

PURCHASE PRICE – although solid state technology offers several advantages, it carries significant purchase cost and operating efficiency penalties at RF power output levels above 20 kW using currently available solid state device technology. The figure illustrates typical purchase cost versus power output of solid state and vacuum tube-type transmitters. Notice that while the cost of solid state tracks more or less linearly with power output, the cost of vacuum tube technology tends to flatten out at higher power levels. The reason for the difference in the shape of the curves is due to the differences in the transmitter architectures. As the power of a solid state transmitter is increased, the number of RF amplifier modules, power supplies, cooling fans, combiners, combiner ports, and span of the control system increases in direct

proportion to the power output level. A high power, single tube, transmitter will have some proportional changes in the size of the vacuum tube and associated power supplies, but they are not in direct relationship to the output power level. For example, the cost of a 40 kW tube amplifier cavity is not twice the cost of a 20 kW cavity and the cost of a 5.0 ampere, high voltage power supply is not twice the cost of a 2.5 ampere power supply.
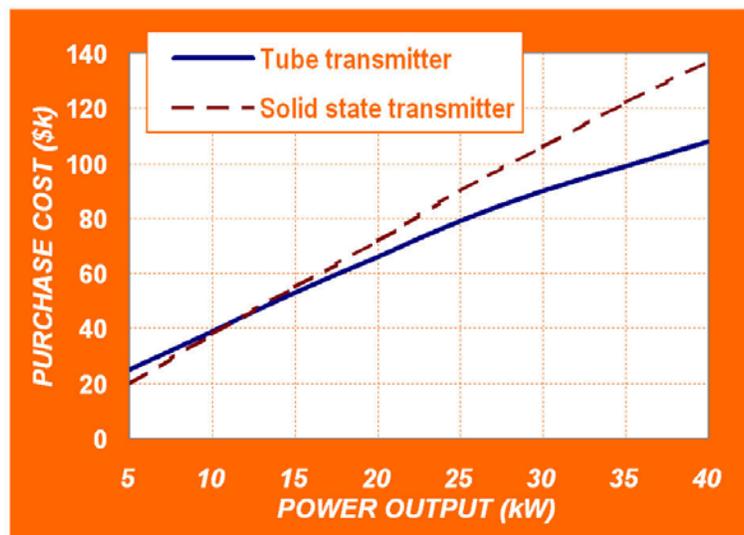
ONGOING ENERGY CONSUMPTION – the long term energy consumption of a transmitter is now more important than ever not only to save electrical power costs, but to provide a "green," reduced carbon footprint. Depending on the power output of a tube-based transmitter, the broadcaster could save as much as $6-10k/yr in energy consumption over a solid state-based transmitter. This is due to the solid state RF combining power

losses which increase at higher power levels, as well as the lower transistor efficiency when compared to a single tube power amplifier.

PA EFFICIENCY – another key consideration in the selection of a high power combined hybrid FM IBOC transmitter architecture is the operating efficiency of the RF amplifier technology and the ability to achieve high operating efficiency over the full range of power output levels required. A vacuum tube amplifier can achieve over 80% operating efficiency in FM mode and over 68% operating efficiency in common amplification mode over the full range of power from less than 10 kW to over 40 kW. On the other hand, a solid state amplifier could achieve only about 60% efficiency in common amplification mode and only at its full rated power. As the power output is decreased, the efficiency will drop, because the solid state amplifier, unlike the tube amplifier, typically lacks the ability to have its load line changed for optimum efficiency at reduced output power.

AIR COOLING TEMPERATURE DROP – cooling efficiency is another key consideration for a high power transmitter design. Air cooling is most efficient when the heat sink surface being cooled has a high temperature drop compared to the ambient air temperature. Due to the thermal resistance from the silicon junction to the heat sink, the maximum heat sink temperature in a solid state transmitter is limited to about 85 degrees centigrade in order to maintain a semiconductor junction temperature of less than 150 degrees centigrade. A high power vacuum tube anode heat sink does not have the multiple thermal interface resistances like a solid state amplifier and can operate at up to 225 degrees centigrade, therefore less cooling air volume is required to remove the same amount of heat from the tube type transmitter. As the HD Radio digital sideband levels are raised, the amplifier has to be biased into a more linear operating point which reduces the PA efficiency. Ultimately, the ability to remove heat from the amplifying device places the upper limit on power output available at -10 dBc HD Radio digital sideband levels.

This paper is authored by Geoff Mendenhall, vice president, Transmission Research & Technology, Harris Broadcast Communications, Mason, Ohio. It will be presented on Sunday, April 19, 2009 starting at 10:30 a.m. in room S226/227 of the Las Vegas Convention Center. It will also be included in its entirety in the *2009 NAB Broadcast Engineering Conference Proceedings*, on sale at the 2009 NAB Show Store and available on-line from the NAB Store (www.nabstore.com) after the convention. For additional conference information visit the NAB Show Web page at www.nabshow.com; a complete listing of the radio-related BEC conference sessions, papers, and presenters can be found in the February 2, 2009 issue of *Radio TechCheck*.

TECHNOLOGY INNOVATION AWARDS DEBUT AT 2009 NAB SHOW

NAB has selected the National Institute of Information and Communications Technology (NICT) and the NHK Science and Technical Research Laboratories to receive NAB Technology Innovation Awards. This new award recognizes organizations that bring exhibits and demonstrations of significant merit to the NAB Show, presenting advanced research and development projects in communications technologies. The awards will be presented Wednesday, April 22 during the NAB Show Technology Luncheon.

The Technology Luncheon will include a keynote presentation by digital media research scientist Mimi Ito, and will also feature the presentation of the prestigious NAB Engineering Achievement Awards. Since 1959, the awards have honored individuals who have made outstanding achievements and contributions in the broadcast engineering profession. For additional information on the NAB Show go to www.nabshow.com.