Feasibility Report

A Viable Digital Solution for All Radio in India

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Preface

Our efforts are targeted to demonstrate all the value-added features such as traffic information, user experience, programme information, graphics such as album art and associated data capabilities plus superior audio quality (no multipath or noise) in actual working conditions. You will be surprised to see how efficient the implementation of value added services including CAP (Common Alerting Protocol) compliant "Emergency Alert" could be. It will further show the robustness of an HD Radio™ signal and lack of multipath or other extraneous noise in terrain or large cities. The end-to-end system synergy and connectivity will leave nothing to the imagination and will establish why the HD Radio system is the choice of millions of listeners and thousands of broadcasters.

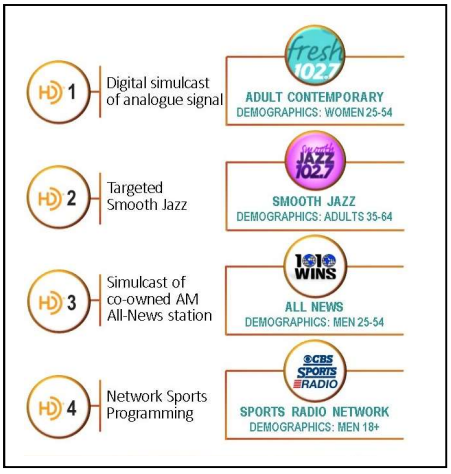
Objectives

Objectives are to create awareness among decision makers about availability of this mature and proven digital radio technology. Also we endeavour to provide a practical real and operational demonstration of HD Radio technology which has proven itself with successful implementation at thousands of stations in more than 5 countries and 10s of millions of users. This will also allow authorities to experience and feel the advantages this digital technology.

Target

The target is to make one full-featured FM HD Radio demonstration transmitter operational to cover the NCR region. We can arrange and install the system at one of the AIR antenna systems existing in NCR. The operational part including program feeds could be easily supplied by AIR by feeding the existing services to this transmitter also without disturbing any existing services. This evaluation can continue for several months if needed and reasonable numbers of HD Radio receivers will be brought for conducting listening tests.

This arrangement will provide a first-hand comparison of the quality and features and demonstrate how value-added services will enhance the listener experience. Our target includes making operational the traffic information with user experience of text and pictures associated with the audio.



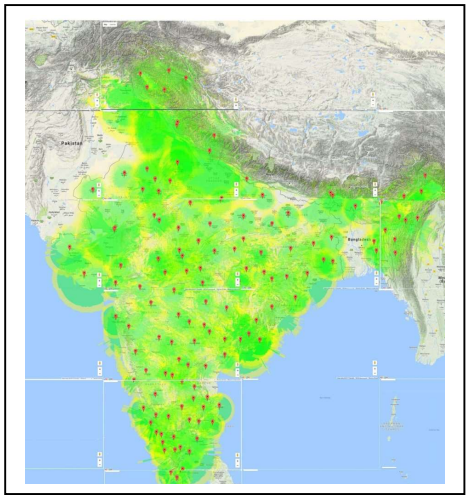
To be demonstrated:

- FM digital simulcast of analogue signal (HD1)
- Three additional digital audio streams on the same frequency (HD2, HD3, HD4)
- Graphics such as album art or advertiser logos
- Common Alerting Protocol (CAP) for emergency alerts
- Additional data services to be determined such as traffic/weather, etc.

Future Prospects

Presently there are two or three national AIR stations in each market. The present FM network covers only about half of the India population. Further, the network is a patchwork of frequency allocations originally constructed prior to the roll out of private broadcasting. Today, there are more demands on the regulators for frequencies for private broadcasters plus AIR has much programming that is not able to be aired live due to the existing analogue allocations.

Through some re-allocation work and the advent of multicasting on HD Radio, more frequencies become available AND at the same time, more efficient use of spectrum is made by these multicast channels. For instance, in the various cultures, languages and regions of India, much more programming could be made available to the population. Punjab might not be of interest to the people of South India, so something relevant would be programmed there. Meanwhile, the HD1 and HD2 could be national programming available everywhere.



Further gains in spectrum efficiency would be yielded by making the major AIR networks into a Single Frequency Network (SFN) throughout the country. Imagine an SFN with the identical frequency covering 90+ percent of the population, using EXISITING infrastructure and towers. The identity, unification and return on investment become readily apparent. Branding of the services now easily incorporates the dial position because it is consistent. This also applies to private broadcasters who may operate in regions or even nationally. As the population continues to grow, the available services may continue to expand also, to better service the people.

Why

Our expert team has closely observed implementation of all the digital radio broadcast standards (DRM, DAB, DAB+, ISDB, FMeXtra, Sirius/XM, HD Radio broadcasting plus some variants in China and Russia). On deeper study of available digital standards and in particular to the HD Radio system, we are impressed by the robustness, performance and excellent additional features including wide coverage areas. This has put us in contact with the HD Radio technology owner and developer, XPERI. Today, the more mature, proven and advanced digital radio technology is available in the form of HD Radio broadcasting.

To supplement our study and first-hand experience, the author, who lives in the United States, has visited numerous operational radio stations with HD Radio technology. The listening experience and smooth operation of diverse value-added services such as traffic information and program associated data, etc. are quite remarkable. The undersigned is convinced that the HD Radio system is 8-10 years ahead of competing DRM system in various terms. This is particularly noted in the area of receivers as tens of millions of HD Radio receivers are in the marketplace today in the Americas, with additional countries in the Hemisphere rolling out the standard in addition to the USA (Canada and Mexico being the most recent) plus The Philippines. The automobile market is particularly strong for HD Radio receiver uptake with 41%+ of new car sales in the USA having an HD Radio receiver, the latest year statistics were available, with Canada and Mexico not far behind.

Method

Evaluation of digital radio technology is not so straight forward and involves listeners' feedback significantly for a medium like radio, in addition to the technical evaluation of engineers. The fact is that digital technology offers many value-added services and features. It is easy to claim the many features as part of system design but proper implementation is the key factor both in the transmission equipment as well as in receivers. In other words an end-to-end eco system of

relevant tools, interfaces and consistency is essential for success of any technology. Perception of radio reception becomes more subjective with its half-dozen value-added services offered by digital systems.

In light of all this, we recommend the evaluation a real working system over long period of a few months in its actual challenging environment of a metropolis like Delhi by all stakeholders and actual users. To make the decision error-free we also recommend conducting a technical survey of the coverage. For this, Eastern Arts are willing to provide a full working system (hardware) with all its value-added services operational, at its own cost. AIR would need to use its national broadcaster authority and allow use of its tower and antenna system along with program feeds.

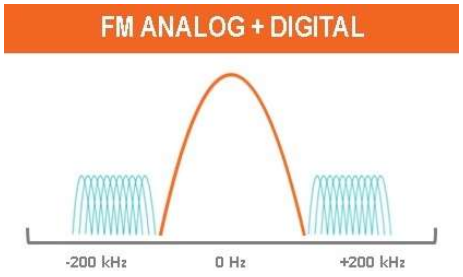
Team

The author has worked in the past with people from Eastern Arts as well as the transmission equipment vendors. We all will be happy to supplement operation of this evaluation setup with a team of expert engineers for technical support along with XPERI Corporation. The Team anticipates providing technical seminars to AIR technical and programming personnel as well as any other stakeholders which AIR may advise, including private broadcasters, if so desired.

Our combined team from Digital Systems Solutions, Eastern Arts and XPERI Corporation will be more than happy to assist the evaluation group from AIR/Prasar Bharti. This few months-long day-to-day interaction with authorities and stakeholders will showcase all the benefits of the HD Radio system and also expose weaknesses, if any.

Resources

We are willing to bring all equipment including transmitter, encoding equipment and over one hundred radio receivers required for such a trial at our own expense without any obligation on your part. We will bring the transmission equipment and install the same at your premises using an existing antenna atop the tower in Akashwani Bhawan, using your specially assigned licensed frequency in FM band. The system will act as a proof of performance by covering almost the entire state of Delhi and NCR. Standard HD Radio automobile receivers will be provided to install into cars for driving tests along with table-tops for home/office evaluation.



We will start with the FM HD Radio system as this will showcase all the powerful features and capabilities of digital radio technology. As the current system is focused on American listenership preferences, its flexibility will permit AIR to fine-tune the system to Indian listener preferences which are best known to AIR. It will also allow experts from XPERI Corporation to evaluate how quickly HD Radio broadcasting on MW AM band can also be demonstrated in a second step. This AM trial will require a little more time to configure and fine-tune to allow an apples-to-apples comparison of competing technologies. While a well-implemented DRM-30 installation is fully compatible with HD Radio transmission,

and simply we substitute an HD Radio exciter, an antenna analysis with possibly a minor adjustment may be necessary to optimize for the differences with HD Radio.

Our offer includes following:

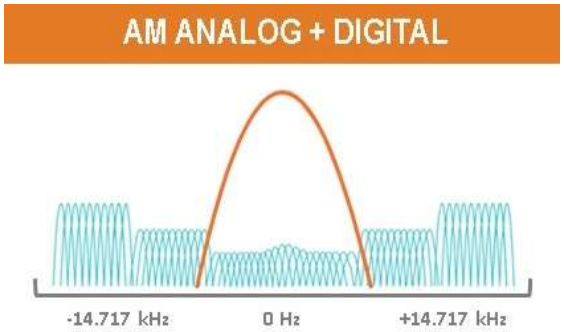
- HD Radio digital encoding equipment (Exporter/Importer/Exgine Exciter).
- HD Radio ready 2.5 KW FM transmitter, suitable to work in simulcast mode or full digital mode as per your choice of operation (or both) during the trial).
- More than one hundred HD Radio receivers for critical listening and showcasing the availability of receivers in the market.
- Availability of a technical expert from XPERI Corporation to explain and clarify all queries at beginning, during and end of trial. Our expert engineers and consultants will also be available to assist AIR's high power team during critical evaluation of technology.

What we will need from National Broadcaster:

- Allow use of your antenna on the existing tower at Akashwani Bhawan.
- Suitable space to set the transmitter in AIR premises/and control.
- Parallel feed of popular programs such as FM Gold, FM Rainbow and Vividbharti, etc.
- Power source for the equipment. (approx. 6 KVA or less)
- Minor Assistance during Installation.

To conduct a multilateral technology evaluation, partner Eastern Arts are willing to retain the complete installation for a few months. As discussed, the real trial of the AM HD Radio system can be taken up subsequently to the FM trial, but it requires a revaluation and possible minor readjustment of the existing antenna system. Eastern Arts have required expertise available including necessary instrumentation to do it without disturbing the existing services (this will be conducted overnight while the existing service is off-air).

We are 99.9% sure that it is feasible to convert AIR AM network to Dual DRM and HD Radio capabilities (one at a time) in transmitter during the trial period. This 0.1% uncertainty is due to inherent balanced design of the sidebands in HD Radio broadcasting versus and unbalanced side-band design in case of DRM system.



A fundamental difference between DRM-30 and the HD Radio AM system is arrangement of the digital OFDM carriers. In DRM, all digital carriers are placed either above or below the AM analogue centre frequency (but not both). In the HD Radio system, the carriers are above, below and beneath the analogue carrier. A rough analogy is professional balanced audio versus consumer unbalanced audio. This concept makes the AM HD Radio system more robust and allows for greater forward error correction. It also allows for a maximum of 36 kB/second along with

the AM analogue audio. For best HD Radio performance, something called Hermetian Symmetry is desired. This is the tuning of the AM antenna system such that the bandwidth is essentially flat (impedance and reactance) over about 15 kHz above and below the assigned frequency. It should also be pointed out when such bandwidth is achieved by proper antenna tuning, the analogue will modulate more densely (enhance loudness and coverage) and have lower audio distortion.

- Frequency diversity in the HD Radio system allows the digital signal to be more robust in conditions of frequency selective fading or interference. In mobile reception, the partially degraded signal on one side of the spectrum can be combined with the in-tact signal on the other side of the spectrum to recover the data.
- Frequency diversity and combining provides added benefit. Because each sideband is complementary, there is a power benefit (+3 dB) and a coding gain (+4 dB in AWGN) when the upper and lower sidebands are combined. This yields 7 dB gain compared to the case when only one of the two digital sidebands is present. This gain will generally be greater than 7 dB for fading channels, or when impulsive noise is present.

Receivers

To help you conduct a fair, independent and true evaluation, we plan to bring in enough numbers of HD Radio capable receivers with different features and capabilities. There are nearly one hundred models for HD radio receivers available in market, manufactured by dozens of renowned leading consumer electronics manufacturers like Sony, JVC, Panasonic, Kenwood, etc. High quality reception with many value-added features are well established reality today with the HD Radio system, rather than a promise for future digital radio. These numbers do not include the OEM automobile receivers.

In contrast the very limited models of radio receivers available for DRM lack quality, features and performance. The only reason our team could think of is other than India and some short wave broadcasts, DRM has yet to achieve any form of mass rollout thus receiver demand in the mass market has been non-existent.

Further, in the AM system operating in a hybrid or simulcast mode, neither system in the foreseeable future would have more than one digital audio channel in terms of practicality. In an all-digital world, multicast on medium wave might be practical for both systems.

Technology selection

In my opinion, AIR's engineering team chose DRM, the most cost-effective and arguably the best digital broadcast system for AM medium wave radio available around 2006, for your country. Our current attempt is to highlight progress made by the different systems from year 2006 to date. Technologically, DRM and HD Radio's AM system were on an almost equal level over development in 2006 and DAB was being deployed in Europe, the choice seemed to make sense at the time. As of this date, HD Radio systems deployment and listenership is in great expansion, rivalling DAB (DAB+) while DRM is struggling with virtually no receiver base or new station rollouts. The Eureka 147 DAB/DAB+ system being an out-of-band system, may be out of consideration for India due to needing an entirely new band allocated, DRM and HD Radio technology utilise the existing band, of course. DRM consortium's proposed solution for a new CODEC implementation would render all existing DRM receivers obsolete (useless) and requires upgrades to your purchased DRM transmission equipment. This changing design and implementation has put AIR investments in DRM at risk. Thus it makes commercial sense to review technology suitability for India with an open mind, based upon the real-world ten years after initial decisions were taken. The HD Radio system has had no changes in CODECS since its introduction in 2002, nor is one being contemplated, to our knowledge. The very first receiver manufactured will still work today (although newer features in the HD Radio system will not be available on that receiver). Transmission equipment has evolved to become more reliable, compact, more efficient and less costly. The key equipment manufacturers have implemented fully, all of the HD Radio technology standards which is not always the case with DRM. Equipment and receiver demand is driven by the fact that nearly 3000 stations have converted and the broadcast equipment manufacturers have seen demand thus funded research and development to continuously improve the product offerings including implementation cost reductions as the technology has advanced. For example, first-generation HD Radio exciters were built on a Personal Computer (PC) base. Today, they are all using advanced processors such as FPGAs etc., reducing cost and adding significant reliability. Some DRM components such as ContentServer continue to operate on a PC base in most cases.

The author is convinced that the two major world digital systems in mass deployment (HD Radio technology and DAB/DAB+) are both here to stay and continue to develop, add more features and enjoy a large base of receivers in multiple form factors.

Just a quick word here on why the author does not believe DAB/DAB+ would be suitable for India and that is the sheer size of the country. DAB/DAB+ operates more in the concept of a cellular telephone platform with many towers. The coverage of a single DAB transmitter is far less than either standard FM analogue and certainly less than the high power medium wave signals. Thus to cover all of India would be a financial impossibility with DAB. AIR is certainly aware of how many cellular towers it takes to give good coverage of the whole country. Think about having DAB transmitters on most of those towers in order to accomplish a similar goal, all arranged in a Single Frequency Network (which is how they cover Europe). Even in Delhi, more than several

transmitters would be required, just as there are more than several in London, UK. (**Greater London DAB Sites**: Alexandra Palace *6*, Arkley *1*, BT Tower *6*, Colindale House *2*, Croydon *3*, Crystal Palace *5*, Harrow Weald *2*, Honor Oak Park *1*, Kenley *1*, Mount Vernon *2*, Richmond Hill *2*, Shooters Hill *2*, Southwood Park Highgate *1*). DAB is successful in Europe, yes. But there the countries are much smaller than India, many being the size of a single State in India. If the entire country of India was the "Golden Triangle" of Jaipur, Agra and Delhi, DAB or DAB+ might be practical. But this is just not the case, so we have written this technology off as not practical for India. With both a working and heavily deployed system on Medium Wave and FM, we believe HD Radio technology to be the only practical solution to a digital India.

The Transition

As with DRM-30 simulcast, the existing base of tens of millions of analogue receivers in India will continue to work as they always worked in the past in the HD Radio environment. Think of it compared to colour television versus black and white. Black and white television receivers continued to work as colour was rolled out until virtually all of the old black and white receivers died of old age and were replaced by new colour sets. The hybrid analogue/digital system may continue for as long (or short) as desired until the full digital transition is made.

- **During Transition (Analogue + Digital)**
  Listener gets:
  1 Analog FM audio service
  4 Digital audio services PLUS
  Additional value added services

- **Post Transition (All Digital)**
  Listener gets:
  8-15 Digital Audio services
  Enhanced data services
  Additional payload for additional data

All major auto brands offer factory-installed HD

Commercial considerations

If we look at combined expenditure on transmission and reception together then we get very astonishing results as shown below:

Sr. No.	Expense Item	DRM	HD Radio	DAB
1	Total Cost of Ownership for 1 AM Transmitters covering 400 KM radius In India	$ 1,000,000	$ 1,000,000	$ 200,000,000
2	Present cost of 1 million radio receivers	$ 100,000,000	$ 30,000,000*	$ 35,000,000
3	Total cost to country	$ 101,000,000	$ 31,000,000*	$ 235,000,000
4	Savings to Country with ref to DRM	0.0 current reference based on DRM implementation	-$70,000,000 average saving per station (69.9% savings)	$134,000,000 more expense (133% costly)

*Does not include OEM Automobile receivers which in many cases with new cars does not add to purchase cost. Financials shown are based on gathered information by M/s **Eastern Arts** on basis of total cost of ownership for a new station setup.

It is common knowledge that the present investments made by AIR in Transmission equipment, is 98% convertible to HD Radio. By changing from DRM to the HD Radio standard, available commercial advantages could make “Digital India” a reality in the field of radio. The above table is based on DRM transmitters in MW band where the comparison is based on realistic shelf prices. In case of FM band the table gets weirder as there are no DRM+ transmitters working in FM band anywhere in the world nor are there any DRM+ receivers available for purchase.

Known Issues

In addition to the financial differences, the value-added services implementation is not standardised between manufacturers of DRM equipment. Some manufacturers have seen fit to incorporate some features using their own implementation and not others, leaving the broadcaster unable to take advantage of the full standard. As mentioned previously, the HD Radio transmission equipment MUST properly incorporate the standard. This is raises further uncertainties with DRM, when will we see end-to-end implementation completed? The public perception of digital radio reception will receive a quantum jump with adoption of HD Radio technology.

To expand on the implementation of what digital standards are incorporated in the broadcast equipment, there is a major difference between how DRM and HD Radio broadcast gear comes to market. In the case of HD Radio licensed equipment (including both transmission and receivers), in order to gain certification, the equipment must go to an authorized HD Radio test laboratory in the USA, Europe, Japan, or India. The lab technicians review the equipment and technical manuals for proper and complete implementation of the standard. Under the long-standing license agreements, the equipment may not be sold into the marketplace unless and until it receives the certification. Thus the customer (broadcaster, listener) is assured that they will receive the proper experience and features built into the standard. This is not to say that every receiver must offer every item in the standard, but is required to show that the receiver operates properly, without "bugs" for the features it does incorporate, per the standard. For example, a lower cost receiver may not offer a colour graphics display but rather simple text. It will be determined that the text operates properly, displaying that which it is supposed to. So when an item from the standard is incorporated into a receiver in the HD Radio system, listeners and broadcasters are assured that it will work properly.

With the DRM "Open Standard", manufacturers of receivers and broadcast equipment are left to their own on what and how to implement the features within the standard and no one is certifying the technical competence of any piece of equipment other than its manufacturer.

To sum up, our effort is to revive the glorious reputation of radio as the most powerful medium for mass communication, entertainment and education. We confirm once again that our offers are non-binding on you or any commercial commitment from you.

We are requesting you to consider our request at the earliest possible time.

Most cordially
For Digital Systems Solutions LLC

Hal Kneller, Vice President
Digital Systems Expert