# Postprint Summary of DRM Digital Upgrade for DX Series Medium-Wave Broadcast Transmitters

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## Abstract

An attempt is made to conveniently retrofit DX series analog medium-wave broadcast transmitters into DRM digital modulation transmitters through the use of DRM adapter boards. The adapter board enables switching between the two modulation modes via a simple toggle switch, thereby preserving the original transmitter's analog modulation functionality while adding digital modulation capability.

## Full Text

### Summary of DRM Digitalization Modification for DX Series Medium Wave Broadcast Transmitters

**Abstract:** This paper presents a method to conveniently convert DX series analog medium wave broadcast transmitters into DRM digital modulation transmitters through the use of a DRM adapter board. This adapter board enables switching between two modulation modes via a simple toggle switch, preserving the original transmitter's analog modulation capability while adding digital modulation functionality.

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With technological advancement, audience demands for broadcast quality have increased correspondingly. However, in traditional medium and shortwave broadcasting, complex and interference-prone channel characteristics combined

with analog amplitude modulation result in broadcast quality far below listener expectations. Conventional analog AM broadcasting can no longer satisfy audience requirements, leading to declining listenership.

Through analysis of traditional analog broadcast transmitter principles and DRM signal characteristics, it is evident that the suitability of existing medium wave transmitters for DRM modification depends on their capability to support independent DRM carriers and carry digital bitstreams within allocated bandwidth. Transmitters targeted for modification must meet specific conditions including noise performance, group delay, bandwidth, and matching networks adaptable to bandwidth requirements.

### 1.2 Digital RF Excitation Modulator

To implement digital DRM signal transmission on traditional analog AM transmitters, the digital baseband signal from the channel coding modulator must be upconverted to the transmitter's actual operating RF frequency. This requires replacing the carrier generator with a DRM digital RF excitation modulator.

### 1.3 Audio Channel Digital Signal Processing Issues

Traditional analog AM transmitters primarily rely on analog technology for audio channel signal processing. Although some circuits currently employ DSP (Digital Signal Processing) technology, without specialized and targeted digital modifications, the transmitted signals still fail to meet the technical specifications required by DRM standards.

## 2. Key Points of Transmitter Modification Scheme

To achieve DRM digital AM broadcasting technical transformation, traditional analog AM broadcast systems require digital modification of the audio front-end, specifically adding a DRM encoder/modulator and modifying transmitter equipment structure. The DRM baseband signal generated by the DRM encoder/modulator consists of I/Q component signals and an envelope signal calculated from these I/Q components. The amplitude variation component is fed into the modulation channel of the existing analog AM transmitter, while the I/Q component signals are converted to RF phase components ($\Phi$) through an RF frequency synthesizer and delivered to the excitation channel of the existing AM transmitter. The I/Q signals are digital; phase calculations are performed in the frequency synthesizer to phase-modulate the RF carrier signal generated by a Direct Digital Synthesizer (DDS). This phase-modulated RF carrier is fed into the transmitter to replace the constant-amplitude carrier produced by the original exciter, while the envelope signal is fed into the transmitter's audio input port. The transmitter's amplitude modulation functionality is then utilized to implement amplitude modulation on the phase-modulated carrier. The amplified envelope and phase signals are subsequently sent to a mixing circuit

for frequency conversion, achieving DRM signal power amplification and modulation. This approach fully leverages the existing circuits and equipment of the AM transmitter.

The DRM adapter board developed by Communication University of China addresses three key technical issues: time delay control between audio and phase channels, digital RF excitation modulation, and audio channel digital signal processing. The modification scheme involves replacing the DX series transmitter's analog input board and A/D conversion board with the DRM adapter board, which provides the digital envelope signal and phase-modulated carrier required by the transmitter. Both analog and digital modulation are accomplished by controlling the number of active power amplifier modules. For transmitters from different manufacturers and categories, simple adjustments to the power supply, control, and RF amplification units enable digital modulation functionality. A toggle switch facilitates switching between modulation modes, preserving the original analog modulation capability while adding digital modulation. When analog audio modulation is required, the analog audio signal is fed into the adapter board and converted into power and modulation control codes to control the number of active power amplifier units. For DRM digital modulation, the TS stream after source coding and channel coding is fed into the adapter board and converted into control codes to complete amplitude-phase modulation of the RF carrier.

During actual modification implementation, we successfully conducted modification trials on the AM253S5-I transmitter from Shaanxi Broadcasting Equipment Factory and the GZ-GS25K-III transmitter from Harbin Broadcasting Equipment Factory, both achieving analog and digital modulation. This accumulated valuable experience for digital modulation modifications of various transmitter types.

### 1.1 Time Delay Control Between Audio and Phase Channel Signals

Digital modification of traditional analog AM transmitters requires feeding the digital baseband signal from the channel coding modulator separately into the transmitter's audio and phase channels—one path for envelope information and another for phase information. Due to differences in signal processing paths and steps, time delay errors occur when the signals reach the mixer tube for synthesis, significantly impacting DRM broadcast signal transmission.

### 2.1 Key Points of AM253S5-I Transmitter Modification (Shaanxi Broadcasting)

Key points for modifying the AM253S5-I transmitter from Shaanxi Broadcasting Equipment Factory: Remove the original analog input board and A/D conversion board, remove the power amplifier fuses, set the PA switch to "OFF" on the control board, and install the DRM adapter board in the original analog input board position. Analysis of the DRM adapter board reveals the follow-

ing connector functions and connections: (1) X1 is a 5-pin connector serving as the adapter board's power supply interface, connecting to the transmitter's low-voltage power configuration board. (2) Connector A34X8 is the RF output sampling frequency input, while A34X3 is the distributor sampling frequency input, providing sampling pulse signals to the adapter board. (3) Connector A34X6 is the adapter board's 12-bit digital audio input, outputting digital audio to the transmitter's modulation encoding board. (4) Connector A34X7 is the adapter board's fault detection output port, providing +5V fault, +15V fault, -15V fault, and conversion fault signals to the transmitter control board. (5) Connector X3 is the transmitter power sampling input port, connecting to the transmitter's fuse board for power compensation and envelope fault detection. (6) Connector A35X6 is the "audio + DC" sampling output port, providing sampling voltage to the DC regulated power supply to modulate the "B-" voltage, which improves power amplifier transistor switching time and compensates the RF envelope. (7) Connector A35X4 is the adapter power control input port, connecting to the transmitter control board to receive 12-bit power control data and transmit +15V fault, power sampling, and PA shutdown signals to the control board. (8) Connector A35X2 is the analog audio signal input port; DIN1 of X2 is the digital audio signal input.

After connecting all functional boards with the adapter board, install the PA fuses, turn on the PA switch, and connect analog and digital audio signals to complete the transmitter modification.

### 2.2 Key Points of GZ-GS25K-III Transmitter Modification (Harbin Broadcasting)

Following successful trials of the DRM adapter board on the 25kW transmitter from Shaanxi Broadcasting, in March 2017 we modified the GZ-GS25K-III transmitter manufactured by Harbin Broadcasting Equipment Co., Ltd. This transmitter type differs in its use of circulating modulation and floating carrier technology, with control and protection functions implemented by microcomputer, eliminating complex circuits on the control board. The analog input board and A/D conversion board have partially different interface functions, and the control board fault alarm circuits and ports differ significantly, presenting challenges for this transmitter's modification.

Comparative analysis between the two transmitter models revealed: (1) The Harbin transmitter's low-voltage configuration board provides +22V, -22V, and +8V, slightly lower than the 762 Factory's +24V, -24V, and +9V, but generally equivalent. (2) The Harbin transmitter does not provide RF output sampling frequency, only distributor frequency output. (3) On the Harbin transmitter's analog input board, power sampling inputs are X5-8 and 9, whereas the 762 Factory uses X5-8 and 10. (4) The Harbin transmitter's analog input board "audio + DC" outputs are X6-5 and 7, while the 762 Factory uses X6-6 and 7. (5) For the Harbin transmitter's analog input board power control input, X4-31 is -15V fault, with X4-37 and 39 unused; the 762 Factory uses X4-31 as unused,

X4-37 for power sampling, and X4-39 for PA shutdown.

Modification measures adopted: The adapter board's slightly lower power supply has no impact on operating status and requires no treatment. The RF output sampling frequency input does not affect adapter board functionality and remains unconnected. Connect the adapter board's X3 and A35X6 connectors to the corresponding transmitter wiring. The Harbin transmitter's -15V fault diagnosis circuit on the control board was designed for the original analog input board and is now obsolete; therefore, resistor R105 on the control board was disconnected to disable this fault diagnosis circuit. Adapter board terminal A35X4-39 is normally low-level; if it becomes high-level, the entire unit shuts down the PA with no power output. Since the Harbin transmitter does not provide this low-level signal, this point remains high-level, causing no power output. Consequently, A35X4-39 was shorted to terminal 40 (ground) to artificially provide a low-level control signal. Through these measures, the transmitter's digital modulation modification was completed.

## 3. Post-Modification Summary

The DRM modification at Nanyang Medium Wave Relay Station primarily serves emergency broadcasting purposes. The medium wave propagation path for emergency broadcasting employs DRM digital modulation, improving spectral efficiency in the broadcast band, enhancing medium wave broadcast audio quality, and effectively increasing resistance to spurious interference. The DRM baseband encoder can provide control commands for selective broadcast control, while the content server offers multi-type information distribution, expanding the application domains of broadcasting.

Different DX transmitter types exhibit variations in control and protection interfaces, port definitions, and low-voltage power supply. For instance, the low-voltage supply of Shaanxi Broadcasting transmitters is higher than that of Harbin and Beijing Broadcasting transmitters, and the functional definitions of Harbin transmitter's power control input ports differ from those of Beijing Broadcasting transmitters. By comparing and analyzing the functions of various ports for different transmitters, adjustments and modifications were made to original ports and voltages during the modification process, successfully achieving matching between various transmitter types and the adapter. This modification project verified the compatibility and operability of the DRM modification scheme, providing a reliable solution and practical foundation for future DRM digitalization modifications of DX series analog modulation transmitters.

The modified transmitters can implement both analog and digital modulation, with modulation modes switchable via a simple toggle. The effective coverage range of the analog modulation mode shows no significant change compared to pre-modification, while the digital modulation mode's effective coverage range has slightly increased. Listening effects within the digital modulation coverage area have been substantially improved, with greatly enhanced audio quality.

Following digital modulation modification, field measurements of the digital modulation signal were conducted. Analysis yielded the required field strength and co-channel protection ratios for achieving good reception in digital modulation mode, along with various factors affecting digital modulation broadcast effectiveness, providing valuable reference for future analysis of digital modulation broadcast performance.

**References:** [1] Liu Hengzhang. RF Transmission Link in DRM Broadcasting Chain [J]. Radio & TV Broadcast Engineering, 2007, 34(4): 106-108.

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*Note: Figure translations are in progress. See original paper for figures.*