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Design of Dual-mode High-Power Transmitter for Terrestrial Digital TV Service

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Abstract

Developing an efficient high-power transmitter is essential to extend service coverage of terrestrial broadcasting service. Furthermore, it is important to develop a dual-mode transmitter platform that satisfies both ATSC and DVB-T2 in order to reduce development costs. In this paper, we present a design method of dual-mode high-power transmitter with 2.5KW transmit power for terrestrial digital TV service.

Keywords: *Terrestrial HDTV, high-power transmitter, dual-mode terrestrial transmitter*

1. Introduction

The terrestrial digital TV standards are divided into the US-led ATSC method and the European-led DVB-T method. Terrestrial broadcasting technology is evolving to increase transmission capacity (HD/UHD service) and to improve flexibility (IP based interactive service). Recently, terrestrial ultra-high definition (UHD) service becomes realization. The UHDTV is a next-generation broadcasting service that offers four times (4K UHDTV) clear screen than existing HD broadcasting, and offers interactive services such as T-commerce and VOD. Indoor reception capability of UHD broadcasting is much better than the existing broadcasting, so if you have UHD antenna, you can enjoy ultra-high quality video in the terrestrial environment. The typical terrestrial broadcasting systems are DVB-T2 [1] and ATSC. The standard for UHDTV transmission system is underway with ATSC3.0 [2-3].

Developing an efficient high-power transmitter is essential to extend service coverage of terrestrial broadcasting service. Furthermore, it is important to develop a dual-mode transmitter platform that satisfies both ATSC and DVB-T2 in order to reduce development costs.

In this paper, we present a design method of dual-mode high-power transmitter with 2.5KW transmit power for terrestrial digital TV service. The proposed dual-mode transmitter can support ATSC and DVB-T2 with high power of 2.5KW.

2. System Requirements and Model

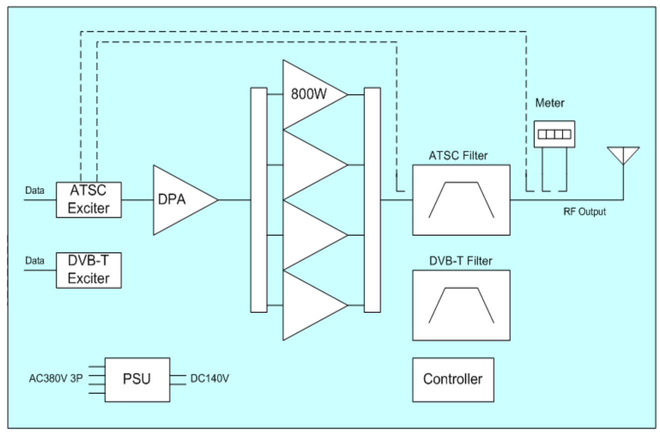


Fig. 1 System configuration of 4-way combined high-power transmitter

The transmitter for terrestrial digital broadcasting service is composed of the exciters for multiplexing and modulating baseband signals and the high-power amplifier (HPA) for RF (radio frequency) amplification. In addition, MASK filter corresponding to digital TV mode, power supply, controller and monitoring technology are also necessary for high-power transmitter implementation. Basic system configuration of high-power transmitter is shown in Fig. 1.

The proposed system contains both ATSC and DVB-T exciters for supporting two terrestrial digital broadcasting services. The driver power amplifier (DPA) module ensures stable output signal level and moderate system gain. Since the design of HPA is key to developing a high-power transmitter, we consider 4-way combined HPA to have 2.5KW RF power with each component HPA of 800W. In designing of 800W component HPAs and a combiner, it is necessary to improve frequency response characteristics, inter-modulation distortion (IMD), efficient combining method. In addition, a heat dissipation method is important. The MASK filters corresponding to ATSC/DVB-T2 are designed to satisfy the frequency response characteristic and out of channel emission requirement. The power supply unit (PSU) should provide stable 3-phase power that has an input of AC380V and an output of DC140V. The controller and monitoring block presents the system operation, monitoring and remote control function. Finally, since the transmitter system must operate for a very long time without interruption, the heat dissipation design is very important.

3. Dual-mode High-power Transmitter for Terrestrial Digital Broadcasting Service

3.1 Implementation of Component Blocks

In this section, we present the implementation results of the component blocks as shown in Fig. 2.

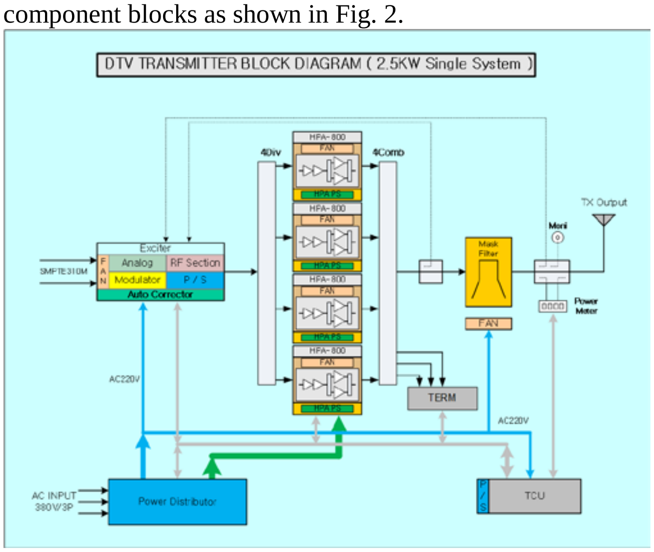


Fig. 2 Block diagram of the proposed dual-mode DTV transmitter

In Fig. 3, we present an illustration of the proposed HPA unit with 800W. It is composed of phase/level adjust module, drive power amplifier, 4 dividers and 4 combiners.

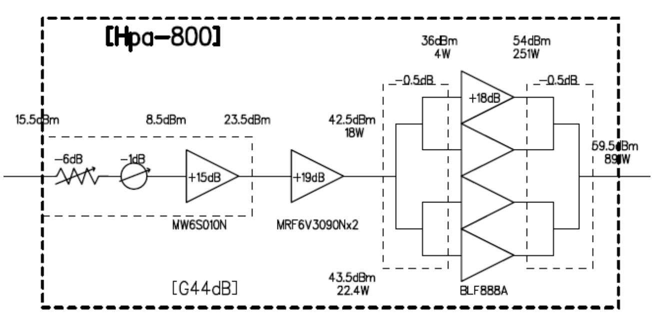


Fig. 3 Illustration of the proposed HPA unit with 800W

The DVB-T2 and ATSC mask filters' specifications [4] are shown in Fig. 4 and Fig. 5, respectively.

ITEM	Specifications		TEMP +25℃
Frequency Range	48CH (Center Frequency: 690MHz, 686MHz~694MHz)		
Insertion Loss	Fc	0.5dB Max	0.26
	Fc±3.805MHz	1.3dB Max	0.83
Return Loss	20dB Min		21.91
Attenuation (Min.)	685.8MHz (Fc-4.2MHz)	4dB Min	5.10
	694.2MHz (Fc+4.2MHz)	4dB Min	6.06
	Fc ± 4.2MHz	4dB Min	5.10
	684MHz (Fc-6MHz)	20dB Min	24.69
	696MHz (Fc+6MHz)	20dB Min	22.77
	Fc ± 6MHz	20dB Min	22.77
	678MHz (Fc-12MHz)	40dB Min	43.77
	702MHz (Fc+12MHz)	40dB Min	43.73
	Fc ± 12MHz	40dB Min	43.73
Group Delay	300ns Max		275.34

Fig. 4 Specification of ATSC mask filter

ITEM	Specifications		Sample
Frequency Range	14CH (470MHz~476MHz)		
Insertion Loss	Fc	0.7dB Max	0.31
	Fc±3.0MHz	1.1dB Max	0.49
Return Loss	20dB Min		22.96
Attenuation(Min.)	469MHz (Fc-4MHz)	5.5dB Min	7.50
	477MHz (Fc+4MHz)	5.5dB Min	7.51
	Fc ± 4MHz	5.5dB Min	7.50
	468MHz (Fc-5MHz)	18dB Min	26.26
	478MHz (Fc+5MHz)	18dB Min	26.51
	Fc ± 5MHz	18dB Min	26.26
	467MHz (Fc-6MHz)	30dB Min	41.71
	479MHz (Fc+6MHz)	30dB Min	43.19
	Fc ± 6MHz	30dB Min	41.71
	464MHz (Fc-9MHz)	64dB Min	87.07
	482MHz (Fc+9MHz)	64dB Min	68.53
	Fc ± 9MHz	64dB Min	68.53
Group Delay	200ns Max		119.31

Fig. 5 Specification of DVB-T2 mask filter

Transmitter control unit (TCU) presents monitoring of the system operation and enables remote control function with ethernet protocol and RS-485 protocol. The TCU unit is shown in Fig. 6.

Fig. 6 Illustration of the TCU unit of the proposed system

3.2 System Performance

In this sub-section, we present the system performances of component block.

The mask filter performances of DVB-T2 and ATSC are given in Fig. 7 and Fig. 8, respectively.

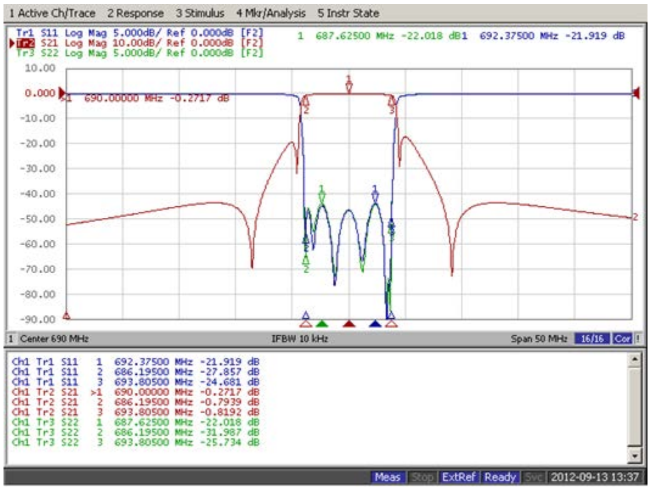


Fig. 7 Performance of DVB-T2 Mask Filter

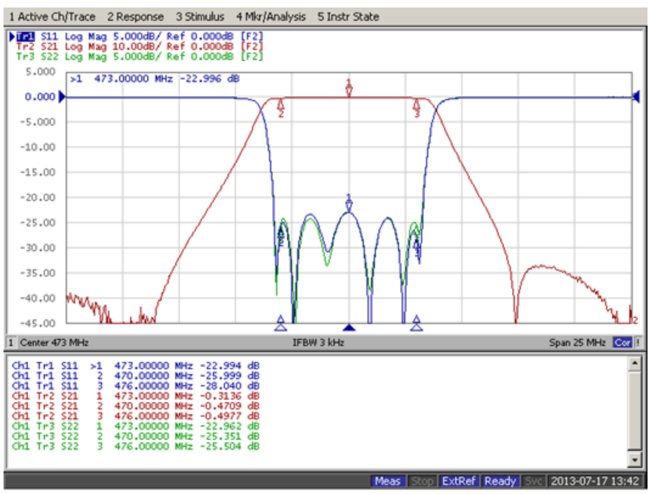
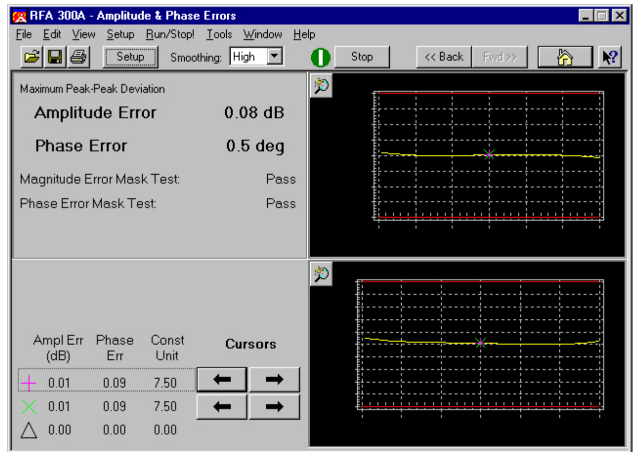
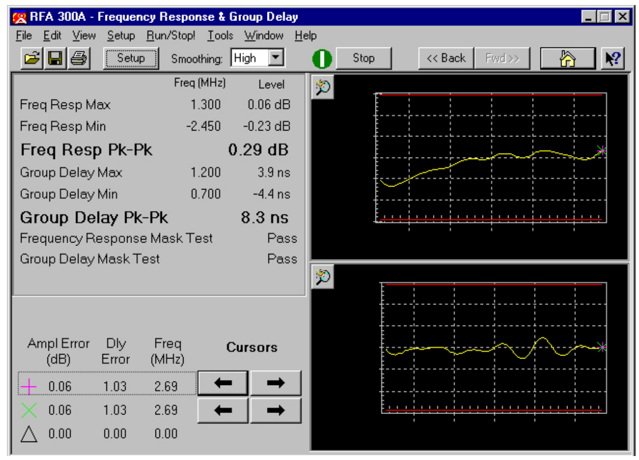


Fig. 8 Performance of ATSC Mask Filter

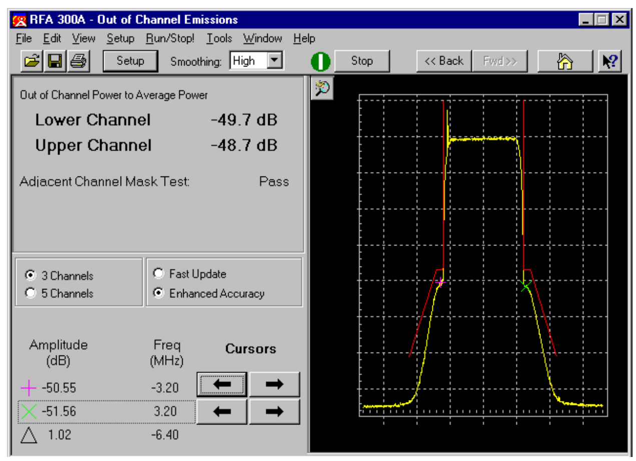
We have also tested electrical characteristics of the proposed system. The performances of the ATSC system are given in Fig. 9 such as the amplitude and phase errors, frequency response and group delay, and the out of channel emission.



(a) Amplitude and phase errors



(b) Frequency response and group delay



(c) Out of channel emissions

Fig. 9 System performances of ATSC system

4. Conclusions

For terrestrial digital broadcasting service, an efficient high-power transmitter is essential to extend service coverage of terrestrial broadcasting service. Furthermore, it is important to develop a dual-mode transmitter platform that satisfies both ATSC and DVB-T2 to reduce development costs. In this paper, we considered a system requirement of the dual-mode transmitter and presented a high-power transmitter with 2.5KW transmit power for terrestrial digital broadcasting service. The proposed system has presented stable and good system performances and was actually deployed and operated in Korea successfully.

Acknowledgments

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Minki Kim received MS degree and a PhD canidate from Graduate School of Nano IT Design Fusion Technology in Seoul National University of Science and Technology. His research interests include UHDTV system and receiver implementation and immersive multimedia system.

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Dong Ho Kim is an associate professor of Seoul National University of Science and Technology in the department of Electronics and IT media Engineering. His research interests include wireless communication systems and immersive multimedia system.