그랜드 얼라이언스 디지털 TV 송신기의 주파수 상향기 설계 및 제작

Design and Implementation of a Grand Alliance Digital Television RF up-converter

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Abstract

In this paper, designed scheme and the performance results of implemented Grand alliance DTV RF up-converter are described. It can generate all channel band (ch.2-ch.60) of Korean broadcasting channel band. The experiment result shows the implemented RF up-converter satisfy the ATSC standards

I Introduction

Grand alliance Digital television (DTV) system can be seen to consist of three subsystems, source coding and compression, service multiplex and transport, and RF/transmission. In the RF/transmission subsystem, RF up-converter translates the filtered flat intermediate frequency(IF) Vestigial side-band(VSB) signal spectrum to the desired RF channel. The frequency of the RF up-converter oscillator will typically be the same as the used for NTSC except for frequency offset. The frequency offset is required to avoid several interference, DTV-to-DTV co-channel, NTSC-to-DTV, and DTV-to-NTSC upper adjacent channel. In the DTV-to-DTV co-channel interference condition, an offset of 1.5 times the segment frequency (i.e 19,403 Hz) appears to provide the best performance[1][2]. For satisfying this offset, frequency oscillator in up-converter should be controlled with a resolution of below 1Hz The allowable level of phase noise of DTV frequency oscillator shall be no greater the −104 dBc/Hz @ 20 kHz [1][2]. Also the DTV RF up-converter system should maintain a linearity. Ideally the RF output from DTV up-converter would be an exact linear translation of the input IF band signal with no amplitude or phase distortion or added noise, and at exactly the level required by following power amplifier.

Of course, this ideal condition is not achieved in practice, but these imperfection generate a out-of–band emission, spurious emission, in-band intermodulation distortion, and so on[3].

II Designed scheme of DTV RF up-converter

In this section, the designed scheme and the performance result of implemented DTV RF up-converter are described. Fig. 1 shows the block diagram of designed RF up converter. It can generate all channel band(ch.2-ch.60) of Korean broadcasting channel band. The input of the up converter can be select internal IF, which is output of ETRI VSB modulator with 13.45 MHz frequency band, or external IF which is other VSB modulator with 43MHz~46MHz frequency band. Also, it has spectrum mirroring mode, so location of carrier of output VSB spectrum can be mirroring right side to left side or left side to right side by selecting a 2nd IF frequency 850MHz~970MHz with 1Hz frequency resolution. By this frequency resolution, it is possible to offset the VSB spectrum with 1Hz resolution. So, we can reduce the several interference effects which sensitive to frequency offset. The 2nd IF LO synthesizer is made of the fractional frequency synthesizer and direct digital frequency synthesizer (DDS).

The structure of frequency conversion is same as a backward flow of tuner of DTV receiver. It means that we need not using a band pass filter (BPF) for channel selection at up-converter. So, we can select any channel among the UHF TV channel band without changing the BPF. For a detail explanation of the structure and signal flow of up-converter in Fig. 1, we assumed that ETRI VSB modulator output is an input of the up-converter. Fig. 3 shows the ETRI VSB modulator output spectrum with carrier located right side. The center frequency of the spectrum is about13.45MHz.

By the digital signal Processing of the VSB modulator, an output the D/A converter generate a harmonics of original spectrum. The first stage low pass filter (LPF) suppress this harmonics. The LPF output spectrum is converted to 44MHz or 70MHz by the first mixer. The first mixer is driven by the first local oscillator(LO), which is generated by a voltage controlled crystal

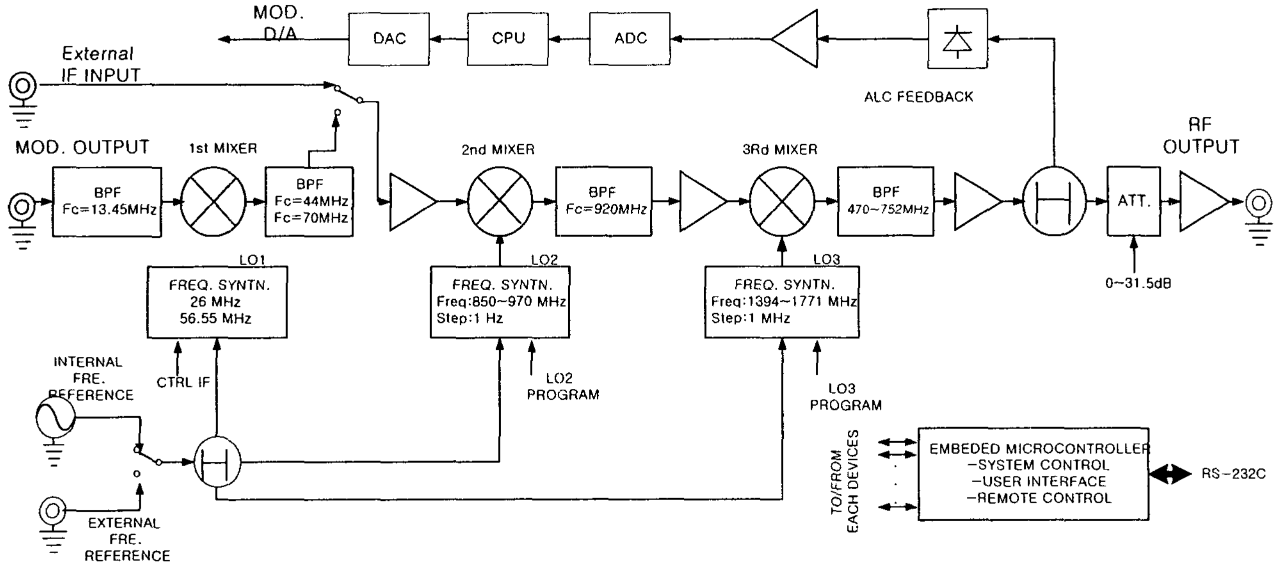


Fig 1. Block diagram of designed RF up-converter

oscillator(VCXO)

A BPF, following the mixer, limits 6 MHz frequency band which is spectrum band of VSB signal in case of 44 MHz IF. But, in the case of 70 MHz IF, it limits great than 6 MHz band. The first case is selected for a non-pre-correction mode and the last is selected for a pre-correction mode. Pre-correction mode used for a compensation of non-linearity of a power amplifier. Selecting a pre-correct mode, modulator output is pre–distorted by a pre-corrector in the VSB modulator. It means that the output spectrum of the VSB modulator contain a inter-modulation distortion (IMD) term. The IMD term is not a noise that must be removed but a information for pre-correction, so we have to use a BPF with 18MHz pass band in pre-correction mode.

The second mixer is driven by the second LO, which can generate frequency from 850 MHz to 970 MHz

The third mixer is followed by a 960 MHz band-pass dielectric filter. A channel selection is performed in the last mixer using a high side injection. The last LO generate a frequency from 1394 MHz to 1709 MHz with 1MHz step size. By changing the last LO frequency, we can select a channel should be transmitted.

The LC filter, after the last mixer, rejects high frequency spurious above 760 MHz.

The output level of the RF up-converter is controlled by automatic level control(ALC) loop. It makes output spectrum maintaining constant level within ±0.5 dB. For ALC loop, a signal is monitored by precise RF power detector and enveloping filter at LC filter output and feedback to the modulator by the ADC, CPU, and DAC. All of the control (system control, user interface, remote control) of the RF up-converter is performed by using a microcontroller with RS-232C.

III Implementation of DTV RF up-converter

On the base of the design scheme, we implement a RF up-converter.

Ideally, the RF output from a RF up-converter would be an exact linear transition of the input IF band signal with no amplitude or phase distortion or added noise. It is ,unfortunately, impossible to avoid this effects, distortions and added noise. But we can reduce the effects by planning of signal level budget.

Fig. 2 shows the signal level budget planning of the up-converter. The signal level, P_o, in Fig. 2 is average power of VSB signal plus peak to average ratio. Each component of the system has a own characteristics such as noise figure(NF), gain, output intercept point(OIP), 1 dB compression point(IP1dB), and so on. So, this factor, especially OIP and IP1dB, are very useful information of constructing a RF transmit system.

Our goal level of reducing the distortion is 60 dB and output level is 0 dBm average power, so we plan the level of input to amplifier and mixer blow minimum 14 dB than the IP1dB and the total gain is around 12 dB. Where the input level of the system is –10 dBm average power.

IV Experiment results

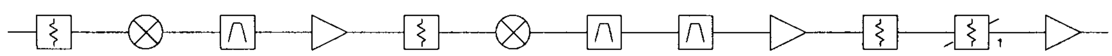
Fig. 4 shows a ch.14's signal spectrum of the RF up-converter output. It is shown that there is no additional channel spillage, except noise flow increased about 3.5 dB. We designed a signal level plane a 3rd IMD of the Mixer, amplifier, and etc in RF up-converter not to exceed 60 dB.

Fig. 5 shows the phase noise characteristics of RF up-converter. It shows that the phase noise does not exceed a 104 dBc @20 kHz and it means the results satisfy the ATSC standards.

Fig. 6 shows the eye diagram and constellation of demodulating the 8-VSB signal of RF up-converter output. The signal to ratio of the 8-VSB signal is more than 33dB It shows that quality of the in-band signal spectrum. The results are obtained by using an 8-VSB measurement set.

Fig. 7 shows the photographs of implemented RF up-converter and VSB modulator by the ETRI.

Up-converter



	ATT. (Level control)	Mixer LO=13dBm	BPF Fc=920MHz	AMP.	ATT. (Level control)	Mixer LO=10dBm	LPF Fc=800MHz	BSF Fc=920MHz	AMP.	Power splitter	ATT. (0-30dB)	AMP.	Total
NF (dB)	4.00	8.50	3.00	8.40	4.00	8.00	2.00	0.10	5.20	3.00	0.00	4.50	26.85
Gain (dB)	-4.00	-8.50	-3.00	11.20	-4.00	-8.00	-2.00	-0.10	14.00	-3.00	0.00	20.00	12.60
OIP3 (dBm)		9.00		36.00		5.00			33.00			38.00	30.13
IP1dB (dBm)				6.00					2.00			5.00	
Po (dBm)	-8.40	-16.90	-19.90	-8.70	-12.70	-20.70	-22.70	-22.80	-8.80	-11.80	-11.80	8.20	

Input Pwr (dBm) -4.40 System Temp (K) 290.00

Fig 2. Signal level budget diagram of RF up-converter

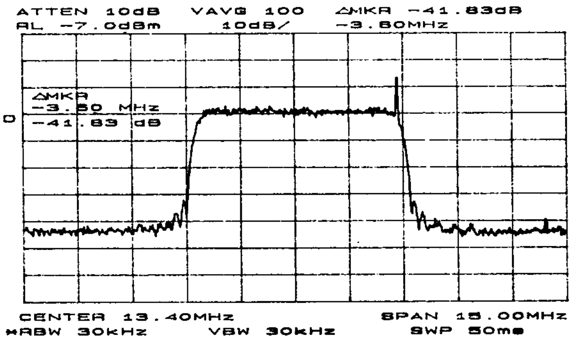


Fig. 3. IF signal spectrum of 8-VSB modulator output.

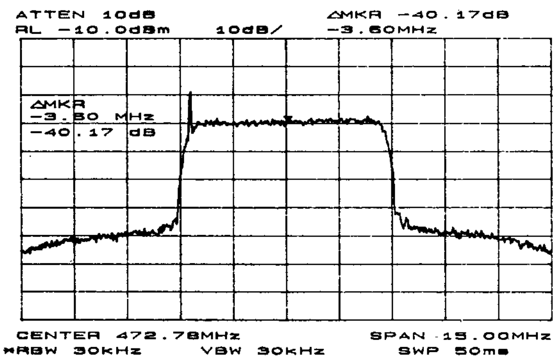


Fig. 4. RF signal Spectrum of RF up-converter output (ch.14).

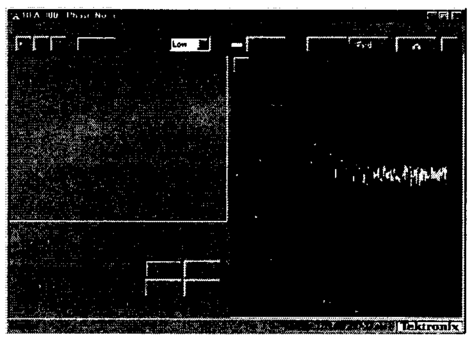
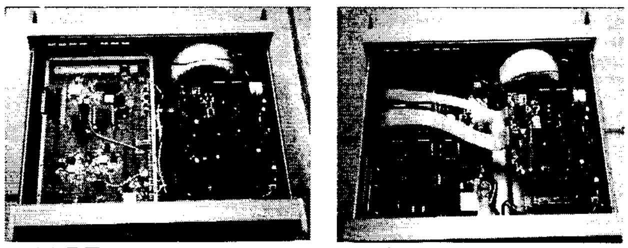


Fig. 5. Total phase noise characteristics of the RF up-converter

Fig. 6. The eye diagram and constellation of the system.



(a) RF up-converter (b) 8-VSB modulator

Fig. 7. The photographs of the implemented systems.

V Conclusion

We described the designed scheme and the performance results of implemented Grand alliance DTV RF up-converter. The experiment result shows the implemented RF up-converter satisfy the ATSC standards.

VI Reference

[1] ATSC, "Guide to the Use of the Digital Television standard", Advanced Television Systems Committee, Washington, D.C., Doc.A/54,1995.

[2] Grand Alliance HDTV system specification. Ver. 2.0, December 7, 1994.

[3] William E. Sabin, Edger O. Schoenike, "*Single side band systems & circuits*", McGraw-Hill, pp135 -180, 1987.