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Performance Enhancement of Network Interface Module in HD Receivers

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ABSTRACT

Network Interface Module (NIM) is a front-end receiver block, which interfaces incoming signals from outside world in to the High Definition (HD) Radio Frequency (RF) receivers. In most of the cases, NIM receives only one type of signal and down converts RF in to Intermediate Frequency (IF). In modern receivers there could be a separate block for this signal interface or there could be single silicon which acts as network interface module, Tuner and demodulator. Introduction of modularity concept in the front-end block of receivers will helps to enhance the performance of the receivers as and when required.

Introduction

In a normal scenario, as a front-end block, NIM access incoming signal source and down converts in to Intermediate Frequency and it will be processed further in blocks in HD receiver. The idea here is to enhance the capability of NIM to access different types of signal sources and capability to regenerate / redistribute the signals as per the requirement. This will add totally new dimension to the use of NIM not only in TV channel reception, but also as a major trans-receiver block in rural broad band distribution using TV white space. Objective is to introduce modular concept at NIM stage with multiple functional capabilities to enhance receiver function. Some of the Targeted multiple features are:

- Capabilities to receive multiple types of signals such as DVBC/T/S
- Capabilities to trans- modulate the signal.
- Capability to receive broadband data

There are different types of signal sources like DVBC, DVBT or DVBS , which need to be accessed by the receivers.

- Receiving the digitized signal from Satellite using DVBS Set top box
- Receiving the digital Cable signal through DVBC
- Set top box.
- Terrestrial signal reception using DVBT Set top box
- Digital signal reception in Hand held devises such as mobile phones
- Digital signal reception in PC / Computers

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When it comes to TV program broadcasting, there are three different types of distribution mechanisms which are in place as on today, namely, over the air (OTA) terrestrial method, direct to home (DTH) satellite method, Operator-specific Cable Television (CATV) method. In all of these methods, the end device is either an analog or a digital TV set which captures the media and displays the video and audio content [1] At present most of receivers work with one type of signal. For example, the receiver which is used to receive DVBS signal cannot be used to receive DVBT or DVBC signal. It is not practical .solution to have different receivers to access different signal sources.[2],[15] In future, the requirement to access different forms of signal will increase and consumers need receivers which can handle different types of signals and capability to regenerate signals of required form. Once the front-end is integrated to main SOC and dedicated to one type of signal source, then it will be difficult to upgrade the architecture to enhance the performance. Front-end block need to be flexible in nature to upgrade the performance to take care of sensitivity, selectivity and issues related to high voltage protection etc.

Most of the HD receivers available today are with single SOC front-end integrated with demodulator and decoder, capable of receiving either DVBC/T or DVBS signal source. No flexibility to access different types of signal sources, since front-end block architecture is fixed and integrated to demodulator and decoder. No provision to add the required filters or protection circuits based upon the signal source or the application environment and hence non-optimized front-end, which leads to sensitivity and selectivity issues in the field.[9]

Adding multifunctional dimension to NIM is useful not only in HD receivers, but also has potential to act as trans receiver module in rural broad band distribution network, Modular concept at front-end brings more flexibility to modify or upgrade the design. The proposed NIM architecture brings reception of RF and IP contents in the single architectural platform. Signal regeneration is the new concept which is added at receivers, where one form of signal can be converted in to another form which can be handled by the existing devices in the home.

The design concept

The receivers in the home need to work like a communication hub as it is accessed very frequently by the users. As a front-end receiver block, NIM plays an important role to address these functions. The conventional NIM has blocks like filters, amplifiers, Mixer, Oscillator PLL, IF amplifiers as shown in Figure 1. The inside architecture may be designed with discrete components or with single chip Tuner with different demodulator and decoder configurations [3-6]

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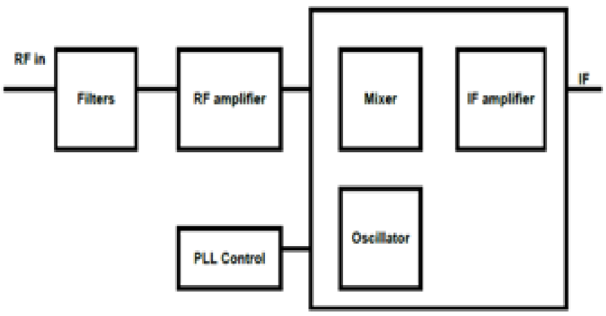

Figure 1. Block diagram of the conventional NIM

The futuristic NIM needs to perform many more functions in addition to improved quality of reception to enhance the performance of the receivers. The block diagram of the enhanced NIM is shown below in Figure 2.

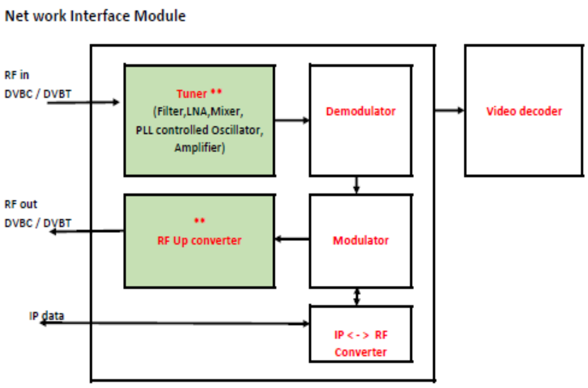

Figure 2. Block diagram NIM with enhanced features

Some of the functions those can be integrated with in the receivers are:

- Capability to receive DVC, DVBT and DVBS signals- use of universal demodulator and decoders
- Converting one form of signal in to another form (Trans modulation), so that it can be used by other devices of user's choice
- Receiving IP signals from IP camera and displaying on TV screen
- Reception of Ethernet signals and converting it in to RF for further distributions.

Modular concept at the front-end block brings flexibility in the HD receivers design. As shown in Fig. 2, the top level block diagram of the system consists of the Frequency down converting block, Frequency up converting block and the block to handle IP data**.**

The complete architecture of the NIM is sub divided in to 3 sections.

1. Front-end RF receiver block
2. RF Trans modulator block
3. IP trans receiver block

Front-end RF receiver block design:

Concept of Modularity is implemented at front-end block of the HD receiver so that HD receiver design engineers can build the flexible applications around the proposed NIM module.

The front-end module is built with necessary filter banks and the protection circuits. Design engineers can use any demodulator and decoders of their choice which can be interconnected to the proposed NIM without spending time on front-end optimizing process.

The front -end circuit can be matched to any Tuner SOC and filter bank selection is possible depending on the type of signal source and the filed of application. It brings flexibility to access different types of signal sources like DVBC/T/ S in the same receiver, which reduces cost of duplication of control processors. The front-end RF switch enables to select required filter banks depending on the type of incoming signal. For example, while receiving DVBC/T cable, it is required to activate filter which blocks Ethernet over cable and wifi frequencies which will adversely affect the performance of the receiving signal. We can have common high voltage protection circuit for all types of signals reception. While receiving DVBT signal, the interference due to other frequencies associated with mobile communication and LTE is very high which need to be suppressed. Depending on type of receiving signal the filter architecture can be changed to have best signal reception10 point Times New Roman for figure labels. Use words rather than symbols or abbreviations when writing figure-axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”.

Figure 3 shows the architecture of proposed front-end RF receiver block where RF switch and filter banks with high voltage protection circuit are interfaced with DVBC/T or DVBS tuner

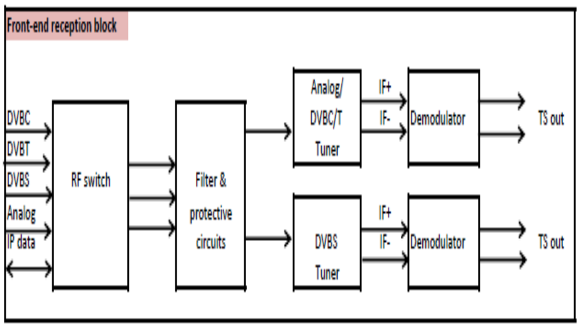

Figure 3. RF Switch and Filter interface with Tuner block

Tuner

It consists of front-end Filter / matching circuits, LNA, mixer, PLL controlled Oscillator and IF amplifier. Filters will be designed with the characteristics FM rejection, IF rejection and LTE frequency rejection, along with High Voltage protection circuit. The single chip one SOC can be used for DVBC/T reception and another SOC is for DVBS reception. Internally, Tuner SOC are embedded with wide band LNA, matching circuits, PLL controlled Oscillators.[7-12] For DVBC and DVBT, the operating frequency is 50 MHz to 900 MHz and for the DVBS the frequency is from 900 MHz to 2.4 GHz Some of the main specifications of the Tuner section are as follows:

- Frequency coverage range : 48 MHz to 855 MHz
- Vcc : 5 V + / - 0 %
- Current : 150 mA max.
- AGC : 0 to 4V
- Power Gain : 35 dB min
- Gain Deviation : 10 dB max
- Image rejection : 50 dB min.
- IF rejection : 55 dB min
- Noise figure : 10 dB max
- DC – DC Converter : 5 V to 33 V in built
- Tuning system: IIC Controlled, Heterodyne

Demodulator and Modulator

The output from the Tuner will be a simple IF, which can be connected to digital demodulator / decoder SOC. This gives flexibility to the designer to use any demodulator or decoder SOC. Transport stream from the Demodulator output will be given to decoder. In some cases, there could be integrated demodulator and decoder section. In the figure 3, the options to have 2 Tuners with separate demodulator and decoder unit is shown.

RF Trans modulator block

This block is used to modulate the signal to the required type based on the need. The transport stream from the demodulator section will be modulated. The modulated signal is transmitted over cable or it can be retransmitted over air using small antenna. Power amplifier can be switched on to get the required amplified signal, which need to be decided based on the range of signal transmission required, The block diagram of modulator section is shown in Figure4

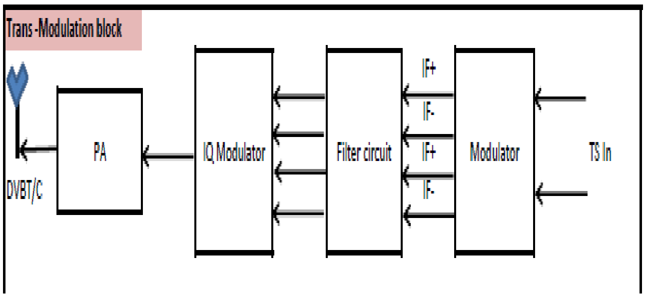

Figure 4. Block diagram of Trans –modulator section

The modulator will take digital transport stream from the demodulator and gives out I and Q signal. or low IF signal. Universal Modulator SOCs are used for this purpose, which adds flexibility to tans modulate the frequency. The IQ signal lines are connected to IQ modulator section to get the RF ouput. To suppress 3^{rd} harmonic components during mixing at IQ Modulator, a filter bank is attached at the output of modulator. The power amplifier will be used to amplify the RF in case if it needs to be transmitted over air locally. The signal regeneration has many applications. Depending on the requirement, signal can be internally regenerated which can be accessed by other equipments in the home.

IP trans receiver block

This block will convert IP data in to RF. The output RF is in the frequency range of 470 MHz to 590 MHz, with channel spacing of 6 MHz / 8 MHz with QPSK or 16 QAM modulation with data rate of 12 to 15Mbps for uplink and down link. The operating mode may be TDD or FDD.

The received IP data will be converted in to Digital transport stream using programmable SOC. The Digital Transport stream is then converted in to Low IF using by using SDR (Software Defined Radio) technology based Digital Modulators using DSP algorithms. The low IF or I and Q out put from this block will be then up converted in to RF in the frequency range of 470 to 590 MHz. The RF output level will be increased using power amplifiers and will be transmitted through air using antenna with a power of about 0 to +5 dbm. At the receivers, the RF will be received using Tuner and then converted back in to IP data.

Figure 5 shows the Transmitter and receiver blocks used for IP data distribution over TV white space or Cable, depending on the requirements.

The received IP data is converted in to Digital Transport Stream (TS) and this data is processed in digital programmable Modulators using DSP. The out come of this process will be Low IF or I-Q signal, which need to be up converted to a band of 470 to 590 MHz. This will be amplified using power amplifiers and transmitted over air using antenna. As a receiver, the NIM receives RF and Tunes it to get IF, which will be demodulated and processed at Digital demodulator or FPGA to get TS and IP packets back using DSP. QPSK or 16 QAM modulation with data rate of 12 to 15 Mbps for up link and down link is targeted using TDD or FDD.

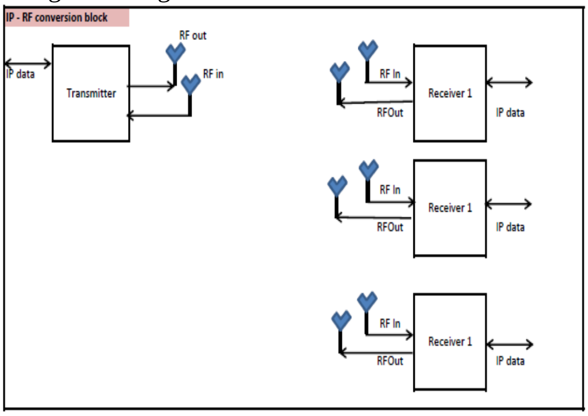

Figure 5. Block diagram IP data communication system

Broad band over TV white space

Due to transition to Digital from analog TV, additional spectrum became available for broadband applications. This spectrum is called TV White Space and is attractive, due to it's much lower frequency compared to existing unlicensed spectrum. Lower frequencies propagate better over greater distances and through walls.[16]

Narrow band applications have narrow bandwidth problem even though range is good. Broad band applications suffer due to shorter range, where as white space offers improved bandwidth and range.

Traditional wi-fi technology uses 2.4GHz ISM band where as TV white space uses 470 to 698 MHz ISM band.

Hence Broad band distribution over TV white space is emerging trend as an alternative to wi fi.

Integrating the receiver with broad band reception capability is an add advantage for the consumers in rural area.

Advantages of Proposed Methodology

HD receivers are very frequently used , mostly to view TV channels. The proposed methodology aims to enhance the performance of HD receivers by addressing the architecture of NIM.

The modularity concept at NIM stage, makes designers to implement flexible features in the HD receivers with reduced cost and reduced design implementation time.

Once the multifunctional capability is built at NIM stage, designing of HD box become easy and same demodulator / decoder control processor can perform many tasks. This will enhance the function of HD receiver and reduce the cost of receiver. No need to have multiple receivers to execute multiple tasks or to receive signals from multiple types of resources.

While designing NIM, the general basic requirements like sensitivity, Image suppression, High Voltage protection etc are also considered so that front-end block will give optimized performance to the receiver. The proposed NIM will also can be used as front-end module for broad band communication over TV white space. There could be standalone receivers for TV white space applications. But the proposed NIM integrates TV reception and broad band reception in one platform to reduce cost and implementation time

Conclusion

By enhancing the performance of NIM, the over all performance of HD receiver can be enhanced. The modularity concept implemented at front-end gives flexibility in HD box design implementation. NIM has potential to add multiple functional capabilities like Trans modulation, IP data reception along with reception of multiple signal sources. The proposed methodology will help to introduce flexible and cost effective HD receiver designs.

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