DVB-H architecture for mobile communications systems

The availability of new low-power, small form-factor digital video broadcast hand-held (DVB-H) demodulator and silicon tuner solutions now enable the reception of digital TV signals on hand-held devices where small displays and limited battery power are a fact of life. The requirement for improved video display functionality and support for multimedia applications makes DVB-H[1] an attractive complementary technology to existing 3G in-band solutions.

By Stuart Pekowsky and Khaled Maalej

The deployment of handsets with integrated support for the reception of digital TV signals is now a reality. Until now, the feasibility of such support has been limited by several key factors, namely power consumption, performance and size. Most attempts at addressing the hand-held receiver market have been based on adapting existing home set-top box solutions to the demanding environment of mobile reception. Experience has shown that this is not possible due to the constantly changing receiver environment. The quality of the received signal is affected by the receiver's ability to manage adjacent-channel rejection, low signal-to-noise ratios and Doppler compensation. Mobile DVB-T receivers have implemented antenna diversity technology but at the cost of increasing power consumption and size. While small form-factor diversity solutions do exist, in practice they are not feasible for deployment in cell phones since antenna diversity requires a minimum distance between the two antennas that is not readily available.

The DVB-H standard, actually an extension to the digital video broadcast terrestrial (DVB-T) standard, has specified the use of time-slicing to reduce receiver power consumption and multiprotocol encapsulation forward error correction (MPE-FEC) to provide an additional layer of error correction in order to provide a more robust signal in mobile environments where diversity solutions are typically the norm. In addition, DVB-H provides for the use of services based on Internet protocol (IP) datacasting. An example of a DVB-H broadcast configuration is shown in Figure 1. Figure 2 depicts potential head-end architectures for provision of content in a DVB-H network.

This article focuses on the receiver (specifically, the silicon tuner and demodulator modules) and discusses the methods of addressing the demands placed on the receiver in the mobile environment without sacrificing performance on hand-held devices.

Adaptations to DVB-T toward DVB-H

DVB-H specifies the use of the following to address hand-held constraints:

- Time-slicing to reduce power consumption.
- IP datacasting for lower resolution video streaming.
- MPE-FEC for more robust signal reception.
- Introduction of the 4K carrier mode for network optimization.

DVB-H front-end: Silicon tuner plus demodulator

In order to be able to integrate the DVB-H front-end into a cell phone, it was necessary to address several important issues: power consumption, performance and mechanical size. All of these problems are solved by the new generation of silicon tuners and demodulators.

Silicon tuner characteristics

The silicon tuner is the most recent type of tuner to evolve from the so-called "in-can" tuners commonly found in set-top boxes and TV tuner PC peripherals for home use. The performance of the "in-can" tuner can be quite good and is used as a baseline for measuring the performance of silicon tuners.

The interface between the tuner and the demodulator was changed from intermediate frequency (IF) (for DVB-T) to baseband (for DVB-H). This offers the possibility to do the adjacent-channel filtering in baseband and integrate it into the silicon tuner. Doing so

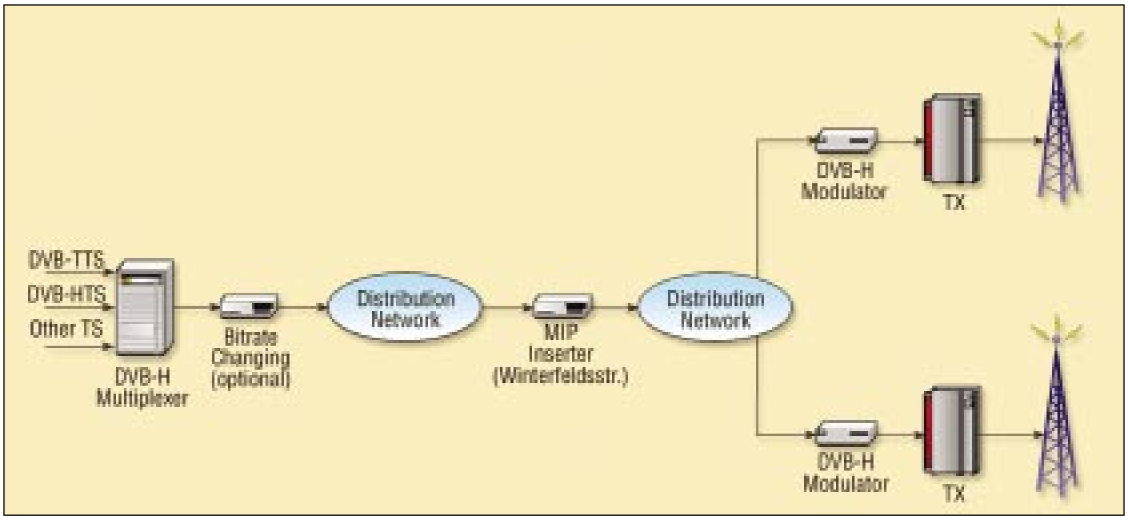

Figure 1. DVB-H broadcast network.

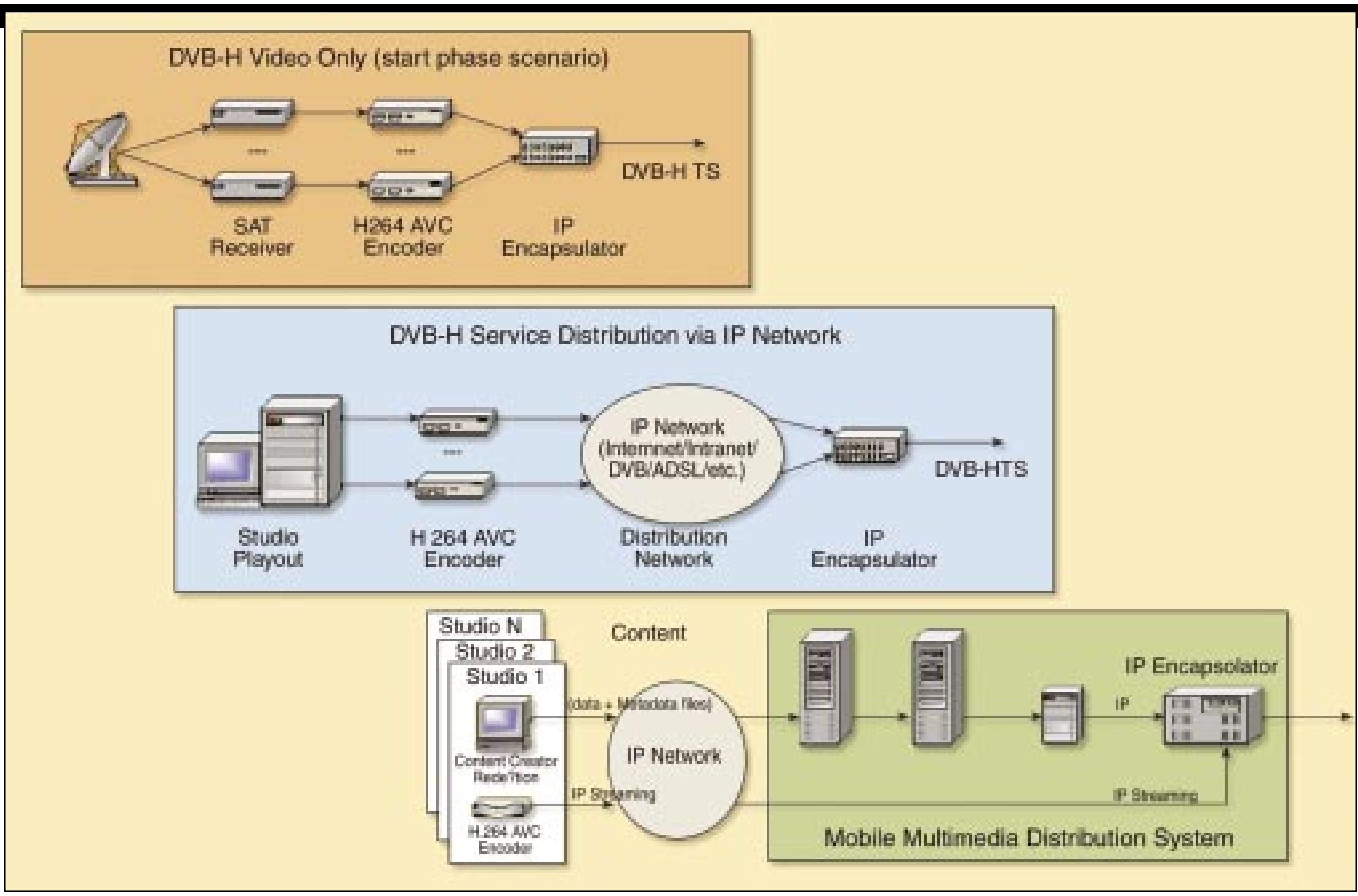

Figure 2. DVB-H sources and encoding.

contributes to the reduction of the footprint of the complete solution. As a result, the power consumption of such tuners has been reduced to 300 mW. DVB-H has been considered for use in the UHF band but has been adapted for use in other frequncy ranges as well (e.g., 1.672 GHz for U.S. trials).

DVB-H demodulator characteristics

The primary requirement for the demodulator is to provide good reception performance in mobile environments. The Doppler compensation requirement for a DVB-H receiver is at least 100 Hz. The receiver must be able to handle a channel with this variation and at the same time maintain the same signal-to-noise ratio as the one obtained for low Doppler frequencies for the same quality of service (QoS). This point is critical for broadcasters when they do their network planning. The network coverage must stay the same when the speed of the receiver varies.

In addition to Doppler compensation, the receiver will face channel profile variations. The different echoes received at the antenna will vary and the distance between them will change continuously. The receiver must compensate for these variations in order to avoid de-synchronization with the transmitter and to maintain good reception.

Co-channel interference is an important transient disturbance that comes from different industrial sources that are generated in the operating environment and sometimes even from other neighboring networks. The receiver must provide immunity from such large disturbances and also be capable of maintaining good reception even if the interference exhibits power higher than the desired signal. In a Groupe Spécial Mobile (GSM) cell phone for example, such interference typically comes from the upstream GSM channel.

Sensitivity is an important parameter regarding providing the best geographical coverage. The demodulator design must strive to have an implementation with very low degradation with respect to the theoretical values. An implementation margin of 0.5 dB to 1 dB is something that can be achieved.

Figure 3 shows the block diagram of a DVB-H receiver with the two main parts: demodulation and media access control (MAC) processing.

In addition to the demodulation, the link layer or MAC is also integrated into the demodulator. This layer handles the time slicing, the IP data extraction and the IP data error correction. Because of the high bit rates that DVB-H must support, the Reed-Solomon decoding is implemented in hardware.

Power consumption

In general, a DVB-T Moving Pictures Experts Group (MPEG-2) program stream can use up to 10 Mbits/s, which is above what a cell phone or hand-held device can reasonably process or display on a quarter video graphics array (QVGA) screen. A bitstream of less than 500 Kbits/s can provide good quality video resolution on small screens. Time slicing (i.e., data bursting) was introduced in order to adapt the DVB-T stream to the cell phone. The receiver is turned on for a short period and then shut off the rest of the time. In order to receive 500 Kbits/s, the receiver can be turned on only 500/10000 or 5% of the total receive duty cycle, which will offer a power consumption reduction with the same ratio. This calculation is theoretical and the synchronization time of the receiver must be added to the total "on" time in order to compute the power reduction. It is assumed here that a 90% reduction of the total on-time power consumption is achievable. The latest DVB-T front-end (tuner plus demodulator) technology consumes approximately 500 mW). Therefore, a power consumption of 50 mW for the complete DVB-H front-end may be calculated in order to receive 500 Kbits/s.

In addition to reducing power consumption, time-slicing supports the seamless service hand over between transmitters. The receiver can scan for other available RF channels while maintaining the current service to the user and switch to a new cell

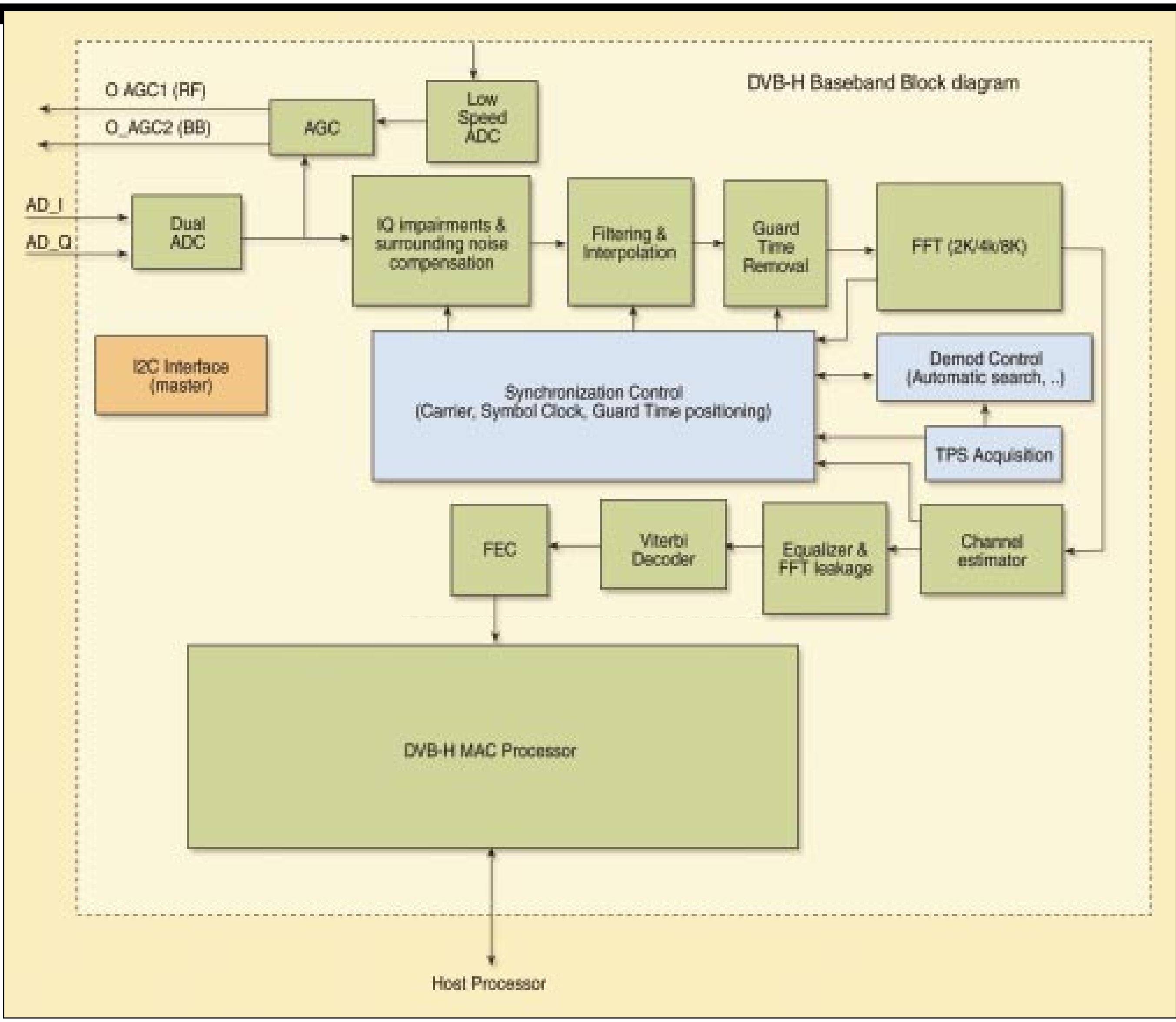

Figure 3. DVB-H demodulator block diagram.

if the signal received from this cell has a better signal level and provides the same service.

IP datacasting

DVB MPE[3] was adopted as part of the specification for video streaming and data transfer for use in DVB-H systems.

Transmission of IP packets over MPEG-2 is based on digital storage media command and control (DSMCC)[2] sections that are typically not repeated. The transparent transmission of IP is accomplished by encapsulating the entire IP packet payload within the payload of a DSMCC section and by mapping the MAC address to the respective header and payload fields in the DSMCC section. The section format permits fragmenting datagrams into multiple sections. If the length of the datagram is less than or equal to 4086 bytes, the datagram is sent in one section. In the case of IP, the maximum transmission unit (MTU) is set to 4086 bytes or less so that the datagrams will never be fragmented. The MAC address has been divided into 6 bytes that are located in two groups[3]. Bytes 5 and 6 are mapped to the table_id_extension field of the DSMCC section, while bytes 1, 2, 3 and 4 are mapped to the payload area of the DSMCC section. This mapping was done to utilize the limited capabilities of the first generation of demultiplexers.

IP video streaming to devices with small displays is ideal for providing low-resolution, low bit-rate data transfer.

MPE forward error correction (MPE-FEC)

MPE-FEC was added to the DVB-H specification in order to implement time-interleaving and error correction. In a mobile environment, the signal will be subject to attenuation and, therefore, fading. The frequency of this fading will depend on the Doppler effect the receiver is undergoing. The lower the Doppler frequency, the greater the time-interleaving that is needed in the system. The time-interleaving that DVB-H offers is flexible and can be adapted to the service. Typical time-interleaving periods can be as high as 500 ms and as low as 50 ms. These periods can be even lower but then it does not make sense at the system level.

After time-interleaving, a Reed-Solomon encoder is applied in order to protect the data. The code rate is flexible and can also be adapted to the service. A typical code rate may be ¾ but rates as low as ½ or as high as $^7/_8$ may be used.

Figure 4 shows the advantage that MPE-FEC brings to the system. The Doppler frequency is given by the x-axis while the y-axis shows the required carrier-to-noise ratio (C/N) that is required to reach a certain

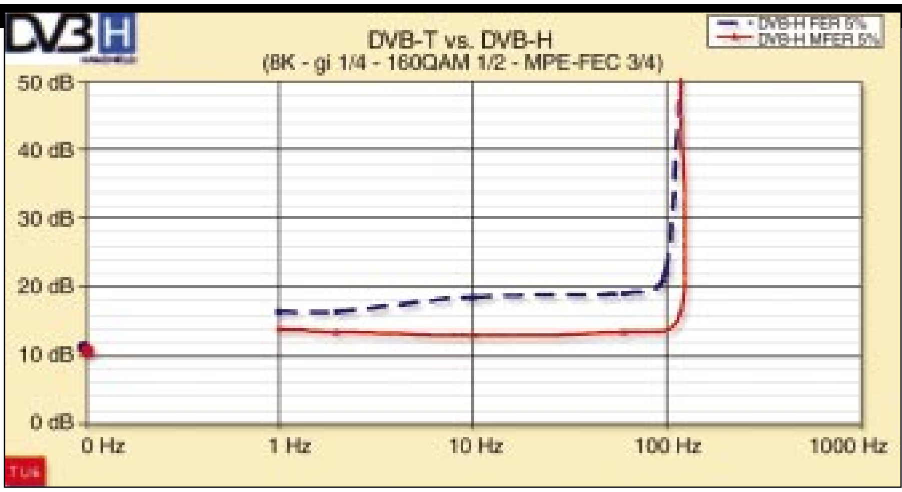

Figure 4. C/N vs. Doppler frequency.

QoS. The blue curve shows the performance without MPE-FEC while the red one shows the performance with MPE-FEC and at a code rate of ¾.

One can see from the graph that the C/N curve is flat up to a Doppler frequency of 120 Hz. This result helps simplify the network planning for the broadcasters.

4K mode

The 4K mode was introduced (in addition to the existing 2K and 8K modes) in order to offer a better compromise between mobility and network robustness in terms of echoes. For the same useful bit rate, the 8K carrier number doubles the level of protection of the system against echoes as compared to 4K.

Of the existing DVB-T networks, 90% utilize the 8K mode. It is field proven and offers the right performance for Doppler and echo protection when used in the ultrahigh-frequency (UHF) band.

Application processing

The output of the DVB-H demodulator is an IP stream that is sent to the device application processor. The application processor is typically responsible for the decoding and rendering of video and audio and the integration of these services within the context of the device type, such as a cell phone or personal digital assistant. RFD

References

1. ETSI EN 302 304 V1.1.1 (2004-11) Digital Video Broadcasting (DVB); Transmission System for Hand-held Terminals (DVB-H).
2. ISO 13818-6 Extension for Digital Storage Media Command and Control.
3. ETSI EN 301 197 DVB Specification for Data Broadcasting.

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