Development of Tuner Module for Mobile Multimedia Broadcasting

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Fujitsu Semiconductor has developed a Mobacas (mobile multimedia broadcasting)-compatible tuner module conforming to the Integrated Services Digital Broadcasting for Terrestrial Multi-Media Broadcasting (ISDB-Tmm) standard. This tuner module incorporates proprietary algorithms developed jointly with Fujitsu Laboratories to significantly improve reception sensitivity and enhance reception performance in a single-frequency network (SFN), thereby helping to expand the reception area. The module comes in two types to meet the design needs of terminal developers. The MB86A35V module makes it easy to achieve a required level of functionality and performance by simply connecting the module to an antenna, and the MB86A35C module enables a terminal developer to add an external filter for removing interference. This paper presents the key issues in the development of this Mobacas-compatible tuner module, describes the measures taken to solve them, summarizes the module specifications, and introduces the module's product lineup.

1. Introduction

Since the launch of the One-Seg mobile broadcasting service in April 2006 in Japan, the total number of One-Seg compatible handsets has come to exceed 100 million. Many of the mobile phones sold in Japan are now equipped with the One-Seg function.

Against this background, the Mobacas (mobile multimedia broadcasting) service[note1)] was launched in April 2012 to provide a mobile broadcasting service in conformance with the Integrated Services Digital Broadcasting for Terrestrial Multi-Media Broadcasting (ISDB-Tmm) standard, which extends the One-Seg system by using the 207.5–222 MHz (V-High) band that became available with the termination of analog television broadcasting in July 2011.[1] Targeting a shipment of about 3 million Mobacas-compatible terminals and the signing up of about 1 million subscribers in the first fiscal year of service, mmbi Inc. is attracting considerable attention in the mobile communications industry.

Mobacas features high-quality, real-time video broadcasts, a new storage-type broadcast service, and interaction between communications and broadcasting media (functions and services). It provides a wide range of content including video and music, newspapers and magazines, e-books, and games.[2] Mobacas is currently provided in that portion of the Kanto region (the greater Tokyo area) covered by the antennas on TOKYO SKYTREE[note2)] and in the prefectures of Aichi, Mie, Osaka, Kyoto, Nara, Hyogo, Fukuoka, and Okinawa. The plan is to expand the coverage area to Hokkaido, the outer edges of the Kanto region, and the prefectures of Miyagi, Shizuoka, Niigata, Nagano, Ishikawa, Wakayama, Okayama, Hiroshima, Kagawa, Ehime, Kumamoto, Saga, and Kagoshima by the end of March 2013 and thereby increase the household coverage rate from about 60% as of April 2012 to about 76%. In three years time, this figure is expected to reach about 90%.

To prepare for the rollout of this service, Fujitsu Semiconductor set out to develop and mass produce a

note1) Mobacas is pronounced "mobakyasu" and is short for "mobile casting."

note2) The TOKYO SKYTREE tower in the Sumida ward of Tokyo is the tallest tower in the world. It was completed in February 2012.

Mobacas-compatible tuner module and succeeded in doing so before the Mobacas launch.

This paper first describes two key issues surrounding the development of this Mobacas-compatible tuner module and the measures taken to resolve those issues. It then summarizes module specifications and introduces the product lineup for this module.

2. Issues in development

Two key issues surrounded the development of this tuner module.

2.1 Improving reception sensitivity (reducing required C/N ratio)

While the One-Seg service uses quadrature phase-shift keying (QPSK) as its modulation system, Mobacas uses 16-quadrature amplitude modulation (16-QAM) to support high-image-quality data. The difference in the required C/N ratio for these two modulation systems is about 4 dB. About 70% of the Mobacas service is made up of real-time broadcasts (at the time of launch), and, in contrast to One-Seg service, Mobacas is a charged service, broadcasting several channels for a fee of several hundred yen a month. Reception must therefore be reliable within the service area. Compared to outdoors, however, signals in an indoor environment degrade by about 10 dB, which makes it imperative that reception sensitivity be improved by reducing the required C/N ratio.

2.2 Improving reception performance of long-delay signals in an SFN

As the name implies, a single-frequency network (SFN) consists of multiple transmitting stations all using the same frequency. An SFN is advantageous because it provides good spectrum efficiency while enabling facilities to be deployed at relatively low cost since all transmitting stations need only support the same frequency.

Taking the Kanto region as an example, the recently constructed TOKYO SKYTREE tower serves to transmit broadcast signals at a transmit power of 25 kW. It was found, however, that signals could not reach some locations in Kanto far removed from the tower. It was for this reason that transmitting stations have also been constructed in Sawara (Chiba prefecture) and Yokohama (**Figure 1**).[3] As shown in the figure, the broadcast zones of the Yokohama transmitting station and Sawara transmitting station overlap with that of TOKYO SKYTREE. Consequently, if a terminal is receiving signals near the Sawara transmitting station, for example, it will receive signals from both that station and TOKYO SKYTREE, but since that location is somewhat distant from TOKYO SKYTREE, the received signals will include long-delay signals.

With One-Seg service, which provides digital terrestrial simulcast broadcasting, the frequency used by a transmitting station depends on the broadcast area. As a result, reception problems associated with long-delay signals as in an SFN are unlikely to occur. However, as all transmitting stations used for the Mobacas service use the same frequency for broadcasts throughout Japan, reception problems associated with SFN long-delay signals have a high possibility of occurring, which makes it highly important that measures for dealing with those signals be developed.

The use of a guard interval is one method for mitigating the effects of long-delay signals in an SFN environment. A guard interval extracts part of the effective symbol in a signal and places it at the front of that symbol's data. The concept of a guard interval

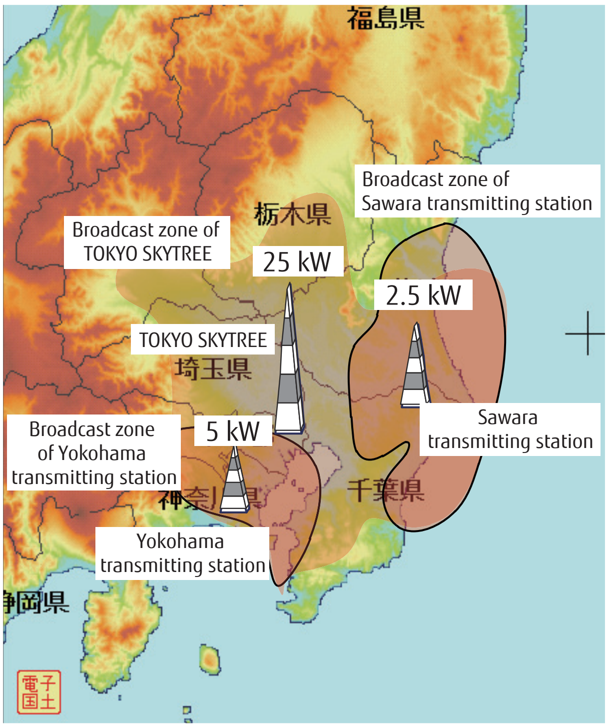

Figure 1
Transmitting stations in Tokyo area.

is shown in **Figure 2**. The horizontal axis represents time. At the time of reception, a direct signal and delayed signal combine to form a composite signal that is picked up by the tuner module. In general, a composite signal includes a component from the previous symbol, but, by having a guard interval, no component from the previous symbol is mixed in even if guard intervals overlap. Reception becomes possible by deleting the guard intervals before demodulation. A large guard interval means that demodulation can be performed even for long delays, but there is a tradeoff since a guard interval that is large relative to the effective symbol interval degrades transmission efficiency. The ISDB-Tmm standard uses a guard interval that is one-fourth the length time-wise of the effective symbol interval.

3. Solutions

In this section, we describe specific measures for resolving the issues described in the previous section.

3.1 Improving reception sensitivity at tuner input terminal

Reception sensitivity at the tuner's input terminal is computed using

Pin = KTBF + required C/N ratio.

The symbols used in this equation are explained as follows:

Pin (dBm): reception sensitivity
C/N ratio (dB): ratio of received carrier level to noise level
required C/N ratio (dB): limiting value of C/N ratio that can be stably received
absolute temperature T (K): 273 + temperature (°C)
Boltzmann constant K (J/K): 1.38×10^{-23}
bandwidth BW (Hz): bandwidth of broadcast signal
thermal noise KTB (dB): 10log (K × T × BW)
noise figure F: noise figure (NF)
receiver noise (dBm) KTBF: KTB + NF.

If BW is set to 5.6 MHz and temperature to 27°C (room temperature), the above equation can be rewritten as

Pin = −106 + NF + required C/N ratio.

A smaller value for reception sensitivity Pin is desirable, and, as can be seen from the equation, reception sensitivity improves as the NF and required C/N ratio become smaller. With this in mind, we equipped this tuner module with two algorithms for reducing the required C/N ratio and improving reception sensitivity. The first algorithm, making use of the fact that Reed-Solomon decoding and Viterbi decoding are used as error correction processing in the ISDB-Tmm

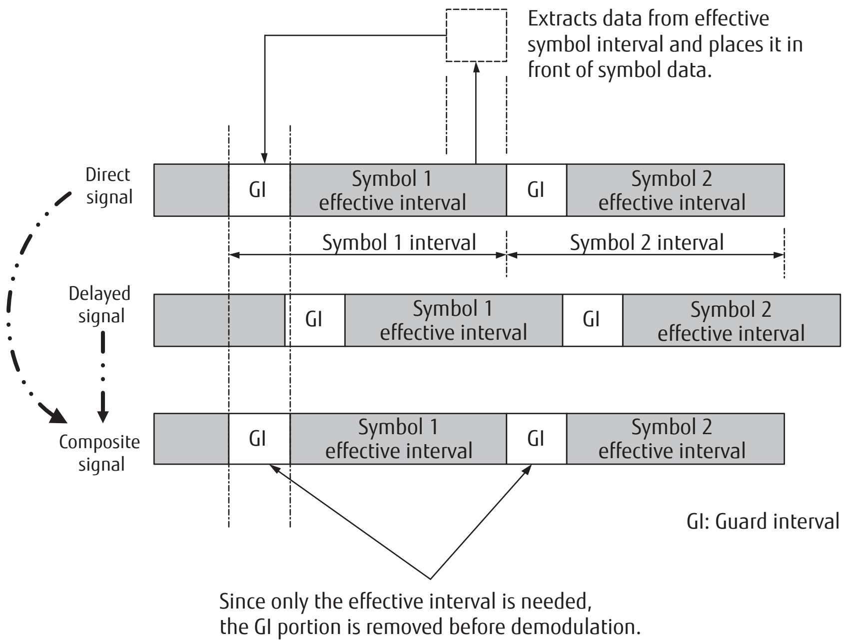

Figure 2
Concept of guard interval.

standard, reuses the results of Reed-Solomon decoding in the Viterbi decoding method. The second algorithm, meanwhile, given that the information input to an error-correction process is usually subjected to soft-decision processing (which adds likelihood information to the quantized stream of received data), varies the number of "soft bits" in accordance with the reception environment. Equipping the tuner module with these two algorithms greatly reduced the required C/N ratio.

The results of comparing the required C/N ratio between an existing product and the new product are shown in **Figure 3**. The horizontal axis represents the C/N ratio; a smaller value means more noise resistance. The vertical axis represents the bit error rate (BER); points at or below 2×10^{-4} (indicated by the broken line in the figure) correspond to the required C/N ratio. These results show that equipping the tuner module with the above two algorithms results in a 2-dB improvement in the required C/N ratio compared to an existing product, thereby improving reception sensitivity by a substantial amount.

3.2 Improving reception performance in SFN environment

In an SFN environment consisting of multiple transmitting stations, a delay occurs in the arrival times of the signals emitted from each station. In particular, the transmission parameters of the ISDB-Tmm standard include a guard interval that can sustain a delay of up to 252 μs in broadcast signals. This means that installing transmitting stations in a configuration in which larger delays occur would require a tuner module with an even higher level of performance to deal with the resulting SFN environment. The ISDB-Tmm standard, however, uses 16-QAM as its modulation system in order to receive large amounts of data and provide high picture quality. Compared with QPSK (used by the One-Seg system), the amount of data handled by 16-QAM is large and reception performance is low. Consequently, to enable reception on par with One-Seg broadcasts, a tuner module that can receive signals with such large delays must be developed.

These considerations led us to equip the tuner model presented here with an equalizer to cancel out delayed signals and improve resistance to signals with delays as long as 252 μs or greater. This equalizer obtains delay information from the received signal and uses that information to regenerate and cancel out the delayed signal from the main signal. The use of this equalizer greatly improves reception performance in an SFN environment.

The results of measuring the amount of delay in the delayed signal with respect to the main signal versus the desired-to-undesired (D/U) signal ratio are shown in **Figure 4**. The vertical axis represents the D/U signal ratio and the horizontal axis the amount of delay; results are plotted for equalizer ON and OFF. Note that signal reception is possible even if high-power

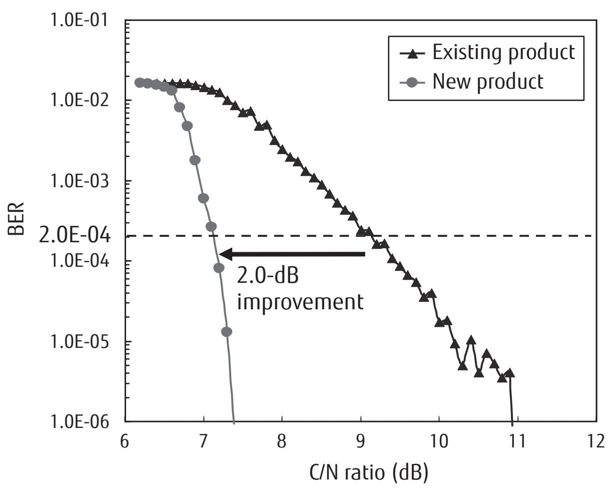

Figure 3
Comparison of required C/N ratio between existing product and new product.

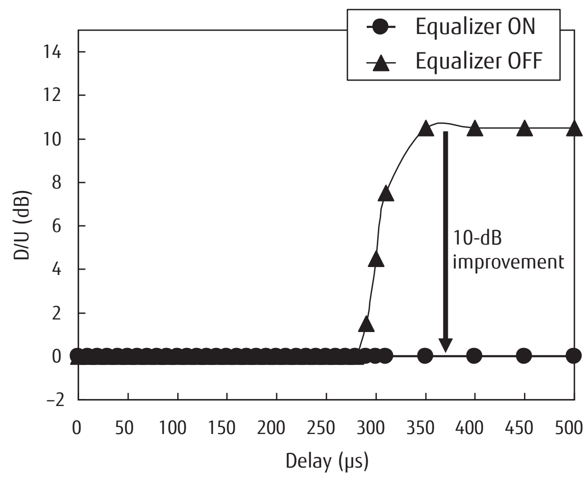

Figure 4
Delay of delayed signal with respect to main signal versus D/U signal ratio.

delayed signals corresponding to a small D/U ratio are present. The power of the input signal was −70 dBm. The results for "equalizer OFF" show that the D/U ratio was significantly degraded for delayed signals in excess of the guard interval (252 μs) while those for "equalizer ON" show that it was improved by about 10 dB by using the equalizer. In actual arrangements of transmitting stations or regions in which signals reflect off mountains, for example, there will be many locations having delayed signals with a delay in excess of such a guard interval. Using this equalizer should thus greatly improve reception performance in an SFN environment. The plan looking forward is to increase the number of transmitting stations to support further penetration of the Mobacas service. As a consequence, tuners that can presently receive Mobacas broadcast signals may not be able to do so as long-delay signals come to be generated in this expanded SFN environment. Using the new tuner module introduced here can avert this problem.

4. Module specifications and product lineup

The following summarizes the specifications of this tuner module and presents the product lineup for this module.

4.1 Module specifications

1) Supported systems
- Mobacas ISDB-Tmm for mobile multimedia broadcasting
- 1-segment/13-segment Integrated Services Digital Broadcasting - Terrestrial (ISDB-T)[4)]

2) Receive frequency
VHF 207.5–222 MHz
UHF 470–770 MHz

3) Functions
Inter-integrated circuit (I^2C) bus interface, automatic gain control, emergency broadcasts, 6/7/8-MHz signal bands, deletion of long-delay signals in an SFN environment

4) Package size
MB86A35C: 7.6 × 8.4 × 1.0 mm
MB86A35V: 6.7 × 6.8 × 1.05 mm

5) Other
Provision of Android drivers

4.2 Product lineup

This tuner model comes in two types to meet diverse user needs.

1) MB86A35V

This is an all-in-one module that can output a transport stream (TS) for decoder use by simply being connected to an antenna. With this product, it is unnecessary for the customer to design circuitry for external components, and target performance can be easily achieved.

2) MB86A35C

This product corresponds to the MB86A35V with the surface acoustic wave (SAW) filter removed. The carrier frequencies used by handsets differ between the various mobile phone companies in Japan, so it is necessary to eliminate interference by using a SAW filter corresponding to the frequency used. A common mobile platform can therefore be achieved by enabling the SAW filter to be changed as needed outside the module.

Android drivers for the MB86A35C and MB86A35V products are provided to support software development. Resources for developing applications and middleware can be centralized to shorten the development period including testing.

A photograph of the MB86A35C and MB86A35V tuner modules is shown in **Figure 5**.

5. Conclusion

In this paper, we introduced a tuner module conforming to the ISDB-Tmm standard used by the

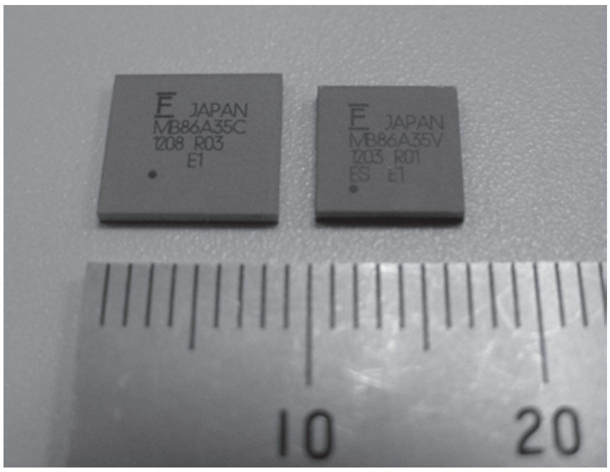

Figure 5
MB86A35C (left) and MB86A35V (right) modules.

recently launched Mobacas mobile multimedia service. We described our strategy for improving the module's reception sensitivity and performance in the face of degradation caused by long-delay signals.

Looking forward, we plan to develop an algorithm that can further improve the required C/N ratio with the aim of achieving reception sensitivity equal to or better than that of the One-Seg service. Other groups are now studying services using the ISDB-Terrestrial for Sound Broadcasting (ISDB-Tsb) system on a different VHF band formerly allocated to analog broadcasting. We plan to apply the technology developed for the Mobacas service to the development of digital radio.

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