Multimedia Broadcasting Mobacas Hardware

Technology Reports

New Service Merging Communications and Broadcasting—NOTTV—

# Mobile Device Technology Supporting Mobacas Service —Radio Hardware Technology—

*Mobacas™[*1] uses the lower frequency band of 200 MHz, which means that Mobacas-capable devices must ensure sensitivity performance without sacrificing mobile-device design and while using an antenna with a harmless length. The 200-MHz band, however, is easily affected by noise such as that generated by the LCD of the mobile device, and to ensure overall radio performance of the mobile device including antenna gain and receiver sensitivity, advanced radio hardware technology is necessary. At NTT DOCOMO, we overcame these technical issues and successfully rolled out Mobacas-capable mobile devices. We also addressed antenna-related issues such as interference with existing radio services and developed a built-in antenna and supplementary external antennas with a connection interface. Additionally, we developed a test system using an anechoic chamber and evaluated the overall radio performance using a figure of merit of OTA sensitivity for the developed Mobacas-capable mobile devices.*

Communication Device Development Department

***Makoto Sasaki***
***Hiroki Shikama***
***Hirohiko Yamamoto***
***Yoshiki Okano***

## 1. Introduction

The NOTTV™[*2] broadcasting service available for smartphones and other mobile devices was launched on April 1, 2012 using the “Mobacas” broadcast system.

This service uses the 207.5-222 MHz frequency band, which became available by the transition from legacy analog terrestrial television broadcasting to newer digital terrestrial television broadcasting. The Integrated Services Digital Broadcasting-Terrestrial for mobile multimedia (ISDB-Tmm)[*3] adopted by Mobacas is a broadcasting system based on ISDB-T[*4], which is presently used for digital terrestrial television broadcasting and “One Seg” services [1] [2].

With the aim of releasing Mobacas-capable devices ahead of the NOTTV service launch, NTT DOCOMO has developed Mobacas-capable smartphones.

Radio hardware technology for the Mobacas service consists of the follow-

---

[*1] **Mobacas™**: A trademark of Japan Mobilecasting, Inc.

[*2] **NOTTV™**: A trademark or registered trademark of mmbi, Inc.

ing components:

- Antenna technology that improves Over-The-Air (OTA) sensitivity for a frequency band lower than that of digital terrestrial television broadcasting
- Noise-reduction technology essential for achieving required sensitivity
- Receiver technology to enable high-quality playback of video content

This article describes radio hardware technology for mobile devices supporting the Mobacas service and the evaluation of OTA sensitivity to ensure the overall radio performance of Mobacas-capable devices developed by NTT DOCOMO.

## 2. Antenna Technology for Mobacas Devices

As described above, Mobacas is a broadcasting service using the 200-MHz band, which means that an antenna for the 200-MHz band is necessary for a mobile device to receive Mobacas signals. Antenna length versus wireless service and frequency band is shown in **Figure 1**. Theoretically speaking, a lower frequency calls for a longer antenna. The 2-GHz band used by FOMA, for example, requires an antenna approximately 7 cm in length (approximately half-wavelength), and an antenna used for One Seg broadcasts must be 20-30 cm in length. In contrast, an antenna approximately 75 cm in length is needed for Mobacas broadcasts. In actual device implementations, an antenna impedance matching circuit[*5] can be used to shorten antenna length. Nevertheless, it would not be hard to understand that installing a Mobacas antenna in a smartphone having an enclosure length of only 12 cm or so is going to require highly sophisticated antenna technology.

Furthermore, since a mobile-device antenna is generally designed so that the Printed Circuit Board (PCB) inside the device chassis is utilized as part of the antenna, the performance of a Mobacas antenna used for receiving signals in the 200-MHz band will greatly depend on the size of the device enclosure. This dependency of Mobacas antenna performance on device size is shown in **Figure 2**. These results were obtained by performing electromagnetic-field-analysis simulations taking device-enclosure size, or more specifically, screen size, into account. As shown in the figure, it can be seen that Mobacas antenna performance is better for tablet devices having larger enclosures/screens than smartphones having smaller enclosures/screens. In other words, achieving high performance with a smartphone having a small enclosure is not an easy task.

Based on the results of this basic study, we employed various types of antennas for Mobacas antennas with the aim of obtaining stable performance in diverse Mobacas usage scenes for either real-time broadcasting (streaming) or storage-type broadcasting (file casting). The types and categories of antennas that we studied for Mobacas are shown in **Figure 3**. As a primary antenna, we adopted a retractable rod antenna mounted on a device as it can satisfy both design and performance objectives. This antenna, which can also be used as a One Seg antenna, has been designed to obtain required performance within length constraints. We also adopted a cradle antenna and ear-

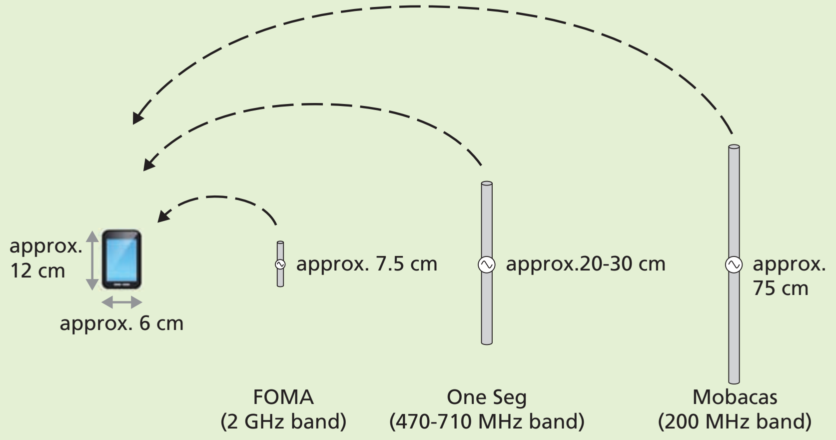


**Figure 1 Antenna length versus wireless technologies and frequency band**

---

*3 **ISDB-Tmm**: A broadcasting system based on the existing ISDB-T (see *4) system used for digital terrestrial television broadcasting and One Seg broadcasts.

*4 **ISDB-T**: Japan's digital terrestrial television broadcasting standard.

*5 **Antenna impedance matching circuit**: A circuit that matches the characteristic impedance between an electrical signal's sending side and receiving side on the transmission path. Used to prevent reflection loss within the transmission path.

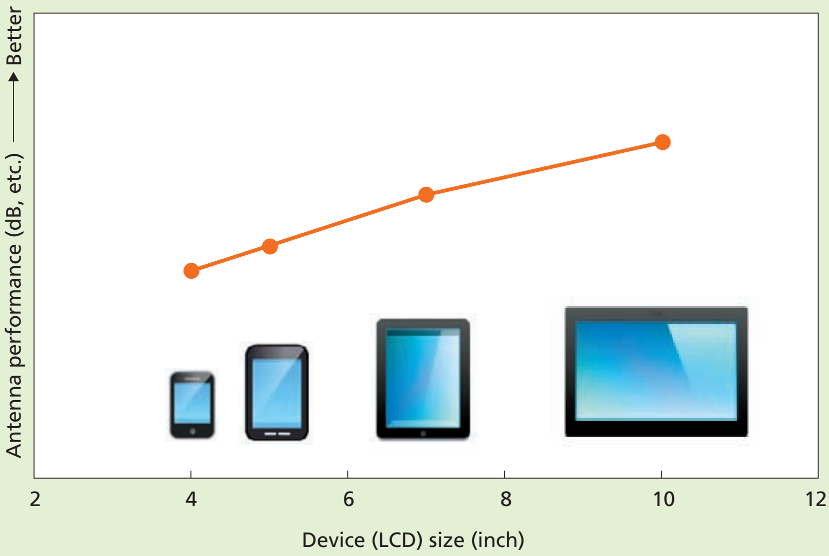


Figure 2  Mobacas antenna performance versus device size

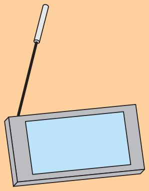
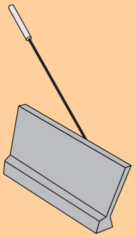
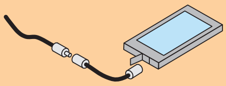
| Appearance |  |  |  |
|---|---|---|---|
| Type | Retractable rod antenna | | Earphone-cable antenna |
| Category | Device-mounted antenna | Cradle antenna | |
| | | Auxiliary antenna | |

Figure 3  Types and categories of Mobacas antennas

phone-cable antenna as supplementary antennas. The cradle antenna makes use of a retractable rod antenna the same as the device-mounted antenna, but in this case, the antenna is longer to improve antenna performance assuming indoor usage. The earphone-cable antenna, meanwhile, assumes mainly outdoor use and consists of an earphone cable of approximately 1 m in length. The above types of antennas can be used to receive stable broadcasts as the situation demands.

We also had to take into account the fact that a Mobacas device will be equipped with a number of antennas supporting FOMA, GPS, Wi-Fi®[*6] and other wireless technologies in addition to Mobacas, and therefore made a study of interference due to mutual coupling between these antennas. As described above, an antenna for mobile-device use is generally designed so that the device chassis is used as part of the antenna. Accordingly, our Mobacas-devices have been optimized to ensure the performance of all antennas including the Mobacas antenna.

## 3. Anti-noise Technology

Advanced anti-noise measures are needed to achieve high receiver performance in Mobacas-capable mobile devices. Anti-noise measures have been applied in the development of past mobile devices, but in noise studies using prototype devices, we found that noise must be reduced to even lower levels in Mobacas-capable devices.

Frequency characteristics of mobile device noise power are shown in **Figure 4**. Mobile device noise includes clock noise generated by the operation of many electronic components embedded in the mobile device and spurious noise radiated from control-signal lines. The harmonic components of the clock and spurious noise influence receiver performance in a wide frequency range, from low to high frequency bands. Furthermore, since lower frequencies are close to the frequency of the noise source, the impact of noise is quite considerable compared to higher frequencies. For example, One Seg service, a broadcast service for mobile devices, operates in the 470-710 MHz frequency band, but Mobacas service operates in

---

[*6] **Wi-Fi®**: A registered trademark of the Wi-Fi Alliance.

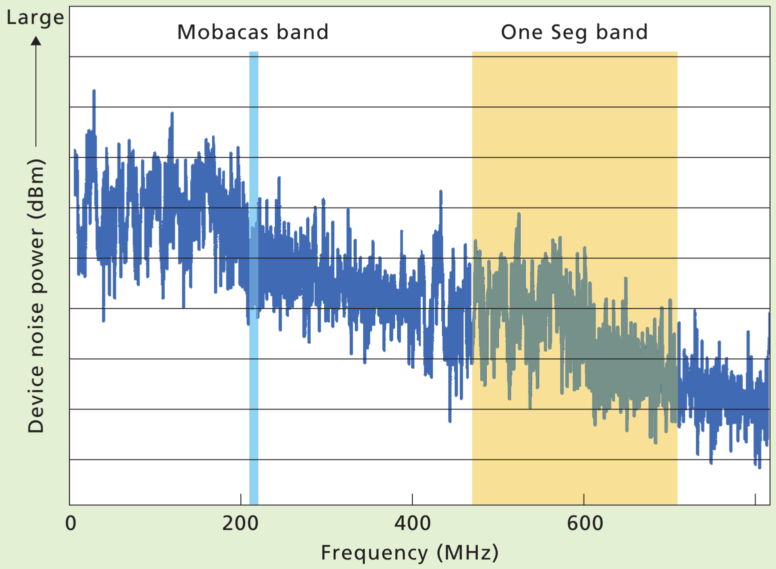


**Figure 4  Frequency characteristics of device noise power**

the 207.5-222 MHz, which is less than half of the frequency band of One Seg. It can therefore be seen that advanced anti-noise measures are vital for Mobacas-capable mobile devices.

Additionally, it is more difficult to develop Mobacas-capable devices based on smartphones than on feature phones since advanced anti-noise measures are required. One reason for this is increased noise from the screen, since the size of Liquid-Crystal Displays (LCDs) in smartphones is larger than that of feature phones. That is to say, a larger LCD requires higher current and the spurious noise radiated from the display increases. A larger LCD also increases the noise generated in the power-supply section, because the amount of current consumption increases.

It can therefore be understood from the above that anti-noise measures are important for Mobacas-capable devices. We have undertaken the reduction of mobile device noise by implementing the following measures:

- Adopt an appropriate layout for components embedded in the mobile device
- Improve ground performance
- Use anti-noise components

With respect to the first measure above, we considered that the LCD section and the power-supply section are main sources of noise. So we placed primary components like the antenna and receiver at locations not easily affected by LCD and power-supply noise despite a limited amount of space as a scheme to reduce the effects of noise. Next, with regard to the second measure, we reinforced the ground connection of the PCB embedded in the mobile device to prevent exogenous noise from getting mixed into the receiver of the mobile device via a ground connection. Finally, as for the third measure, we used proper anti-noise components in noise sources and minimized the effects of noise by optimizing the components' parameter.

As described above, we have succeeded in reducing mobile device noise and achieving high receiver performance of Mobacas-capable mobile devices by identifying the sources of noise, clarifying their radiation mechanisms, and implementing appropriate anti-noise measures. The resolution of LCDs, however, can be expected to increase from here on, which is creating concerns that radiated noise will increase owing to display signals transmitted at even higher speeds. There are also concerns that larger battery capacities and support for high-speed charging will increase the amount of noise from the power-supply section, which means that even more advanced anti-noise measures will be required.

## 4. Receiver Technology for Mobacas

Compared to the mature One Seg service for mobile devices supporting digital terrestrial broadcasting, Mobacas will enable end users to enjoy a more diverse range of high-definition content as summarized in **Table 1**. The Mobacas-capable receiver must therefore feature enhanced receiver performance compared to the receiver supporting One Seg. Furthermore, for mobile devices equipped with a Mobacas receiver as a precondition, tolerance for interference signals must also be achieved to ensure receiver performance. Additionally, as Mobacas is used for a lower frequency band than that of conventional One Seg digital terrestrial broadcasting, the receiver must be robust against fading due to a multipath environment taking into account not only high-speed mobility but low-speed mobility as well. On top of the above, the fact that Mobacas is based on a Single Frequency Network (SFN)[*7] in which all transmitting stations use the same frequency means that achieving good multipath[*8] characteristics in such a SFN environment is essential.

### 4.1 C/N Improvement

The carrier-to-noise ratio (C/N), which expresses the ratio of carrier-wave power to noise power, is one index for assessing the signal quality of a radio system. Here, we call the C/N that the receiver requires to demodulate the signal the "required C/N." A receiver that can demodulate the signal with a low C/N value even in a severe reception environment is considered to have good receiver performance. Required C/N depends on modulation method and error-correction capabilities. To give an example, the Quadrature Amplitude Modulation (QAM)[*9] method used by Mobacas, when compared with the Quadrature Phase Shift Keying (QPSK)[*10] method used by One Seg, can transmit more information with one symbol[*11] but consequently has a greater possibility of generating data errors during the transmission process.

As a result, Mobacas requires higher C/N than One Seg, which means that receiver performance deteriorates exactly according to the increase in required C/N.

In response to the above issues, we applied measures to improve the receiver's error-correction capabilities and the required C/N and succeeded in improving receiver performance.

### 4.2 Anti-interference Measures

A mobile device is equipped with a variety of wireless technologies, which means more sources of self-interference. In addition, the frequency band used for Mobacas is adjacent to the frequency bands used for private radio and aeronautical radio communications as shown in **Figure 5**. As a result, we can assume that devices will face excessive interference in some areas.

To address these issues, we have added to the radio system a high-frequency filter to minimize transmission loss in the desired band while attenuating signals in the aeronautical and private radio bands. We have also configured the high-frequency circuit so as to improve radio-signal interference characteristics.

**Table 1 Comparison of broadcasting systems**

| | | Mobacas | One Seg |
|---|---|---|---|
| Broadcasting system | | ISDB-Tmm | ISDB-T |
| Frequency band | | 207.5～222MHz | 470～710MHz |
| Video | Max. resolution | 720×480 (SD quality) | 320×240 (QVGA quality) |
| | Max. frame rate | 30 | 15 |
| Audio | Max. input ch | 5.1 channels | 2 channels |
| Modulation method | | 16 QAM (7.3Mbps) | QPSK (416kbps) |
| No. of segments | | 13-segment format | 1-segment format |

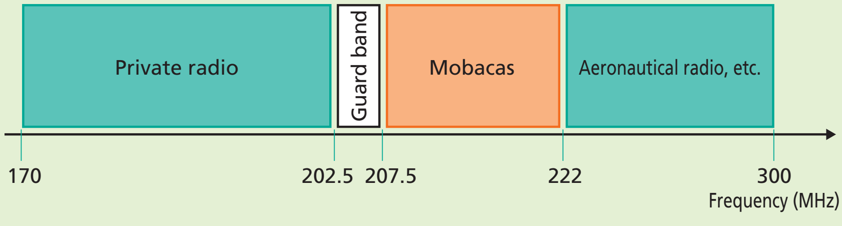


**Figure 5 Mobacas operating frequency band**

---

[*7] **SFN**: A network consisting of master and relay stations all using the same transmission frequency.

[*8] **Multipath**: A phenomenon that results in a radio signal transmitted by a transmitter reaching the receiver by multiple paths due to propagation phenomenon such as reflection, diffraction, etc.

[*9] **QAM**: A digital method of modulating the amplitude and phase of a wave according to a series of data bits. There are several types, according to number of patterns, with names like 16QAM and 64QAM.

[*10] **QPSK**: A digital modulation method that allows transmission of 2 bits of information at the same time by assigning one value to each of four phases.

### 4.3 Anti-fading Measures

Wireless communication systems assume that received power fluctuates quickly due to fading. Anti-fading measures are therefore essential. In particular, for Mobacas, which operates in a frequency band lower than that of conventional digital terrestrial broadcasting, continuously occurring data errors are expected to increase at low-speed mobility. Furthermore, as we can expect Mobacas to be used for high-speed trains too, there is also a need to ensure high performance for high-speed mobility the same as One Seg.

To address these issues, we have improved fading characteristics by adopting a high-accuracy Orthogonal Frequency Division Multiplexing (OFDM)[*12] demodulation circuit that can maintain good performance under both low-speed and high-speed types of device mobility.

### 4.4 Multipath Characteristics in SFN Environment

As described above, Mobacas is based on a SFN in which all broadcast stations transmit the same frequency. SFN features higher spectral efficiency[*13] than a multi-frequency network. On the other hand, receiver performance in a SFN environment degrades when radio signals from multiple broadcast stations arrive at the device with different delay taps. It is therefore essential that good multipath characteristics be achieved in a SFN environment.

To address this issue, we have designed the OFDM demodulation circuit to deal with multipath reception taking delay taps into account thereby ensuring good multipath characteristics.

## 5. OTA Sensitivity Testing in Anechoic Chamber

As described above, we can achieve Mobacas devices with enhanced sensitivity by leveraging appropriate anti-noise measures and overcoming technical issues related to the antenna and the receiver. One method for evaluating OTA sensitivity is to conduct field testing in a real propagation environment, but this presents a number of issues associated with repeatability and signal strength of the waves arriving at the mobile device. Consequently, field testing is not an appropriate method for quantitatively evaluating the OTA sensitivity of Mobacas devices. Accordingly, with the aim of testing the OTA sensitivity of Mobacas devices in a repeatable environment, we have developed an OTA testing system using an anechoic chamber[*14].

The anechoic-chamber testing system for evaluating Mobacas OTA sensitivity is shown in **Figure 6** and a photo of the inside of the anechoic chamber is shown in **Figure 7**. This test system is equipped with a Mobacas signal generator to generate Mobacas signals and a transmit antenna installed on an antenna tower within the anechoic chamber to transmit signals into

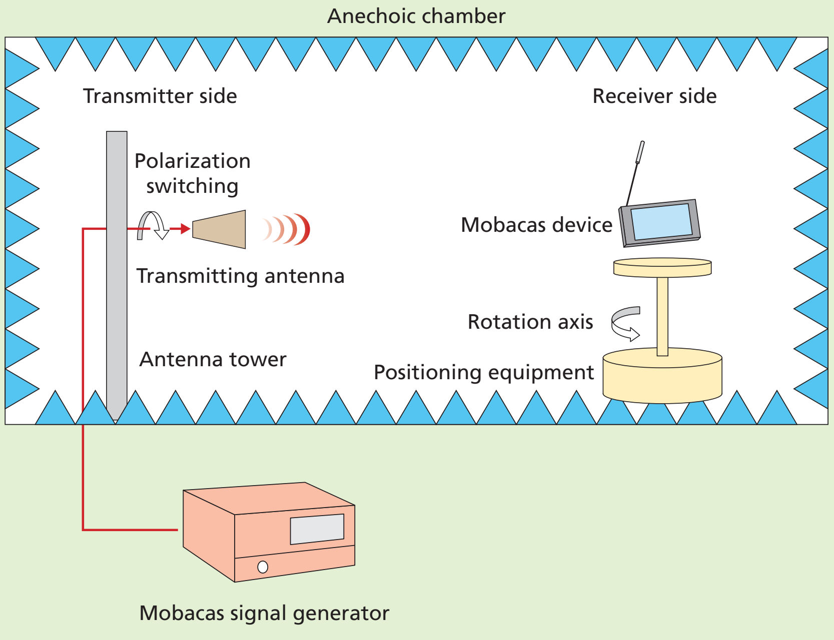


Figure 6 Anechoic-chamber testing system for evaluating OTA sensitivity of Mobacas devices

---

[*11] **Symbol**: In this article, the smallest unit of data to be transmitted. One symbol consists of n bits (where n is a positive integer).

[*12] **OFDM**: A digital modulation system developed to improve resistance to multi-path interference. It converts a signal with a high data rate to multiple low-speed narrow-band signals and transmits those signals in parallel along the frequency axis. OFDM enables signal transmission with high spectrum efficiency.

[*13] **Spectral efficiency**: The number of data bits that can be transmitted per unit time and unit frequency band.

[*14] **Anechoic chamber**: A test facility that is shielded from external radio waves and where the walls, floor and ceiling are covered with an electromagnetic absorbing material to suppress reflections.

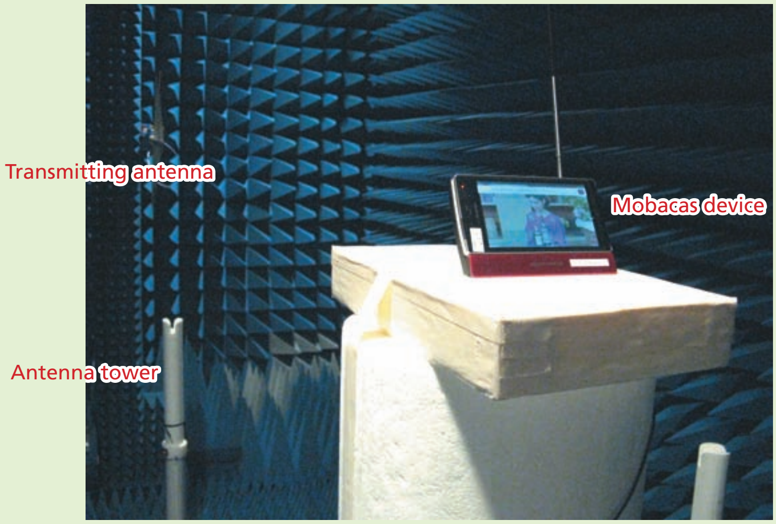


**Figure 7 Testing OTA sensitivity of a Mobacas device in an anechoic chamber**

the mobile device. The transmit antenna has a polarization switching mechanism so that both vertical and horizontal polarized components can be measured. The anechoic chamber also includes positioning equipment for rotating the Mobacas device in the horizontal direction so that the dependency of sensitivity on the device's angle of orientation can be evaluated. Since the Mobacas device is placed inside an anechoic chamber, it is unaffected by interference originating from outside the chamber or by reflections inside the chamber. The test system can therefore evaluate OTA sensitivity with high accuracy. Specifically, we evaluated OTA sensitivity by decreasing the power level of transmitted Mobacas signals in a stepwise manner and measured the power level at the point that video or audio on the Mobacas device would begin to break up. In this way, we evaluated OTA sensitivity for each of the antennas presented in chapter 2 and empirically confirmed high performance considering both antenna gain and receiver sensitivity as overall radio performance. We also confirmed that OTA receiver sensitivity could be improved by applying sufficient anti-noise measures and that the developed Mobacas devices achieve required OTA sensitivity.

## 6. Conclusion

This article described antenna/receiver radio hardware technology and its features for Mobacas devices developed by NTT DOCOMO and introduced an OTA-sensitivity testing system using an anechoic chamber.

Looking forward, we plan to continue to perform OTA receiver sensitivity testing for diverse types of Mobacas devices with the aim of enhancing the performance of Mobacas devices even further.

## REFERENCES

[1] Information and Communications Council, Telecommunications Technology Sub-Council, Broadcasting System Committee (20th meeting), Materials 20-3: "Broadcasting System Committee Report (Draft)"

[2] ARIB STD-B53: "Receiver for Connected Segments for Terrestrial Mobile Multimedia Broadcasting (Desirable Specifications)," Mar. 2011.