Development of the ML2881, a Mobile DLS Sound Generator and MP3 Decoder LSI

Shusaku Maeda Naotaka Saito
Kaoru Tsukamoto

A ring tone is the melody that notifies a user of an incoming call. They are extensively used with mobile phones around the world and are known to users as ring tones in English and bell tones in Chinese. Our ring tone LSIs are built into GSM-type (Global System for Mobile communications) mobile phones, which are popular primarily in regions outside Japan and Korea. The ring tones for GSM-type mobile phones are about to undergo an evolution to respond with content that suits the preferences of individual nations around the world. This paper describes the Mobile DLS (Downloadable Sound) sound generator ML2881 (development code: MD-64RM), which is a ring tone sound generator for the next generation GSM-type mobile phones.

GSM-type mobile phones and ring tone sound generator

GSM-type mobile phones contain a SIM (Subscriber Identity Module) card on which personal information is recorded, including the telephone number and communications carrier information. As for the mobile phone set, the very same unit can be used around the world. Furthermore, the sound generator built into the mobile phone unit generates the ring tones. The Mobile DLS sound generator has been approved by the 3GPP, the standardization organization for GSM-type mobile phones, as a source that supports ring tones to suit musical preferences, which differ in each country and each region, while the popularization of ring tones spreads rapidly throughout the world.

Currently, the GM (General MIDI)®[*1)] sound generator is commonly adopted for GSM-type mobile phones. Support of fundamental functions necessary for musical expression are stipulated for GM sound generators, including 128 musical instrument tones and 47 types of percussion, which are widely used, in order to ensure that a minimum level of quality is maintained for the reproduction of the same musical tune. Individual sounds are recorded in the ROM (Read Only Memory) built inside the LSI after the PCM (Pulse Code Modulation) data with a sound recording of musical instruments has been compressed using a complicated signal processing technology. These types of sound generators are also called "wavetable" sound generators, as the data is also known as the "wavetable". Sound generators currently available contain a ROM on which rewriting of the wavetable data is not possible and contain ring tones that can only be played with a sound tone selected from among the specified sound tones, that is, a predetermined set of musical instruments[1)].

The Mobile DLS sound generators, on the other hand, are sound generators that have predetermined specifications for the wavetable data and store the wavetable data in the RAM (Random Access Memory), which allows for modifications. This may be considered a sound generator suitable for GSM-type mobile phones being sold throughout the world, since users can create sounds with musical instruments and such tones can be used as play back ring tones.

Functions of MD-64RM (ML2881)

A configuration diagram of the functions for the MD-64RM is provided in **Figure 1**, while the features of individual functions are provided below.

(1) Mobile DLS sound generator and MP3 decoder

We built into the MD-64RM not only a Mobile DLS sound generator but also an MP3 decoder, for which there is a very strong demand from our customers.

Specifications for the Mobile DLS sound generator section are as follows:

- Includes 175 tones complying with Level 1 of the GM standard.
- Number of sound tones that can be emitted simultaneously: 16 tones.
- Number of tones that can be emitted simultaneously: 64 polyponies.
- A maximum of 20KB of wavetable complying with the Mobile DLS standard can be registered.

By adopting both the specifications for the GM sound generator and the specifications for the DLS sound

*1) GM and MIDI are registered trademarks of the Association of Musical Electronics Industry (AMEI).

generator, current popularized musical tune content for GM sound generators can be played, while highly individualized content with musical instruments particular to individual local regions or sounds of animals, can also be used as musical instruments.

The MP3 decoder, on the other hand, supports 32.0KHz, 44.1KHz and 48.0KHz for Audio Layer 3 of MPEG1 and 16.0KHz for Audio Layer 3 of MPEG2. Using this function, it is possible to compress actual music into an MP3 format and then use the file as data for a ring tone.

(2) ADPCM (Adaptive Differential PCM) decoder

We loaded the ADPCM decoder into our LSI in order to ensure the inheritance of musical content since they are also built into conventional units.

There are four types of reproducible formats, including a 4-bit and 2-bit ADPCM, which are unique Oki formats, as well as the 16-bit and 8-bit PCM. The LSI supports a broad range of sampling frequencies that cover a range of 4.0KHz to 32.0KHz.

This function makes it possible to play back basic voice guidance, such as "you've got mail" or to play back content with the sound generator synchronized to the ADPCM using our unique multimedia format[2]. Since the sound generator is capable of only playing back fixed musical instruments it is possible to glamorize the musical tune content by mixing in the ADPCM.

(3) External audio input

The external audio input function is used to perform a surround process, described later in this paper, for audio signals output by other LSIs installed in the mobile phone. The sampling frequencies supported as input frequencies include a broad range of basic audio frequencies from 8KHz to 48.0KHz.

(4) Sampling rate conversion

The sampling rate conversion is a function that unifies sampling frequencies in order to mix three different types of sound generators, including the Mobile DLS sound generator as well as the MP3 decoder, the ADPCM decoder and the external audio input. Sound data is converted into 32KHz data in order for it to conform to the MIDI sound generator. Fading in and fading out functions are also available to reduce popping noises that occur with the rapid rise in sound at the beginning of a play back or with the rapid drop in sound when the play back is stopped.

(5) Surround

Once the data has been mixed this function brings about a surround sound effect. There are in all three types of functions built into the LSI as surround functions, including a low bass enhancement, stereo enhancement and vocal enhancement.

The full-scale surround function built into the LSI has been adopted for digital audio player devices, such as MP3 players.

(6) DAC (Digital to Analog Converter)

A digital to Analog Converter is a function used to convert PCM data into an analog signal. A 16-bit stereo DAC of $\Delta\Sigma$-method, which has been adopted by audio equipment, is built into the LSI.

Configuration of MD-64RM (ML2881)

The following two options were suggested as candidates for methods to be used in the development of the MD-64RM.

- Functions that use hardwired logic, as with conventional products.
- Functions that use software based on processors.

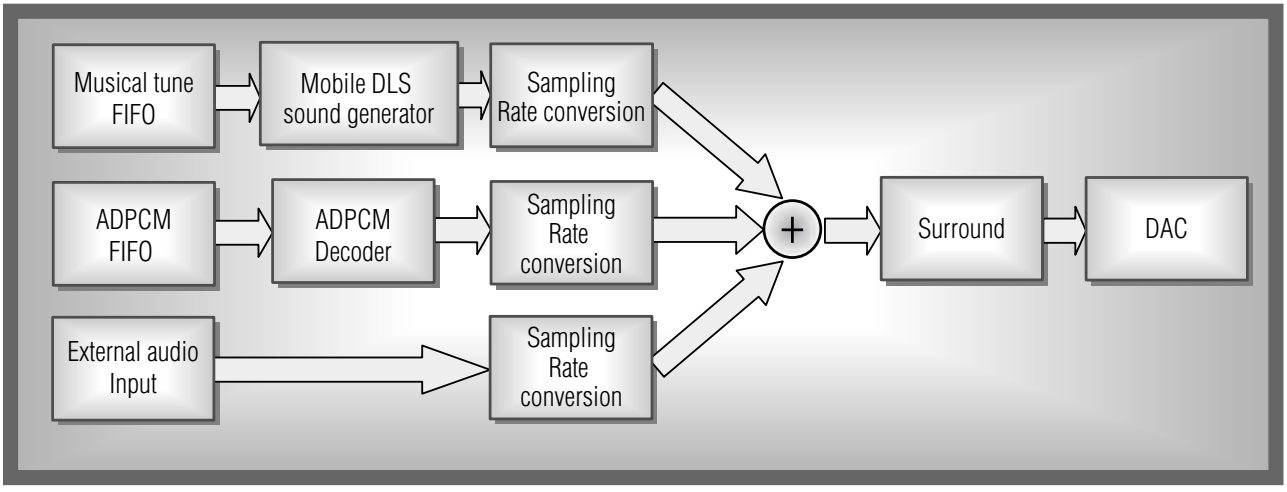

Fig. 1 MD-64RM function configuration diagram

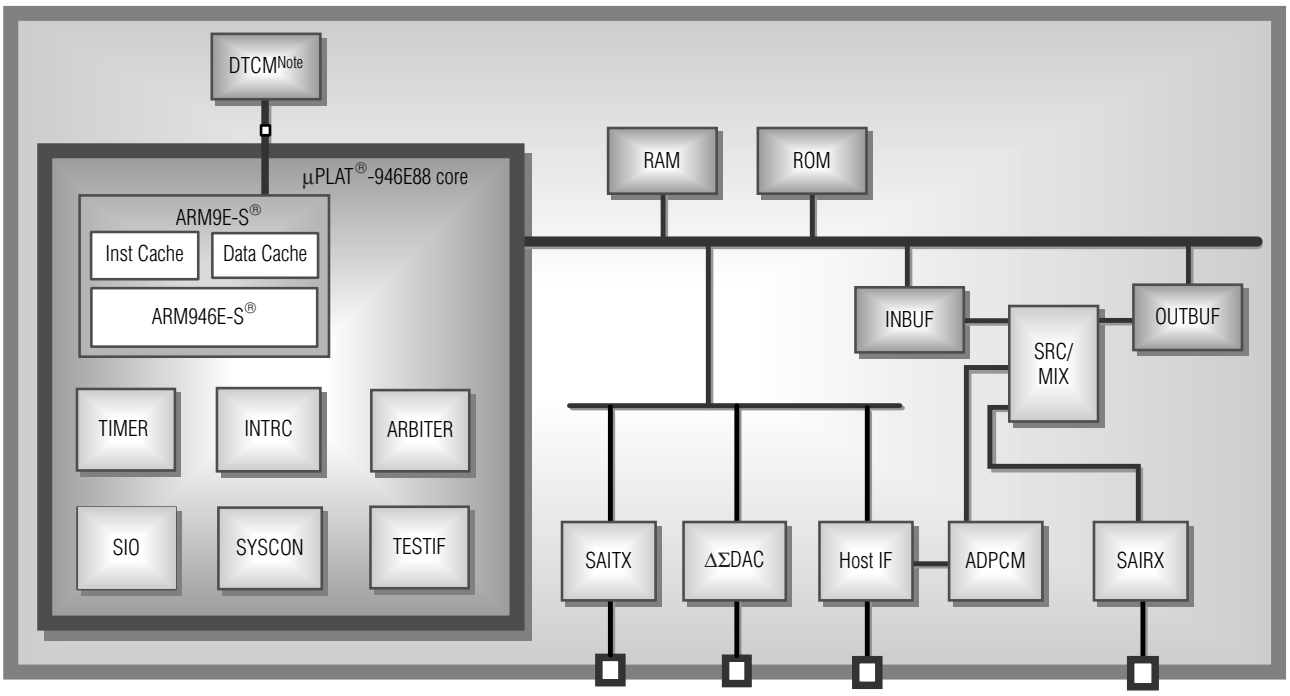

Fig. 2 MD-64RM block diagram.

We prioritized the inclusion of modified standards in the development policy for the future as well as for building the aforementioned MP3 function into the LSI. The fusion of digital audio functions was particularly critical, so we adopted the same system configuration as that of the ML69Q6500, which is our LSI for digital audio. We chose to use the Mobile DLS sound generator and MP3 decoder functions with software, whereas other functions were to be achieved by using dedicated hardware for alternate reasons, which will be described later on in this paper.

A block diagram of the MD-64RM is shown in **Figure 2**.

The MD-64RM is configured by our system LSI development platform µPLAT946®*2) that contains the ARM946E-S®*3), which is identical to the one built in the ML69Q6500, together with peripheral blocks of the platform. The Mobile DLS sound generator and MP3 decoder, as well as the surround functions, were realized by software that operates on the ARM946E-S®*3). Features of the main peripheral blocks are described below.

The Host IF is an interface that exchanges data with the main processor located inside the mobile phone unit. Data, such as control data, musical tune data and MP3 data, is received from the main processor via the Host IF.

The ADPCM is a block that uses the ADPCM decoder function. Our ADPCM technology, which is capable of playing back high quality sounds using small-scale circuits, has been in use for over 20 years. The function, therefore, was realized for this LSI using the hardwired logic that is used in our existing products.

The SAI (Serial Audio Interface) RX is a block dedicated to input external audio. This block performs the parallel conversion of audio signals sent by serial transmissions from external sources so that they can be easily processed inside the LSI.

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The SRC (Sampling Rate Converter) / MIX is a block that performs sampling rate conversions for three types of sound generators and mixing. Complex signal

*2) µPLAT946 is a registered trademark of Oki Electric Industry Co., Ltd.
*3) ARM946E-S is a registered trademark of ARM Ltd.

processing is required of this block, which supports a broad range of sampling frequencies and offers functions that reduce noise even when three types of sounds are played back asynchronously. These functions were realized using dedicated hardwired logic when sampling rate conversions were made with assured sound quality while Mobile DLS sound generator, MP3 decoder and surround processes were performed with ARM946E-S.

Aside from these other blocks were also built into the LSI, including the ROM that stores the Mobile DLS sound generator, the MP3 decoder software as well as the wavetable of the GM sound tune, the RAM used for storing Mobile DLS sound tunes and used as a work area for the MP3 decoder, the DTCM (Data Tightly Coupled Memory), which is connected directly to the ARM946E-S and used to achieve Mobile DLS software processes at a high speed, the timer, which is essential for musical tune play back management, the bus control that regulates interrupt controls and internal data transmission processes as well as numerous other blocks.

Commercialization of MD-64RM (ML2881)

We adopted our ultra compact packaging technology, the W-CSP (Wafer level Chip Size Package) for packing the MD-64RM, in order to miniaturize and reduce the price of the LSI, which the mobile phone market requires for commercialization of the MD-64RM (product name: ML2881). Packaging of the MD-64RM is shown in **Photo 1**.

We were able to realize a product that can respond to the contradicting needs of the market, by adopting a W-CSP technology with miniaturization and multi-functional features, while including a variety of the aforementioned functions.

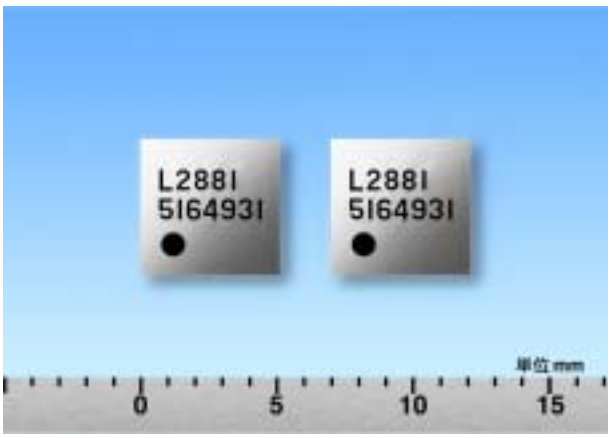

Photo 1 Photograph of MD-64RM package

Conclusion

We realized a Mobile DLS sound generator, MP3 decoder and surround functions for the MD-64RM using software on the µPLAT946. The hardware is highly versatile and functions can be added or modified simply by using the software alone. For this reason the development period can be reduced by more than a third and development costs can be cut by more than half in comparison with design methods using conventional hardwired logic.

Furthermore, aside from the Mobile DLS sound generator, the MP3 decoder and surround technologies, Oki Electric owns numerous audio processing technologies that have been nurtured through the development of sound LSIs for more than 20 years. We intend to provide many new products with unique features in the future by realizing these sound processing technologies using this hardware.

References

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Authors

Shusaku Maeda: Silicon Solutions Company, LSI Design Div., System-on-Chip Design Dept., Sound LSI Design Team

Naotaka Saito: Silicon Solutions Company, LSI Business Div., Sound BU

Kaoru Tsukamoto: Silicon Solutions Company, LSI Design Div., ADC Software Development Dept., Consumer Application Team-2