

# Development of Dedicated LSIs for VoIP Telephones (ML7074/ML7084) and Communications Protocol Control Software

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Various services, utilizing the characteristics of broadband, have been devised in recent years as a consequence of access line broadbandization, such as ADSL, FTTH, etc. Among such services, the Voice over Internet Protocol (VoIP), in particular, has steadily secured its position as the killer application that is capable of effectively utilizing the characteristics of broadband. We developed a voice CODEC (ML7074) for VoIP communications, intended to be used as an LSI for VoIP compatible communications equipment that can add on VoIP functions to existing ADSL modems in a short time and for a low cost. Further, we also developed a communications processor (ML7084), for VoIP communications that can be used to make low cost VoIP compatible business phones, by loading the ARM7TDMI<sup>®</sup><sup>\*1</sup>, Ethernet MAC controller, etc., to the ML7074. Furthermore, a Basic Service Package (BSP), developed together with the ML7084, includes various driver and communications protocol software, which combined, offers a total solution.

involved an internal ROM in the LSI with functions derived from market needs, rather than the downloading of firmware from external sources into an internal RAM. In this configuration, the function changes are performed through the changing of the ROM codes.

The configuration block diagram of the ML7074 is shown in Figure 1, while the LSI specifications are shown in Table 1.

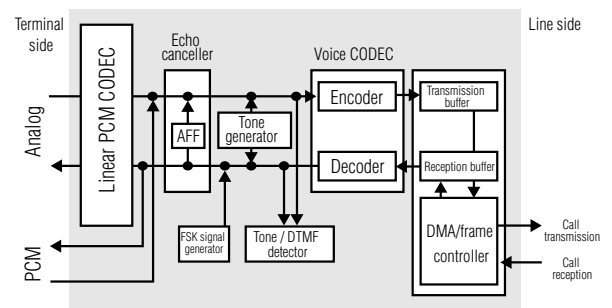


Fig. 1 ML7074 configuration block diagram

## Overview of the ML7074

The ML7074 is a voice CODEC developed as an analog front-end processor for equipment supporting VoIP communications. It performs compression and decompression between the PCM and formats such as the G.729.A, which has a high compression ratio. Besides an ordinary analog type, a PCM interface can also be selected as the terminal interface. Further, with the echo canceller that is capable of eliminating echoes with a maximum lag time delay of 32ms, it is possible to eliminate circuit line echoes arising from SLIC connections. Additionally, a programmable tone detector is also built in that is capable of detecting the CED signal (a 2100Hz tone), used in facsimile communications, as well as the preamble signal (mark = 1650Hz tone), used in the handshaking procedures of V.21 data communications. All of these make it possible to easily turn on the echo canceller disable control whenever the user is ready to engage in a non-voice communication. Aside from the aforementioned features, the processor is equipped with a DTMF tone detector, various tone generators and an FSK signal generator that is able to provide caller ID functions. With all these functions available, the ML7074 is optimally suited for adding VoIP functions to an ADSL modem, a VoIP telephony adapter (VoIP-TA), a router, or a business phone. Although the ML7074 is configured with an analog front-end and a DSP, in order to reduce costs, a method was used that

Table. 1 ML7074 LSI specifications

Voice CODEC	G.711(64Kbps) $\mu$ -law/A-law G.726 (32Kbps) G.729.A (8Kbps)
Voice compression methods interconversion function	G.729.A (8Kbps) $\leftrightarrow$ G.726 (32Kbps)
Echo canceller	Compatible with a maximum lag time delay of 32msec.
Various detection/generation functions	DTMF detection function Two tone detection function systems Tone generating function (including DTMF tones) FSK signal generating function
Terminal side voice interface	Analog or 16-bit linear PCM (expression for a complement of two) or G.711
Analog input/output formats	Loaded with two input amplifier systems, driven at 10k $\Omega$ Loaded with two output amplifier systems, driven at 10k $\Omega$
Master clock	4.096MHz (crystal oscillator/external input)
Operating temperature	-20°C to +60°C
Operating voltage	3.3V $\pm$ 10%
Package	64pin QFP

\*1) ARM7TDMI and AMBA are registered trademarks of ARM Ltd., in the United Kingdom and other countries.

## Overview of the ML7084

A block diagram, depicting the configuration of the ML7084, is shown in Figure 2, while the features of the main blocks are described below.

### (1) CPU platform

The ML7084 is loaded with the  $\mu$ PLAT<sup>®</sup>(2)7D<sup>1)</sup> made by Oki Electric, which has an 8KB built-in cache memory and the ARM7TDMI<sup>®</sup>, to which minimally required peripherals, for running the operating system, have been added.

### (2) CODEC interface

One channel of CODEC was added to the ML7074. Due to this change it is now possible to use both the microphone/speaker and handset simultaneously, when the processor is used for VoIP compatible business phones. Further, when the processor is used for VoIP-TA, the connection paths of analog telephone units can be set internally in the ML7084 to the PSTN circuit lines, making it possible to utilize a variety of detection functions and tone generating functions. With regards to the coding and other various functions, the ML7084 is loaded with functions similar to those of the ML7074.

### (3) MAC controller

The processor is equipped with two MII interface ports that are compatible with the 10Mbps/100Mbps networks. The configuration of these ports is such that one of these ports is used on the VoIP network, while the other one is used for connecting to a personal computer, in consideration for the applications with VoIP compatible business phones.

The path, which allows the transfer of packets between these two ports, in particular, is realized with hardware that makes wire rate transfers possible.

Because of this, CPU processing can be dedicated to the transmission and reception processes of voice packets and application processes.

Further, when a request to transmit voice packets is received from the CPU at the same time as a transmission request is received from another port, the "voice prioritized control function" will prioritize the transmission by giving priority to the voice packets from the CPU, in order to minimize delays during voice packet transmissions.

### (4) Others

Functions necessary to configure VoIP compatible business phones, such as the timer, reset function, universal input/output ports, and LCD interface, have been loaded.

Specifications of the ML7084 LSI are shown in Table 2.

Table 2 ML7084 LSI specifications

Operating frequency	57.344MHz
Internal memory	8KB unified cache memory
External memory Controller	ROM/FLASH/SRAM/I/O EDO-DRAM/SDRAM
Interrupt controller	External: Five-factor IRQ(4) and FIQ(1) Internal: Eleven-factor IRQ(11)
System timer	16bit $\times$ 1ch
Expansion timer	16bit $\times$ 3ch
Universal input/output port	51-bit (with secondary functions)
Reset function	Power-ON reset Watchdog timer reset Software reset
Serial ports	Asynchronous $\times$ 2ch
Operating temperature	-20°C to +60°C
Operating voltage	Core: 2.5V ( $\pm$ 10%) I/O: 3.3V ( $\pm$ 10%)
Package	208-pin QFP

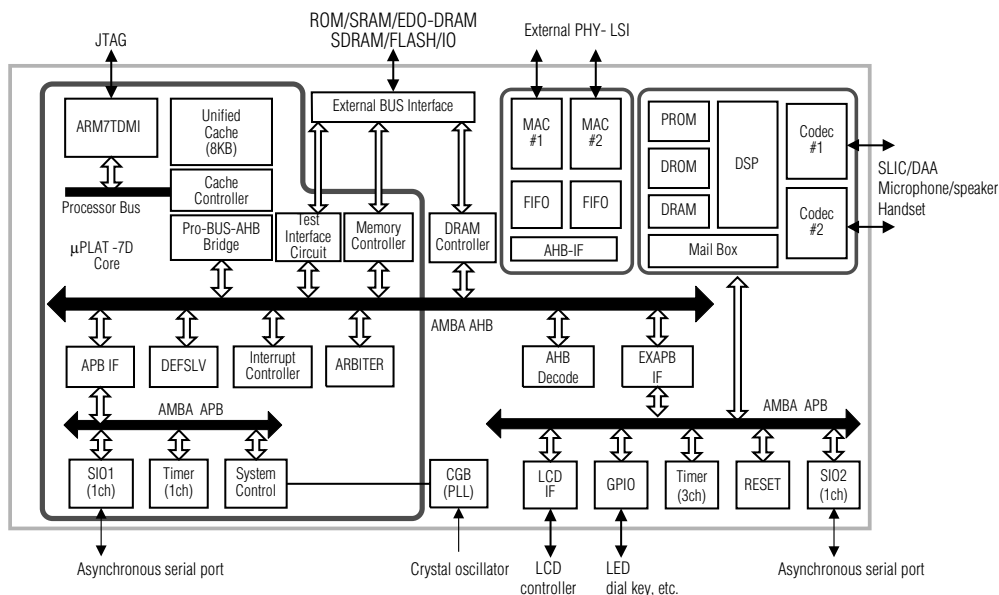


Fig. 2 ML7084 configuration block diagram

\*2)  $\mu$ PLAT is a registered trademark of Oki Electric Industry Co., Ltd.

## Development of Communication protocol for IP telephones and VoIP - TAs

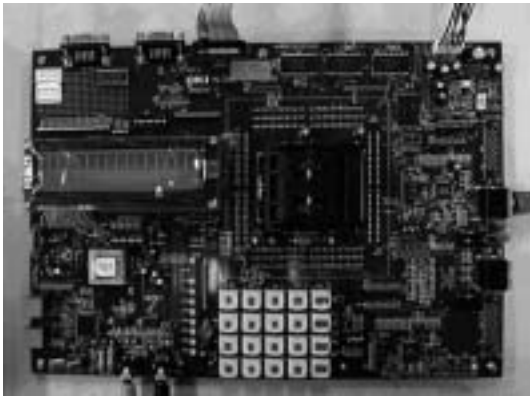
The basic service package (BSP) of the ML7084 was developed as a software that provides various drivers and communications protocol, were conducted with IP telephone and VoIP-TA markets targeted.

The ML7084BSP is a reference design that utilizes the ML7084, which is configured with an ML7084 evaluation board and software. These are described below.

### 1. ML7084 evaluation board

The ML7084 evaluation board and its block diagram are shown in Photo 1 and Figure 3.

The ML7084 evaluation board is equipped with hardware that is necessary during the initial phases of system development, in order to facilitate an easy performance evaluation of various functions of the ML7084 for use in IP telephones and VoIP-TAs. With this it is possible to evaluate the functions of the ML7084 in the initial stages, which will facilitate an early start up for systems that use the ML7084.



Phot. 1 ML7084 evaluation board

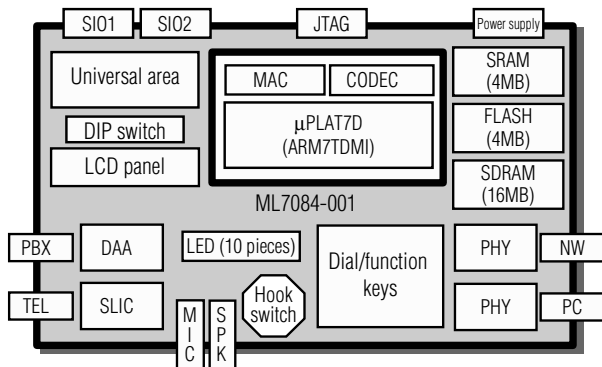


Fig. 3 ML7084 evaluation board block diagram

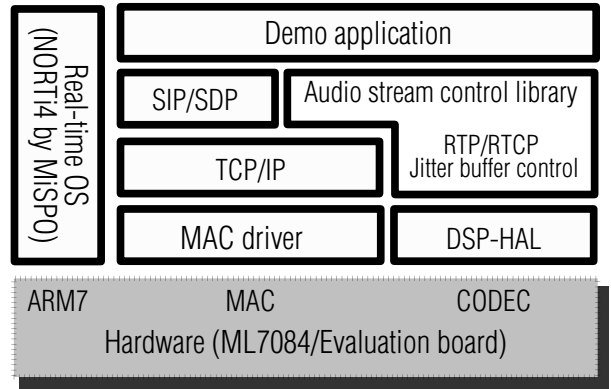


Fig. 4 ML7084BSP software block diagram

### 2. ML7084BSP software

A configuration block diagram of the ML7084BSP software is shown in Figure 4.

The NORTi<sup>4</sup> 4<sup>3</sup>, manufactured by MiSPO, complies with the  $\mu$ TRON<sup>3</sup> 4.0 standard<sup>2</sup>, which is the  $\mu$ PLAT<sup>®</sup> standard real-time operating system (RTOS). The NORTi<sup>4</sup> 4<sup>3</sup> has been adopted for the ML7084 as the built-in  $\mu$ PLAT<sup>®</sup>7D has the ARM7TDMI<sup>®</sup> as its CPU core.

#### (1) MAC driver

The MAC driver is a driver software that controls the ML7084's internal MAC hardware, and also performs the PHY control of the ML7084 evaluation board. It complies with the VLAN tag (IEEE802.1Q/p) that can be applied to the QoS of layer 2, which is critical for the VoIP system, while also accommodating a link capability matching functions between the two LAN ports.

#### (2) DSP-HAL

The DSP-HAL is a hardware abstraction layer (HAL) that provides a C language interface for accessing the internal DSP of the ML7084, which realizes the CODEC functions. It makes access to various functions easy (such as the tone generation and detection functions), while offering numerous and various macro constants that support NTT specifications.

#### (3) TCP/IP

Adopted was the TCP/IP protocol stack, dedicated for embedding that was made by Oki Information Systems Co., Ltd.<sup>4</sup>, the company with a track record in VoIP terminals. This product complies with standards such as IPv4, TCP, UDP, DNS client, DHCP client, and multicast (IGMP). The API complies with the BSD socket interface.

#### (4) SIP/SDP

The Session Initiation Protocol (SIP) and Session Description Protocol (SDP) that have been attracting a lot of attention recently, have been supported, instead of the H.323 call control protocol that has been adopted by numerous existing VoIP systems.

\*3) ITRON is a trademark or registered trademark of the TRON Association.

\*4) NORTi is a registered trademark of the MiSPO Co., Ltd.

As with the TCP/IP, the Oki Information Systems' product<sup>4)</sup>, has been adopted, and the SIP that supports the RFC3261 of the latest specification has been implemented.

### (5) ASC-Lib

The Audio Stream Control Library (ASC- Lib) controls the voice quality, which is the key technology of VoIP terminals. It conducts software processing of the RTP (RFC1889) packets that are transmitted and received over IP networks. Particularly important is the buffer control to counter the jitters (fluctuations), which are typical in IP networks. Further, an audio quality suitable for actual operations has been achieved through such efforts as elaborate devices to limit the internal lag time of the audio.

### (6) Demo application

A demo application was developed in such a manner that allows customers to evaluate hardware and software functions, as well as the performance of the ML7084BSP.

The interconnectivity of the demo application, with its easily obtained software that is described in Table 3, has been verified. This makes it possible to set up VoIP system evaluation environments simply by providing a headset that is readily available on the market, or an analog telephone unit.

**Table 3 Software for which interconnectivity with the demo application has been verified**

SIP proxy server	PARTYSIP (GNU GPL)
	SIP Express Server (GNU GPL)
SIP software telephone	Windows <sup>*5)</sup> Messenger (Microsoft <sup>*5)</sup> )
	linphone (GNU GPL)
	SIP Center User Agent

### Future developments

Individual IP developments, offering products that respond to the needs of customers and the market initially, include the following, which are scheduled in the future roadmap of the ML7074/ML7084:

- Support for facsimile communications ... Support of the ITU-T Recommendation T.38, the protocol for transmitting facsimile transmissions over IP networks.
- Increase the number of channels and improve audio quality levels of the ML7074.
- Raise the performance levels of the ML7084.
- Respond to a variety of customized products.

Further, with the development of the ML7084 basic service package, it is now possible to offer, for VoIP product development, a total solution to customers who

are considering utilizing our LSI. It is expected that this would promote the sale of the product.

Expectations for raised performance levels of LSIs in the future resulted in putting the following technical agendas on the table for the basic service package of the ML7084:

- Raise performance levels of the audio stream control library.  
Packet loss compensation (PLC), DTMF relay function, etc.
- Add communication protocol software.  
IPv6, security, MGCP, etc.
- Support gateway solutions.  
Fax Over IP (T.38), UPnP, etc.
- Add compatible real-time operating systems (RTOS)  
Embedded Linux<sup>\*6)</sup>, VxWorks<sup>\*7)</sup>, Nucleus<sup>\*8)</sup>, etc.

With a consideration for marketability, we shall work on the above-mentioned agendas to increase the functions and to enhance the product's lineup, in order to pursue further sophistication of the Basic Service Package of the ML7084 and to offer VoIP total solutions.

### References

- 1) Kishi, Takatsuka, Nakazawa: "Hardware Development of  $\mu$ PLAT", OKI Technical Review, Issue 184, Vol. 67, No. 3, pp.45-48.
- 2) TRON Project <http://www.tron.org/>
- 3) MiSPO Co., Ltd. <http://www.mispo.co.jp>
- 4) Oki Information Systems Co., Ltd. <http://www.okijoho.co.jp/>

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\*5) Microsoft and Windows are registered trademarks of Microsoft Corporation in the United States and other countries.

\*6) Linux is a registered trademark or trademark of Linus Torvalds in the United States and other countries.

\*7) VxWorks is a trademark or registered trademark of Wind River Systems, Inc., of the United States and other countries.

\*8) Nucleus is a trademark or registered trademark of Mentor Graphics Corporation in the United States and other countries.