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Features

- Voice recording (messaging) and playback (voice prompting)
- DTMF receiver
- Tone Generator (preprogrammed DTMF + user defined tones)
  - Burst mode
  - Optional twist
  - Programmable Gain
- Call progress tone detection
- VAD
- Easy file manage
- Requires very few microprocessor resources
- Work on low cost Voice Processor (ZL38004)

Applications

- Answering Machines
- Analog Speakerphone
- Home Automation

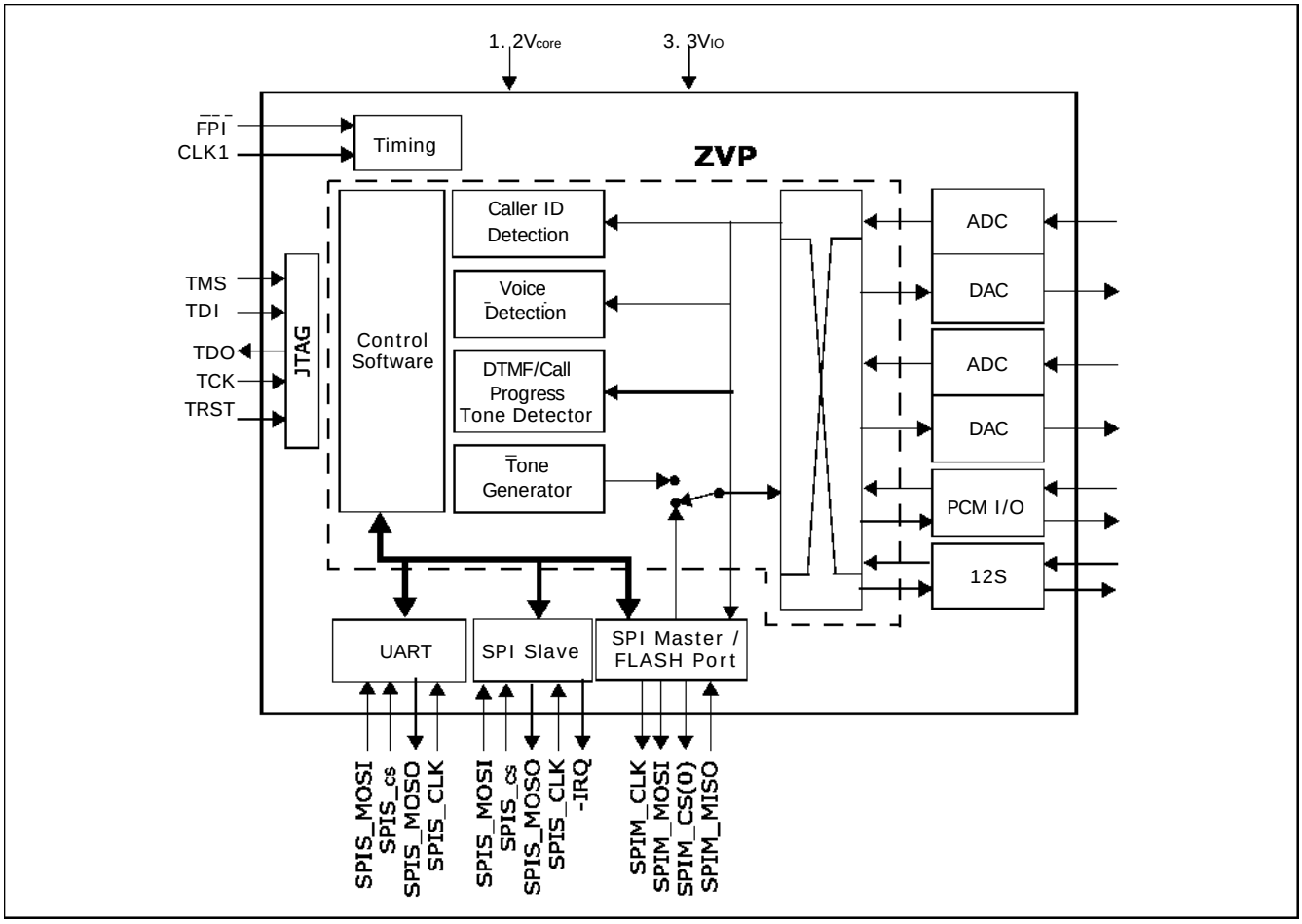


Figure 1 - Firmware Functional Block Diagram

1.0 Functional Description

The ZLS38503 firmware provides voice prompting and voice messaging (VPM) functionality to systems utilizing the ZL38004. In addition to the voice prompting and messaging function the ZLS38503 also provides a DTMF receiver, tone generator, caller ID detection, voice detection, call progress, and tone detection. The current release of the firmware only operates with 8 KHz sampled audio.

The firmware is designed to be easily swapped in and out of working memory to allow multiple firmwares to run on the same platform. For example for a speakerphone with call answer. The ZL38004 hardware platform would be used with the ZLS38502 speakerphone firmware and the ZLS38503 voice prompting and messaging firmware. Both firmwares resides on the same FLASH. During a active call the ZL38502 speakerphone firmware is loaded. During idle period or a call message the ZLS38503 firmware is loaded in. The firmware swap is initiated by a Host processor but is performed automatically by the firmware.ZLS38502.

2.0 Firmware Algorithm Description

Figure 1 describes the block diagram of the ZLS38503 VPM firmware. The VPM firmware provides the following functions:

- **Voice Recording (messaging) and Playback (voice prompting)**
- **Tone Generator:** A programmable tone generator to produce Dual Tone Multiple Frequency (DTMF), Single Frequency (SF), Multi frequency (MF) and tone ringer
- **DTMF Receiver:** A DTMF tone receiver to decode DTMF tones
- **Caller ID Receiver:** Decodes Caller ID information
- **Call Progress Tone detection:** Determines call progress tone type using tone cadence
- **VAD:** Voice Activity Detector determines the end of a message
- **G.169 ALC:** Automatic Level Controller in the Sin to Sout path
- **Gain Pads**: Adjusts signal levels at Rout, Sin and Sout. The Sin Gain Pad is adjustable from -24 to +21 dB in 1.5 dB steps; Gain Pads for Rout and Sout are adjustable from -24 to +21 dB in 3 dB steps. See section 6.0, “Assigning Audio Channels to Ports“ for port definitions.
- **A/μ-Law or Linear:** Converts 8-bit μ-law, A-law or sign magnitude PCM to 16-bit linear data.
- **File Management API:** Reduces program space/processor resources and speeds up the software development process

2.1 Voice Prompting and Messaging

2.1.1 Voice Prompting

The Voice Prompting feature of the VPM firmware allows the designer to either preload special messages (i.e., time and date prompts) or the user can record an outgoing message. In the case of the preloaded special messages, the designer would record the prerecord the messages (in 8-bit A-law or μlaw) and loaded them directly into FLASH at a predetermined location. In the case of the user recording an outgoing message, the firmware API provides a function that automatically digitized the outgoing message, compands it (8-bit A-law or μlaw), and saved to FLASH. The FLASH locations are automatically calculated and stored in a Message Attribution Table (MAT). The firmware API also provides a function that retrieves the prompt FLASH location from the MAT and then play out the recorded message from FLASH.

2.1.2 Voice Messaging

The Voice Messaging feature of the VPM firmware works in a similar way ad the voice prompting feature. Voice data is routed from any source - codec, PCM or I2S ports companded and stored in FLASH. The FLASH address are automatically calculated and store into the MAT. In addition to this the MAT also provides a location to store the time and date voice prompts locations associated with the message. When After a message is recorded the Host can read the caller ID receiver register and determine the time and data. This is then associated with the proper voice prompts. This message is then saved in the MAT. When playing out a message the Host first plays out the series of voice prompts (time and date) from FLASH then plays out the message. The output prompt and message can be routed to any port on the ZL38004.

2.2 Tone Generation and Detection

The VPM firmware provides both a programmable DTMF and tone generator and a DTMF detector. Table shows the DTMF frequencies associated with the keypad digits.

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

Table 1 - DTMF Tones

2.2.1 Programmable Tone Generation

The ZLS38503 firmware incorporates a programmable tone generator, which supports the following features:

- Single or dual tones, with pre-programmed frequencies
- Warble-effect ring tone using a square wave with programmable duty cycle and frequency
- Two sets of eight pre-programmed frequencies in the user config file where each pair of frequencies can be selected. Overall, any of 16 programmable frequencies can be selected.
- Burst mode with programmable burst time (from 0 to approximately 4 seconds). During the burst generation of DTMF any modification to the tone generator is ignored.
- Programmable output gain from -18 to 24 dB in 6 dB steps. (Default is 0 dB)
- Individual output gain for low and high tones
- DTMF output can be switched to Rout or Sout (or both) outputs. During DTMF injection, the signal passing through Sout or Rout is switched out.
- 2-dB twist support mode for DTMF tones. The twist mode can be enabled or disabled.

2.2.2 DTMF Detection

The Q.24 compliant DTMF detection block functions continuously and can be assigned to any port. When a valid DTMF tone is received, the firmware issues an interrupt generated (GPIO10 is used as an interrupt signal) and the DTMF information is saved in the "VPM interrupt status register". Based on either the active low interrupt on GPIO10 or the "DTMFDetection" status bit in the "VPM interrupt status register", the Host decodes bits 7:4 of this register as the detected DTMF tone.

2.3 Caller ID Receiver

The ZLS38503 VPM firmware provides a caller ID detector with the following features:

- a Type 1 Caller ID (CID) detection algorithm which complies with Bellcore GR-30-CORE (formerly known as TR-NWT-000030) and EETS 300 778-
- 1200-baud Bell 202 and ITU v.23 Frequency Shift Keying (FSK)
- Works with and without CAS
- FSK carrier detect status output
- A 64-character buffer for received data

The firmware does not provide CID on Call Waiting (Type 2).

The Caller ID module receives and decodes Type 1 Caller ID messages in both Bellcore and ETSI formats. It is intended to be activated by the Host during periods where Type 1 Caller ID needs to be detected, which is normally only during the initial on-hook period of a phone call.

After device power-up, the Caller ID module automatically initializes and goes into the idle state. Instructing the module to look for Caller ID information is done by setting the CID_ACTIVATE bit. Once activated, Caller ID continuously looks for messages. Since only the Type 1 version of Bellcore and ETSI Caller ID is supported, the Caller ID module should be deactivated before going off-hook.

The Caller ID module decodes the FSK signal, stores the results into a 64-byte buffer, and performs a check sum. The Host is responsible for interpreting the information.

Two commonly message formats, SDMF and MDMF, are used. In both cases the Caller ID module stores the information in the same format as it is received.

2.3.1 SDMF Message Format

SDMF messages contain only the call date, time and number (or other text). Call type for SDMF is always 0x04.

Message Character(s)	Value	Format
0	0x04 (SDMF call type).	Hex
1	Message length (length is number of characters AFTER message length, but excluding the checksum).	Hex
2, 3	Two digits for the month.	ASCII
4, 5	Two digits for the date.	ASCII
6, 7	Two digits for the hour (24-hour clock).	ASCII
8, 9	Two digits for the minute.	ASCII
10 -> (2 + message length)	Calling party number (or other text).	ASCII
(2 + message length) + 1	Checksum	HEX

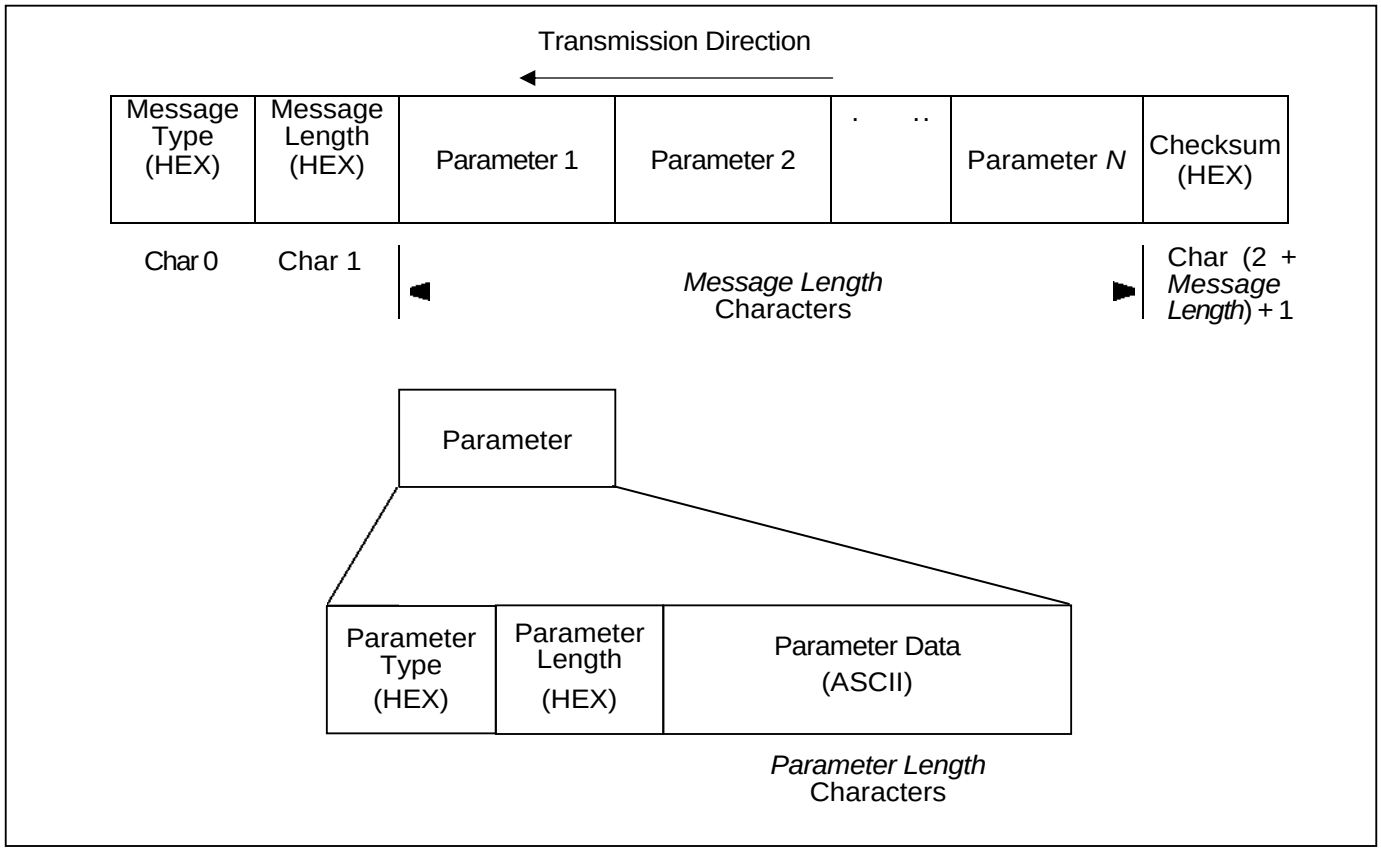
Table 2 - SDMF Message Format

Text information is always sent as ASCII codes, leftmost digits first. Thus a call from 505-555-4455 at 16:23 on March 9 would be sent as [0x04 0x1 2 0x30 0x33 0x30 0x39 0x31 0x36 0x32 0x33 0x35 0x30 0x35 0x35 0x35 0x35 0x34 0x34 0x35 0x35 0x47] in SDMF.

2.3.2 MDMF Message Format

MDMF messages use general format illustrated in Figure 2:

Figure 2 - MDMF Format



The first character is Message Type. For Type 1 Caller ID, this is usually 0x80. The next character is Message Length, which is the number of characters AFTER message length, but *not* including the checksum.

N parameters follow, which themselves have type, length and data fields. There are many different types of parameters, but the most common are 0x01 for date & time, 0x02 for calling number, and 0x07 for calling party name. The last character is the checksum.

Text information is always sent as ASCII codes, leftmost digits first. Thus, a call from Caul R Idee, 505-555-4455 at 16:23 on March 9 would be sent as [0x80 0x23 0x01 0x08 0x30 0x33 0x30 0x39 0x31 0x36 0x32 0x33 0x02 0x0A 0x35 0x30 0x35 0x35 0x35 0x35 0x34 0x34 0x35 0x35 0x07 0x0B 0x43 0x61 0x75 0x6C 0x20 0x52 0x20 0x49 0x64 0x65 0x65 0x05] in MDMF.

2.4 Call Progress Tone Detection

Call Progress Tone Detector detects any tones in the frequency range from 300 Hz to 640 Hz. The tone cadence (on/off times) is measured and saved in a register to be read by the µC. The type of progress tone is determined from the cadence value (see Table 3).

Tones	Power per frequency at the exchange where the tone is applied	Cadence
Dial tone	-13 dBm0	Continuous tone
Recall dial tone	-13 dBm0	3 bursts of 0.1 s followed by a continuous tone
Busy tone	-24 dBm0	Burst 0.5 s / silence 0.5 s
Reorder tone	-24 dBm0	Burst 0.25 s / silence 0.25 s
Audible ringing tone	-19 dBm0	Burst 0.2 s / silence 0.2 s

Table 3 - US Tone Plan as listed in CCITT Fascicle 11.2

2.5 Voice Activity Detector

To ensure that only the message its self is recorded (not silence) a power-based Voice Activity Detector (VAD) is used to signal the end of voice activity on a recorded message. When the end of the message is detected, the recording stops and the system is notified. It operates at both the Sin and Rin ports.

The VAD has two programmable parameters:

- **Threshold**: If the signal level falls below the threshold, the VAD starts the "no voice" timer.
- **Time**: If the signal level remains below the threshold for a fixed time, the VAD declares "no voice".

2.6 G.169 Automatic Level Control

The G.169 Automatic Level Control (ALC) controls the signal level in the Sin and Rin path, ensuring that the recorded levels are constant.

2.7 Programmable Gain Pads

The gain pads are associated with Rout, Sin and Sout. The pads are to be set once during initialization and not adjusted during normal operation. Sin gain pad is adjustable from -24 to +21 dB in 1.5 dB steps; Rout and Sout gain pads are adjustable from -24 to +21 dB in 3 dB steps.

2.8 A/µ-Law or Linear Converter

The Linear to A/µ-Law converters converts 16-bit linear data to 8-bit µ-law/A-law, or sign magnitude PCM and vice versa. The A/µ-Law converters are only on the Rin and Sout ports. This is used to compand (compress and expand) the voice before it is stored in FLASH thus make better use the memory. The converters can be bypassed if the network interface is already in one of the supported formats.

2.9 File Access

The ZLS38503 firmware incorporates an API that simplifies file access for the Host microcontroller (µC). The API has the following commands:

• Play Prompt
- Record Prompt
- Play Message
- Message Record
- Play Special Prompt
- Write Special Prompt
- Delete Message
- Delete Prompt
- Delete Special Prompt
- Delete All
- Load MAT
- Save MAT
- Write Prompt RAM Buffer

These API commands will be covered in more detail in Section 7.0.

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