Mobileer ME Series Polyphonic Synthesizer Technical Information

Updated 07/20/04

For more information, please contact us via our web site at www.mobileer.com or telephone 415-453-4320.

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Overview

The Mobileer ME Series Polyphonic Synthesizer is a software based MIDI synthesizer that can be used to play polyphonic ringtones or other songs on a handheld device. The ME1000 product uses direct synthesis to create the sound of 175 General MIDI instruments in a very small memory footprint. The ME2000 product adds wavetable synthesis for increased acoustic realism on platforms with more available memory. The software is written in portable ANSI 'C' using 32-bit integer arithmetic.

Run-time Architecture

Component	Notes
MIDI File Player*	Parse or play Standard MIDI Files (polyphonic ringtones)
MIDI Command Processor*	Converts MIDI messages such as NoteOn, PitchBend, SysEx, etc. into instructions for synthesizer.
Audio Manager*	Manages synthesizer, allocates voice resources, delivers audio data to application.
Hybrid Polyphonic Synthesizer	Generates and processes audio signals using tone generators, envelopes, filters, mixer, dynamic range compressor, etc.
Instrument Library	Data used to create the sound of 175 General MIDI Instruments.

* can be called directly by applications

Features by Component

Standard MIDI File Decoder and Player

Plays polyphonic songs in MIDI file format.

- Schedules events from multiple tracks to support Format 1 or Format 0 MIDI files.
- Provide copyright info and other meta-information from file to application.
- Supports enabling or disabling of individual tracks for user control of solo or mute.
- Calls back with Lyric meta event information for Karaoke.
- Calculate and return duration of MIDI files in milliseconds.
- Supports rewind and arbitrary positioning within the MIDI file.

MIDI Command Processor

Parses a MIDI byte stream and controls the underlying synthesizer to produce sound.

- Supports standard MIDI commands: NoteOn, PitchBend, etc.
- Recognizes Scalable Polyphony (SP-MIDI) system exclusive messages which are used to prioritize instruments when allocating voice resources.
- Callback for standard Vibrator events that allow the vibrator to be played in time with an SMF song.

The features of this implementation will meet or exceed the capabilities of General

MIDI Lite. It may also meet or exceed the capabilities of General MIDI 1.0 if the speed of the processor allows.

Feature	GM Lite	GM 1.0	ME Series
Number of voices	16	>=24	4 to 128
Velocity Sensitivity	Y	Y	Y
Channel Aftertouch	-	Y	Y
Controller #1 - modulation	Y	Y	Y
Controller #6/38 - RPN data	Y	Y	Y
Controller #7 - main volume	Y	Y	Y
Controller #10 - pan	Y	Y	Y
Controller #11 - expression	Y	Y	Y
Controller #64 - sustain	Y	Y	Y
Controller #100/101 - RPN index	Y	Y	Y
Controller #120 - all sound off	Y	Y	Y
Controller #121 - reset all controllers	Y	Y	Y
Controller #123 - all notes off	Y	Y	Y
RPN #0 - pitch bend sensitivity	Y	Y	Y
RPN #1 - fine tuning	-	Y	Y
RPN #2 - coarse tuning	-	Y	Y
SysEx F0,7E,#,09,01,F7 - GM Lite Reset	Y	-	Y

Audio Manager

Synthesizes audio and fills buffers passed from application.

- Allows simple interface with existing audio drivers.
- Range of sample rates supported including 11025, 16000, 22050, 32000, 44100, and 48000 Hz.
- Dynamic selection of mono or stereo operation, and sample resolutions from 8 to 24 bits.
- Dynamic control over the number of voices to allow real-time adjustments to CPU utilization.

Hybrid Polyphonic Synthesizer

Uses a combination of synthesis techniques to create the sound of 175 General MIDI instruments.

- Hybrid synthesizer with FM, AM, and several "analog" waveforms. Multiple oscillators per voice.
- Oscillator waveforms include sine, triangle, sawtooth, square, white noise, red noise, and random impulse.
- Resonant filter for spectral shaping and special effects.
- Mixer with pan and gain control.
- Reverberation effects processor.
- Dynamic range compression with soft knee to optimize loudness.
- Soft clipping to avoid harsh sounds when over-driven.
- Software optimized for embedded integer CPU with small caches.
- ME2000 includes a wavetable oscillator.

Instrument Library

The General MIDI instruments in the ME1000 are created using mathematical models instead of digital recordings (wavetables). This has the advantage of greatly reducing the memory footprint of the sound library. The ME2000 adds wavetable support to the ME1000 which increases the realism for some instruments, notably piano, violi, guitar, trumpet, etc. We find that direct synthesis works better than wavetables on some instruments, notably organs, "synth" instruments, bells and percussive instruments with enharmonic overtones. Therefore in the ME2000 we can dedicate the wavetable memory to just the instruments that truly need wavetables and a higher sound quality can be achieved for the same memory footprint than a pure wavetable implementation.

Our synthesizer combines several different techniques including FM, AM, phase modulation, subtractive, wavetable and stochastic synthesis. These can be used to create very lively timbres and can match the timbral quality of an instrument quite closely. The following techniques are used to create realistic instrument sounds:

- The overall volume contour of acoustic instrument is matched closely using ADSR envelopes (attack, decay, sustain, release).
- Noise, "shshhh" is added to instruments such as flutes to simulate breath sounds.
- Dual oscillators are detuned to simulate two strings on a piano, string ensembles, or the "Lead 7 (fifths)" instruments.
- Oscillators can modulate each other to generate FM harmonic sidebands characteristic of drums, bells, woodwinds, etc.
- Ring modulation, or AM, can be employed to generate enharmonic overtones common in percussion instruments.
- Filter can be used to shape the spectrum of the sound. This is useful for "muted" trumpet, synthesizer sweeps, percussion, bass, sound effects, and instruments with fixed formants such as clarinets.

- In the ME2000 we also use high fidelity wavetables to enhance realism. These wavetables have been carefully optimized in terms of loop size, sample rate, dynamic range, and size.

Sound Quality

Care was taken to preserve audio fidelity throughout the signal processing chain.

- Audio signal paths are maintained at 32 bit resolution internally. Output can be optionally scaled down to 24, 20, 18, 16, or 8 bits, with greater than 16-bits packed on 32-bit words right aligned, for playback on a DAC.
- Pitch resolution is about 1/65536th of an octave. The human ear can resolve about 1/600th of an octave.
- The wavetables for ME2000 were recorded in state of the art digital studios specifically for Mobileer with undisputed copyrights.

Documentation

- Programming guide and tutorial describes the complete process for porting ME software to a new platform.
- Browse-able reference documentation generated by Doxygen from carefully commented source code.

Example Programs

An extensive suite of example programs that demonstrate proper use of the system.

- Play a MIDI file as simply as possible.
- Print the contents of a MIDI file.
- Play a MIDI file interactively using the ASCII keyboard to mute tracks, pause, resume, etc.
- Play scales on various instruments without a MIDI file.
- Play notes with pitch bend and other controller changes.

Quality Assurance Suite

Numerous test programs are provided to help the engineer validate the operation of ME software on newly supported platforms. These include:

- Various self checking test programs with PASS/FAIL results.
- Suite of broken MIDI files to test error recovery of MIDI parser.
- 'C' tests to stress synthesizer with excessive voices, etc.
- 'C' tests for handling of programmer errors such as passing NULL pointers to API, etc.

Ringtone Library

Mobileer can provide a set of ringtones designed for shipping with mobile phones. Example ringtones rendered using ME1000 and ME2000 can be heard online at "http://www.mobileer.com/ringtones/".

- Original compositions created by or for Mobileer.

- Some traditional ringtones that sound like various telephones.

- Some very loud ringtones designed for noisy environments like airports.

- Some interesting and unusual compositions for modern users.

- Music to suit a variety of tastes including classical, rock, latin, country, jazz, etc.

- Special purpose ringtones that, for example, get louder and louder.

Standards Supported

Support for industry standards allows products with the Mobileer software to play commonly available polyphonic song and ringtones.

Name	AKA	Specifies
Musical Instrument Device Interface	MIDI	musical information such as note on, note off, instruments, pitch bend, modulation, etc.
Standard MIDI File	SMF	binary file format for songs, polyphonic ringtones, Format 0 or 1
General MIDI	GM	instrument definitions, synth capabilities
GM Lite	GMLite	reduced capabilities for portable devices
Scaleable Polyphonic MIDI	SP-MIDI	priorities for instruments within a song to ensure proper playback on devices with a limited number of voices

Resource Requirements

The software is designed for use on embedded systems with 32-bit integer CPUs. The following resource requirements are for 16 voices generating audio at a 22050 Hz sample rate.* Actual performance will vary depending on a number of factors including memory bandwidth, cache sizes, and the behavior of other real-time tasks.

Resource	Required
Arithmetic	32 bit integer multiply, barrel shifter (eg. ARM, MIPS)
RAM	20-30 KB
Code ROM	20-30 KB
Instrument Library ROM for ME1000	14 KB
Instrument Library ROM for ME2000	Additional 50 KB to 1 MB for wavetables depending on desired sound quality.

* Additional information and benchmarks available under NDA