```
The Ad Lib Music Synthesizer Card

P R O G R A M M I N G   G U I D E


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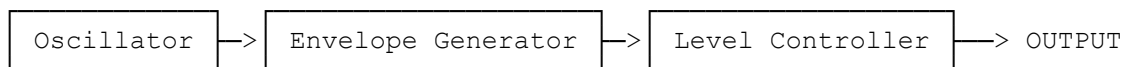
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Ad Lib Synthesizer is made up of oscillators and envelope generators. An oscillator, an envelope generator, and a level controller are linked together to form an "operator":

```
┌──────────────┐     ┌─────────────────────┐     ┌──────────────────┐
│  Oscillator  ├──>  │ Envelope Generator  ├──>  │ Level Controller ├──> OUTPUT
└──────────────┘     └─────────────────────┘     └──────────────────┘
```
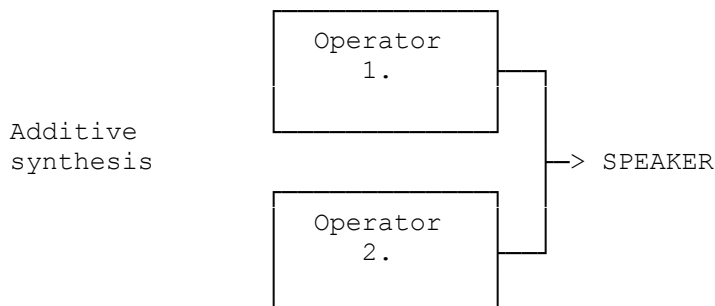
The Ad Lib Music Synthesizer card (ALMSC) contains 18 operators which are generally grouped into pairs in order to produce instrumental sounds. The operators can be combined in three different ways:

    * FM synthesis uses two operators in series. The first operator, the modulator, modulates the second operator, the carrier, via its modulation data input.

```
Frequency          ┌──────────┐     ┌──────────┐
Modulation         │ Operator │     │ Operator │
synthesis          │    1.    ├──>  │    2.    ├──> SPEAKER
                   │(Modulator)│     │ (Carrier)│
                   └──────────┘     └──────────┘
```
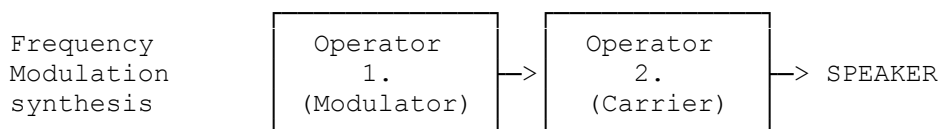
    * Additive synthesis uses two operators in parallel, adding both outputs together. This method of synthesis is not as interesting as FM synthesis, but it can generate good organ-type sounds.

```
                   ┌──────────┐
                   │ Operator │
                   │    1.    │
                   │          │─┐
Additive           └──────────┘ │
synthesis                       ├──> SPEAKER
                   ┌──────────┐ │
                   │ Operator │ │
                   │    2.    │─┘
                   │          │
                   └──────────┘
```

    * Composite sine wave synthesis (CSW) may be used to generate speech or other related sounds by playing all 9 voices simultaneously. When using this method, the card cannot generate any other sounds. This mode is not explained here, because other methods have proved to provide better quality speech.

The ALMSC produces either 9 melodic sounds or 6 melodic sounds and 5   (2)
percussion instruments. For the 9 melodic sounds, the operators are
grouped in pairs. For the percussion mode, the opearators are arranged
as follows:

        * 6 melodic instruments (12 operators)
        * 1 Bass Drum (2 operators)
        * 1 Snare Drum (1 operator)
        * 1 Tom-Tom (1 operator)
        * 1 Cymbal (1 operator)
        * 1 Hi-Hat (1 operator)

        Because ALMSC has only 9 registers for frequency information (one for
        each melodic channel), Cymbal and Hi-Hat pitches are fixed.

In percussion mode, a white noise generator is used to create rhythm sounds.
This white noise generator uses voices 7 and 8 (Snare Drum and Tom-Tom)
frequency information (Block, Frequency Number, Multiplication), and the proper
phase output. Various rhythm sounds are produced by combining this output signal
with white noise. The result is then sent to the operators. Best ratio for the
two frequencies is 3:1 (Snare Drum frequency = 3 * Tom-Tom frequency). Finally,
envelope information is multiplied with the wave table output. As the envelope
is set for one operator which corresponds to a single rhythm instrument, the
values are set in the parameter registers in the same manner as for melodic
instruments.

The ALMSC may be located at four different addresses:

        218h , 288h , 318h , 388h

The port address is currently hard-wired to 388h, but jumpers may be added in
the future, so you should take into account the possibility of using different
addresses when programming. Later on this manual, I will refer only to the
address 388h.

The card decodes two addresses:

        388h - Index register (write), Status register (read)
        389h - Data register (write only)

The index register is used to select the register address, and then data is
written to data register. Status register returns the state of two timers on
the card.

Because of the nature of the card, you must wait 3.3 µsec after a register
select write, and 23 µsec after a data write. Best way to handle this is to read
ALMSC status register in loop, because bus speed is always the same regardless
of processor speed. 6 reads after register select write and 36 reads after data
write should do the job.

Status Register (388h):

D7	D6	D5	D4	D3	D2	D1	D0
IRQFlag	T1Flag	T2Flag					

Write Registers (389h):

REG	D7	D6	D5	D4	D3	D2	D1	D0
01			WSEnable	Test Register				
02	Timer 1 Count (80 µsec resolution)							
03	Timer 2 Count (320 µsec resolution)							
04	IRQReset	T1Mask	T2Mask				T2 Start	T1 Start
08	CSW	NOTE-SEL						
20-35	Tremolo	Vibrato	Sustain	KSR	Frequency Multiplication Factor			
40-55	Key Scale Level		Output Level					
60-75	Attack Rate				Decay Rate			
80-95	Sustain Level				Release Rate			
A0-A8	Frequency Number (Lower 8 bits)							
B0-B8			KEY-ON	Block Number			F-Num (hi bits)	
BD	Trem Dep	Vibr Dep	PercMode	BD On	SD On	TT On	CY On	HH On
C0-C8					FeedBack Modulation Factor			Additive
E0-F5							Waveform Select	

For some of the parameters, there is one register per output channel. For those
parameters, channel number can be used as an offset into the map. For many
parameters, there is one register per operator. However, there are holes in the
address map so that in this case, the operator number CANNOT be used as an
offset. The operator offsets for those registers are (in hex form):

OPR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
OFS	00	01	02	03	04	05	08	09	0A	0B	0C	0D	10	11	12	13	14	15

The next two tables illustrates which operators together form a channel: (5)

M E L O D I C M O D E								
CHAN	0	1	2	3	4	5	6	7	8
OPR1 OPR2	1 4	2 5	3 6	7 10	8 11	9 12	13 16	14 17	15 18

P E R C U S S I O N M O D E										
CHAN	0	1	2	3	4	5	BD	SD	TT	CY	HH
OPR1 OPR2	1 4	2 5	3 6	7 10	8 11	9 12	13 16	17	15	18	14

Status Register:

        D7   IRQ Flag. Set if D5 and/or D6 are/is set.
        D6   Timer 1 Flag. Set when the preset time in Timer 1 has elapsed.
        D5   Timer 2 Flag. Set when the preset time in Timer 2 has elapsed.

        Timer interrupts are not wired, but the timers can be used to detect
        the presence of the card as follows:

        1.   Reset T1 and T2: write 60h to register 4.
        2.   Reset the IRQ: write 80h to register 4.
        3.   Read status register: read at 388h. Save the result.
        4.   Set timer 1 to FFh: write FFh to register 2.
        5.   Unmask and start timer 1: write 21h to register 4.
        6.   Wait in a delay loop for at least 80 µsec.
        7.   Read status register: read at 388h. Save the result.
        8.   Reset T1,T2 and IRQ as in steps 1 and 2.
        9.   Test the results of the two reads: the first should
                be 0, the second should be C0h. If either is incorrect,
                then the ALMSC is not presents.
                NOTE1: You should AND the result bytes with E0h because
                       the unused bits are undefined.
                NOTE2: This testing method doesn't work in SoundBlaster.

01: Test Register / WSE:

        D5   Waveform Select Enable. If clear, all channels will use normal
                sine wave. If set, register E0-F5 (WS) contents will be used.
        D4-D0   Test Register, must be reset to zero before any operation.

02: Timer 1 Count:

        Upward 8 bit counter with a resolution of 80 µsec. If an overflow
        occurs, the status register bit is set, and the preset value is
        loaded into the timer again.

03: Timer 2 Count:

        Same as Timer 1, but with a resolution of 320 µsec.

04: IRQ-Reset / Mask / Start:

        D7   IRQ-Reset. Resets timer and IRQ flags in status register.
                All other bits are ignored when this bit is set.
        D6   Timer 1 Mask. If 1, status register is not affected in overflow.
        D5   Timer 2 Mask. Same as above.
        D1   Timer 2 Start. Timer on/off.
        D0   Timer 1 Start. Same as above.

D7   Composite sine wave mode on/off.

D6   NOTE-SEL. Controls the split point of the keyboard. When 0, the keyboard split is the second bit from the bit 8 of the F-Number. When 1, the MSb of the F-Number is used.

20-35: Tremolo / Vibrato / Sustain / KSR / Frequency Multiplication Factor:

D7   Tremolo (Amplitude vibrato) on/off.

D6   Frequency vibrato on/off.

D5   Sound Sustaining. When 1, operator's frequency will be held at its sustain level until a KEY-OFF is done.

D4   Envelope scaling (KSR) on/off. When 1, higher notes are shorter than lower notes.

D3-D0   Frequency Multiplication Factor (MULTI):

MULTI	Factor
0	½
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	10
12	12
13	12
14	15
15	15

40-55: Key Scale Level / Output Level: (8)

        D7-D6   Key Scale Level. Attenuates output level towards higher pitch:

KSL	Attenuation
0	-
1	1.5 dB/oct
2	3.0 dB/oct
3	6.0 dB/oct

        D5-D0   Output Level. Attenuates the operators output level. In additive
                synthesis, varying the output level of any operator varies the
                volume of its corresponding channel. In FM synthesis, varying
                the output level of the carrier varies the volume of the channel.
                Varying the output of then modulator will change the frequency
                spectrum produced by the carrier.

60-75: Attack Rate / Decay Rate:

        D7-D4   Attack Rate. Determines the rising time for the sound. The
                higher the value, the faster the attack.
        D3-D0   Decay Rate. Determines the diminishing time for the sound.
                The higher the value, the shorter the decay.

80-95: Sustain Level / Release Rate:

        D7-D4   Sustain Level. Determines the point at which the sound ceases

                to decay and chages to a sound having a constant level. The
                sustain level is expressed as a fraction of the maximum level.
                Note that the Sustain-bit in the register 20-35 must be set for
                this to have an effect.
        D3-D0   Release Rate. Determines the rate at which the sound disappears
                after KEY-OFF. The higher the value, the shorter the release.

A0-A8: Frequency Number:

        Determines the pitch of the note. Highest bits of F-Number are stored
        in the register below.

B0-B8: Key On / Block Number / F-Num(hi bits):

        D5   KEY-ON. When 1, channels output is enabled.
        D4-D2   Block Number. Roughly determines the octave.
        D1-D0   Frequency Number. 2 highest bits of the above register.

        The following formula is used to determine F-Number and Block:

                F-Num = Music Frequency * 2^(20-Block) / 49716 Hz

BD: Trem Dep / Vibr Dep / PercMode / BD/SD/TT/CY/HH On: (9)

```
        D7        Tremolo (Amplitude Vibrato) Depth. 0 = 1.0dB, 1 = 4.8dB.
        D6        Frequency Vibrato Depth. 0 = 7 cents, 1 = 14 cents.
                  A "cent" is 1/100 of a semi-tone.
        D5        Percussion Mode. 0 = Melodic Mode, 1 = Percussion Mode.
        D4        BD On. KEY-ON of the Bass Drum channel.
        D3        SD On. KEY-ON of the Snare Drum channel.
        D2        TT On. KEY-ON of the Tom-Tom channel.
        D1        CY On. KEY-ON of the Cymbal channel.
        D0        HH On. KEY-ON of the Hi-Hat channel.
```

C0-C8: FeedBack Modulation Factor / Additive:

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        D3-D1    FeedBack Modulation Factor:
```

MULTI	Factor
0	0
1	$\pi/16$
2	$\pi/8$
3	$\pi/4$
4	$\pi/2$
5	π
6	$2 \cdot \pi$
7	$4 \cdot \pi$

```
        D0        Additive. 1 = Additive synthesis, 0 = Frequency Modulation
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E0-F5: Waveform Select:

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        D7-D2    Not used
        D1-D0    WaveForm Select (WS):
```

WS	WaveForm
00	Sine
01	Half-Sine
10	Abs-Sine
11	Pulse-Sine

```
Field   Size    Type        Description
───────────────────────────────────────────────────────────────────
                            HEADER SECTION
1       1       byte        file version, major
2       1       byte        file version, minor
3       6       byte        signature: "ADLIB-"
4       2       integer     number of list entries used
5       2       integer     total number of list entries in file
6       4       longint     absolute offset in file of start of name list
7       4       longint     absolute offset in file of start of data
8       8       byte        pad (set to zero)

                            INSTRUMENT NAME SECTION RECORD
1       2       integer     index into data section
2       1       byte        flag: 0 if record used, else 1
3       9       byte        instrument name (max 8 chars + NULL)

                            DATA SECTION RECORD
1       1       byte        mode (0=melodic,1=percussion)
2       1       byte        voice number (if percussion mode)

modulator (operator 0) parameters:
3       1       byte        key scale level
4       1       byte        frequency multiplier
5       1       byte        feedback modulation factor
6       1       byte        attack rate
7       1       byte        sustain level
8       1       byte        sound sustaining
9       1       byte        dacay rate
10      1       byte        release rate
11      1       byte        output level
12      1       byte        amplitude vibrato (tremolo)
13      1       byte        frequency vibrato
14      1       byte        envelope scaling
15      1       byte        0=FM synthesis, 1=additive synthesis

carrier (operator 1) parameters (for melodic channels and bassdrum only):
3       1       byte        key scale level
4       1       byte        frequency multiplier
5       1       byte        feedback modulation factor
6       1       byte        attack rate
7       1       byte        sustain level
8       1       byte        sound sustaining
9       1       byte        dacay rate
10      1       byte        release rate
11      1       byte        output level
12      1       byte        amplitude vibrato (tremolo)
13      1       byte        frequency vibrato
14      1       byte        envelope scaling
15      1       byte        unused

29      1       byte        waveform for modulator
```

The following table contains frequencies in Hertz for the notes in octaves
1 to 8. Middle C is in octave 5.

NOTE	1	2	3	4	5	6	7	8
C	16.352	32.703	65.406	130.81	*261.63*	523.25	1046.5	2093.0
C#	17.324	34.648	69.295	138.59	277.18	554.37	1108.7	2217.5
D	18.354	36.708	73.416	146.83	293.66	587.33	1174.7	2349.3
D#	19.445	38.890	77.781	155.56	311.13	622.25	1244.5	2489.0
E	20.601	41.203	82.406	164.81	329.63	659.26	1318.5	2637.0
F	21.826	43.653	87.307	174.61	349.23	698.46	1396.9	2793.8
F#	23.124	46.249	92.499	184.99	369.99	739.99	1480.0	2960.0
G	24.499	48.999	97.998	195.99	391.99	783.99	1568.0	3136.0
G#	25.956	51.913	103.82	207.65	415.31	830.61	1661.2	3322.4
A	27.500	55.000	110.00	220.00	440.00	880.00	1760.0	3520.0
A#	29.135	58.270	116.54	233.08	466.16	932.32	1864.7	3729.3
B	30.867	61.735	123.47	246.94	493.88	987.77	1975.5	3951.1