Yamaha FM-Sound Synthesizer Unit documentation Ver:1.0
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GENERAL

This document contains short description about programming FM sound Synthesizer (YM2151) of the FM sound synthesizer unit(II), that was made by Yamaha for CX5M MSX computer, but that was also available for other MSX computers trough Yamaha Unit Connector UCN-01. This unit includes also D/A converter (YM3012), so 8 audio tone signals can be obtained at the R and L channels. The YM2151 has 8-note capability and it is also equipped with a noise generator, vibrato oscillator, amplitude modulation circuit, tonal effect generator and timer circuitry. 2 sets of timers are used and when a timer overflows an interrupt request takes place. This unit has also YM2148 chip, that has a MIDI function, keyboard scan function and it supports MODE 2 IRQ for CPU, but this document does not tell, how to use these features. Addresses, that are needed for accessing this chip can be anyway founded from address table.

HOW TO FIND THE FM-SOUND SYNTHESIZER UNIT

Because Yamaha made a Unit Connector, that can be inserted to any expansion slot, it is not sure, that this Unit is always connected to slot #3. That means, that you have to find this with your own routine. The standard way to do that is to search text "MCHFM0" from address #80 in every slot. Here is a simple routine to do that, activate this slot, run your FM-program part and exit to previous routine.

```
  LD HL,BBEGIN
  LD DE,BEGIN
  LD BC,END-BEGIN
  LDIR
  JP BEGIN
BBEGIN
  ORG #4000
BEGIN
  DI                ; Interrupts must be disabled, other ways we can't
                    ; switch slots in #0000-#3FFF area.
  LD (TOHL),SP      ; We have to be sure, that SP is in area #4000-#BFFF
  LD HL,0
TOHL
  EQU $-2
  LD SP,#8000
  PUSH HL
  IN A,(#A8)
  PUSH AF
  AND %00111100
  LD D,A
  LD B,3

SEARCHM             ; Loop to search from main-slots.
  LD A,B
  RRCA
  RRCA
  OR B
  OR D
  OUT (#A8),A
  PUSH BC
  LD A,(#FFFF)
  CPL
  PUSH AF
  AND %11111100
  LD E,A
  LD B,3

SEARCHS             ; Inner loop for sub slot search.
  LD A,B
  OR E
  LD (#FFFF),A

  EXX
  LD B,6
  LD HL,IDTXT-1
  LD DE,#80-1
SEID
  INC HL
  INC DE
  LD A,(DE)
  CP (HL)
  JR NZ,NOMATCH
  DJNZ SEID

; It was found, so we will call a main program (you have to make that one),
; and after that we will select a slot, that was selected before running
; this part and we will exit with C flag as zero.

  CALL FM_PROGGRAM

  POP AF
  LD (#FFFF),A
  POP AF
  POP AF
  OUT (#A8),A
  POP HL
  LD SP,HL
  XOR A
  RET

IDTXT
  DEFB "MCHFM0"
```

```
NOMATCH
  EXX
  DJNZ SEARCHS
  POP AF
  LD (#FFFF),A
  POP BC
  DJNZ SEARCHM

; We didn't find it, and we will set C flag to detect an error

  POP AF
  OUT (#A8),A
  POP HL
  LD SP,HL
  SCF
  RET
```

- **ADDRESS TABLE**

#3FF0 (R)	FM Status register
#3FF0 (W)	FM Address register
#3FF1 (R/W)	FM Data register
#3FF2 (R/W)	Yamaha external keyboard (YK-01 or YK-10) I/O address.
#3FF3 (W)	MIDI IRQ vector address
#3FF4 (W)	External IRQ vector address
#3FF5 (R/W)	MIDI UART Data read and write buffer
#3FF6 (R)	MIDI UART Status Register
#3FF6 (W)	MIDI UART Command Register

- **USING THE FM-CHIP** (Ready for write, timer overflows)

- **STATUS REGISTER**

7	6	5	4	3	2	1	0
BUSY						Timer B	Timer A

WRITEABLE REGISTERS

- **REGISTER #00 (NOT USED)**

- **REGISTER #01 (TEST & LFO RESET)**

7	6	5	4	3	2	1	0
						LFO R	

- **REGISTER #02 - #07 (NOT USED)**

- **REGISTER #08 (KEY ON)**

7	6	5	4	3	2	1	0
	MOD1	CAR1	MOD2	CAR2	Channel Number		

- **REGISTER #09 - #0E (NOT USED)**

- **REGISTER : #0F (NOISE ENABLE, NOISE FREQUENCY)**

7	6	5	4	3	2	1	0
NE			Noise Frequency				

- **REGISTER #10 (NOT USED)**

- **REGISTER #11 (CLOCK A1)**

7	6	5	4	3	2	1	0
B9	B8	B7	B6	B5	B4	B3	B2

- **REGISTER #12 (CLOCK A2)**

7	6	5	4	3	2	1	0
						B1	B0

- **REGISTER #13 (CLOCK B)**

7	6	5	4	3	2	1	0
B7	B6	B5	B4	B3	B2	B1	B0

- **REGISTER #14 (CLOCK FUNCTIONS)**

7	6	5	4	3	2	1	0
CSM		F RESET		IRQ EN		LOAD	

- **REGISTER #15 - #17 (NOT USED)**

- **REGISTER #18 (LOW FREQUENCY)**

7	6	5	4	3	2	1	0
LOW OSCILLATION FREQUENCY							

REGISTER #19 (PHASE AND AMPLITUDE MODULATION)

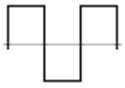
7	6	5	4	3	2	1	0
F	PHS OR AMP MODULATION DEPTH						

(F=0: Amplitude, F=1: Phase)

REGISTER #1A (NOT USED)

REGISTER #1B (CONTROL OUTPUT & WAVE FORM SELECT)

7	6	5	4	3	2	1	0
CT2	CT1					Wave Form	

WF= 0	WF=1	WF=2	WF=3
			
SAW	SQUARE	TRIANGLE	NOISE

REGISTER #1C-1F (NOT USED)

REGISTER #20 (CHANNEL CONTROL)

7	6	5	4	3	2	1	0
RGT	LFT	FB			CONNECT		

REGISTER #28-2F (KEY CODE)

7	6	5	4	3	2	1	0
	Octave			Note			

Register = #28 + Channel number (0-7)

REGISTER #30-37 (KEY FRACTION)

7	6	5	4	3	2	1	0
Key Fraction							

Register = #30 + Channel number (0-7)

REGISTER #38-3F (PHASE & AMPLITUDE MODULATION SENSITIVITY)

7	6	5	4	3	2	1	0
	PMS					AMS	

Register = #38 + Channel number (0-7)

REGISTER #40-5F (DETUNE & PHASE MULTIPLY)

7	6	5	4	3	2	1	0
	Detune(1)			Phase multiply			

Register = #40 + 8 * DEV* + Channel number (0-7)

REGISTER #60-7F (TOTAL LEVEL)

7	6	5	4	3	2	1	0
	Total level						

Register = #60 + 8 * DEV* + Channel number (0-7)

REGISTER #80-9F (EG ATTACK)

7	6	5	4	3	2	1	0
KeyScl		Attack rate					

Register = #80 + 8 * DEV* + Channel number (0-7)

REGISTER #A0-BF (EG DECAY 1)

7	6	5	4	3	2	1	0
ASE			First decay rate				

Register = #A0 + 8 * DEV* + Channel number (0-7)
ASE = Amplitude modulation Sensitivity Enable (1=enable)

REGISTER #C0-DF (EG DECAY 2)

7	6	5	4	3	2	1	0
Detune(2)			Second decay rate				

Register = #C0 + 8 * DEV* + Channel number (0-7)

REGISTER #E0-FF (EG DECAY LEVEL, RELEASE RATE)

7	6	5	4	3	2	1	0
First decay level				Release rate			

Register = #C0 + 8 * DEV* + Channel number (0-7)

* If you change value of MODULATOR1 then DEV=0
If you change value of MODULATOR2 then DEV=1

If you change value of CARRIER1 then DEV=2
If you change value of CARRIER2 then DEV=3

HOW TO HANDLE EXTERNAL YAMAHA KEYBOARD

Yamaha keyboards are easy to use. They have been divided to 8 separate rows, that each have 6 keys. When you want to read some key, you first have to select a row to read. This is done by sending this row number to #3FF2 in format:

7	6	5	4	3	2	1	0
ROW7	ROW6	ROW5	ROW4	ROW3	ROW2	ROW1	ROW0

This means, that you can calculate current row by using formula:

[to #3FF2] = 2 ^ [ROW NUMBER 0-7]

After this you need to wait a little while. Unfortunately I don't know how little, but something like one microsecond. Then you can read this address, and you will get a value in following format:

7	6	5	4	3	2	1	0
	KEY5	KEY4	KEY3		KEY2	KEY1	KEY0

1=Not pressed
0=Pressed

Current key number from bottom to up can be calculated by using formula:

KEYNUMBER + ROW * 6

Please note, that YK-01 does not have few bottom keys at all.

REST THAT I WANT TO SAY

I want to thank "Greg_" about helping me to collect this information, I mean, that this information is not a offical documentation, but I have just collected it from different sources and rest is just generated by testing.

Here are the Yamaha part-numbers for the most important chips, that are in FM-Sound Synthesizer Unit:

YM2151	(IC101):	#IT-21-51-00	(FM-chip)
YM3012	(IC102):	#IT-30-12-00	(Stereo D/A converter)
YM2148	(IC103):	#IT-21-46-00	(Midi handling)
YM22702	(IC104):	#IT-22-70-20	(ROM)

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