Register content and address map
The OPN register is provided with the internal address as shown in the address map. The content of each register (address) is as follows.

(1)	$00 ~ $05	Generates frequency of the square wave sound source.
(2)	$06	Generates frequency of noise source.
(3)	$07	Controls the input and output of the input and output ports and the output of musical sound and noise.
(4)	$08 ~ $0A	Controls sound volume. It is possible to select the fixed sound volume system (programmable) or the variable sound volume system.
(5)	$0B ~ $0C	Controls the envelope cycle in the variable sound volume system.
(6)	$0D	Specifies the envelope shape in the variable sound volume system.
(7)	$0E ~ $0F	8 bit general-purpose input and output ports.
(8)	$21	Test information, always set to "0".
(9)	$24 ~ $26	Gives the set time of Timers A and B.
(10)	$27	Controls the operation of Timers A and B, and sets the third channel mode of the FM sound source.
(11)	$2D ~ $2F	Specifies the dividing number of the input clock. The dividing numbers 2 through 6 are for the FM sound source, and the numbers 1 through 4 are for square wave sound source.
(12)	$30 ~ $3E	Controls Detune and Multiple. This is used to set tones. This controls the relationship between the fundamental wave and harmonic.
(13)	$40 ~ $4E	Gives the total level. This information becomes the modulation index of the sound volume and modulation wave of the modulated wave.
(14)	$50 ~ $5E	Key - Scale controls the rate of change of A - D - S and R according to the keyboard information. Attack rate gives the rate of change of the envelope at the time of attack.
(15)	$60 ~ $6E	Decay Rate shows the rate of change of the envelope at the time of decay.
(16)	$70 ~ $7E	Sustain Rate shows the rate of change of the envelope at the time of sustain.
(17)	$80 ~ $8E	Sustain level shows the level of the shift from decay to sustain. Release rate shows the rate of change of the envelope at the time of release.
(18)	$90 ~ $9E	Generates the envelope including the repeat pattern similar to that of square wave sound source.
(19)	$A0 ~ $A6	Gives key-code (F-number) of each channel.
(20)	$A8 ~ $AE	Gives the key-code (F-number) of three channels when set to the special mode.
(21)	$B0 ~ $B2	Gives the modulation system (connection) of the FM modulation and the modulation factor of the feedback FM (self-feedback).

FM system
In the FM system, musical sounds are synthesized by controlling various high harmonic waves by use of the frequency modulation. The basic equation of the FM system is as follows.

waves by use of the frequency modulation. The basic equation of the FM system is as follows.

(Equation 1) F = A sin (omega Ct + I sine omega Mt)

Where A is output amplitude, I is modulation index, and omega C and omega M are angular frequencies of carrier and modulator, respectively. This equation can also be expressed as follows.

(Equation 2) F = A [J0 (I) sin omega Ct + J1 (I) (sin (omega C + omega M)t - sin (omega C - omega M)t)
+ J2 (I) (sin (omega C + 2 omega M)t - sin(omega C - 2 omega M)t)
+ .....]

Where, Jn (I) is the first class Bessel function of nth As shown in the above equation, the FM system contains various harmonics and can control them. The OPN provides the multiple FM modulation and feedback FM modulation shown in (3) and (4) in addition to the above FM modulation to produce every possible sound.

(Equation 3) F = A sin [omega Ct + I1 sin (omega M1t + I2 sin omega M2t)]
(Equation 4) F = A sin (omega Ct + ßF)

WRITE DATA

Address	Data Bits							Comment
21	TEST							LSI TEST DATA
24	TIMER-A							8 most significant bits of TIMER-A
25	not used						TIMER-A	2 least significant bits of TIMER-A
26	TIMER-B							TIMER-B data
27	MODE		RESET B	RESET A	ENABLE B	ENABLE A	LOAD B	LOAD A	TIMER-A/B control and 3 channel mode
28	SLOT				CH			Key-ON/OFF
2D	don't care							Set pre-scaler
2E	don't care							Selection of the dividing numbers of 1/3 and 1/6
2F	don't care							Set a divider to the dividing number of 1/2
30-3E	not used		DT		MULTI			Detune/Multiple (Addresses 33, 37, 3B are empty)
40-4E	not used		TL					Total Level (Addresses 43, 47, 4B are empty)
50-5E	KS	not used	AR					Key Scale/Attack Rate (Addresses 53, 57, 5B are empty)
60-6E	not used		DR					Decay Rate (Addresses 63, 67, 6B are empty)
70-7E	not used		SR					Sustain Rate (Addresses 73, 77, 7B are empty)
80-8E	SL				RR			Sustain Level/Release Rate (Addresses 83, 87, 8B are empty)
90-9E	not used				SSG-EG			SSG-Type Envelope Control (Addresses 93, 97, 9B are empty)
A0-A2	F-Num. 1							F-Numbers/BLOCK
A4-A6	not used		BLOCK		F-Num. 2			
A8-AA	3CH * F-Num. 1							3CH-3slot F-Numbers/BLOCK
AC-AE	not used		3CH * BLOCK		3CH * F-Num. 2			
B0-B2	not used		FB		CONNECT			Self-Feedback/Connection

READ/WRITE DATA

B0-B2	not used	FB	CONNECT	Self-Feedback/Connection

READ/WRITE DATA

Address	Data Bits								Comment
00	Fine Tune								Channel-A Tone Period
01	not used				Coarse Tune				
02	Fine Tune								Channel-B Tone Period
03	not used				Coarse Tune				
04	Fine Tune								Channel-C Tone Period
05	not used				Coarse Tune				
06	not used				Period Control				Noise Period
07	IN/OUT IOB	IN/OUT IOA	_NOISE	_TONE					_ENABLE
08	not used			M	Level				Channel-A Amplitude
09	not used			M	Level				Channel-B Amplitude
0A	not used			M	Level				Channel-C Amplitude
0B	Fine Tune								Envelope Period
0C	Coarse Tune								
0D	not used				C	ATT	ALT	HLD	Envelope Shape/Cycle
0E	I/O Port-A								I/O Port Data
0F	I/O Port-B								

READ DATA

Address	Data Bits				Comment
xx	BUSY	not used	FLAG B	FLAG A	Status

• ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Rating

ITEM	RATING	UNIT
Terminal voltage	-0.3 ~ 7.0	V
Ambient operating temperature	0 ~ 70	°C
Storage temperature	-50 ~ 125	°C

2. Recommended Operation Conditions

ITEM	SYMBOL	MIN.	STD.	MAX.	UNIT
Supply voltage	Vdd	4.75	5.0	5.25	V
	Vss	0	0	0	V

3. DC Characteristics

ITEM		SYMBOL	CONDITIONS	MIN.	STD.	MAX.	UNIT
Input high level voltage	Total input	V_{IH}		2.0		V_{DD}	V
Input low level voltage	Total input	V_{IL}		-0.3		0.8	V
Input leakage current	øM, _WR, _RD, A0	I_L	V_{in} = 0 ~ 5V	-10		10	µA
Three-state (off) input current	D0 ~ D7	I_{TSL}	V_{in} = 0 ~ 5V	-10		10	µA
Output high level voltage	Output except _IRQ	V_{OH1}	I_{OH1} = 0.4mA	2.4			V
		V_{OH2}	I_{OH2} = 40µA	3.3			V
Output leakage current (off)	_IRQ	I_{OL}	V_{OH} = 0 ~ 5V	-10		10	µA
Analog output voltage	ANALOG-CHA, B, C	V_{OA}	Max. Sound volume, no mixing	0.95		1.35	V_{pp}
Power current		I_{DD}				120	mA

voltage	C	VOA	volume, no mixing	0.95		1.35	Vpp
Power current		IDD				120	mA
Pull-up resistance	IOA0 ~ IOA7, IOB0 ~ IOB7, _IC, _CS	RPU		60		600	k
Input capacitance	Total input	CI	f = 1MHz			10	pF
Output capacitance	Total output	CO				10	pF

4. AC Characteristics

ITEM		SYMBOL	CONDITIONS	MIN.	STD.	MAX.	UNIT
Input clock frequency	øM	fC	Pre-scaler function (Fig. A-1)	0.7		4.2	MHz
Input clock duty	øM			40	50	60	%
Input clock rise time	øM	TR	(Fig. A-1)			50	ns
Input clock breaking time	øM	TF	(Fig. A-1)			50	ns

5. Access to FM sound source

ITEM		SYMBOL	CONDITIONS	MIN.	STD.	MAX.	UNIT
Address set-up time	A0	TAS	(Figs. A-2 and A-3)	10			ns
Address hold time	A0	TAH	(Figs. A-2 and A-3)	10			ns
Chip select write width	_CS	TCSW	(Fig. A-2)	200			ns
Chip select read width	_CS	TCSR	(Fig. A-3)	250			ns
Write pulse write width	_WR	TWW	(Fig. A-2)	200			ns
Write data set-up time	D0 ~ D7	TWDS	(Fig. A-2)	100			ns
Write data hold time	D0 ~ D7	TWDH	(Fig. A-3)	20			ns
Read pulse width	_RD	TRW	(Fig. A-3)	250			ns
Read data access time	D0 ~ D7	TACC	CL = 100pF (Fig. A-3)			250	ns
Read data hold time	D0 ~ D7	TRDH	(Fig. A-3)	10			ns
Output rise time	øS	TOR1	CL = 100pF (Fig. A-4)			200	ns
	OP-O, SH	TOR2	CL = 100pF (Fig. A-5)			300	ns
Output rise time	øS	TOF1	CL = 100pF (Fig. A-4)			200	ns
	OP-O, SH	TOF2	CL = 100pF (Fig. A-5)			300	ns

6. Access to SSG sound source

ITEM		SYMBOL	CONDITIONS	MIN.	STD.	MAX.	UNIT
Address set-up time	A0	TSAS	(Figs. A-7 and A-8)	10			ns
Address hold time	A0	TSAH	(Figs. A-7 and A-8)	10			ns
Chip select write width	_CS	TSCSW	(Fig. A-7)	250			ns
Chip select read width	_CS	TSCSR	(Fig. A-8)	400			ns
Write pulse write width	_WR	TSWW	(Fig. A-7)	250			ns
Write data set-up time	D0 ~ D7	TSWDS	(Fig. A-7)	0			ns
Write data hold	D0 ~	TSWDH	(Fig. A-7)	20			ns

Write data set up time	D0 ~ D7	TSWDS	(Fig. A-7)	0			ns
Write data hold time	D0 ~ D7	TSWDH	(Fig. A-7)	20			ns
Read pulse width	_RD	TSRW	(Fig. A-8)	400			ns
Read data access time	D0 ~ D7	TSACC	CL = 100pF (Fig. A-8)			400	ns
Read data hold time	D0 ~ D7	TSRDH	(Fig. A-8)	10			ns

ITEM		SYMBOL	CONDITIONS	MIN.	STD.	MAX.	UNIT
Reset pulse width	_IC	TICW	(Fig. A-9)	73*			cycle

* Depends on the dividing number of prescaler. Pulse width = (dividing number) x 12

- **TIMING DIAGRAM**

  (Timing is set on the basis of the values: VIH = 2.0V and VIL = 0.8V).
  - **Fig. A-1 Clock Timing**
    (figure not available online)
  - **Fig. A-2 FM section write timing**
    (figure not available online)
    Note. TCSW, TWW and TWDH are determined based on the time when either _CS or _WR goes to the high level.
  - **Fig. A-3 FM section read timing**
    (figure not available online)
    Note. TAAC is determined based on the time when either _CS or _RD goes to the low level. TCSR, TRW and TRDH are determined based on the time when either _CS or _RD goes to the high level.
  - **Fig. A-4 -a øM and øS (dividing numbers: 2 and 3)**
    (figure not available online)
  - **Fig. A-4-b øM and øS (dividing number: 6)**
    (figure not available online)
  - **Fig. A-5 øM and SH . OP-O**
    (figure not available online)
  - **Fig. A-6 Timing of øS and OP-O/CH at each dividing number**
    (figure not available online)
  - **Fig. A-7 SSG section write timing**
    (figure not available online)
    Note. TSWDS is determined based on the time when either _CS or _WR goes to the low level. TSCW, TSWW and TSWDH are determined based on the time when either _CS or _WR goes to the high level.
  - **Fig. A-8 SSG section read timing**
    (figure not available online)
    Note. TSACC is determined based on the time when either _CS or _RD goes to the low level. TSCSR, TSRW and TSRDH are determined based on the time when either _CS or _RD goes to the high level.
  - **Fig. A-9 Reset pulse**
    (figure not available online)