YAMAHA LSI

YM2413

OPLL (FM OPERATOR TYPE-LL)

■ **OUTLINE**

This LL-Type FM Operator incorporates a DA Converter and a Quartz Oscillator in addition to a YAMAHA original FM Sound Generator, allowing for a much easier and economical sound generating system assembly than conventional LSIs. Tone data are stored in ROM for software simplicity, making it possible to execute data alterations involved in tone changes with just one Instruments selection operation. Furthermore, a built-in Tone Data Register with capacity for one tone permits sound effects and original tones generation. Tones applicable to the "CAPTAIN" and TELETEXT are included among built-in tone data.

■ **FEATURES**

- FM Sound Generator for real sound creation.
- Two selectable modes: 9 simultaneous sounds or 6 melody sounds plus 5 rhythm sounds (different tones can be used together in either case).
- Built-in Instruments data (15 melody tones, 5 rhythm tones, "CAPTAIN" and TELETEXT applicable tones).
- Built-in DA Converter.
- Built-in Quartz Oscillator.
- Built-in Vibrato Oscillator/AM Oscillator.
- TTL Compatible Input.
- Si-Gate NMOS LSI.
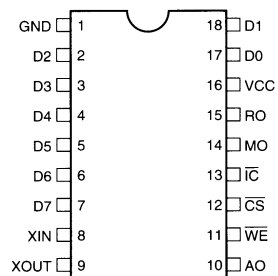- A single 5V power source.

■ PIN ASSIGNMENT

● YM2413

```
        ┌──┐ ┌──┐
GND ☐ │1        18│☐ D1
 D2 ☐ │2        17│☐ D0
 D3 ☐ │3        16│☐ VCC
 D4 ☐ │4        15│☐ RO
 D5 ☐ │5        14│☐ MO
 D6 ☐ │6        13│☐ IC
 D7 ☐ │7        12│☐ CS
XIN ☐ │8        11│☐ WE
XOUT☐ │9        10│☐ AO
        └──────────┘
```

18 pin DIP Top View

● YM2413-F

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        ┌──┐ ┌──┐
 GND ☐ │1        24│☐ D1
  D2 ☐ │2        23│☐ D0
  D3 ☐ │3        22│☐ NC
  D4 ☐ │4        21│☐ VCC
  D5 ☐ │5        20│☐ RO
  NC ☐ │6        19│☐ MO
  D6 ☐ │7        18│☐ NC
  NC ☐ │8        17│☐ IC
  D7 ☐ │9        16│☐ NC
 XIN ☐ │10       15│☐ CS
XOUT ☐ │11       14│☐ WE
  NC ☐ │12       13│☐ AO
        └──────────┘
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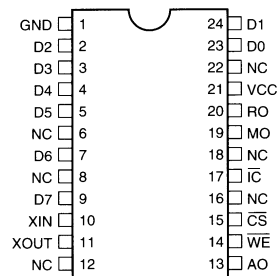
24 pin SOP Top View

■ BLOCK DIAGRAM

YM2413

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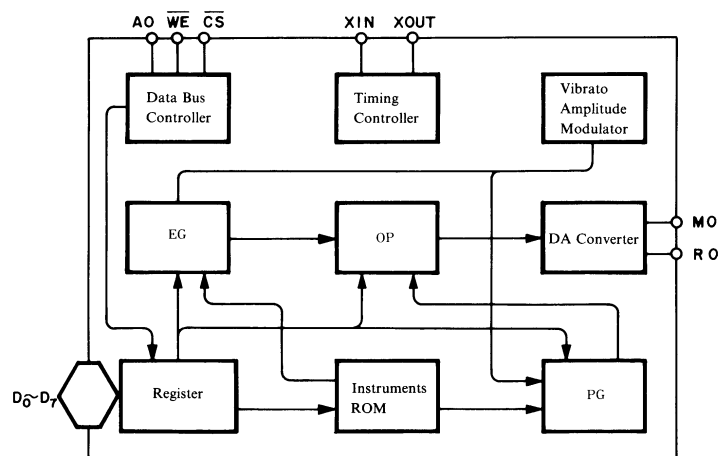
■ PIN FUNCTIONS

SYMBOL	I/O	FUNCTION
XIN XOUT	I O	A quartz oscillator (3.579545 MHz) is connected between these two pins.
D_0 $\wr$ D_7	I/O	8-Bit Data Bus for OPLL control.
A_0 $\overline{CS}$ $\overline{WE}$	I	For controlling the $D_0 \sim D_7$ Data Bus. $\overline{CS}$ $\overline{WE}$ A_0 0　0　0　Writes register address into OPLL. 0　0　1　Writes register contents into OPLL. 0　1　0　Outputs OPLL test data to D_0/D_1 Pins. Normally not used. 0　1　1 0　x　x　OPLL Data Bus high impedance
$\overline{IC}$	I	Resets the system when level is low, clearing OPLL Registers.
MO RO	O	Melody (MO) and Rhythm (RO) Outputs. Both sound types are output by a source follower. Integrated circuitry and an amplifier are necessary for subsequent processing.
V_{CC}	I	+5V Power Pin.
GND	—	Ground Pin.

Note: Please do not connect NC.

■ EXPLANATION OF FUNCTIONS

This OPLL is a FM Sound Generator LSI with a built-in 9-Bit DA Converter. It has two sound generation modes: 9 melody sounds or 6 melody sounds plus 5 rhythm sounds, both allowing for simultaneous generation of different tones. Selection between these two modes can be performed from the software. One of the special features of this LSI is its built-in Instruments ROM. As shown in the table hereunder, this ROM incorporates 15 melody tones and 5 rhythm tones, as well as all tones used for "CAPTAIN" and TELETEXT for easy application to "CAPTAIN" Adaptors and Character Multiplex TVs. Furthermore, a built-in Tone Register with capacity for one tone allows for sound effects and original sounds creation. By controlling the parameters of this register (E, w_1, I and w_2 in the equation below), all kinds of harmonic can be created on the basis of the sample wave w_1.

$$FM = E \sin (w_1 t + I \sin w_2 t)$$

Unlike conventional FM sound generators, this OPLL has a bulti-in Instruments ROM, permitting a substantial simplification of sound generation commands from the processor. First, the desired Instruments code is stored in the Instruments Selection Register. Then, after data has been input at the fixed intervals and timing, the unit starts generating sound. Processor automatic play can be easily performed by writing data appropriate to the music into the Sustain and Volume Registers. For using an original tone, the Instruments Selection Register must be cleared after writing data into the Tone Register as explained above. Rhythm sounds are generated by turning ON or OFF the corresponding bits in the Rhythm Control Register. In this case, the specified data must be input to the Key ON/OFF and F-Number Registers 8CH and 9CH.

■ REGISTER MAP

Address	D7	D6	D5	D4	D3	D2	D1	D0	
00	A M	V I B	E G T Y P	K S R	MULTI				User Tone Register
01									
02	KSL		T L M						
03	KSL			DC	DM	F B			
04	A R				D R				
05									
06	S L				R R				
07									
0 E			R	BD	SD	TOM	T-CT	HH	Rhythm Control
0 F	T E S T								OPLL Test Data
10	F-Num. 0 ~ 7								F-Number LSB 8 bits
~									
18									
20			SUS ON/OFF	KEY ON/OFF	BLOCK 0 ~ 2			F Num 8	F-Number MSB, Octave set
~									Key ON/OFF Register
28									Sustain ON/OFF Register
30	INST.				VOL				Instruments Selection and Volume Register
~									
38									

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Register Contents

	Address	Bit	
1	00, 01	D_7	Amplitude modulation ON/OFF switch
		D_6	Vibrato ON/OFF switch
		D_5	Sustained sound/decaying sound switch. 0: decaying sound 1: sustained sound
		D_4	RATE key scale
		$D_0 \sim D_3$	Controls MULTI sample wave - harmonics relationship
2	02, 03	D_6 D_7	LEVEL key scale
3	02	$D_0 \sim D_5$	Modulated wave total level. Modulation index control
4	03	D_3 D_4	Carrier and modulated wave distortion waveform (flat wave rectification) ON/OFF switch
		$D_0 \sim D_2$	FM feedback constant
5	04, 05	$D_4 \sim D_7$	Attack envelope change rate control
		$D_0 \sim D_3$	Decay envelope change rate control
6	06, 07	$D_4 \sim D_7$	Indication of decay - sustain level
		$D_0 \sim D_3$	Release envelope change rate control
7	0E	D_5	Rhythm sound mode selection. 1: Rhythm sound mode 0: Melody sound mode
		$D_0 \sim D_4$	Rhythm instruments ON/OFF switch
8	$10 \sim 18$	$D_0 \sim D_7$	F-Number LSB 8 bits
9	$20 \sim 28$	D_5	Sustain ON/OFF switch
		D_4	Key ON/OFF
		$D_1 \sim D_3$	Octave setting
		D_0	F-Number MSB
10	$30 \sim 38$	$D_4 \sim D_7$	Instruments selection
		$D_0 \sim D_3$	Volume data

Tone Data

	Instrument		Instrument
0	Original	8	Organ
1	Violin	9	Horn
2	Guitar	10	Synthesizer
3	Piano	11	Harpsichord
4	Flute	12	Vibraphone
5	Clarinet	13	Synthesizer Bass
6	Oboe	14	Acoustic Bass
7	Trumpet	15	Electric Guitar

Envelope Waveforms

Decaying Sounds

DP : 10^{ms} (0 →48dB)
RR : 310^{ms} (0 →48dB)
RS : 1.2^s (0 →48dB)
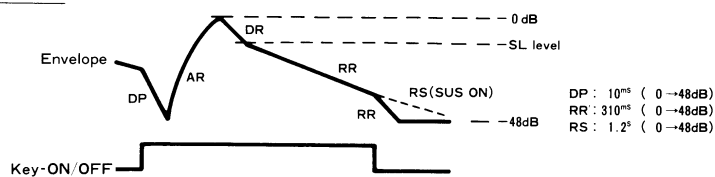
Sustained Sounds
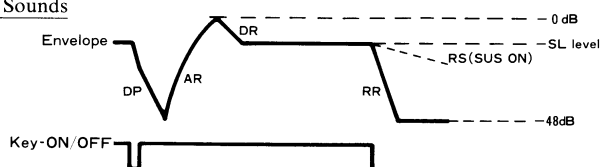
■ **TIMING DIAGRAMS** (Standard timing settings are V_{IH} = 2.0V, V_{IL} = 0.8V)

Fig. A-1 Write Timing

*t_{WDS} > 10ns : t_{CSW} < $t_{\emptyset M}$×7
t_{WDS} > 10+t_{CSW}-$t_{\emptyset M}$×7ns
: t_{CSW} > $t_{\emptyset M}$×7
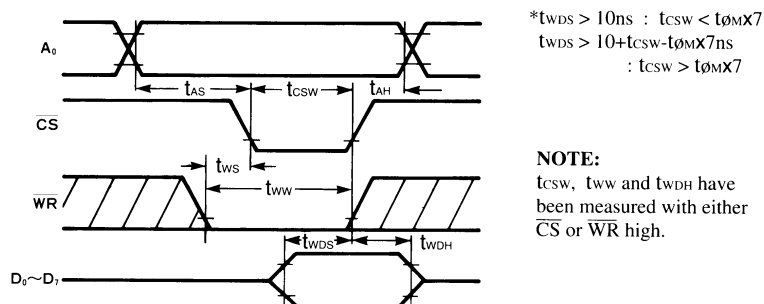
NOTE:
t_{CSW}, t_{WW} and t_{WDH} have
been measured with either
$\overline{CS}$ or $\overline{WR}$ high.
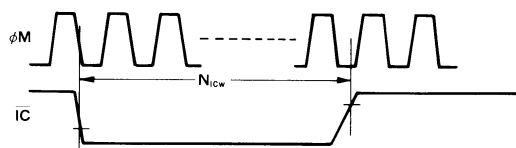
Fig. A-2 Reset Timing

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■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

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

2. Recommended Operating Conditions

ITEM	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply voltage	V_{CC}	4.75	5	5.25	V
	GND	0	0	0	V

3. DC Characteristics

ITEM		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
High level input voltage	All input	V_{IH}		2.0			V
Low level input voltage	All input	V_{IL}				0.8	V
Leak input current	A0, $\overline{WE}$	I_L	Vin = 0~5 V	−10		10	μA
Three-state (off) Input current	D0~D7	I_{TSL}	Vin = 0~5 V	−10		10	μA
Analog output voltage	MO	V_{MOA}	$R_{LOAD} = 2.2\Omega$ peak to peak		1.6		V
	RO	V_{ROA}	$R_{LOAD} = 2.2\Omega$ peak to peak		1.6		V
Pullup resistance	$\overline{IC}$, $\overline{CS}$	R_U		100			kΩ
Input capacity	All input	C_I				10	pF
Output capacity	All input	C_O				10	pF
Power current		I_{CC}			40	80	mA

4. AC Characteristics

ITEM		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Address setup time	A0	t_{AS}	Fig. A-1	10			ns
Address hold time	A0	t_{AH}	Fig. A-1	10			ns
Chip select write width	$\overline{CS}$	t_{CSW}	Fig. A-1	80			ns
Write pulse write width	$\overline{WE}$	t_{WW}	Fig. A-1	110			ns
Write pulse set up	$\overline{WE}$	t_{WS}	Fig. A-1	30			ns
Write data setup time	D0～D7	t_{WDS}*	Fig. A-1	10			ns
Write data hold time	D0～D7	t_{WDH}	Fig. A-1	25			ns
Reset pulse width	$\overline{IC}$	N_{ICW}	Fig. A-2		80		cycle

■ OUTLINE DIMENSIONS

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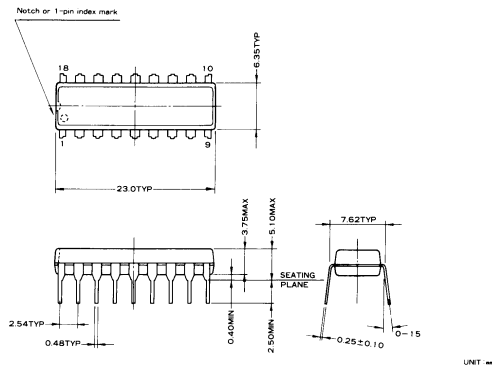
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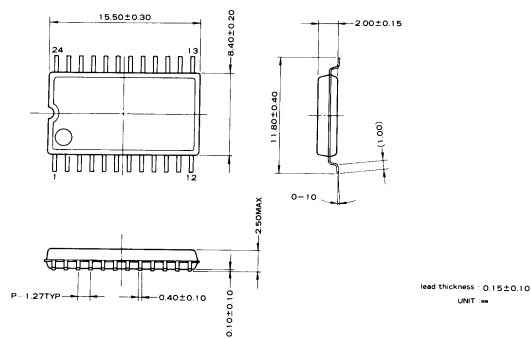
Note : The LSIs for surface mount need especial consideration on storage and
soldering conditions. For detailed information, please contact your
nearest agent of yamaha.