SGS-THOMSON MICROELECTRONICS

M112

POLYPHONIC SOUND GENERATOR

- 8μP PROGRAMMABLE SOUND GENERATOR CHANNELS
- 2MHz CLOCK
- INTERNAL TOS WITH POSSIBILITY OF EXTERNAL SYNCHRONIZATION FOR MULTICHIP USE
- 6 COMPLETE OCTAVE KEYBOARDS (72 KEYS)
- FIVE HOMOGENEOUS FOOTAGES μP PROGRAMMABLE BY ADDING A CONSTANT K TO THE KEYBOARD SITUATION
- SEVEN OCTAVE RELATED OUTPUTS ENVELOPED WITHOUT CONSTANT DC LEVEL (4 FOOTAGES)
- SEVEN FOOTAGE RELATED OUTPUTS WITH DIFFERENT CONFIGURATIONS FOR :

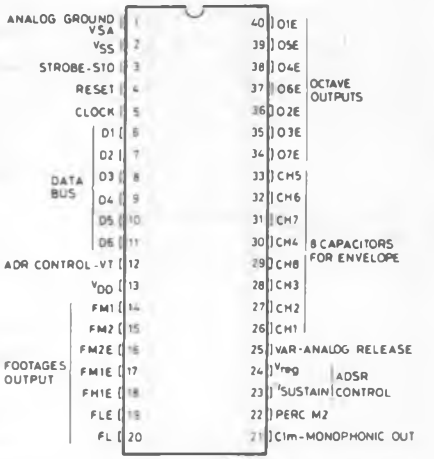
– FOOTAGES WITH ENVELOPE (WITHOUT CONSTANT DC LEVEL) AND:
– FOOTAGES WITHOUT ENVELOPE (WITH CONSTANT DC LEVEL) AND:
– VARIOUS SOUND CHANNEL DIVISIONS (SEE OPTION I, II AND III)

- POSSIBILITY OF EXCLUDING ONE OR MORE SOUND CHANNELS FROM THE NON ENVELOPED FOOTAGE OUTPUTS
- ONE MONOPHONIC OUTPUT NON ENVELOPED RELATED TO SOUND CHANNEL 1 WITH THE POSSIBILITY OF CHOOSING THE FOOTAGE (TWO ADDITIONAL MONOPHONIC OUTPUTS ON OPTION II)
- 50% DUTY CYCLE ON ALL OUTPUTS
- DIGITAL DRAWBAR CONTROL (32 LEVELS)
- ATTACK - DECAY - SUSTAIN - RELEASE (ADSR) ENVELOPE DEFINITION WITH DIGITAL CONTROL ON A.D.R. AND ANALOG CONTROL ON S
- ADDITIONAL ANALOG CONTROL ON RELEASE
- ANALOG PERCUSSION INPUT TO ENVELOPE ONE FOOTAGE (M2) ON THE OCTAVE RELATED OUTPUTS
- SPECIAL EXTERNAL ENVELOPE POSSIBILITY USING HOLD AND/OR RELEASE ∞
  HOLD AND RELEASE ∞ ARE DEDICATED TO DECAY AND PEDAL EFFECT

DIP-40 Plastic

ORDERING NUMBER: M112B1

PIN CONNECTION



- N-CHANNEL TECHNOLOGY - 12V SINGLE SUPPLY.

The M112 is a polyphonic sound generator that combines eight generators with envelope shapers and drawbar circuitry in a single package.
This versatile circuit simplifies the design of a wide range of polyphonic instruments and, interfacing directly with a microcomputer chip, gives designers an unprecedented degree of flexibility. The M112 is realized on a single monolithic silicon chip using low threshold N-channel silicon gate MOS technology. It is available in a 40 lead plastic package.

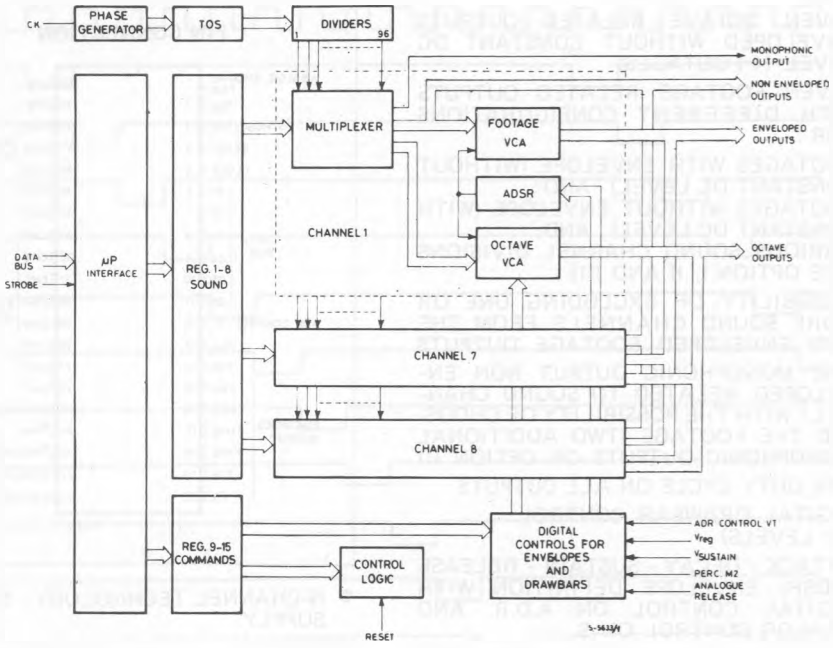
ABSOLUTE MAXIMUM RATINGS

V_{DD} *	Supply voltage	-0.3 to 20	V
V_i	Input voltage	-0.3 to V_{DD}	
$V_{O\ (off)}$	Off state output voltage	-0.3 to 20	V
P_{tot}	Total power dissipation	500	mW
T_{stg}	Storage temperature	-65 to 150	°C
T_{op}	Operating temperature	0 to 70	°C

Stresses above those listed under "Absolute Maximum Rarings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

* All voltages are with respect to V_{SS}.

BLOCK DIAGRAM



RECOMMENDED OPERATING CONDITIONS

Parameter		Test conditions	Values			Unit
			Min.	Typ.	Max.	
V_{DD}	Highest Supply Voltage		11.4	12	12.6	V

STATIC ELECTRICAL CHARACTERISTICS

(V_{DD} = 12V ± 5%, V_{SS} = 0V, T_{amb} = 0 to 50°C unless otherwise specified)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
INPUT SIGNALS						
V_{IH}	Input High Voltage	Pins 3, 6 to 11	2.4		V_{DD}	V
		All other inputs	6		V_{DD}	V
V_{IL}	Input Low Voltage	Pins 3, 6 to 11	-0.3		0.8	V
		All other inputs	-0.3		1	V
VSA	Analog Ground	R < 10Ω C = 100μF	0	0	1	V
VT	ADR Control Time	R = 1K C = 1μF (note 3)	0		V_{DD}	V
VAR	Analog Release	R = 10K C = 0.1μ	0		V_{DD}	V
V_{reg}	Control OFF Asymptote	R < 10Ω C = 100μ	0	0	1	V
$V_{SUST.}$	Control Level Sustain	R = 1K C = 100μ (note 2)	0		V_{DD}	V
Perc. M2	Control Level Percussion	R = 10K	0		V_{DD}	V
I_{LI}	Input Leakage Current	$V_I = V_{DD}$			1	μA
OUTPUT SIGNALS (One key pressed)						
I_{OL}	Output Low current	$V_{OL} = V_{DD/2-1V}$ (note 1)	10	30	50	μA
I_{OH}	Output High Current	$V_{OH} = V_{DD/2+1V}$ (note 1)	10	30	50	μA
		V_{OH} = 10V $V_{CHN} = V_{DD}/2$(*)	100	300	500	μA
		V_{OH} = 10V $V_{CHN} = V_{DD}/2$	10	30	50	μA
$I_{O(off)}$	Off state output current	$V_O = V_{DD}$ (all output pins)			1	μA
		$V_O = V_{SS}$ (pins 14-15-20 in 3rd state)			-1	μA
POWER DISSIPATION						
I_{DD}	Supply current	T_{amb} = 25°C			50	mA

Notes: 1. Refers only to FL, FM1, FM2 (pins 20, 15, 14).
2. With a standard ADSR $V_{SUST} \leq 4.5V$
3. The best region is $V_T - V_{SUST} \geq 4V$
(*) Refers only to octave outputs with drawbar max.

DYNAMIC ELECTRICAL CHARACTERISTICS

Parameter		Test conditions	Min.	Typ.	Max.	Unit
CLOCK						
f_i	Input Clock Frequency		250	2000.24	2.300	kHz
t_r, t_f	Rise and Fall Times 10% to 90%				30	ns
t_{on}, t_{off}	ON and OFF Times		150			ns
RESET						
t_w	Pulse Width	Clock = 2 MHz	10			μs
t_f	Fall Time				30	ns
OUTPUT SIGNALS						
t_{on}, t_{off}	Outptu duty cycle			50		%

GENERAL DESCRIPTION

The M112 contains a microprocessor interface, eight programmable sound generator channels, a top octave synthesiser, a divider chain and control circuitry, (see fig. 1). Each generator consists of logic to select the desired notes and harmonics from 96 frequencies obtained by division, an ADSR envelope generator and two voltage-controlled amplifiers. Programmable attenuators are included for drawbar control of the harmonic content of the sound.

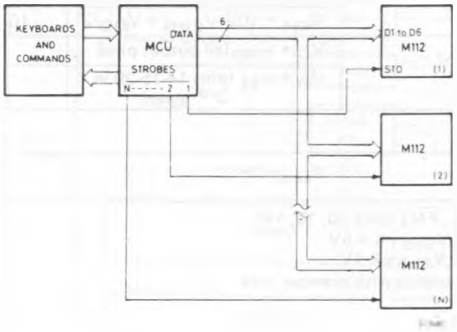
To simplify system design the signals generated in each channel are directed to octave separated outputs and footage outputs. Two voltage-controlled amplifiers are provided for each channel to keep the octave and footage outputs separate.

The attack time, decay time, release time and sustain level are set for all eight channels by common controls. Tone selection, the attack, decay, release parameters, drawbars and special effects are all software controlled.

In a typical configuration (fig. 2), one or more M112s are connected to a microprocessor which scans the keyboard and front panel controls in a matrix arrangement. When the microprocessor detects a key depression it chooses one of the sound generators and allocates it to that note. If another key is pressed the microprocessor allocates another sound generator and so on. This process can be repeated until there are no more free channels, i.e. when 8N keys are pressed simultaneously where N is the number of M112s used.

When one of the keys is released the microprocessor resets a control bit in the appropriate generator channel which will then be re-allocated to another key when needed.

Fig. 2



OUTPUTS

The M112 has 15 music output pins. Seven of these are octave outputs, seven are footage outputs and the last is a monophonic output from channel one. This standard configuration can be changed under program control.

The octave outputs, which are enveloped, are so called because there is one output for each octave, i.e. output signals from all eight channels that fall within the same octave are routed to the same output. These outputs are provided to simplify the generation of sinewaves from the squarewaves generated by the M112s digital circuitry. Since each of these outputs handles a limited range of frequencies – exactly one octave – a simple low pass or bandpass filter will do the job. The blend of harmonics sent to the octave outputs is controlled by the drawbar attenuators.

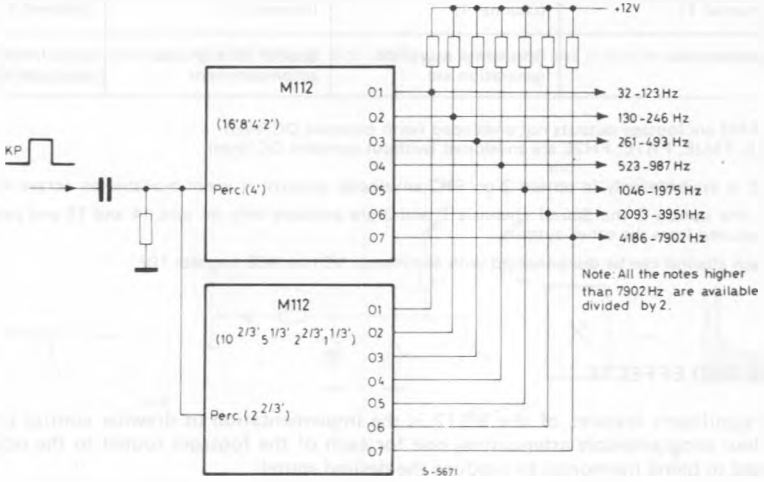
The footage outputs are related to the five footages generated by the M112. These are referred to as L, M1, M2, H1 and H2 (L = Low, M = mid, H = high) and can be programmed to give the three different ranges given in table 1, adding a constant K (number of half tones) to the keyboard information.

All five footages can be obtained from these outputs but only four are mixed by the drawbar circuitry and routed to the octave outputs.

TABLE 1 - THE THREE FOOTAGE RANGES OF THE M112

	Enveloped footage outputs (option 2)				
	Octave outputs				
	Non Enveloped Footage Outputs				
Footage / K	L	M1	M2	H1	H2
0	16'	8'	4'	2'	1'
7	10 2/3'	5 1/3'	2 2/3'	1 1/3'	2/3'
4	12 4/5'	6 2/5'	3 1/5'	1 3/5'	4/5'

Fig. 3 - Example of octave related output "EVEN" and "ODD" with Percussion input.



In no case will the maximum frequency be higher than 7902 Hz (with a 2 MHz clock).
The output configuration for the octave and footage outputs can be changed under program control as mentioned above. There are three options, including the standard configuration, and these are:

- Option 1, the normal configuration gives four enveloped footage outputs, LE, M1E, M2E, H1E, and three non-enveloped outputs, L, M1 and M2. All eight channels are present on each output.
- Option 2 is a special configuration for sawtooth generation (sawtooth waveforms are frequently used in sound synthesis). In this case channels two and three appear **only** on the outputs FM1 and FM2 (footages M1 and M2) and are excluded from the rest. All five footages are available as enveloped outputs.
- Option 3 is intended for sophisticated automatic accompaniment circuits. All the channels appear on three non-enveloped outputs (FL, FM1, FM2) for chord generation and can be disconnected or command. Channels 4, 5, 6 and 7 appear on four enveloped outputs for arpeggi. The octave outputs are used for the bass and include only channel 8.

TABLE 2 - OUTPUT CONFIGURATIONS

Pin	Option I	Option II	Option III	Option IV
15	FM2	FM2 (Channel 3)	FM2	FM2 (Ch. 3)
14	FM1	FM1 (Channel 2)	FM1 (All channels (see note 3))	FM1 (Ch. 2)
20	FL	FH2E	FL	FH2E (Ch. 4, 5, 6, 7, 8)
18	FH1E	FH1E	FH1E	FH1E
16	FM2E	FM2E	FM2E (only channels 4-5-6-7)	FM2E (only channels 4-5-6-7)
17	FM1E	FM1E	FM1E	FM1E
19	FLE (For the 8 channels)	FLE	FLE	FLE
40	O1E	O1E (Only channels 1-4-5-6-7-8)	O1E	O1E
36	O2E	O2E	O2E	O2E
35	O3E	O3E	O3E	O3E
38	O4E	O4E	O4E (only channel 8)	04E (only channel 8)
39	O5E	O5E	O5E	O5E
37	O6E	O6E	O6E	O6E
34	O7E	O7E	O7E	O7E
21	Monophonic out (channel 1)	Mono (channel 1)	Mono (channel 1)	Mono (channel 1)
	Standard use	Special for sawtooth generation etc.	Special for high class accompaniment	Only for information (no musical meaning)

– FL, FM1, FM2 are footage outputs not enveloped (with constant DC level)
– FLE, FM1E, FM2E, FH1E, FH2E are enveloped (without constant DC level).

Notes: 1) H2 is available only in option 2 on FH2 enveloped outputs. It is not available on octave related outputs.

2) In the option 2 the Sound channels 2 and 3 are available only on pins 14 and 15 and consequently are excluded from the other outputs.

3) Each channel can be disconnected with commands NC1 to NC8 (register 10).

DRAWBARS AND EFFECTS

One of the significant features of the M112 is the implementation of drawbar control circuitry. This consists of four programmable attenuators, one for each of the footages routed to the octave outputs, which are used to blend harmonics to produce the desired sound.

Other features of the M112 include hold, pedal and percussion effects, all of which are enabled/disabled under software control. Hold, when active, interrupts the decay of the ADSR envelope and Pedal interrupts the release curve. Hold and pedal permit external control of the envelope. This feature can be used, for example, to synthesize very realistic piano and harpisichord sounds.

A piano effect can be produced by suitably programming the envelope shapers but by using the hold and pedal controls and a few external components much greater realism can be obtained. Fig. 4 shows a simplified schematic of one of the envelope shapers together with the type of envelope generated. The envelope parameters are controlled by RA, RD, RR and V_{SUS} (RA, RD and RR are programmed resistors controlling attack, decay and release). Disabling the natural decay and release and adding a handful of components a close approximation to the ideal waveform can be produced (fig. 5). R1 is a very large resistance (typically 3 MΩ) to give the long (several seconds) time constant for the second decay.

Fig. 4 - With an external capacitor the M112's envelope shapers produce the standard ADSR envelope.

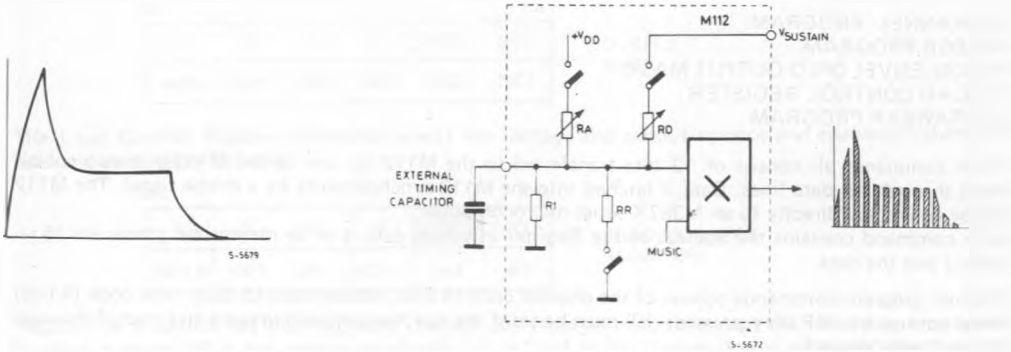
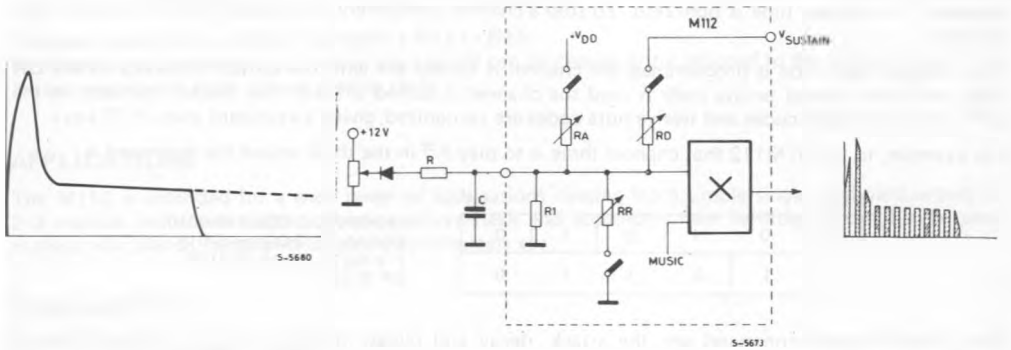


Fig. 5 - Disabling the normal decay and release and adding a few external components a realistic piano envelope can be produced.



INPUTS

Eight pins on the M112 are used to define the elementary time interval of the ADSR envelope shapers (Pins 26 to 33). Capacitors, nominally 1μF, are connected to these pins. Eight separate capacitors are necessary because the envelope shapers are independently triggered. Analog inputs are also provided to adjust the asymptotic release level (V_{reg} pin 24) and the charge/discharge current for attack, decay and release (VT pin 12) in order to compensate the differences of ADR time constant between several M112s used in the same instrument.

The sustain level is fixed by the voltage at pin 23.

The release time constant, digitally controlled by software, can also be fine adjusted by a trimmer connected at pin 25.

PROGRAMMING

The M112 is programmed using five basic commands:

- CHANNEL PROGRAM
- ADSR PROGRAM
- NON-ENVELOPED OUTPUT MASK
- LOAD CONTROL REGISTER
- DRAWBAR PROGRAM

These commands all consist of 12 bits transferred to the M112 (or one of the M112s) in two six-bit bytes through six data lines. Data is latched into the M112 synchronously by a strobe signal. The M112 can be connected directly to an M387X series microcomputer.
Each command contains the address of the Register in which data is to be memorized (there are 16 registers) and the data.

Channel program commands consist of the channel code (4 bits), octave code (3 bits), note code (4 bits) and a control bit, KP (key pressed). KP must be set if the key has just been pressed and reset if the note has just been released.

D1					D6
CHANNEL				KP	O2
O1	O0	NOTE			

CHANNEL PROGRAM

Resetting KP does not necessarily silence the channel because the sound continues after the key has been released if the release time is non-zero. To stop a channel completely the unused note and octave codes are used.

If an unused note code is programmed the channel is turned off with the output transistor in the ON state and if an unused octave code is used the channel is turned off with the output transistor in the OFF state. Six octave codes and twelve note codes are recognized, giving a keyboard span of 72 keys.

For example, to tell an M112 that channel three is to play F# in the third octave the command is:

D1					D6
0	0	1	0	1	0
1	1	0	1	1	0

CHANNEL 3 CODE IS 0010
OCTAVE 3 CODE IS 011
F # NOTE CODE IS 0110
KP IS SET

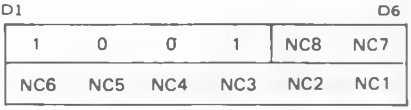
The ADSR Program command sets the attack, decay and release times for all the envelope shapers. This command takes the form:

D1					D6
1	0	0	0	r3	r2
r1	d2	d1	a3	a2	a1

ADSR PROGRAM

The code 1000 selects the ADSR control register, a3/a2/a1 is the attack time, d2/d1 is the decay time and r3/r2/r1 is the relase time. These times are all multiples of the time interval set by external capacitors. With the suggested 1μF values this time interval is 3ms. The release code 000 is used to enable the pedal effect.

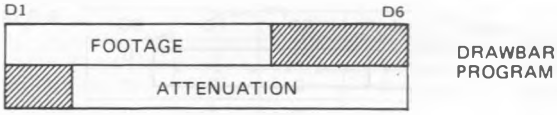
The Non-Enveloped Output Mask command is used to select which channels are to be routed to the non-enveloped footage outputs. Any or all of the eight channels can be excluded by setting the appropriate bit.



The Load Control Register command selects the footage and output options and enables/disables the hold and percussion facilities.

"NC1m" is a control bit that excludes channel one from all outputs except the three non-enveloped footages outputs. PO is the percussion disable bit, m2/m1 is the footage option select code for the monophonic output and OP2/OP1 the output configuration select code.

The drawbar-controlled attenuators are set independently for each footage using the Drawbar Program Command which has the form:



Footage is selected by addressing registers R12 to R15.
Attenuation is controlled in 32 linear steps which can be conveniently reduced to the conventional 16 or 8-step logarithmic scale using a lookup table.

APPLICATIONS

The M112 is intended for a wide range of applications ranging from simple single-keyboard organs to 2-3 manual instruments with sophisticated synthesis and accompaniment facilities. It can also be used in electronic pianos, harpsichords, string synthesizers etc.

DESCRIPTION

Pin 1 - VSA Analog ground

Ground connection of all outputs. It is typically connected to V_{SS}. By adjusting its value with respect to V_{SS} (plus/minus) it is possible to modify the output current and compensate the differences in current between several M112s used in the same applications.

Pins 2 and 13 - V_{SS}, V_{DD}

Power supply connections. V_{DD} is nominally 12V; V_{SS} is to be connected to GND.

Pin 4 - Reset input

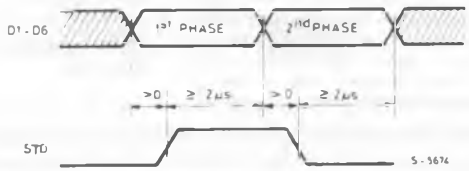
It is used to synchronize various M112s in multichip use. The reset is activated when the input is at H Level. In this condition the chip is blocked.

Pin 5 - Clock input

It has to be connected to an external oscillator of 2 MHz.

Pin 6 to 11 - D1, D6 Data bus input
Pin 3 - STD Data Strobe input

These pins are used to transfer the 12 bits of data from the microprocessor to the registers of various M112s using a two phase procedure.
The first six bits of data are latched on the positive edge of STD, while the other six bits are latched on the negative edge of STD.



Each 2 x 6 bit of information contains the address of the register (4 bit/16 registers) and the data up to 8 bits to be memorized in the selected register.

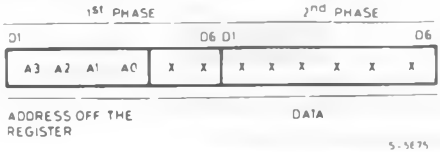


TABLE 3 - REGISTER SELECTION

A0	A1	A2	A3	Register n°	Register function
0	0	0	0	1	
1	0	0	0	2	
0	1	0	0	3	
1	1	0	0	4	Note–octave etc.
0	0	1	0	5	For Sound channel
1	0	1	0	6	
0	1	1	0	7	
1	1	1	0	8	
0	0	0	1	9	
1	0	0	1	10	
0	1	0	1	11	
1	1	0	1	12	Control Commands
0	0	1	1	13	
1	0	1	1	14	
0	1	1	1	15	
1	1	1	1	16	Used for test*

* This address sets the Ic in a test condition that can only be modified by a Reset command on pin 4.

Registers 1 to 8

There registers are related to the sound channels

	Bus	Data	
PHASE 1	D1	A3	must be "0"
	D2	A2	Sound
	D3	A1	Channel
	D4	A0	Selection
	D5	KP	
	D6	O2	
PHASE 2	D1	O1	Key
	D2	O0	information
	D3	N3	
	D4	N2	
	D5	N1	
	D6	N0	

A0-A2: Sound channel selection with reference to table 3, register 1 is related to channel 1, register 2 to channel 2 and so on up to channel 8.

KP : 1 = pressed key 0 = relased key
O0-O1-O2: Octave code of the note (Table 4).

TABLE 4

O0	O1	O2	Code	Octave	
0	0	0	0		Note OFF
1	0	0	1	1	
0	1	0	2	2	
1	1	0	3	3	
0	0	1	4	4	
1	0	1	5	5	
0	1	1	6	6	
1	1	1	7		Note OFF

Output transistor "OFF"

N0-N1-N2-N3 = Note Code (Table 5)

TABLE 5

N0	N1	N2	N3	Code	Note	
0	0	0	0	0	DO	
1	0	0	0	1	DO#	
0	1	0	0	2	RE	
1	1	0	0	3	RE#	
0	0	1	0	4	MI	
1	0	1	0	5	FA	
0	1	1	0	6	FA#	
1	1	1	0	7	SOL	
0	0	0	1	8	SOL#	
1	0	0	1	9	LA	
0	1	0	1	10	LA#	
1	1	0	1	11	SI	
0	0	1	1	12	Note "OFF"	Output transistor "ON"
1	0	1	1	13	Note "OFF"	
0	1	1	1	14	Note "OFF"	
1	1	1	1	15	Note "OFF"	

Register 9 to 15

These registers are related to the various control commands

TABLE 6

	Register / Data Bus	R9	R10	R11	R12	R13	R14	R15	R16
PHASE 1	D1	1	1	1	1	1	1	1	1
	D2	0	0	0	0	1	1	1	1
	D3	0	0	1	1	0	0	1	1
	D4	0	1	0	1	0	1	0	1
	D5	r3	NC8	X	X	X	X	X	X
	D6	r2	NC7	PO	X	X	X	X	X
PHASE 2	D1	r1	NC6	HOLD	X	X	X	X	X
	D2	d2	NC5	OP3	L5	M1 5	M2 5	H1 5	X
	D3	d1	NC4	OP2	L4	M1 4	M2 4	H1 4	X
	D4	a3	NC3	NC1m	L3	M1 3	M2 3	H1 3	X
	D5	a2	NC2	m2	L2	M1 2	M2 2	H1 2	X
	D6	a1	NC1	m1	L1	M1 1	M2 1	H1 1	X
		Envelope	Channel off	Various	Drawbar level on four footages only for octave outputs				Test

Register 9 - R9 selects the ADR envelope parameters for ADSR control (see fig. 6)

Attack – a1 - a2 - a3 = 3 bit
Decay – d1 - d2 = 2 bit
Release – r1 - r2 - r3 = 3 bit
} 8 bit

Fig. 6 - ADSR envelope control

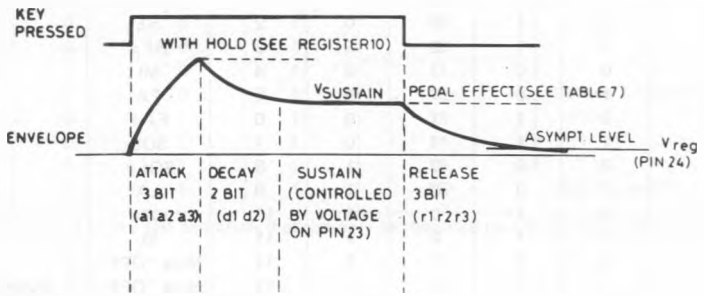


Table 7 shows the various time constants for Attack, Decay and Release.

TABLE 7

a3	a2	a1	Attack		
	d2	d1		Decay	
r3	r2	r1			Release
0	0	0	T/2	4T	* ∞
0	0	1	T	8T	T
0	1	0	2T	16T	2T
0	1	1	4T	32T	4T
1	0	0	8T		8T
1	0	1	16T		16T
1	1	0	32T		32T
1	1	1	64T		64T

* In this case it is possible to obtain the pedal effect.
T = 3 ms is the typical time constant unit with 8 external capacitors of 1 μF connected to pins 26 to 33.

Register 10 - Contains 8 commands to exclude the corresponding sound channel from the non-enveloped footage outputs (FL-FM1-FM2)
0 = ON 1 = OFF

Register 11 - Contains the following 8 commands: m1 and m2 select one of the four footages available for the monophonic output (C1m) according to table 8.

TABLE 8

m1		0	1	0	1
m2		0	0	1	1
K	0	16'	8'	4'	2'
	7	10 2/3'	5 1/3'	2 2/3'	1 1/3'
	4	12 4/5'	6 2/5'	3 1/5'	1 3/5'

OP2-OP3 – Select the four output options described in table 2 according to tabel 9.

TABLE 9

BIT / OPTION	OP2	OP3
I	0	0
II	1	0
III	0	1
IV	1	1

HOLD - If 0, disconnects the external 8 capacitors of envelope (1 μF) from the $V_{SUSTAIN}$ pin (pin 23) in the decay phase.

PO (Percussion Off) - If 1, the percussion input is inhibited (see pin 22 description).

NC1m-If1, eliminates channel 1 from all outputs except the 3 footage outputs not enveloped (it can be eliminated from these outputs through the command NC1 of register 10).

N.B. NC1m command is inoperative on the monophonic output (C1m) where channel 1 is always present.

Registers 12-13-14-15

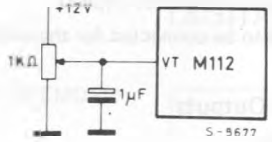
These registers contain the drawbar control for 4 footages on the octave related output.
Footages L, M1, M2 and H1 are controlled in 32 linear levels or for example, using conversion table in the microprocessor in 8 or 16 logarithmic levels.
Table 10 shows an example of footage L with 32, 16 and 8 step control in dB.

TABLE 10

L 5	L 4	L 3	L 2	L 1	Attenuation in dB		
					32 steps	16 steps	8 steps
0	0	0	0	0	OFF	OFF	OFF
0	0	0	0	1	-29.8	-29.8	-29.8
0	0	0	1	0	-23.8	-23.8	-23.8
0	0	0	1	1	-20.3	-20.3	-20.3
0	0	1	0	0	-17.8	-17.8	
0	0	1	0	1	-15.8	-15.8	
0	0	1	1	0	-14.3	-14.3	-14.3
0	0	1	1	1	-12.9		
0	1	0	0	0	-11.8	-11.8	
0	1	0	0	1	-10.7		
0	1	0	1	0	-9.8	-9.8	
0	1	0	1	1	-9.0		-9.0
0	1	1	0	0	-8.2	-8.2	
0	1	1	0	1	-7.5		
0	1	1	1	0	-6.9	-6.9	
0	1	1	1	1	-6.3		
1	0	0	0	0	-5.7	-5.7	
1	0	0	0	1	-5.2		
1	0	0	1	0	-4.7		
1	0	0	1	1	-4.2	-4.2	-4.2
1	0	1	0	0	-3.8		
1	0	1	0	1	-3.4		
1	0	1	1	0	-3.0	-3.0	
1	0	1	1	1	-2.6		
1	1	0	0	0	-2.2		
1	1	0	0	1	-1.9		
1	1	0	1	0	-1.5	-1.5	
1	1	0	1	1	-1.2		
1	1	1	0	0	-0.9		
1	1	1	0	1	-0.58		
1	1	1	1	0	-0.29		
1	1	1	1	1	0	0	0

Pin 12 - VT - ADR Control

It is used to adjust the ADR time constant for several M112s used in the same application. Using a single M112 it has to be connected to V_{DD}.



Pin 14 to 20 - FM1, FM2, FM2E, FM1E, FH1E, FLE, FL (Footages output)

The "wired-or" function is possible on all outputs.
The non enveloped outputs (with constant DC level) are push-pull current generators.
The enveloped outputs (with non constant DC level) are open drain sink current generators. Output duty cycle is 50%.

Pin 21 - C1m

Monophonic output of channel 1 (always present). Duty cycle of the waveform is 50%. Open drain output.

Pin 22 - Percussion M2

Using a specific signal on this input it is possible to have a percussion effect on M2 footage for the octave related output.

Pin 23 - $V_{SUSTAIN}$

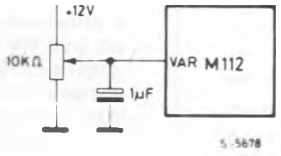
This input defines the level of sustain (see fig. 6).

Pin 24 - V_{reg}

This pin controls the asymptote of $V_{RELEASE}$ through the gate of a transistor which discharges the envelope capacitor. If the performance at the end of release time is considered satisfactory, this pin must be connected to V_{SS}. Otherwise this input can be connected to a voltage not higher than 1V.

Pin 25 - VAR Analog release

This pin is intended for analog control of the release time constant when it is required in addition to the digital one controlled by software.



It allows intermediate values not included in table 7 (see explanation of register 9). In the case of pedal effect connect this input to V_{SS}.

Pin 26 to 33 - CH1, CH8 Envelope capacitor inputs

8 capacitors (typical value = 1μF) have to be connected for the ADSR envelopes.

Pin 34 to 40 - O1E, O7E Octave Outputs

Octave related outputs. Duty cycle is 50%.