MOS INTEGRATED CIRCUIT

M 251

ARPEGGIO, CHORD AND BASS ACCOMPANIMENT GENERATOR

CHOICE OF OPERATING MODE:
- AUTOMATIC WITH MEMORIZATION OF THE SELECTED KEY
- SEMIAUTOMATIC WITH MEMORIZATION OF THE SELECTED KEYS
- SEMIAUTOMATIC WITHOUT MEMORIZATION OF THE SELECTED KEYS

SIMPLE KEY SWITCH REQUIREMENTS (24 NOTE KEYBOARD WITH ONE SWITCH PER KEY)
INTERNAL ANTI-BOUNCE CIRCUITS
THREE OUTPUTS FOR THE ARPEGGIOS
ANALOG OUTPUT FOR CHORDS
BASS OUTPUT (AUTOMATIC OR ALTERNATE)
TRIGGER OUTPUTS FOR PERCUSSION EFFECT ON BOTH ARPEGGIO AND BASS SECTIONS
MULTIPLE CHOICE POSSIBILITY ON THE CHORDS IN AUTOMATIC MODE:
- MAJOR OR MINOR THIRD
- FIFTH OR DIMINISHED FIFTH
- SIXTH OR SEVENTH

LOW DISSIPATION: $<$400 mV TYP.
STANDARD SUPPLIES (+ 5V AND - 12V)
INPUTS PROTECTED FROM ELECTROSTATIC DISCHARGE

The M 251 is realized on a single monolithic silicon chip using low threshold P-channel silicon gate MOS technology. It is available in a 40-lead ceramic or plastic package.

ABSOLUTE MAXIMUM RATINGS

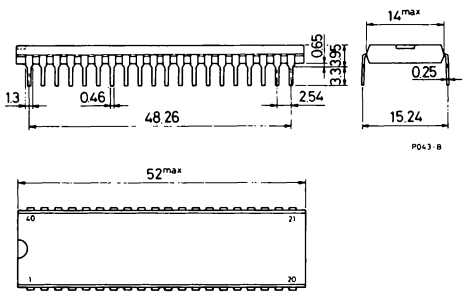
V_{GG}*	Source supply voltage	-20 to 0.3	V
V_I*	Input voltage	-20 to 0.3	V
I_O	Output current (at any pin)	3	mA
T_{stg}	Storage temperature	-65 to 150	°C
T_{op}	Operating temperature	0 to 70	°C

* This voltage is with respect to V_{SS} pin voltage

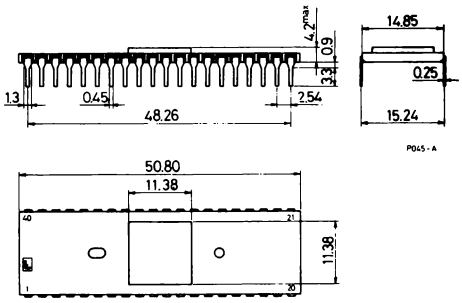
ORDERING NUMBERS: M 251 B1 AC for dual in-line plastic package
M 251 D1 AC for dual in-line ceramic package

MECHANICAL DATA (dimensions in mm)

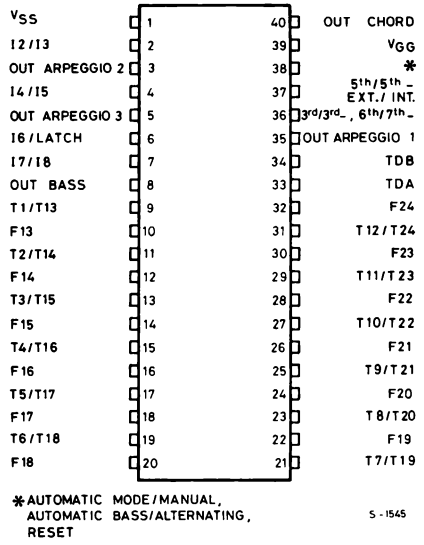
M 251 B1 AC



M 251 D1 AC



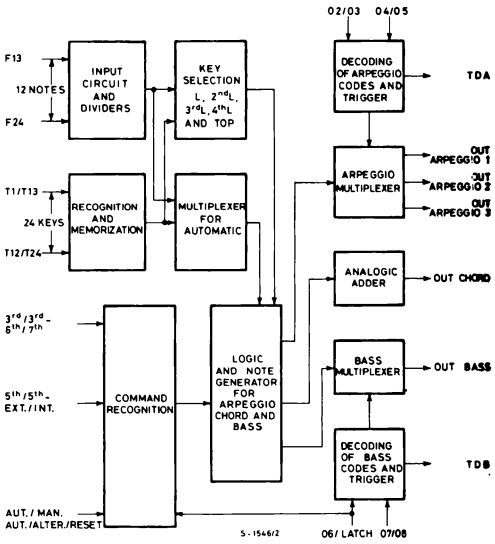
CONNECTION DIAGRAM



*AUTOMATIC MODE/MANUAL, AUTOMATIC BASS/ALTERNATING, RESET

S-1545

BLOCK DIAGRAM



GENERAL CHARACTERISTICS

The circuit comprises:

a) 12 pins for input frequencies

b) 12 inputs from the keyboard with the possibility to provide the control of two octaves (in semiautomatic modes only) by multiplexing the two octaves. In automatic mode the second octave repeats the first

c) 4 multiplexed data inputs for addressing the internal selection circuits. These inputs are normally coming from the outputs of an external memory

d) 5 signal outputs: arpeggio 1, arpeggio 2, arpeggio 3, bass and chord respectively

e) 2 trigger outputs: arpeggio (TDA), and bass (TDB), respectively. These outputs, in conjunction with an external time-constant, allow the formation of the envelope of the arpeggio and bass notes.
The duration of the trigger pulses is equivalent to one period of the external memory clock line

f) 3 inputs for mode selection

g) 2 supply pins.

M 251 is normally used in conjunction with an external self-scanning ROM (such as the M 252 - 3 or 4) which performs the selection of the various notes in the arpeggio/chord/bass accompaniment.

AUTOMATIC OPERATION

When a number of keys in the two available octaves are played, the lowest key is taken as a reference by the circuit and this note is memorized internally. When the lowest key played changes, the memory is erased and the new information from the keyboard is now fed into the circuit and memorized. When all the keys are released the last "update" is held in the memory and is only changed when a different lowest key is played. If keys in the upper octave only are played then the two octaves act in parallel. The memorized key by means of the internal multiplexer selects the corresponding tonic and all the other notes programmed for arpeggio, chord and bass accompaniment in the correct relationship of intervals. Internal dividers provide all the octaves we need as shown in the tables below. By means of the external commands it is possible to choose between major third and minor third, between fifth and diminished fifth and between sixth and seventh. To reset the key memorized at the end of a piece played the automatic signal must be interrupted for a moment while none of the keys on the two available octaves is played.

ARPEGGIO TRUTH TABLE (positive logic)

EXTERNAL MEMORY CODE				SELECT 6th			SELECT 7th		
05	04	03	02	ARP. I	ARP. II	ARP. III	ARP. I	ARP. II	ARP. III
1	1	1	1	TONIC	3rd	5th	TONIC	3rd	5th
1	1	1	0	3rd	5th	TONIC x 2	3rd	5th	7th
1	1	0	1	5th	TONIC x 2	3rd x 2	5th	7th	3rd x 2
1	1	0	0	6th	—	—	7th	—	—
1	0	1	1	TONIC x 2	3rd x 2	5th x 2	7th	3rd x 2	5th x 2
1	0	1	0	3rd x 2	5th x 2	TONIC x 4	3rd x 2	5th x 2	TONIC x 4
1	0	0	1	5th x 2	TONIC x 4	3rd x 4	5th x 2	TONIC x 4	3rd x 4
1	0	0	0	6th x 2	—	—	7th x 2	—	—
0	1	1	1	TONIC x 4	3rd x 4	5th x 4	TONIC x 4	3rd x 4	5th x 4
0	1	1	0	3rd x 4	5th x 4	TONIC x 8	3rd x 4	5th x 4	7th x 4
0	1	0	1	5th x 4	TONIC x 8	3rd x 8	5th x 4	7th x 4	3rd x 8
0	1	0	0	6th x 4	—	—	7th x 4	—	—
0	0	1	1	TONIC x 8	3rd x 8	5th x 8	7th x 4	3rd x 8	5th x 8
0	0	1	0	3rd x 8	5th x 8	TONIC x 8	3rd x 8	5th x 8	7th x 8
0	0	0	1	5th x 8	TONIC x 8	3rd x 8	5th x 8	6th x 8	3rd x 8
0	0	0	0	No Change	No Change	No Change	No Change	No Change	No Change

VERY IMPORTANT NOTE: TONIC is the input note, corresponding to the selected key, divided by 16. 3rd is the correct third corresponding to this TONIC. And so on.

BASS and CHORD TRUTH TABLES (positive logic)

EXTERNAL MEMORY CODE 08	07	06	AUTOMATIC BASS
1	1	1	2nd/2
1	1	0	8ve/2
1	0	1	9th/2
1	0	0	6th or 7th/2
0	1	1	5th/2
0	1	0	3rd/2
0	0	1	TONIC/2
0	0	0	NO CHANGE

"NO CHANGE" is interpreted as an instruction to sustain the previous notes until new information is presented.

EXTERNAL MEMORY CODE 07	06	ALTERNATE BASS
1	1	–
1	0	TONIC/2
0	1	5th/2
0	0	NO CHANGE

EXTERN. MEMORY CODE 01	CHORD	
	SELECT 6th	SELECT 7th
1	TONIC +3rd +5th	TONIC +3rd +5th +7th
0	NO CHANGE	NO CHANGE

SEMIAUTOMATIC OPERATION WITH MEMORIZATION OF THE KEYS

When any number of keys are played within the two available octaves they are memorized and sent to an internal recognition circuit which selects the lowest four keys, the top key played and their respective frequencies. This information is updated every time a different group of keys is played. Between the playing of two groups of keys there must be a pause during which none of the keys is down, otherwise the new group of keys is memorized without the previous group being cancelled. Again the keys recognized can be extended to more octaves by means of the internal divider. The following are positive logic truth tables showing the actual keys,instead of the notes.Top is the first key from the right(the top key played), L the lowest key played, and 2L the second lowest and so on. The relationship between keys and input frequencies is as follows: L in the first octave to the left represents corresponding input note divided by 16, while in the second octave it is divided by 8. And so on. To erase the memorization at the end of a piece played it is necessary to select "automatic" for a moment and then return to semiautomatic while none of the keys is played. The trigger signals, TDA and TDB, are sent out only if 3 or more keys are played.

ARPEGGIO TRUTH TABLE (positive logic)

EXTERNAL MEMORY CODE 05	04	03	02	MEANING OF THE CODES ARP. I	ARP. II	ARP. III
1	1	1	1	L	2nd L	3rd L
1	1	1	0	2nd L	3rd L	L x 2
1	1	0	1	3rd L	L x 2	2nd L x 2
1	1	0	0	4th L	–	–
1	0	1	1	L x 2	2nd L x 2	3rd L x 2
1	0	1	0	2nd L x 2	3rd L x 2	L x 4
1	0	0	1	3rd L x 2	L x 4	2nd L x 4
1	0	0	0	4th L x 2	–	–
0	1	1	1	L x 4	2nd L x 4	3rd L x 4
0	1	1	0	2nd L x 4	3rd L x 4	L x 8
0	1	0	1	3rd L x 4	L x 8	2nd L x 8
0	1	0	0	4th L x 4	–	–
0	0	1	1	L x 8	2nd L x 8	3rd L x 8
0	0	1	0	2nd L x 8	3rd L x 8	L x 8
0	0	0	1	3rd L x 8	L x 8	2nd L x 8
0	0	0	0	NO CHANGE	NO CHANGE	NO CHANGE

BASS and CHORD TRUTH TABLES (positive logic)

EXTERNAL MEMORY CODE 08 07 06	AUTOMATIC BASS OUTPUT	ALTERNATE BASS OUTPUT
1 1 1	TWO 8ve BELOW TOP	–
1 1 0	L	–
1 0 1	ONE 8ve BELOW TOP	–
1 0 0	ONE 8ve BELOW 4th L	–
0 1 1	ONE 8ve BELOW 3rd L	–
0 1 0	ONE 8ve BELOW 2nd L	ONE 8ve BELOW L
0 0 1	ONE 8ve BELOW L	ONE 8ve BELOW TOP
0 0 0	NO CHANGE	NO CHANGE

EXTERN. MEMORY CODE 01	CHORD OUTPUT
1	L +2nd L +3rd L +4th L
0	NO CHANGE

"NO CHANGE" is interpreted as an instruction to sustain the previous notes until a new information is presented.

SEMIAUTOMATIC OPERATION WITHOUT MEMORIZATION OF THE KEYS

This method of operation is the same as the previous one except that the keys are not memorized.

CHARACTERISTICS COMMON TO ALL 3 MODES OF OPERATION

The signals from the keyboards, those from the external memory and those for selecting the mode of operation have to be multiplexed into the M 251 since the number of pins available is not enough. The method used to differentiate between the two distinct commands applied to the multiplexed input pins is as follows: two anti-phase pulse trains are generated internally from the highest note in the upper octave (pin 32). These two pulse trains are used to separate the input information during the "1" and "0" status of F24. With AUTOMATIC mode and EXTERNAL command selected the four frequencies of the highest octave can be made available at pins 2, 3, 4 and 5 as the 8 x tonic, 8 x major 3rd or 8 x minor 3rd, 8 x 5th or 8 x diminished 5th and 8 x 6th or 8 x 7th. Likewise in semiautomatic mode, the L x 8, 2nd x 8, 3rd x 8, 4th x 8 notes selected appear at the respective pins. These signals give the designer considerable flexibility in the formation of accompaniments not directly produced by the M 251 itself.

EXTERNAL MODE OUTPUTS

T1 is the key farthest to the left of the keyboard. For "L" see SEMIAUTOMATIC OPERATION WITH MEMORIZATION OF THE KEYS. In the external mode the four frequencies of the highest octave appear at pins 2, 3, 4 and 5 as shown in the table.

PIN N°	AUTOMATIC MODE	SEMI-AUTOM.
2	8 x TONIC	8 x L
3	8 x FIFTH DIMINISHED FIFTH	8 x 3rd L
4	8 x MAJOR THIRD OR MINOR THIRD	8 x 2nd L
5	8 x SIXTH OR SEVENTH	8 x 4th L

STATIC ELECTRICAL CHARACTERISTICS (positive logic, V_{GG}= -11 to -13V, V_{SS}= 4.75 to 5.25V, T_{amb}= 0 to 70°C unless otherwise specified)

Parameter		Test conditions		Min.	Typ.	Max.	Unit
INPUT SIGNALS							
V_{IH}	Input high voltage	note 1		V_{SS}-2.5		V_{SS}	V
		note 2		V_{SS}-1		V_{SS}	V
V_{IL}	Input low voltage	note 1		V_{GG}		V_{SS}-6	V
		note 2		V_{GG}		V_{SS}-4	V
I_{LI}	Input leakage current	V_i=V_{SS}-14V	T_{amb}= 25°C			10	μA

STATIC ELECTRICAL CHARACTERISTICS (continued)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
OUTPUT SIGNALS*						
R_{ON}	Output resistance	V_o=V_{SS}-1 to V_{SS}		300	500	Ω
V_{OH}	Output high voltage	I_o = 1 mA	V_{SS}-0.5		V_{SS}	V
$I_{o(off)}$	Output leakage current	$V_i = V_{IH}$ V_o=V_{SS}-10V T_{amb}= 25°C			10	µA
POWER DISSIPATION						
I_{GG}	Supply current	T_{amb}= 25°C		20	30	mA
CHORD OUTPUT SIGNAL						
ΔV_o	Variation in output voltage (for each note)	R_L = 5 kΩ	1	1.5	2	V
R_L	External resistance connected between the output and V_{GG}				5	kΩ
R_O	Output dynamic resistance		10			MΩ
V_O	Output voltage when no note is present	R_L = 5 kΩ	V_{GG}+8		V_{GG}	V

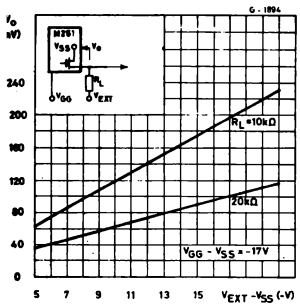
Note 1: Refers only to the F13 - F24 inputs
Note 2: Refers to the other inputs
* With the exception of the chord output

DYNAMIC ELECTRICAL CHARACTERISTICS (positive logic V_{GG}= -11 to -13V, V_{SS}= 4.75 to 5.25V, T_{amb}= 0 to 70°C unless otherwise specified)

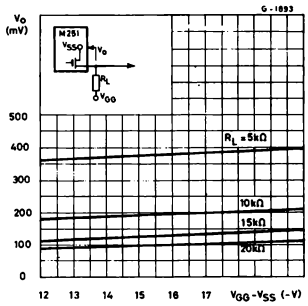
Parameter		Min.	Typ.	Max.	Unit
f_i	High input frequency (F 24)	1	4	12	kHz
t_1	Delay time of the internal phases	0.5	0.7	1	µs
t_2	Length of the internal phases	3	6	15	µs
t_3	Set-up time between data IN and F24	10		T/4	µs
t_4	Hold time between F24 and data IN	30		T/4	µs
t_5	Delay time between falling edge of external memory code and TDA or TDB	1.5T		2.5T	µs
t_6	Delay time of the internal strobe pulse	T		2T	µs
t_7	Length of the internal strobe pulse		T/2		µs
T_1	Period of external code pulses	3T			µs
T_2	Return to zero or no significant external code	2T			µs

T is the period of F24 with duty-cycle of 50%
All the times are measured at 50% of the swing

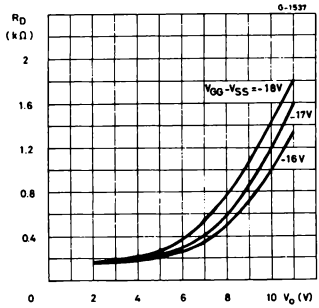
*Output voltage vs. external supply voltage (V_{EXT}-V_{SS})



*Output voltage vs. supply voltage (V_{GG}-V_{SS})



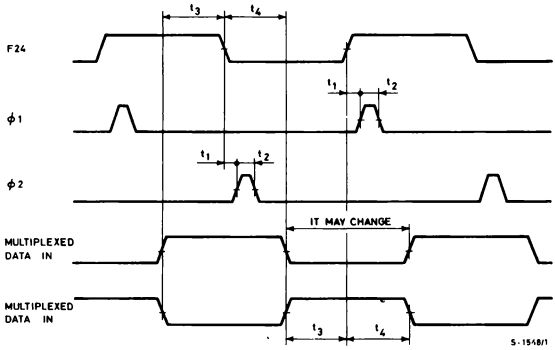
*Output dynamic resistance vs. output voltage



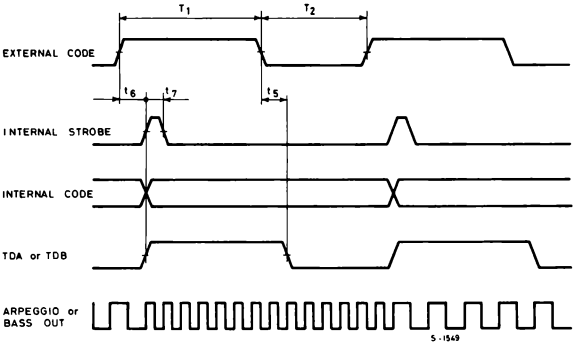
* With the exception of the chord output

TIMING WAVEFORMS (positive logic)

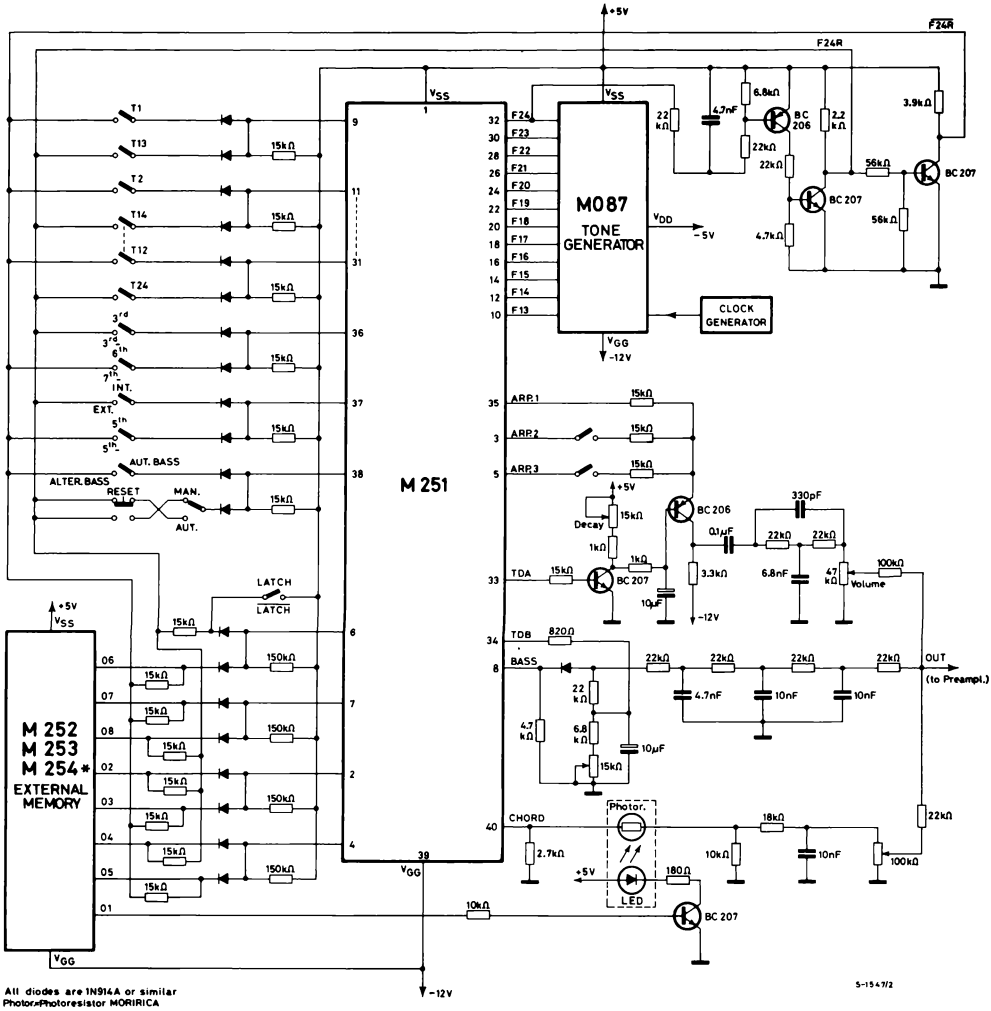
Internal phases (ϕ 1 and ϕ 2) and timing for data inputs



Internal strobe, internal code and TDA or TDB as a function of the external code



TYPICAL APPLICATION



* For this application a version of the M 254 with standard memory content is available both for interfacing with the M 251 and for driving 4 instrument simulators (8 rhythms). Ordering number is M 254 AD.