Tunes Synthesizer

FEATURES

- 25 Different Tunes Plus 3 Chimes
- Mask Programmable with Customer Specified Tunes for Toys, Musical Boxes, etc.
- Minimal External Components
- Automatic Switch-Off Signal at End of Tune for Power Savings
- Envelope Control to Give Organ or Piano Quality
- Sequential Tune Mode
- 4 Door Capability When Used as Doorchime
- Operation with Tunes in External PROM if Required
- Single Supply (+5V) Operation

DESCRIPTION

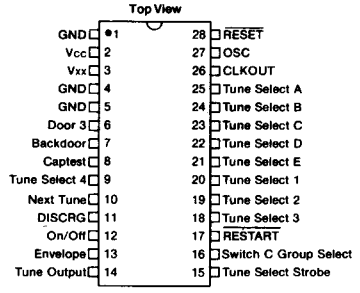
The AY-3-1350 is an N-Channel MOS microcomputer based synthesizer of pre-programmed tunes for applications in toys, musical boxes, and doorchimes. The standard device has a set of 25 different popular and classical tunes chosen for their international acceptance. In addition there are 3 chimes making a total of 28 tunes.

The chip is mask-programmable during manufacture enabling the quantity user to select his own music. Up to 28 tunes of varying length can be chosen.

The device has multi-mode operation making it suitable for a wide variety of applications.

PIN CONFIGURATION

28 LEAD DUAL IN LINE



TUNES

The standard AY-3-1350 contains the following tunes:

A0 Toreador
B0 William Tell
C0 Hallelujah Chorus
D0 Star Spangled Banner
E0 Yankee Doodle

A1 John Brown's Body
B1 Clementine
C1 God Save the Queen
D1 Colonel Bogey
E1 Marseillaise

A2 America, America
B2 Deutschland Leid
C2 Wedding March
D2 Beethoven's 5th
E2 Augustine

A3 O Sole Mio
B3 Santa Lucia
C3 The End
D3 Blue Danube
E3 Brahms' Lullaby

A4 Hell's Bells
B4 Jingle Bells
C4 La Vie en Rose
D4 Star Wars
E4 Beethoven's 9th

Chime X Westminster Chime
Chime Y Simple Chime
Chime Z Descending Octave Chime

ELECTRICAL CHARACTERISTICS

Maximum Ratings*

Storage Temperature ..... −55°C to +150°C
Voltage on any pin with respect to ground (V_{SS}) ..... −0.3V to +10.0V

Standard Conditions (unless otherwise noted)

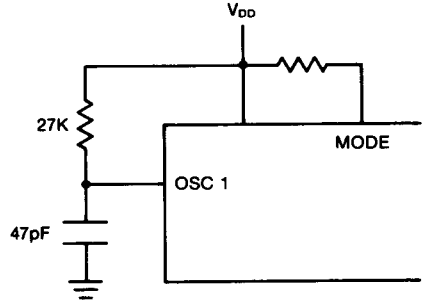
Operating Temperature (T_A) = 0°C to +70°C

*Exceeding these ratings could cause permanent damage to the device. This is a stress rating only and functional operation of this device at these conditions is not implied—operating ranges are specified in Standard Conditions. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Data labeled "typical" is presented for design guidance only and is not guaranteed.

Characteristics	Sym	Min	Max	Units	Conditions
DC CHARACTERISTICS					
Primary Supply Voltage	V_{DD}	4.5	7	V	
Output Buffer Supply Voltage	V_{XX}	4.5	9	V	
Primary Supply Current	I_{DD}	—	55	mA	No load
Output Buffer Supply Current	I_{XX}	—	5	mA	No load
Logic Input Low Voltage	V_{IL}	−0.2	0.8	V	
Logic Input High Voltage (Note 2) (Except $\overline{RESET}$ and OSC when driven externally)	V_{IH_1}	2.4	V_{DD}	V	
Logic Input High Voltage ($\overline{RESET}$ and OSC)	V_{IH_2}	4	V_{DD}	V	
Logic Output High Voltage (Note 2)	V_{OH}	2.4		V	I_{OH} = 100 μA
Logic Output Low Voltage	V_{OL}	—	0.45	V	I_{OL} = 1.6μA, V_{XX} = 4.5V
	—	—	0.90	V	I_{OL} = 5mA, V_{XX} = 9V
	—	—	0.50	V	I_{OL} = 5mA, V_{XX} = 9V
	—	—	0.90	V	I_{OL} = 10mA, V_{XX} = 9V (Note 1)
AC CHARACTERISTICS					
Oscillator frequency variation for a fixed RC network	Δf	−20%	+20%		@ CLK OUT 167KHz (Note 3)
CLK OUT Output					
Period	t_{CY}	4	20	μs	
High Pulse Width	t_{CLKH}	¼ t_{CY}			
Low Pulse Width	t_{CLKC}	¾ t_{CY}			

NOTES: 1. Total I_{OL} for all registers must be less than 150mA under any conditions.
2. Except following pins which have open drain outputs/inputs: 6, 7, 8, 12 and 13.
3. Test circuit:



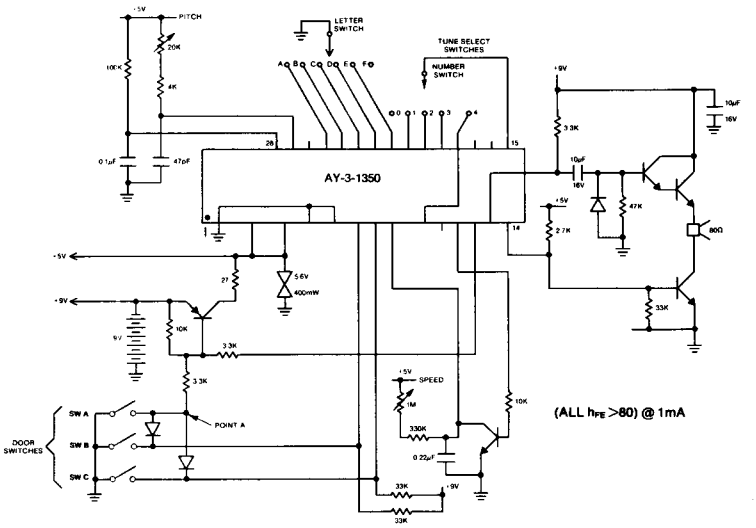


Fig. 1 SYSTEM DIAGRAM

OPERATION SUMMARY

Use of the AY-3-1350 can be split into three groups which are described in detail in separate sections:

ONE CHIP AY-3-1350 system generating 25 tunes plus 3 chimes which have been pre-programmed into the standard device.

ONE CHIP AY-3-1350 system generating any number of tunes desired. This involves mask programming during manufacture and is usually not suitable for small quantity production.

TWO CHIP AY-3-1350 plus PROM system generating any tunes desired as above, but using the standard device so that applications, including small quantities, become feasible. (CMOS gate also required.)

ONE CHIP STANDARD AY-3-1350 SYSTEM

Typical Implementation

There are many ways to connect the standard device depending on the exact application. Figure 1 shows just one implementation of the device in a doorchime. This circuit gives access to all 25 tunes from switch A and one of 5 tunes from switch C as well as the descending active chime from switch B. The tune selected for switch B follows the tunes list according to the setting of the two tune select switches (A—E and 0—4). The tune selected from switch C in Figure 1 is one of the five tunes A0 through E0 depending on the setting of the letter switch. For example, with the letter switch set at E and the number switch set at 4, the tunes available will be:

Switch A: Beethoven's 9th (E4)
Switch C: Yankee Doodle (E0)
Switch B: Descending Octave Chime (Chime Z)

When the letter switch is in position F there will be chimes on all doors independent of the number switch setting as follows:

Switch A: Westminster Chime
Switch C: Simple Chime
Switch B: Descending Octave Chime

There is virtually no power consumption in the standby condition (external transistor leakages only). When any door switch is activated the circuit powers up, plays a tune, and then automatically powers down again to conserve the battery, even if the operator keeps his finger on the switch to the end of the tune. He must release it and re-press to play again with the circuit in Figure 1. Activating any of the door switches will pull point A to ground turning on the PNP transistor in the power supply line. This causes +5V to be applied to the AY-3-1350 and the first operation of the chip is to put ON/OFF (pin 12) to logic 0. This maintains the power through the PNP, even after the switch is released. The device can turn off its own power at the end of a tune by raising ON/OFF to logic 1.

Figure 1 shows only a typical one-chip implementation. Further options come from use of different switching and/or from use of the next tune facilities built into the chip. These will now be considered in turn.

Switching Options

In Figure 1 the Switch C Group Select pin (16) is not connected, and one of the five tunes (A0 through E0) will play if switch C is activated. Other number groups can be chosen by connecting the Switch C Group Select pin as follows:

TABLE 2

Switch C Group Select pin (16) is connected to:	Switch C Tunes
no other pin	A0—E0
Tune Select 1 (pin 20)	A1—E1
Tune Select 2 (pin 19)	A2—E2
Tune Select 3 (pin 18)	A3—E3
Tune Select 4 (pin 9)	A4—E4

Which of the five possible switch C tunes will be played depends on the current setting of the LETTER SWITCH A—E.

Switch C selection can be made by hard-wire connection for a permanent selection or a third switch can be added for an additional group selection feature.

LED Direct Drive

Vxx drives the gate of the output buffer, allowing adjustment of drive capability:

Vxx	VOUT	ISINK (typ.)
5V	0.4V	2.5mA
5V	0.7V	4.2mA
10V	0.4V	5.8mA
10V	0.7V	10.0mA
10V	1.0V	14.1mA

AUDIO

Using the power-up circuit of Figure 1, the AY-3-1350 will have +5V applied and be latched within a few microseconds (dependant upon external components) from any bell-push closing. The device starts to operate when the RESET pin reaches logic 1 (about 10ms with components shown) but in fact the tune select switches are not interrogated until approximately 6ms later. The total is sufficient for most bell-pushes to complete any bounce period and for a firm selection of tunes to be made.

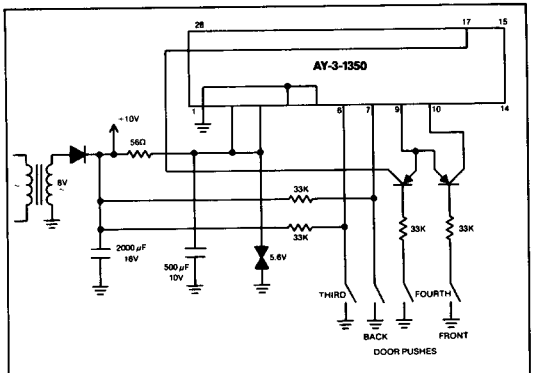
Next Tune Facilities

At the end of tune play the circuit of Figure 1 powers down because ON/OFF (pin 12) is raised to a logic 1. This simplified flow diagram in Figure 3 shows that before the power down there is a test for connection between NEXT TUNE (pin 10) then RESTART (pin 17) with TUNESELECT 4 (pin 9). At this time NEXT TUNE (pin 10) then RESTART (pin 17), which are normally at logic 1, output a logic 0. This is looked for at input TUNESELECT 4 (pin 9). If neither is found the power down system is reached as in Figure 1.

A NEXT TUNE (pin 10)—TUNE SELECT 4 (pin 9) connection at the moment of test causes the next tune in the list to be played after a short pause (equal to a musical breve—the actual time depends on the setting of the tune speed control). The order of the tunes is A0 to E4 as given in the listing of standard AY-3-1350 tunes. If the last tune (E4) was played then the circuit will go on to play the first tune A0 (and then successive ones). The chimes are not included in the cycling sequence.

A RESTART (pin 17)—TUNESELECT 4 (pin 9) connection at the moment of test at the end of a tune causes the same selected tune to be played again. Figure 3 shows that in this case the tune sensing mechanism is passed through once more so the tune would be different the second time if the switches were altered while the first tune was playing.

The connections referred to cannot be permanent because otherwise the circuit would never stop playing tunes. Figure 2 shows how transistors are used to make the connection in a practical application.



PIN	FUNCTION
6	DOOR 3
7	BACKDOOR
9	TUNESELECT 4
10	NEXT TUNE
17	RESTART

Fig. 2

ONE CHIP CUSTOM TUNES SYSTEM

Customizing the Tunes

The AY-3-1350 has pre-programmed tunes, but the device is mask programmable during manufacture with any music required. A minimum of 1 tune to a maximum of 28 tunes can be incorporated. Examples as follows:

Tunes	Total No. of notes, all tunes together	Average notes per tune
1	252	252
2	251	126
5	248	50
10	243	24
20	233	12
25	228	9

(The general formula is Total No. of notes = 253—No. of tunes.)

As an indication, about 90 seconds of music can be incorporated

All musical rests are counted as one note. Semiquavers, quavers, dotted quavers, crotchets, dotted crotchets, minims, dotted minims and semibreves can all be accommodated. The range is about 2½ octaves. The position of these octaves can be chosen by the user up to a maximum pitch of A = 1760Hz. The tunes for incorporation in the device should be presented to General Instrument as normal music manuscript.

Applications for Customized Tunes

If the number of tunes is less than the number of switch positions then the circuit will automatically proceed directly to power down if this mode is being used, or will find the next available tune if in the sequential mode.

All the different facilities described are still available when user tunes are masked into the device.

For toys, sequential tune playing adds variety and reduces the number of switches required, keeping costs to a minimum.

For musical boxes, playing the same tune repeatedly preserves the traditional features.

TWO CHIP STANDARD AY-3-1350 PLUS PROM SYSTEM

Introduction

With the addition of an external ROM or PROM the standard AY-3-1350 will play almost any tune or tunes desired. 28 tunes averaging 8 notes each or one tune of up to 252 notes is available. General Instrument can later integrate the external tunes into the main synthesizer to give a one chip system.

Overall Coding Scheme

The external PROM should be 256 x 8 bits and of any static TTL compatible type.

It can have more words, but the tunes synthesizer will only use 256 x 8 bits at a time, e.g. if PROM type 2708 is used (1K x 8 bits), the two higher order address lines should be connected to ground or switches put on them to give 4 times the amount of music (see logic diagram Figure 4). The rest of this article will assume a 256 x 8 bit PROM, and the addresses will be referred to as 000 to 377. Octal notation is used throughout.

The PROM address 000 must contain data 377 and address 377 must contain data 125 which is a key to open up the external PROM features. All other addresses can contain tune data.

Each tune consists of a series of notes with one byte of PROM for each. Every tune must have a tune end marker byte 377 after the last note, and the final tune must have a byte 376 after the 377 end marker. The memory allocation is shown diagrammatically in Figure 5. Tunes can be of any length and there can be any number of them subject only to the memory limit (28 max.).

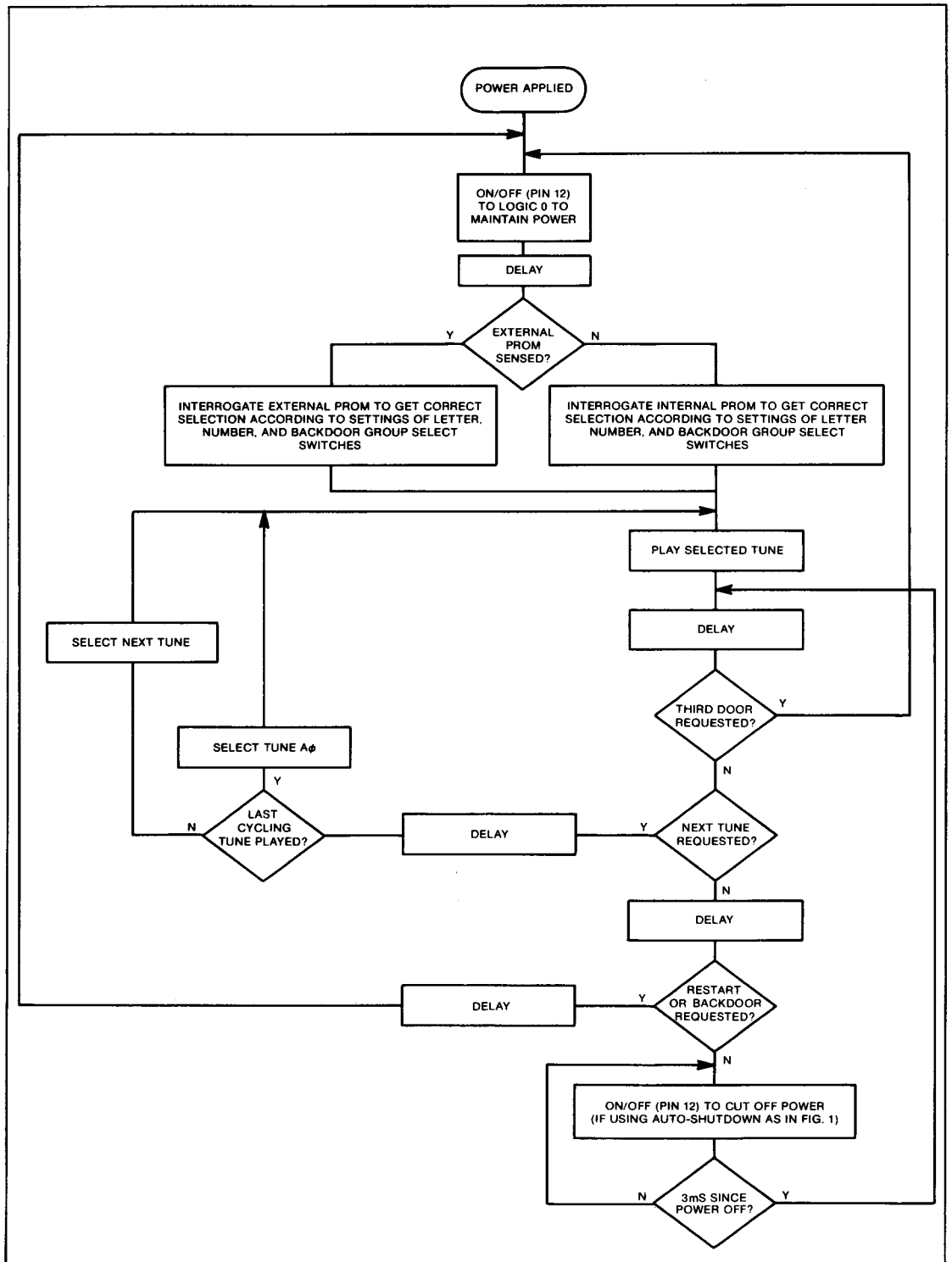


Fig. 3 SIMPLIFIED FLOW DIAGRAM

PROM Memory Allocation

Address	DATA	
0	377	(tunes select timeslot)
		Tune 1
	377	(end of tune marker)
		Tune 2
	377	(end of tune marker)
		More tunes
		Last Tune
	377	(end of tune marker)
	376	(end of listing)
	000	
	000	Not used
	000	
	000	
377	125	(external ROM enable key)

Fig. 4

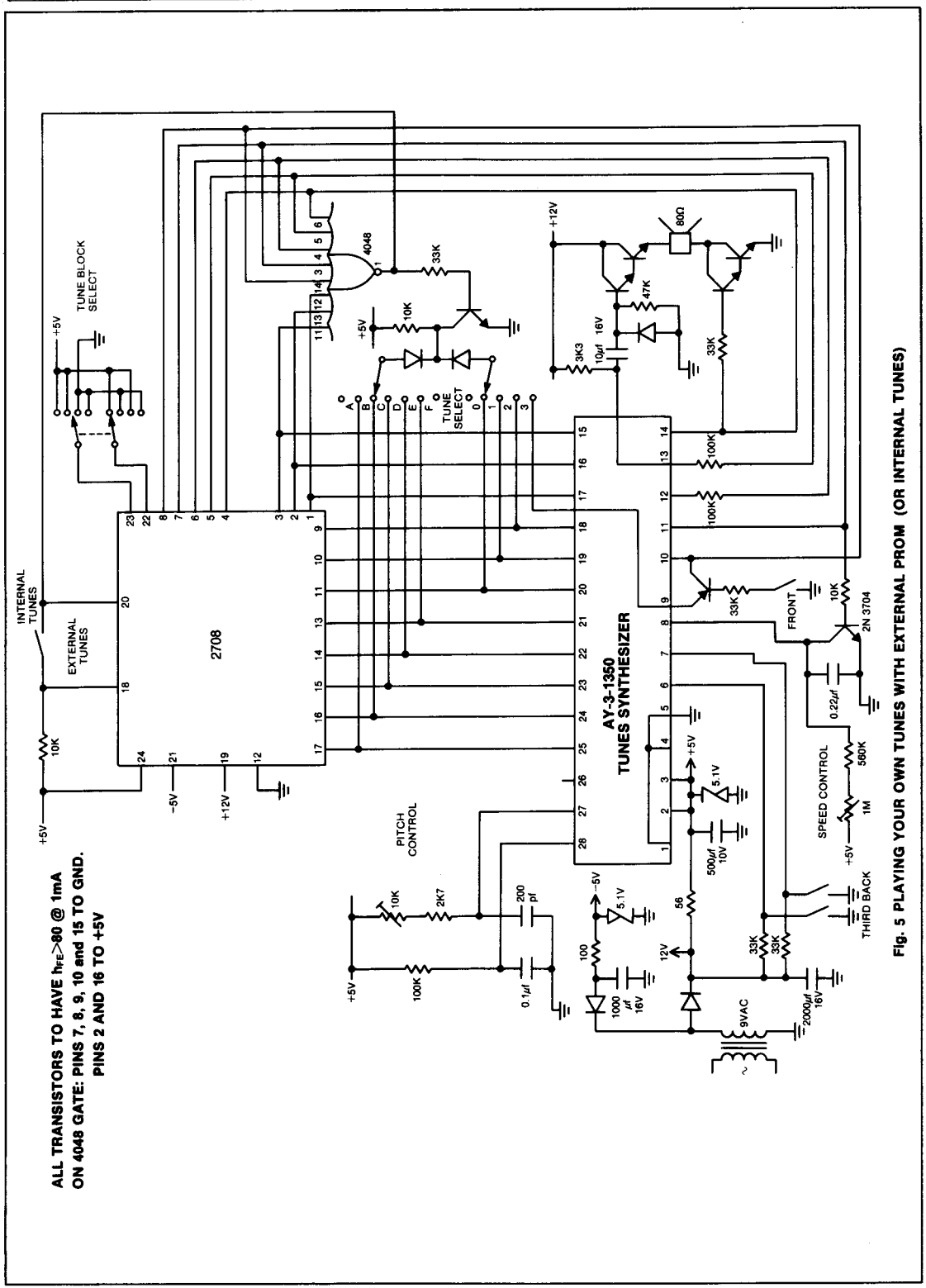


Fig. 5 PLAYING YOUR OWN TUNES WITH EXTERNAL PROM (OR INTERNAL TUNES)