5.5 Applications

While many applications of the PSG in music generation are apparent, for instance in the area of toys and games, other applications are possible even in the area of high accuracy sophisticated musical instruments such as high-end electronic organs. With tone frequencies generated from another source to meet the exacting requirements of organ operation, the PSG can be used as a complex envelope generator. The PSG is also effective for generating bass notes and rhythms with percussion instruments, taking advantage of the PSG's high accuracy in producing low frequency notes. The following paragraphs detail examples of these applications.

5.5.1 ORGAN ENVELOPE GENERATION

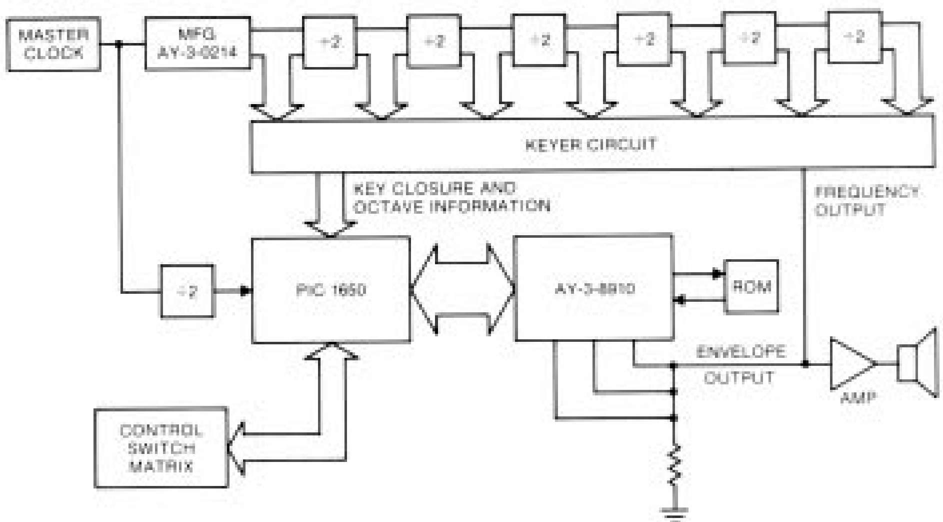
The envelope generation diagram shown in Fig. 25 illustrates how an AY-3-8910 can be configured to produce envelopes for organ voicing. All functions are controlled by a microcomputer.

The basis of this system consists of a master frequency generator with a string of dividers. This produces all frequencies for the keyboard. The microcomputer and the AY-3-8910 are actually used to replace the usual components of voicing filters that would ordinarily be used in an electronic organ.

The microcomputer shown is a GI PIC 1650 controlled by inputs from the keyboard keyer circuit and a control switch matrix. The keyer inputs octave and key closure information to develop the envelope amplitude and duration for the note to be played. The control switch matrix can be used to control sustain and add other special effects. The ROM shown connected to the AY-3-8910 is optional depending on the amount of data necessary for the microcomputer.

The system shown here may also consist of multiple AY-3-8910's, all controlled by a single microcomputer. It represents an economical solution to developing voicing control with a minimum of components.

Fig. 25 ORGAN ENVELOPE GENERATION



5.5 Applications (cont.)

5.5.2 ORGAN RHYTHM GENERATION

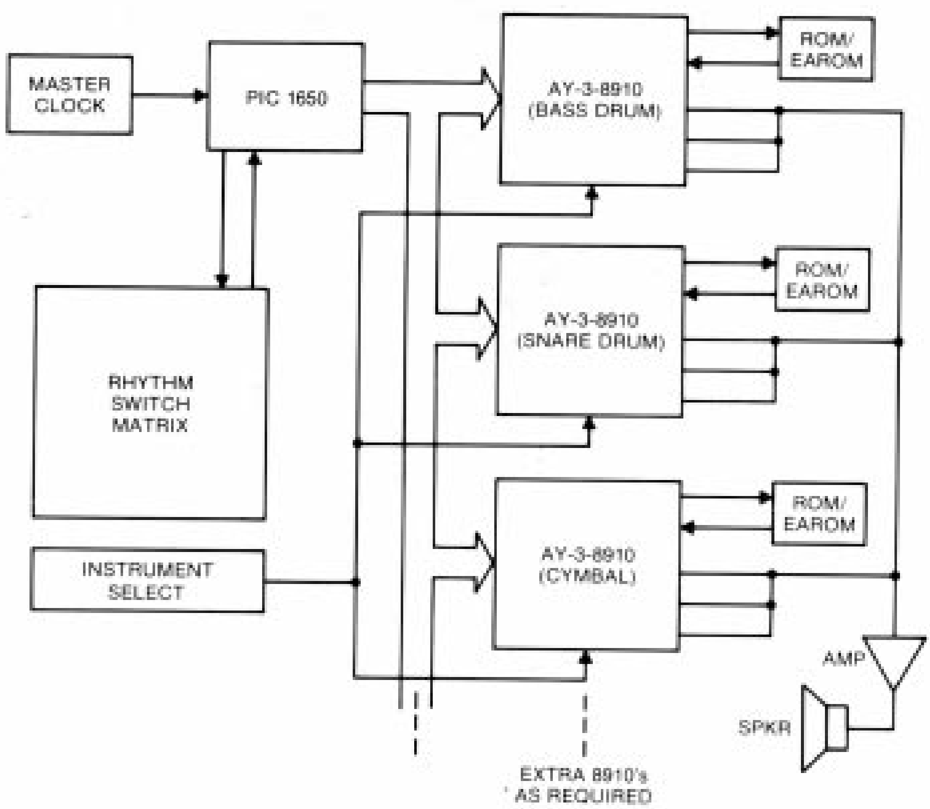
The rhythm generation diagram (Fig. 26) illustrates a simplified version of how a microcomputer can be implemented with the AY-3-8910 to provide a percussion instrument section for an electronic organ.

The microcomputer used in this case could be a GI PIC 1650 which can be internally programmed to drive a series of AY-3-8910's, all hardwired to an I/O port of the PIC. Each AY-3-8910 provides a separate output envelope and frequency of the instrument it is to synthesize.

The Rhythm Switch Matrix is used to select any preprogrammed rhythm pattern and tempo from the PIC. The Instrument Select switches allow manual in/out selection of the 8910's via the A8 and A9 address lines providing additional instrument sound variations. These switches are intended to be user-selected and mounted in a convenient position on the instrument.

In addition, optional ROMs could be added to the PSG I/O ports, saving microcomputer ports, to provide extra rhythm length or number of patterns. These ROMs could also be replaced by EAROMs to provide user rhythm programming from a modified Rhythm Switch Matrix. The programmable rhythm feature could be used to add new or original user rhythms to update the instrument.

Fig. 26 ORGAN RHYTHM GENERATION



6 SOUND EFFECTS GENERATION

One of the main uses of the PSG is to produce non-musical sound effects to accompany visual action or as a feature in itself. The following sections outline techniques and provide actual examples of some popular effects. All examples are based on a 1.78977MHz PSG clock.

6.1 Tone Only Effects

Many effects are possible using only the tone generation capability of the PSG without adding noise and without using the PSG's envelope generation capability. Examples of this type of effect would include telephone tone frequencies (two distinct frequencies produced simultaneously) or the European Siren effect listed in Fig. 27 (two distinct frequencies sequentially produced).

Fig. 27 EUROPEAN SIREN SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R0	376	Set Channel A Tone period to 2.27ms
R1	000	(440Hz).
R7	076	Enable Tone only on Channel A only.
R10	017	Select maximum amplitude on Channel A.
(Wait approximately 350ms before continuing)		
R0	126	Set Channel A Tone period to 5.346ms
R1	001	(187Hz).
(Wait approximately 350ms before continuing)		
R10	000	Turn off Channel A to end sound effect.

6.2 Noise Only Effects

Some of the more commonly required sounds require only the use of noise and the envelope generator (or processor control of channel envelope if other channels are using the envelope generator).

Examples of this, which can be seen in Figs. 28 and 29, are gunshot and explosion. In both cases pure noise is used with a decaying envelope. In the examples shown the only changes are in the length of the envelope as modified by the coarse tune register and in the noise period. Note that a significantly lower explosion can be obtained by using all three channels operating with the same parameters.

Fig. 28 GUNSHOT SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R6	017	Set Noise period to mid-value.
R7	007	Enable Noise only on Channels A,B,C.
R10	020	Select full amplitude range under direct control of Envelope Generator.
R11	020	
R12	020	
R14	020	Set Envelope period to 0.586 seconds.
R15	000	Select Envelope "decay", one cycle only.

Fig. 29 EXPLOSION SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R6	000	Set Noise period to max. value.
R7	007	Enable Noise only, on Channels A,B,C.
R10	020	Select full amplitude range under direct control of Envelope Generator.
R11	020	
R12	020	
R14	070	Set Envelope period to 2.05 seconds.
R15	000	Select Envelope "decay", one cycle only.

6.3 Frequency Sweep Effects

The Laser, Whistling Bomb, Wolf Whistle, and Race Car sounds in Figs. 30 thru 33 all utilize frequency sweeping effects. In all cases they involve the increasing or decreasing of the values in the tone period registers with variable start, end, and time between frequency changes. For example, the sweep speed of the Laser is much more rapid than the high gear accelerate in the race car, yet both use the same computer routine with differing parameters.

Other easily achievable results include "doppler" and noise sweep effects. The sweeping of the noise clocking register (R6) produces a "doppler" effect which seems well suited for "space war" type games.

Fig. 30 LASER SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R7	076	Enable Tone only on Channel A only.
R10	017	Select maximum amplitude on Channel A.
R0 R0	060 (start) 160 (end)	Sweep effect for Channel A Tone period via a processor loop with approximately 3ms wait time between each step from 060 to 160 (0.429ms/2330Hz to 1.0ms/1000Hz).
R10	000	Turn off Channel A to end sound effect.

Fig. 31 WHISTLING BOMB SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R7	076	Enable Tone only on Channel A only.
R10	017	Select maximum amplitude on Channel A.
R0 R0	060 (start) 300 (end)	Sweep effect for Channel A Tone period via a processor loop with approximately 25ms wait time between each step from 060 to 300 (0.429ms/2330Hz to 1.72ms/582Hz).

After above loop is completed, follow with sequence in Fig. 28.

6.4 Multi-Channel Effects

Because of the independent architecture of the PSG, many rather complex effects are possible without burdening the processor. For example, the Wolf Whistle effect in Fig. 32 shows two channels in use to add constant breath hissing noise to the three concentrated frequency sweeps of the whistle. Once the noise is put on the channel, the processor only need be concerned with the frequency sweep operation.

Fig. 32 WOLF WHISTLE SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R6	001	Set Noise period to minimum value.
R7	056	Enable Tone on Channel A, Noise on Channel B.
R10	017	Select maximum amplitude on Channel A.
R11	011	Select lower amplitude on Channel B.
R0 R0	100 (start) 040 (end)	Sweep effect for Channel A Tone period via a processor loop with approximately 12ms wait time between each step from 100 to 040 (0.572ms/1748Hz to 0.286ms/3496Hz).
	(Wait approximately 150ms before continuing)	
R0 R0	100 (start) 060 (end)	A processor loop with approximately 25ms wait time between each step from 100 to 060 (0.572ms/1748Hz to 0.429ms/2331Hz).
R0 R0	060 (start) 150 (end)	A processor loop with approximately 6ms wait time between each step from 060 to 150 (0.429ms/2331Hz to 0.930ms/1075Hz).
R10 R11	000 000	Turn off Channels A and B to end effect.

Fig. 33 RACE CAR SOUND EFFECT CHART

Register #	Octal Load Value	Explanation
Any not specified	000	—
R3	017	Set Channel B Tone period to 34.33ms (29Hz).
R7	074	Enable Tones only on Channels A and B.
R10	017	Select maximum amplitude on Channel A.
R11	012	Select lower amplitude on Channel B.
*R1/R0 *R1/R0	013/000 (start) 004/000 (end)	Sweep effect for Channel A Tone period via a processor loop with approximately 3ms wait time between each step from 013/000 to 004/000 (25.17ms/39.7Hz to 9.15ms/109.3Hz).
R1/R0 R1/R0	011/000 (start) 003/000 (end)	A processor loop with approximately 3ms wait time between each step from 011/000 to 003/000 (20.6ms/48.5Hz to 6.87ms/145.6Hz).
R1/R0 R1/R0	006/000 (start) 001/000 (end)	A processor loop with approximately 6ms wait time between each step from 006/000 to 001/000 (13.73ms/72.8Hz to 2.29ms/436.7Hz).
R10 R11	000 000	Turn off Channels A and B to end effect.

*Decrement R1/R0 as a whole number, e.g. start at 013/000, then 012/377, then 012/376, etc.

7 ELECTRICAL SPECIFICATIONS

7.1 Maximum Ratings

Storage Temperature .... −55° C to +150° C
Operating Temperature .... 0° C to +40° C
V_{CC} and all other input and output
voltages with respect to V_{SS} .... −0.3V to +8.0V

Exceeding these ratings could cause permanent damage to these devices. Functional operation at these conditions is not implied—operating conditions are specified below.

7.2 Standard Conditions

V_{CC} = +5V ±5%
V_{SS} = GND
Operating temperature: 0° C to +40° C

7.3 DC Characteristics

Characteristic	Sym	Min.	Typ.*	Max.	Units	Conditions
All Inputs						
Logic "0"	V_{IL}	0	—	0.6	V	
Logic "1"	V_{IH}	2.4	—	V_{CC}	V	
All Outputs (except Analog Channel Outputs)						
Logic "0"	V_{OL}	0	—	0.5	V	I_{OL}=1.6 mA, 20pF
Logic "1"	V_{OH}	2.4	—	V_{CC}	V	I_{OH}=100μA, 20pF
Analog Channel Outputs	V_0	0	—	60	dB	Test circuit: Fig. 34
Power Supply Current	I_{CC}	—	45	75	mA	

*Typical values are at +25° C and nominal voltages.

Fig. 34 ANALOG CHANNEL OUTPUT TEST CIRCUIT

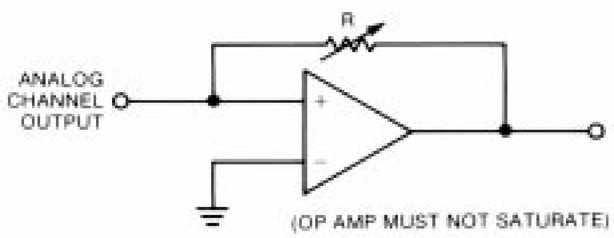
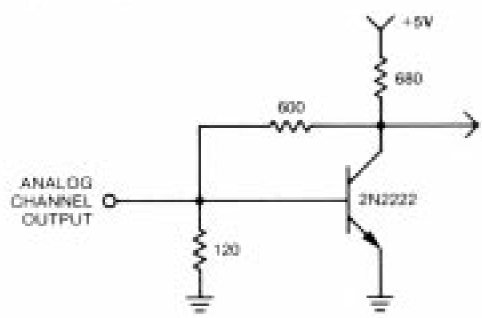


Fig. 35 CURRENT TO VOLTAGE CONVERTER



7.4 AC Characteristics

Characteristic	Sym	Min.	Typ.*	Max.	Units	Conditions
Clock Input						
Frequency	f_C	1.0	—	2.0	MHz	Fig. 36
Rise time	t_r	—	—	50	ns	Fig. 36
Fall time	t_f	—	—	50	ns	Fig. 36
Duty Cycle	—	25	50	75	%	Fig. 36
Bus Signals (BDIR, BC2, BC1)						
Associative Delay Time	t_{BD}	—	—	50	ns	Fig. 36
$\overline{\text{Reset}}$						
$\overline{\text{Reset}}$ Pulse Width	t_{RW}	500	—	—	ns	Fig. 37
$\overline{\text{Reset}}$ to Bus Control Delay Time	t_{RB}	100	—	—	ns	Fig. 37
$\overline{\text{A9}}$, A8, DA7--DA0 (Address Mode)						
Address Setup Time	t_{AS}	400	—	—	ns	Fig. 38
Address Hold Time	t_{AH}	100	—	—	ns	Fig. 38
DA7--DA0 (Write Mode)						
Write Data Pulse Width	t_{DW}	500	—	10,000	ns	Fig. 39
Write Data Setup Time	t_{DS}	50	—	—	ns	Fig. 39
Write Data Hold Time	t_{DH}	100	—	—	ns	Fig. 39
DA7--DA0 (Read Mode)						
Read Data Access Time	t_{DA}	—	250	500	ns	Fig. 40
DA7--DA0 (Inactive Mode)						
Tristate Delay Time	t_{TS}	—	100	200	ns	Fig. 40

*Typical values are at 25°C and nominal voltages.

Fig. 36 CLOCK AND BUS SIGNAL TIMING

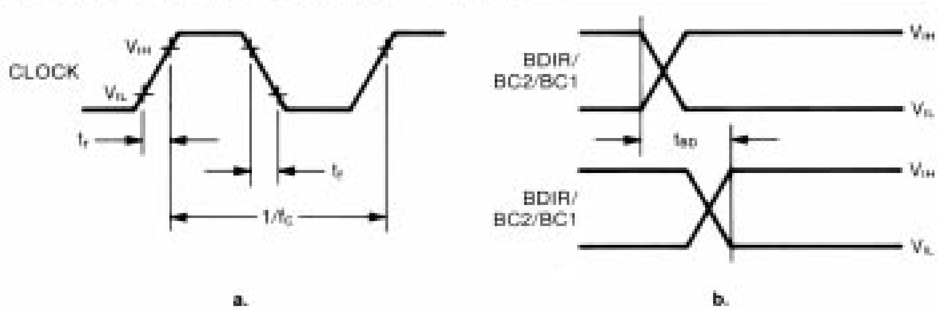


Fig. 37 RESET TIMING

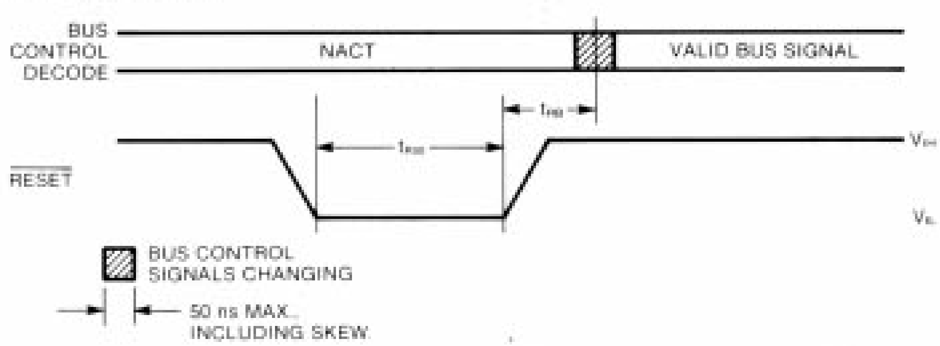
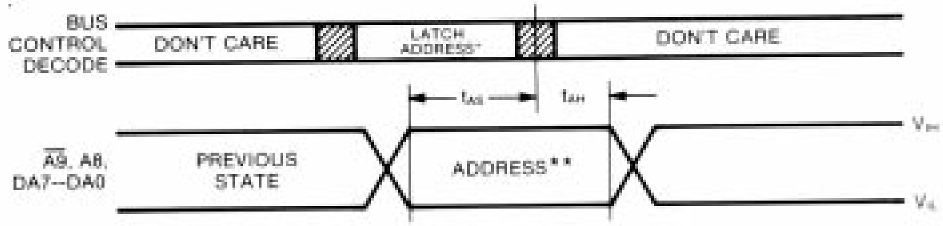


Fig. 38 LATCH ADDRESS TIMING



BUS CONTROL SIGNALS CHANGING

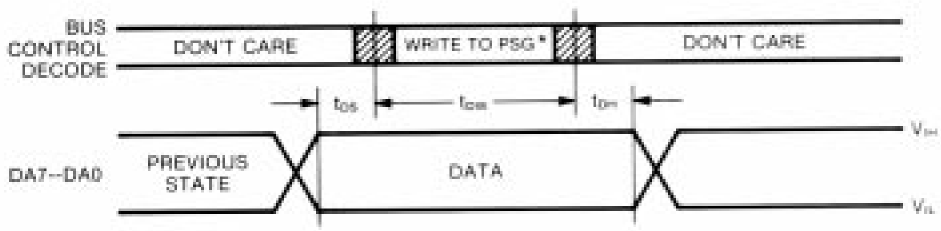
50 ns MAX., INCLUDING SKEW.

**REFER TO PARAGRAPH 2.1.1 FOR A DESCRIPTION OF "VALID" PSG ADDRESSING.

*ANY COMBINATION OF BDIR, BC2, BC1 WHICH DECODE "LATCH ADDRESS":

	BDIR	BC2	BC1
	0	0	1
or	1	0	0
or	1	1	1

Fig. 39 WRITE DATA TIMING



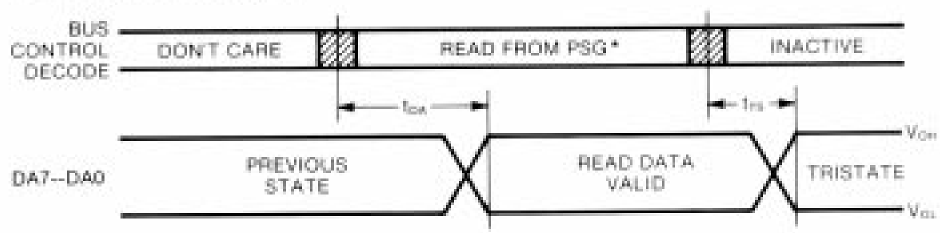
BUS CONTROL SIGNALS CHANGING

50 ns MAX., INCLUDING SKEW.

*"WRITE TO PSG":

BDIR	BC2	BC1
1	1	0

Fig. 40 READ DATA TIMING



BUS CONTROL SIGNALS CHANGING

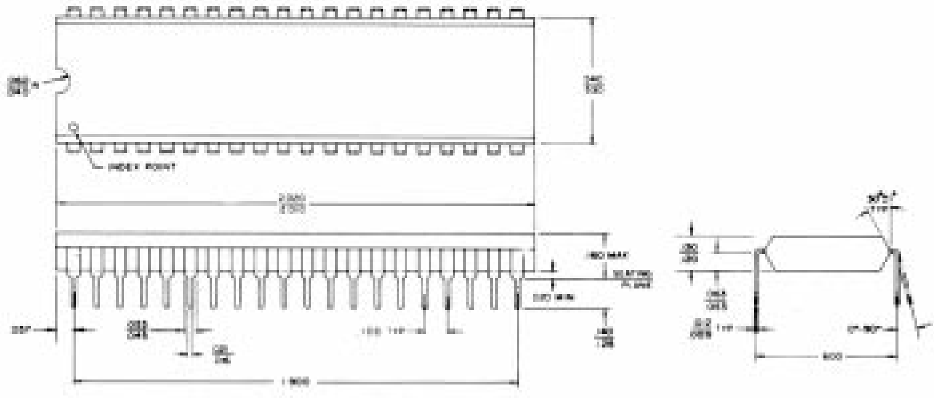
50 ns MAX., INCLUDING SKEW.

*"READ FROM PSG":

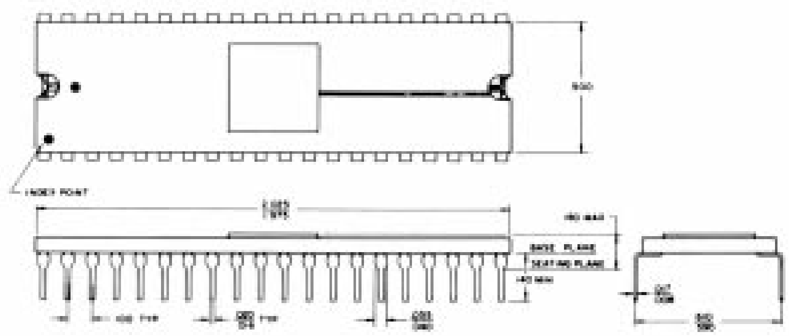
BDIR	BC2	BC1
0	1	1

7.5 Package Outlines

Fig. 41 40 LEAD DUAL IN LINE PACKAGES (for AY-3-8910)

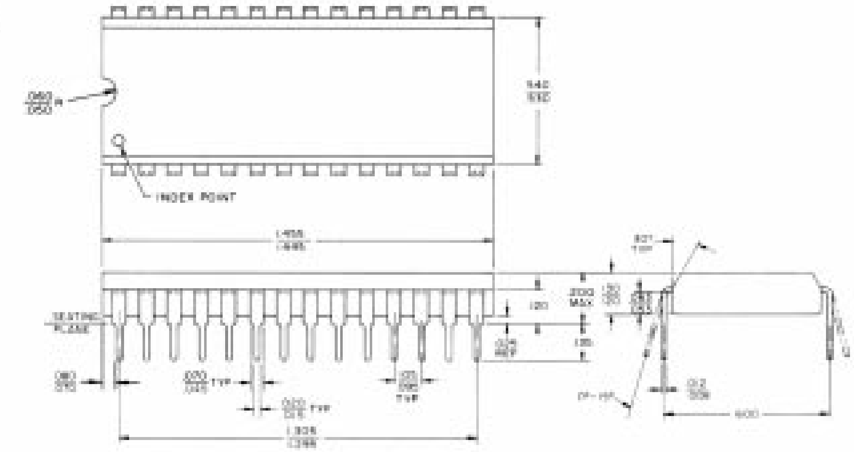


PLASTIC

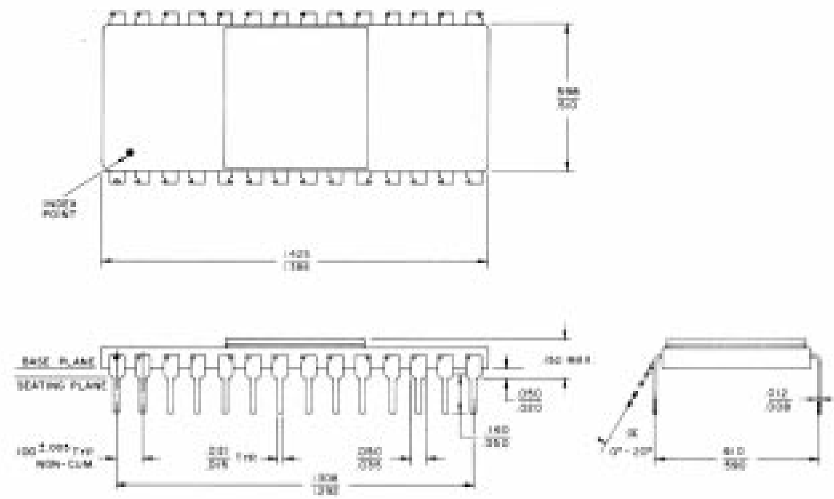


CERAMIC

Fig. 42 28 LEAD DUAL IN LINE PACKAGES (for AY-3-8912)



PLASTIC



CERAMIC