ESS Technology, Inc.

ES690/ES981 Wavetable & ROM Data Sheet

ES690 DESCRIPTION

The ES690 is a single, highly integrated, high-performance, and economical wavetable music synthesizer chip for personal computers, delivering superior acoustic sound comparable to expensive professional synthesizers. The ES690 includes chorus and reverb special effects without need of external RAM. With its embedded microcontroller, the ES690 supports a General MIDI instrument set, providing for 128 melodic instruments with the ability to play back 32 voices of 16-bit data at a sampling rate of 44.1 kHz. Music is produced in high fidelity with the realism of a live symphony orchestra.

The ES690 is used with the ES981 wavetable ROM chip to provide a complete wavetable solution. The ES981 provides digitally recorded sound samples of musical instruments, encoded in a ROM size of 512K x 16-bit.

The ES690 is designed to interface with the ES981 and with the ES1xxx ESS *Audio***Drive**® chips without requiring any glue logic or external DAC. The ES690 interfaces with the music DAC of the ES1xxx through the third serial port of the host chip, providing a cost-effective implementation of a complete wavetable music synthesizer.

Advanced power management features include suspend/ resume and automatic power-down when MIDI input is idle.

The ES690 is available in an industry-standard 52-pin Plastic Quad Flat Pack (PQFP) package.

Figure 1 shows the ES690 Wavetable Music Synthesizer in conjunction with an ES1xxx *Audio***Drive**® chip to create a complete PC audio solution.

ES690 FEATURES

- Single chip, high-performance wavetable music synthesizer
- Chorus and reverb special effects without external RAM
- Playback of 16-bit data at 44.1 kHz via the ES1xxx DAC
- Stereo pan for each voice
- 32-voice polyphony
- MIDI serial port compatible with MPU-401 serial port of the ES1xxx
- General MIDI instrument set – 128 melodic and 47 rhythm instruments
- Digital serial interface to the ES1xxx
- Glueless interface with the external wavetable ROM, 512K x 16-bit and with an ES1xxx *Audio***Drive**® chip
- Advanced power management with automatic power-down when MIDI input is idle
- Context upload/download for suspend/resume
- 52-pin PQFP package

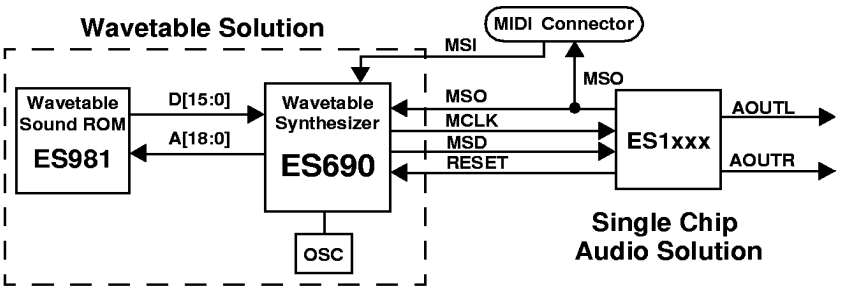


Figure 1 ES690 Wavetable Solution with ES1xxx

CONTENTS

FIGURES

TABLES

ES690 PINOUT

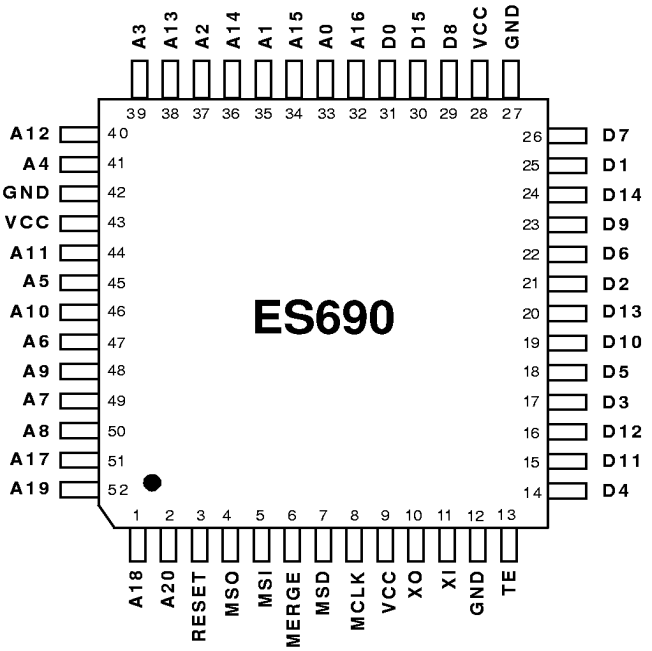


Figure 2 ES690 Pinout

ES690 PIN DESCRIPTION

Name	Number	I/O	Definition
A[20:0]	1, 2, 41:32, 52:44	I	External ROM address. (Word addresses).
RESET	3	I	Active-high reset input.
MSO	4	O	MIDI serial output for two-way connection to ES1xxx *Audio***Drive**® controller.
MSI	5	I	MIDI serial input from ES1xxx *Audio***Drive**® controller.
MERGE	6	I	Input with pull-up resistor. For one-way MIDI connection, this pin is left no-connect. For two-way MIDI connection, this pin is an external MIDI input. Normally, this pin is internally connected to the MSO pin.
MSD	7	O	Music serial data to the ES1xxx *Audio***Drive**® controller.
MCLK	8	O	Music serial clock to the ES1xxx *Audio***Drive**® controller.
VCC	9, 28, 43	I	Power supply voltage (4.5 to 5.5 V).
XO	10	O	Oscillator output. Connect to 33.000 MHz crystal.
XI	11	I	Oscillator input. Connect to 33.000 MHz crystal.
GND	12, 27, 42	I	Ground.
TE	13	O	Test pin (reserved). Connect to GND for proper operation.
D[15:0]	26:14, 31:29	O	External ROM data.

FUNCTIONAL DESCRIPTION

Figure 3 shows the internal architecture of the ES690 Wavetable Synthesizer, including audio and control signal inputs and outputs. MIDI commands are received by the chip's buffered MIDI Serial Port (MSI pin).

The General MIDI Interpreter functional block inspects each MIDI command passed to it by the MIDI Serial Port and transfers it to the next appropriate functional block, while also enabling the external wavetable ROM (ES981) through active-low chip enable output CEB. The Interpreter notifies the Synthesizer Control Unit which sound sample to access.

The Synthesizer Control Unit synchronizes the ES690's address signals (A[20:0]), locates the requested sound sample in the external wavetable ROM (refer to the ES981 information in this document), and informs the Synthesis Unit block that the sample will be transmitted through the Serial Port. The Synthesizer Control Unit can be programmed to transmit an ID string to the ES1xxx upon request from the *Audio***Drive**® controller.

Sound sample data is shifted out on MIDI Serial Data pin 7, under control of the Serial Port's Bit Clock output pin 8, for D/A conversion by the ES1xxx MIDI Serial Data input.

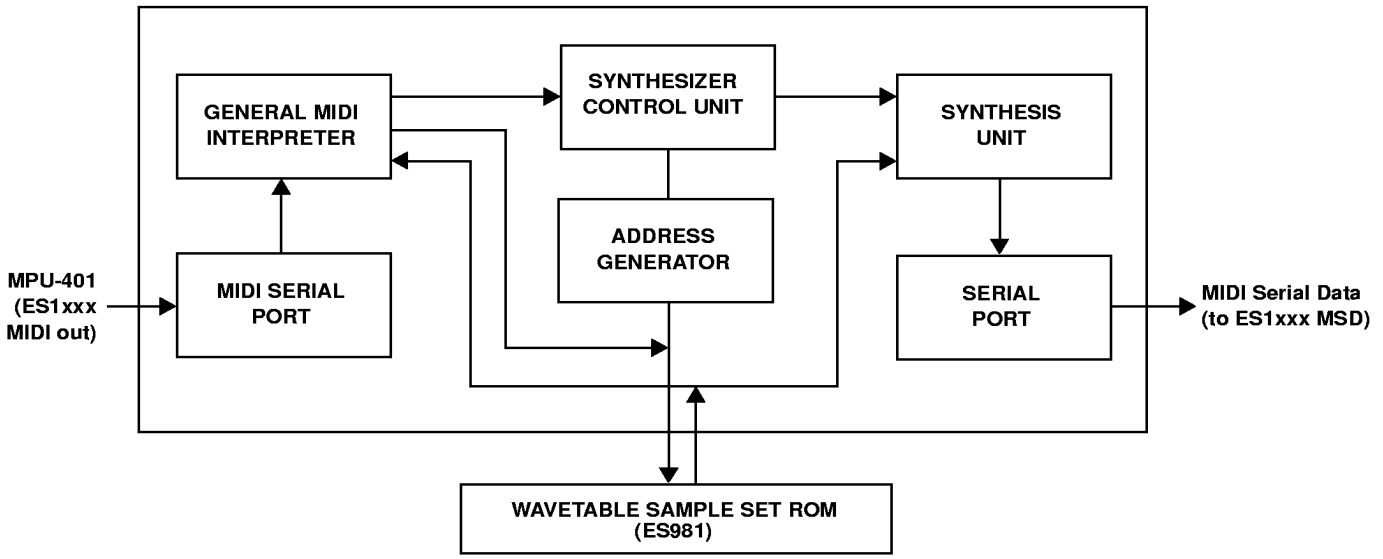


Figure 3 ES690 Block Diagram

MIDI IMPLEMENTATION

A proper MIDI implementation of the ES690 requires connections for receiving the MIDI MPU-401 standard set-up described below:

- MIDI Channels. 1 to 16 channels; Channel 10 is the percussion channel.
- Mode. Third mode: Omni Off and Poly.
- Number of Notes. 0 to 127 recognized, 12 to 108 True Voice.
- Velocity. Note ON.
- After-touch. Not available.
- Pitch Bend. Default range is ±2 semitones.
- Controller 1. Modulation controller.
- Controller 6. Data entry MSB.
- Controller 7. Channel volume.
- Controller 10. Pan (except drums).
- Controller 11. Expression.
- Controller 64. Hold pedal.
- Controllers 100, 101. RPN LSB, MSB.
- Controller 120. All sounds off.
- Controller 121. Reset all controllers.
- Controller 123. All notes off.
- Program Change. 0 to 127, or programs 1-128.
- System Exclusive. General MIDI on. Same as resetting all controllers.
- System Common. Not available.
- System Real Time. Not available.

A typical MIDI implementation is shown in Figure 1 on the first page. A connection scheme between the ES690 and ES1xxx *Audio***Drive**® controller is described later in this data sheet.

MIDI Implementation Chart

Table 1 ES690 MIDI Implementation Chart

Function		Transmitted	Received	Remarks
MIDI channels		No	1-16	Channel 10 is the percussion channel.
Mode		No	3	Omni off, poly
Note number	Recognized	No	0-127	
	True Voice	No	12-108	
Velocity	Note ON	No	Yes	
	Note OFF	No	No	
Aftertouch	Key	No	No	
	Channel	No	No	
Pitch bend		No	Yes	Default range: ±2 semitones
Controllers	1	No	Yes	Modulation controller
	6	No	Yes	Data entry MSB
	7	No	Yes	Channel volume
	10	No	Yes	Pan (except drums)
	11	No	Yes	Expression
	64	No	Yes	Hold pedal
	100,101	No	Yes	RPN LSB, MSB
	120	No	Yes	All sounds off
	121	No	Yes	Reset all controllers
	123	No	Yes	All notes off
Program change		No	0-127	Programs 1-128
System exclusive		No	General MIDI ON	Same as reset all controllers
System common		No	No	
System real time		No	No	

General MIDI Sound Set

The ES690's MIDI sound set is shown in Table 2, listed by instrument group and group program numbers.

Table 3 shows the complete sound set, by instrument and instrument program number, available using all channels except Channel 10, which is mapped out in Figure 4. Note that the transmitted program numbers 0 to 127 correspond to the MIDI standard 1 to 128.

Table 2 General MIDI Sound Set Groupings

Program Numbers	As Transmitted	Instrument Group
1 - 8	0 - 7	Piano
9 - 16	8 - 15	Chromatic Percussion
17 - 24	16 - 23	Organ
25 - 32	24 - 31	Guitar
33 - 40	32 - 39	Bass
41 - 48	40 - 47	Strings
49 - 56	46 - 55	Ensemble
57 - 64	56 - 63	Brass
65 - 72	64 - 71	Reed
73 - 80	72 - 79	Pipe
81 - 88	80 - 87	Synth Lead
89 - 96	88 - 95	Synth Pad
97 - 104	96 - 103	Synth Effects
105 - 112	104 - 111	Ethnic
113 - 120	112 - 119	Percussive
121 - 128	120 - 127	Sound Effects

Table 3 General MIDI Sound Set

Prog	Instrument	Prog	Instrument	Prog	Instrument	Prog	Instrument
1	Acoustic Grand Piano	33	Acoustic Bass	65	Soprano Sax	97	FX 1 (Rain)
2	Bright Acoustic Piano	34	Electric Bass (Finger)	66	Alto Sax	98	FX 2 (Soundtrack)
3	Electric Grand Piano	35	Electric Bass (Pick)	67	Tenor Sax	99	FX 3 (Crystal)
4	Honky-tonk Piano	36	Fretless Bass	68	Baritone Sax	100	FX 4 (Atmosphere)
5	Electric Piano 1	37	Slap Bass 1	69	Oboe	101	FX 5 (Brightness)
6	Electric Piano 2	38	Slap Bass 2	70	English Horn	102	FX 6 (Goblins)
7	Harpsichord	39	Synth Bass 1	71	Bassoon	103	FX 7 (Echoes)
8	Clavinet	40	Synth Bass 2	72	Clarinet	104	FX 8 (Sci-Fi)
9	Celesta	41	Violin	73	Piccolo	105	Sitar
10	Glockenspiel	42	Viola	74	Flute	106	Banjo
11	Music Box	43	Cello	75	Recorder	107	Shamisen
12	Vibraphone	44	Contrabass	76	Pan Flute	108	Koto
13	Marimba	45	Tremolo Strings	77	Blown Bottle	109	Kalimba
14	Xylophone	46	Pizzicato Strings	78	Shakuhachi	110	Bagpipe
15	Tubular Bells	47	Orchestral Harp	79	Whistle	111	Fiddle
16	Dulcimer	48	Timpani	80	Ocarina	112	Shanai
17	Drawbar Organ	49	String Ensemble 1	81	Lead 1 (Square)	113	Tinkle Bell
18	Percussive Organ	50	String Ensemble 2	82	Lead 2 (Sawtooth)	114	Agogo
19	Rock Organ	51	Synth Strings 1	83	Lead 3 (Calliope)	115	Steel Drums
20	Church Organ	52	Synth Strings 2	84	Lead 4 (Chiff)	116	Woodblock
21	Reed Organ	53	Choir Aahs	85	Lead 5 (Charang)	117	Taiko Drum
22	Accordion	54	Voice Oohs	86	Lead 6 (Voice)	118	Melodic Tom
23	Harmonica	55	Synth Voice	87	Lead 7 (Fifths)	119	Synth Drum
24	Tango Accordion	56	Orchestra Hit	88	Lead 8 (Bass + Lead)	120	Reverse Cymbal
25	Acoustic Guitar (Nylon)	57	Trumpet	89	Pad 1 (New Age)	121	Guitar Fret Noise
26	Acoustic Guitar(Steel)	58	Trombone	90	Pad 2 (Warm)	122	Breath Noise
27	Electric Guitar (Jazz)	59	Tuba	91	Pad 3 (Polysynth)	123	Seashore
28	Electric Guitar (Clean)	60	Muted Trumpet	92	Pad 4 (Choir)	124	Bird Tweet
29	Electric Guitar (Muted)	61	French Horn	93	Pad 5 (Bowed)	125	Telephone Ring
30	Overdriven Guitar	62	Brass Section	94	Pad 6 (Metallic)	126	Helicopter
31	Distortion Guitar	63	Synth Brass 1	95	Pad 7 (Halo)	127	Applause
32	Guitar Harmonics	64	Synth Brass 2	96	Pad 8 (Sweep)	128	Gunshot

35	Acoustic Bass Drum
36	Bass Drum
37	Side Stick
38	Acoustic Snare
39	Hand Clap
40	Electric Snare
41	Low Floor Tom
42	Closed Hi-Hat
43	High Floor Tom
44	Pedal Hi-Hat
45	Low Tom
46	Open Hi-Hat
47	Low Mid Tom
48	Hi Mid Tom
49	Crash Cymbal 1
50	High Tom
51	Ride Cymbal 1
52	Chinese Cymbal
53	Ride Bell
54	Tambourine
55	Splash Cymbal
56	Cowbell
57	Crash Cymbal 2
58	Vibraslap
59	Ride Cymbal 2
60	Hi Bongo
61	Low Bongo
62	Mute Hi Conga
63	Open Hi Conga
64	Low Conga
65	High Timbale
66	Low Timbale
67	High Agogo
68	Low Agogo
69	Cabasa
70	Maracas
71	Short Whistle
72	Long Whistle
73	Short Guiro
74	Long Guiro
75	Claves
76	Hi Woodblock
77	Low Woodblock
78	Mute Cuica
79	Open Cuica
80	Mute Triangle
81	Open Triangle

Figure 4 General MIDI Percussion Map (Channel 10)

One-Way MIDI Interface

Figure 5 shows the simplest MIDI interface between the ES690 and ES1xxx chips. MIDI data is transmitted from the MPU-401 port to the ES690, but cannot be received from the ES690. This prevents the host processor from detecting the presence of the ES690. It also prevents using the context upload capability for suspend/resume. This is the easiest connection method if these two drawbacks are not serious, and it works especially well when the ES690 is an optional daughter card.

The ES1xxx MPU-401 transmit and receive wires share a DB15 connector with a joystick (not shown). A special adapter cable that splits the joystick from the MIDI must be used. The 2.2k ohm resistors protect against static electricity.

Note that, from the point of view of the MPU-401 transmitter, the ES690 is in parallel with any external synthesizers.

The ES1xxx's MPU-401 serial port can be in one of two modes: "Smart" or "UART." When transmitting to the ES690 or receiving MIDI from an external source, the port is always in UART mode. When not in use, the port may be left in Smart mode, in which all MIDI data coming into the MPU-401 port's MSI input is automatically echoed back out the MSO output. Thus, in Smart mode, an external keyboard would be able to transmit indirectly to the ES690 through the MPU-401 port.

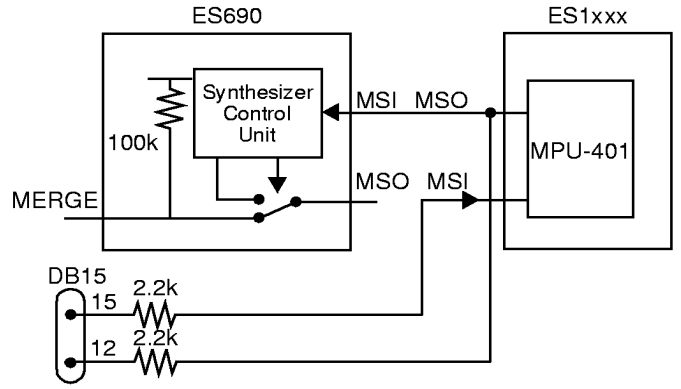


Figure 5 One-Way MIDI Interface

Two-Way MIDI Interface

With a two-way interface like the one shown in Figure 6, the ES690 can transmit data back to the ES1xxx. The host processor then commands the ES690 to send back an ID string (see Table 4) to detect the presence of the ES690. It can also ask for a context upload for suspend/resume.

Normally, the ES690's MERGE input is passed through to its MSO output. When the Synthesizer Control Unit must transmit back to the ES1xxx, it controls a switch that enables transmit.

Before switching the MSO output away from MERGE, the controller waits for inactivity on the MERGE input (i.e., more than 10 serial bits are high). The host system software is responsible for discarding any MIDI data received from the MERGE pin that comes in before the controller is able to access the MSO output.

After completing its transmission, the controller restores the MERGE-to-MSO connection and waits for a period of inactivity on the MERGE pin before switching.

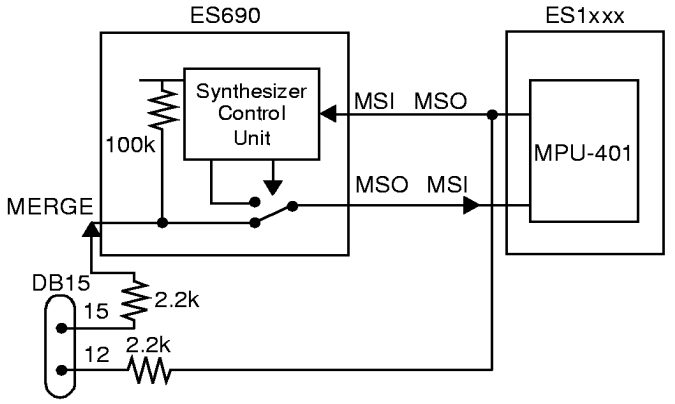


Figure 6 Two-Way MIDI Interface

System Exclusive Messages

MIDI provides a command, called System Exclusive, that allows messages that are unique to a single manufacturer. Other MIDI devices are guaranteed to ignore System Exclusive messages with different manufacturer ID numbers. The ES690 manufacturer ID is the following three-byte sequence: 00h, 00h, 7Bh.

The format of a System Exclusive message is:

F0h <id bytes><command>[<data>]F7h

A list of System Exclusive commands currently supported is shown in Table 4 below.

Table 4 Sysex Commands

Sysex Command	Function
0	Return ID string. Causes the ES690 to transmit a message as: F0 00 00 7B "ES690nn"... Where "nn" is the version number in ASCII. Up to 32 bytes follow the version number. These bytes must be read and discarded. The ID string is not guaranteed to contain F7h at the end of the ID string. The recommended procedure is to have a loop to read up to 32 bytes after the version number. The read loop should have a short time-out of about 1 millisecond between bytes received.
1	Reset ES690. Restores all initial conditions.
3	Disable activity detection. Activity detection is the mode in which the ES690 stops the MCLK output after 5 seconds of not receiving any data on its MSI pin.
4	Enable activity detection. Activity detection is the mode in which the ES690 stops the MCLK output after 5 seconds of not receiving any data on its MSI pin. This enable command has no effect if the ES690 is operating in Serial mode.
5	Disable automatic power-down when MSI input is idle. This is the reset default.
6	Enable automatic power-down when MSI input is idle for 30 seconds. The MSI pin must be continuously high for 30 seconds to cause the ES690 to enter power-down state. The oscillator continues to run. The operating current is typically reduced to 0.5 mA. The ES690 wakes when MSI goes low.
7	Power-down command. This command puts the ES690 to upload in a low-power state. The oscillator continues to run. The ES690 wakes from the low-power state if the MSI goes low.
8	Suspend request. This command causes the ES690 to upload its current context.
9	Resume command. This command causes the ES690 to download its current context after power is restored.

DESIGN CONSIDERATIONS

Audio Serial Port

The ES690 does not require an external DAC. It interfaces to the ESS *Audio***Drive**® chips that allow the ES690 to automatically acquire the DAC that is normally used by the internal FM synthesizer.

In order for the ES690 to acquire the FM DAC, bit 4 of Mixer Extension register 48h inside the ES1xxx must be set high. When bit 4 is set high, activity on the ES690 MCLK signal causes the FM DAC to be connected to the ES690. If MCLK stays low for more than a few sample periods the ES1xxx reconnects the FM DAC to the FM synthesizer.

After reset, the ES690 transmits samples continuously. In this mode, bit 4 of Mixer Extension register 48h must be set/cleared to assign the current owner of the FM DAC. The ES690 can be programmed to enter Activity Detect mode, using System Exclusive command 4, in which the ES690 blocks the serial port output (i.e., sets MCLK low) if no MIDI input is detected on the MSI pin for a period of 5 seconds. The ES690 then resumes output of serial port data as soon as a MIDI input is detected on the MSI pin.

Choosing the Oscillator Crystal

The ES690 requires a 33.000 MHz crystal. Either a load capacitance or "series" type crystal can be used. The load capacitance is determined by the series combination capacitance on oscillator pins XI and XO. If you determine both XI and XO have 10 pF capacitors, plus 5 pF of stray capacitance, the load capacitance for the crystal is 15 pF. Note: ESS recommends 10 pF capacitors to ground on XI and XO oscillator pins.

If the crystal used is specified for a different load capacitance, it will oscillate at a slightly incorrect frequency. Usually this produces a very small, unnoticeable error in pitch. A series type crystal oscillates about .2% faster than specified.

33.000 MHz crystals are designed to operate in either a "fundamental" or "overtone" mode. Overtone crystals are usually less expensive and can often operate at a fundamental frequency that is lower than the desired 33.000 MHz. ESS does not guarantee all overtone crystals oscillates at 33.000 MHz without adding an LC filter to the XO output pin.

Shown in Figure 7 below is an example of an LC circuit that has a "tank" circuit tuned for a 33 MHz third overtone crystal. Resistor Ro may not be required, or may be of some low value such as 150 ohms.

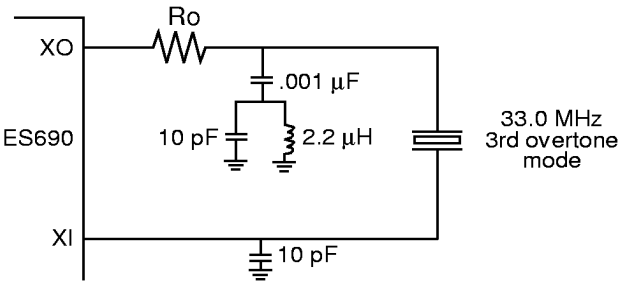


Figure 7 Using a Crystal in Overtone Mode

CONFIGURATION PROCEDURE

This section describes the steps necessary to enable the ES690 to work with an ES1xxx audio chip. The following assumptions are made:

- The control connection to the ES690 is through the MPU-401 port of the ES1xxx.
- The ES1xxx does not try to detect the ES690. If the ES690 is not present, the configuration procedure still runs unless the MCLK input to the ES690 is subject to excessive digital noise. This happens if there is a long trace between the MCLK input of the ES1xxx and the connector to an ES690 daughter card. The MCLK input has a pull-down device, but a long trace acts as an antenna when the ES690 daughter card is not plugged in. A symptom is intermittent operation of the FM synthesizer. A pull-down resistor to the MCLK pin solves this problem.
- The ES690 uses the two-wire serial link (MCLK and MSD) to gain access to the FM DAC inside the ES1xxx chip.

BIOS or DOS Startup

The following startup procedure configures the ES690 for handling DOS applications:

1. Configure and enable the MPU-401 serial interface. The desired addresses are 330h/331h. The address range can be configured for 330h/301h, 310h/311h, 320h/321h, or 330h/331h. **No interrupt is required for MIDI transmit.** It is not necessary to configure an interrupt, unless you want to run DOS applications that record MIDI input.
2. Reset the MPU-401 port. Write 0FFh to the command register (3x1) and then read back the acknowledge byte 0FEh from the data register (3x0).
3. Put the MPU-401 port in UART mode. Write 03Fh to the command register and then read back the acknowledge byte 0FEh. It is not necessary to poll or delay before sending FFh and 3Fh. It is not necessary to delay before reading the acknowledge byte.
4. Set bit 4 of Mixer Extension register 48h. If this bit is not high, the ES690 cannot use the FM DAC.
5. Program the Special Extension register 0BCh to attenuate the FM DAC output -1.5 dB relative to default. The reason is that the dynamic range of the ES690 is generally larger than FM because the number of voices is greater. Lowering the FM DAC volume by -1.5 dB reduces the chances of clipping in the analog circuits. The balance between FM and digitized audio changes slightly. After hardware reset, the contents of register BCh is B6h. Write 36h to register BCh to lower the FM DAC volume by -1.5 dB.
6. Send the System Exclusive ES690 reset message. This message turns off all voices and initializes the chip. System Exclusive messages include an ID number(s) that is unique to each manufacturer. (See below.) The ESS ID number is the three byte sequence: 00h, 00h, 7Bh. The ES690 reset message is:

F0h, 00h, 00h, 7Bh	<sysex-start><id triplet>
01h	<ES690 reset command>
F7h	<end-of-sysex>

7. By default, after hardware or software rest, the ES690 audio output runs continuously. In this mode, it "owns" the DAC as long as bit 4 of Mixer Extension register 48h is set high. In Activity Detect mode, the ES690 activates MCLK only as long as it receives MIDI serial input. Specifically, if the ES690 does not see any activity on its MSI input for 5 seconds, it turns off the MCLK output, causing the DAC to be restored to the FM synthesizer.

   It is recommended in DOS or a Windows™ DOS-box to use Activity Detect mode. This mode is activated by sending ES690 System Exclusive command 4:

F0h, 00h, 00h, 7Bh	<sysex-start><id triplet>
04h	<enable activity-detect mode>
F7h	<end-of-sysex>

   NOTE: If the ES1xxx MPU-401 port is in Smart mode rather than UART mode, MIDI data received by the chip's MSI pin echoes back out the MSO pin. In this case, MIDI data into the ES1xxx also reaches the ES690. If an external MIDI device (e.g., a keyboard) is plugged in, the device can directly drive the ES690. This is not a problem. However, some keyboards generate no-op MIDI bytes regularly at all times. These bytes are used for "active sensing," which allows MIDI devices to detect when something is unplugged from the MIDI network. Such active sensing can prevent the ES690 from releasing the DAC. Of course, if a keyboard is plugged in, it is unlikely the FM synthesizer will be used, especially in Windows.

APPLICATION SCHEMATICS

Application Schematic 1 – ES1788 with ES690

The schematic in Figure 8 shows the connections between the ES690 and the ES1788.

MIDI output from the ES1788 is directed to both the ES690 and the Joystick/MIDI connector.

MIDI output from the ES690 is connected to the MIDI input pin of the ES1788.

MIDI input from the Joystick/MIDI connector is connected to the MERGE pin of the ES690. The ES690 normally passes this signal directly through to its MSO pin except when in transmit mode.

Resistors R1 and R2 (2.2k) are for protection against static electricity.

The ES981 is a 512K x 16-bit masked ROM.

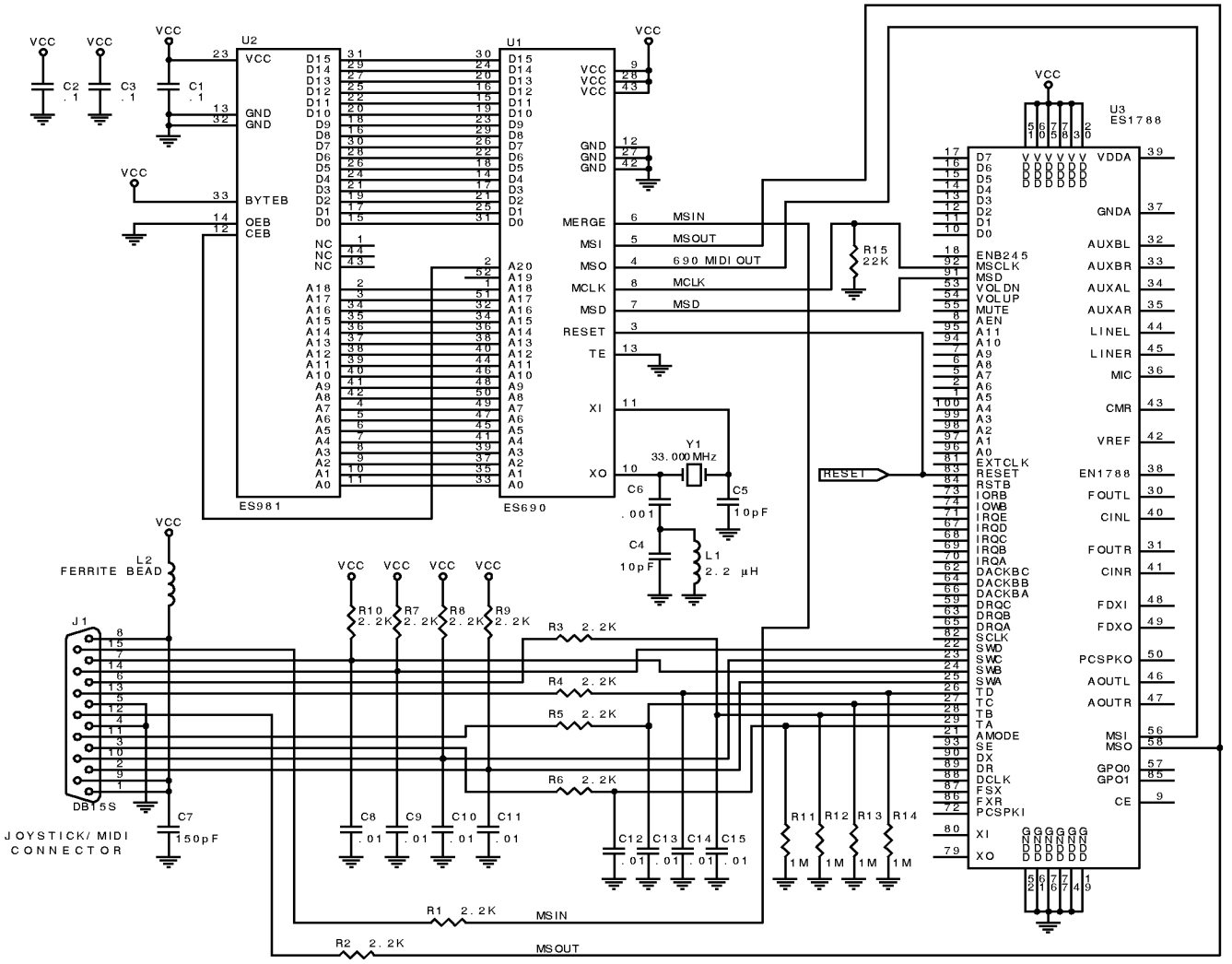


Figure 8 ES1788 with the ES690

Application Schematic 2 – ES690 Daughter Card

Figure 9 is the schematic of the ES690 daughter card which works with any sound card equipped to interface to an external wavetable music synthesizer.

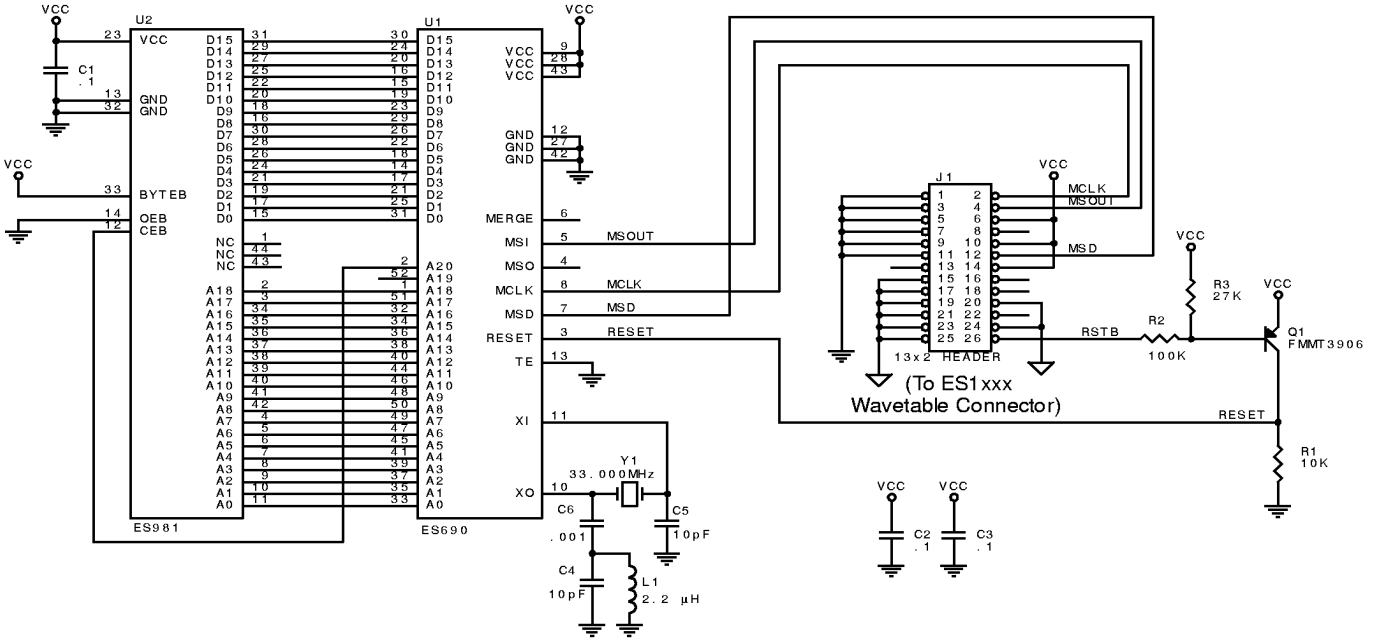


Figure 9 ES690 Daughter Card

ES981 DESCRIPTION

The ES981 Wavetable Sound ROM is 16-bit mask Read-Only-Memory, designed to be a companion chip to the ES689 and ES690 Wavetable Music Synthesizer chips. The ES981 is organized as 512K x 16-bit memory; with an access time of 150 ns.

The ROM offers automatic power-down, controlled by the chip enable (CEB) input. When CEB deselects the ROM, the ROM powers down automatically and remains in a low-power standby mode.

The ES981 is available in an industry-standard 44-pin Small Outline Package (SOP).

ES981 FEATURES

- 512K x 16-bit CMOS wavetable mask ROM
- General MIDI instrument set – 128 melodic and 47 rhythm instruments
- 150 ns fast access time
- Total static operation
- Single +5 V power supply requirement
- Operating current of 60 mA
- Standby current of 100 µA
- 44-pin Small Outline Package (SOP)

ES981 PINOUT

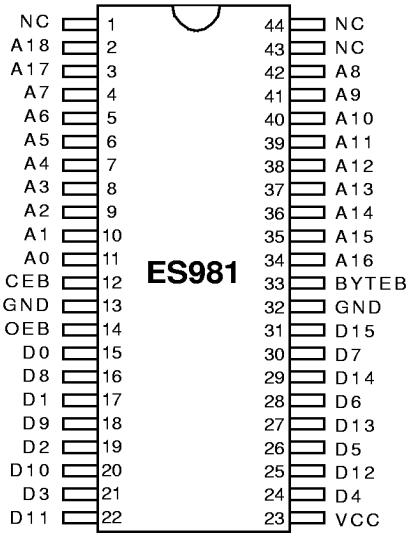


Figure 10 ES981 Pinout

ES981 PIN DESCRIPTION

Name	Number	I/O	Definition
A[18:0]	11:2, 42:34	I	ROM address. (Word addresses).
CEB	12	I	Active-low chip enable.
GND	13, 32	I	Ground.
OEB	14	I	Active-low output enable.
D[15:0]	22:15, 31:24	O	ROM data.
VCC	23	I	Power supply voltage (4.5 to 5.5 V).
BYTEB	33	I	Word address selection. Connect to VCC.
NC	1, 44:43		No connection.

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

Ratings	Value	Units
Power supply voltage	-0.3 to 7.0	V
Operating temperature range	0 to 70	Deg C
Voltage range on any pin	-0.3 to 7.0	V
Storage temperature range	-50 to 125	Deg C

WARNING: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

Thermal Characteristics

The ES690 was designed to operate at case temperatures between 0°C and +70°C.

Operating Conditions

The ES690 operates under the following conditions:

Operating temperature range	0 to 70 °C
Supply voltage VCC	4.75 V to 5.25 V (5 volts ± 5%)

Table 5 ES690 Electrical Characteristics

Parameter	Symbol	Min	Typ	Max	Unit (conditions)
Operating voltage	VCC	4.5		5.5	volts
Input low voltage	VIL			0.8	volts (VCC = 5 V)
Input high voltage: all inputs except XI	VIH	2.0			volts (VCC = 5 V)
Output low voltage: all outputs except XO	VOL			0.4	volts (IOL = 4mA)
Output high voltage: all outputs except XO	VOH	2.4			volts (IOH = -3mA)
Operating current	ICC			75	milliamps (VCC = 5 V)
Power-down supply current	ICCP			7.5	milliamps (VCC = 5 V)
Input leakage current high: all inputs except RESET	IILH1	0		10	microamps (VCC = 5 V, VIN = 5 V)
Input leakage current high: RESET	IILH2	50		150	microamps (VCC = 5 V, VIN = 5 V)
Input leakage current low: all inputs except XI, MERGE	IILL1	0		10	microamps (VCC = 5 V, VIN = 5 V)
Input leakage current low: XI, MERGE	IILL2	25		100	microamps (VCC = 5 V, VIN = 5 V)

Table 6 ES981 Electrical Characteristics

Parameter	Symbol	Min	Typ	Max	Unit (conditions)
Operating voltage	VCC	4.5		5.5	volts
Input low voltage	VIL			0.8	volts (VCC = 5 V)
Input high voltage	VIH	2.2		5.0	volts (VCC = 5 V)
Output low voltage	VOL			0.4	volts (IOL = 2.1mA)
Output high voltage	VOH	2.4			volts (IOH = 1.0mA)
Operating current	ICC			60	milliamps (VCC = 5 V)
Power-down supply current	ICCP			100	microamps (VCC = 5 V, VIN = 0 V)
Input leakage current	IIL			10	microamps (VCC = 5 V, VIN = 5 V)

ES981 Timing Characteristics

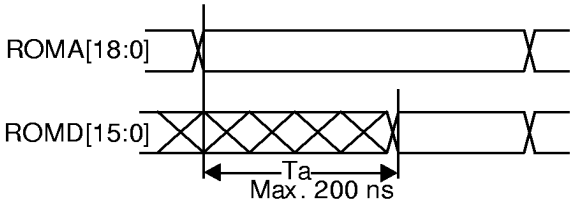
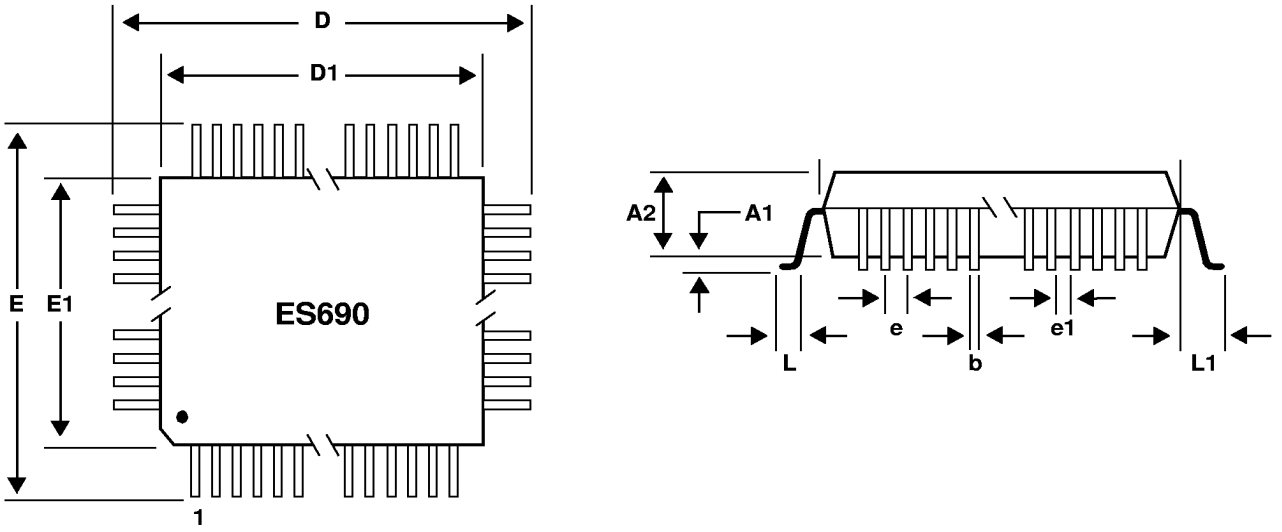


Figure 11 ES981 ROM Access Timing Diagram

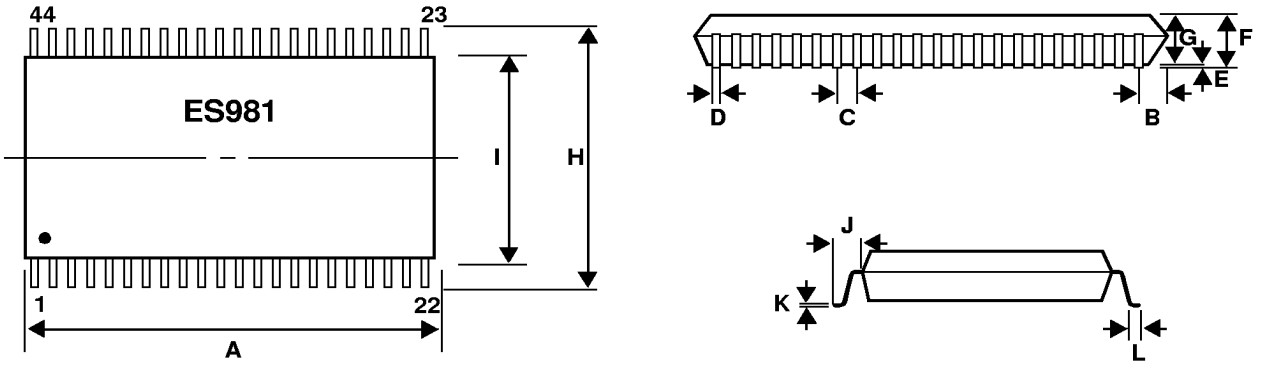
ES690 MECHANICAL DIMENSIONS



Symbol	Description	Millimeters		
		Min	Nom	Max
D	Lead to lead, X-axis	12.95	13.20	13.45
D1	Package's outside, X-axis	9.90	10.00	10.10
E	Lead to lead, Y-axis	12.95	13.20	13.45
E1	Package's outside, Y-axis	9.90	10.00	10.10
A1	Board standoff	0.10	0.25	.35
A2	Package thickness	1.90	2.00	2.20
b	Lead width	0.20	0.30	0.40
e	Lead pitch	-	0.65	-
e1	Lead gap	0.24	-	-
L	Foot length	0.65	0.80	0.95
L1	Lead length	1.52	1.60	1.68
-	Foot angle	0°		7°
-	Coplanarity	-	-	0.102
-	Leads in X-axis	-	13	-
-	Leads in Y-axis	-	13	-
-	Total leads	-	52	-
-	Package type	-	PQFP	-

Figure 12 ES690 Mechanical Dimensions

ES981 MECHANICAL DIMENSIONS



Symbol	Description	Millimeters		
		Min	Nom	Max
A	Package's length	-	-	28.70
B	Lead pitch to package's outside	-	1.10	-
C	Lead pitch	-	1.27	-
D	Lead width	0.30	0.40	0.50
E	Board standoff	0.010	-	-
F	Package height	-	-	3.00
G	Package thickness	2.67	2.80	2.93
H	Foot print	15.74	16.04	16.34
I	Package width	-	12.60	-
J	Lead length	-	1.72	-
K	Lead thickness	0.05	0.15	0.25
L	Foot length	0.60	0.80	1.00
-	Coplanarity	-	-	0.102
-	Leads in X-axis	-	22	-
-	Total leads	-	44	-
-	Package type	-	SOP	-

Figure 13 ES981 Mechanical Dimensions

APPENDIX A: SAMPLE CODES

```
/* Program to enable ES690 for interfacing to the ESS AudioDrive chip. It is assumed that the
audio chip has already been configured at the base address 220H.

Read Mixer Extension Register 40H to find the MPU-401 address. If no address is selected,
configure it for 330H.

Special extended register BC allows us to modify the gain of the FM DAC. This program selects a
value of -1.5 dB relative to the default value:

76    +3 dB

B6  +1.5 dB  <- h/w reset default

36     0 dB  <- this program

F6  -1.5 dB

*/

#include <stdio.h>

#include <stdlib.h>

#include <dos.h>

#include <conio.h>

#include <string.h>


#define BASE_PORT 0x220

#define FM_DAC_VOLUME 0x36


int mpu_port;

// Send value to ES1788 command port 2xC

int sb_send(int x)

{

  int i;

  i=10000;

  while(i && (inp(BASE_PORT+0x0c) & 0x80)) i--;

  outp(BASE_PORT+0x0c,x);

  return(i);

}

// Read value from ES1788 data port 2xA

int sb_read(void)

{

  int i;

  i=10000;

  while(i && !(inp(BASE_PORT+0x0c) & 0x40)) i--;

  if (i)

    return(inp(BASE_PORT+0x0a));

  else

    return(-1);

}
```

```
// S/W reset ES1788, send command 0xC6 to enable access to extended registers
int sb_reset(void)
{
  outp(BASE_PORT+6,1);
  inp(BASE+PORT+6);
  outp(BASE_PORT+6,0);
  if (sb_read() != 0xAA)
    return(0);    // read AA byte
  sb_send(0xc6);  // enable extended mode commands
  return(1);
}

// Transmit data via MPU-401 to ES690
send690(int x)
{
  int i;
  i=32767;
  while ((i--) && (inp(mpu_port+1) & 0x40));
  if (!i) {
           printf("Error: MPU-401 transmit busy\n");
           exit(0);
           }
  outp(mpu_port,x);
}
```

```
main()
{
  int i,j;
  unsigned char uc;

  if (!sb_reset())
    printf("\a\nError: audio chip does not respond at base address 220H.\n");
    exit(0);
    }

 //find MPU-401 port
  outp(BASE_PORT+4,0x40);
  i=inp(BASE_PORT+5);
  if ((i & 0xe0) == 0) {
```

```
      // no MPU-401 port enabled: use 330H
      printf("Configuring MPU-401 port at address 330H, no IRQ\n");
      i = (i & 3) | 0x38;
      outp(BASE_PORT+5,i);
      mpu_port=0x330;
      }
    else {
       mpu_port=0x300 + ((i << 1) & 0x30);
       printf("MPU-401 port found at address %x\n", mpu_port);
       }

    // reset MPU-401 and put in UART mode
    outp(mpu_port+1,0xff);
    inp(mpu_port);
    outp(mput_port+1,0x3f);
    inp(mpu_port);

    //set bit 4 of Mixer Extension Register 48H to enable 690 serial
    // audio interface
    outp(BASE_PORT+4,0x48);
    outp(BASE_PORT+5,inp(BASE_PORT+5)|0x10);     //enable 690 ifc

    // reset FM mixer to mid-range
    outp(BASE_PORT+4,0x36);
    outp(BASE_PORT+5,0x88);

    // reset audio and adjust FM DAC -1.5 dB vs default. This
    //makes objectionable clipping less likely.
    sb_send(0xbc); sb_send(FM_DAC_VOLUME);

    // send system exclusive reset message
    send690(0xf0); send690(0x0); send690(0x0); send690(0x7b);
    send690(0x1);
    send690(0xf7);

    // enable activity-detect mode of sharing DAC with FM
    send690(0xf0); send690(0x0); send690(0x0); send690(0x7b);
    send690(0x4);
    send690(0xf7);
    printf("\n");
  }
```

APPENDIX B: SCHEMATIC EXAMPLE

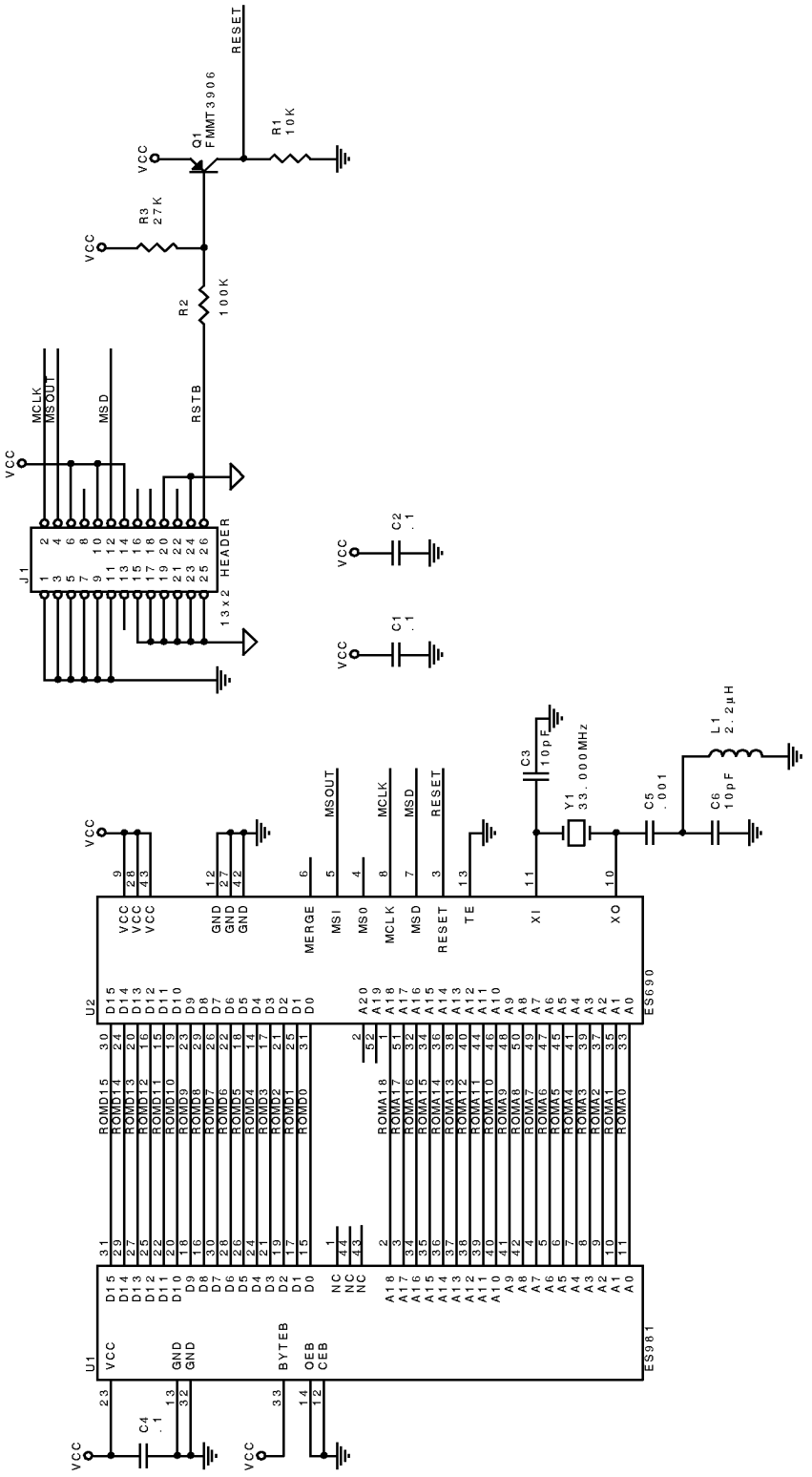


Figure 14 ES690 Daughter Card with ES981 Schematic

APPENDIX C: ES690 WITH ES981 BILL OF MATERIALS

Table 7 ES690 with ES981 Bill of Materials (BOM)

Item	Quantity	Reference	Part
1	3	C1, C2, C5	0.1 µF, 1206
2	2	C3, C6	10 pF, 1206
3	1	C4	0.001 µF, 1206
4	1	J1	13x2 Header, female
5	1	L1	2.2 µH, 1210
6	1	Q1	FMMT3906 SOT-23
7	2	R1, R2	100K 1206
8	1	R3	47K 1206
9	1	U2	ES981 SOP-44
10	1	U3	ES690 PQFP-52
11	1	Y1	33.000 MHz PCB Options: Ecliptek EC38CT-xx-33.000M Epson CA-301 Metal Can Epson MA-506 Surface Mount Low Profile HC-49 or equivalent