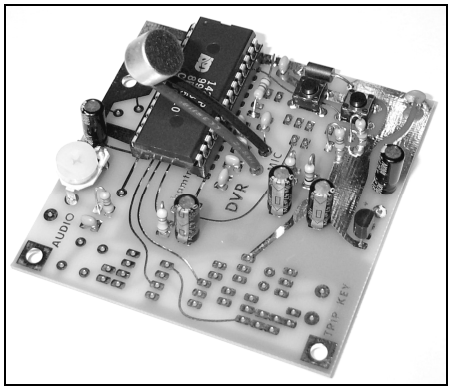
HAMTRONICS® DVR-4 DIGITAL VOICE RECORDER: INSTALLATION, OPERATION, AND MAINTENANCE



GENERAL INFORMATION.

Functional Description.

The DVR-4 is a versatile pc board module, which is designed primarily as a voice recorder and playback module. It is a special version of the general purpose DVR-1 module. The difference is that the DVR-4 is optimized for use in applications other than radio repeaters, where a simple pushbutton control provides recording and playback. A built in microphone allows the recording to be made without the need for external audio sources.

The DVR-4 module is based on the ISD-1420P chip, using direct analog eeprom technology. The recording is good speech quality, equivalent to what you would expect using a cassette tape recorder. The solid-state recording lasts ten years or more and requires no battery backup.

Enhancements.

The 20 seconds of recording time normally is accessed all as one unit. However, with the addition of some external addressing switches, the 20 second capacity can be broken up, any way you like, into multiple messages. Although, switching circuitry to do this is not provided, the address line connections are provided, and information on how to add switches to do your own enhancements is given later in the manual.

Other enhancements may be added to suit your application. With a few changes, you can make the message repeat periodically or loop continuously.

Recording Quality.

The ISD-1420P is an amazing ic which implements an entire digital voice recording and playback system in one chip. This allows for real voice recording at a previously unheard-of low price. However, we don't want you to expect a one-chip system to sound like a music CD.

Limitations imposed by the restraints of putting everything on one chip result in good communications quality sound, but not hi-fi. There is a little noticeable hiss and a little distortion because of the digitizing and the limited sampling rate imposed by the number of eeprom cells which will fit on a chip. It is definitely real voice, though, and not a synthesized, artificial-sounding voice.

If you want to enjoy the benefits of digital recording technology at an attractive price and are willing to live with less than perfect audio, you will be pleased. We tell you this now because expectations have a lot to do with satisfaction.

ASSEMBLY.

Construction Methods.

Assembly is relatively straight forward. Use the parts list and component location drawing as guides.

During assembly, orient the board right side up as shown in the component location diagram. The top is the side with the terminal numbers.

The four labeled holes around the perimeter of the board are for wires connecting to the COR board.

The five pads at the upper left are for optional address line connections, which are only used if you choose later to enhance operation with multiple messages. For now, disregard these holes; there are no components to install in them.

There are many pads on the board which are not used in this model.

Precautions.

Note that the voice recorder ic is static sensitive because it uses cmos technology. The warranty does not cover static damage; so handle it with care. Leave it in its protective carrier until assembly is done; and then plug it in, using suitable static handling precautions. A grounded wrist strap should be worn whenever cmos parts are handled. Even after assembly, it is possible to damage cmos parts if static builds up from walking or sliding a chair on a carpet, etc. Always use precautions when handling a board with cmos parts.

The pc board uses plated-through holes; so only the bottom of the board needs to be soldered. Because it is more difficult to remove parts from plated-through holes, be sure parts are correct before soldering. Traces are close together; so use a fine tip on the soldering iron. All parts should be installed flush with the board.

Assembly Procedure.

Install and solder the parts in each of the following steps as you proceed.

a. If you intend to mount the DVR-4 board in a chassis or other enclosure, you should use the blank pc board as a template before assembling any components. Set it in place, and mark where to drill the mounting holes.

b. Install the ic socket on the board, orienting the end with the notch as shown.

c. Install the two pushbutton switches. Note that they fit properly only with the leads oriented toward the left and right, not up and down.

d. Install potentiometer R8.

e. Install ferrite bead Z1.

f. Install all capacitors, observing polarity on electrolytics.

g. Install all resistors. On vertically-mounted parts, the body of the part is indicated by a circle on the diagram. Note that R3 is soldered from the lower of a pair of pads to the trace along the top of the board. There is no hole for the top lead; simply tack solder it to the trace.

h. Install the microphone on the pc board, soldering the red and black leads to E5 and E6 as shown. Be sure to observe polarity. Note that the microphone is supported simply by its wire leads about an inch over the board. The microphone head can be tilted gently upward so that it faces the user when the cover is off the repeater.

i. Using suitable static protection described earlier, carefully unpack the ISD-1420 ic and install it in the socket. Be sure to orient it with notch as shown. Be careful that all the pins actually go into the socket. It is easy for some to bend underneath or extend over the outside of the socket. Do not bend any of the pins excessively, as they may break from repeated stress.

j. This completes assembly. Check over construction to be sure all parts are installed in proper places, with proper polarities, and check solder connections for any cold solder joints, solder splashes, etc. If any parts are missing, check to be sure that other parts are not left over; since a part may have been installed in the wrong place.

INSTALLATION.

Mounting.

Four mounting holes are provided in the corners of the board to accept 4-40 screws and standoffs for mounting the module to a chassis.

Caution: The digital recorder ic is static sensitive. Use suitable handling precautions, including grounding yourself, to avoid damage.

Wiring.

Use #22 hookup wire to connect the various pads on the board to your external circuit as follows.

a. Connect +12Vdc power supply to E4.

b. Connect power supply common to the chassis to allow the mounting hardware to carry this ground connection to the board.

c. Connect E1 audio output to your external audio input device.

d. If you wish to playback remotely, connect a wire to the "Playback Control" input pad on the board as shown on the Component Location Diagram. A simple ground pulse will start the playback. It is not necessary to hold this lead low, just pulse it low to start the playback.

e. If you need a dc output voltage to tell an external circuit when the voice is in playback, you can connect a wire to E7 on the board. The voltage on E7 is normally at ground during rest and goes to approximately +1.5Vdc when the voice is being played back. Not that this is a logic level output; you should not try to draw much current from this output.

f. Normally, the on-board record switch is used to make the recording in conjunction with the built in microphone. However, should you wish to record remotely, you can connect an external record switch across S2. In addition, you can remove the built in microphone and connect an audio source to E5. E6 is the ground return for that audio. If you are using a balanced audio source, you can break the trace on the top of the board from E6 to ground plane and use E6 as the floating common connection for the audio input.

OPERATION.

Recording a Message.

To record, just press RECORD switch S2 and speak into on-board microphone. Be sure to allow a second or two after pressing record switch before speaking, and allow about 1 second after the end of your message before releasing the record switch. This will allow for smooth transition between turn on and message. Total recording time is 20 seconds.

To playback for testing, momentarily depress PLAYBACK switch S1.

Audio Level Adjustment.

Audio level pot R8 should be adjusted for desired output level.

Recording Technique.

Some practice will be necessary in order to find the best distance to be from the microphone and how loud to speak in order to maximize intelligibility and minimize distortion. For starters, try using a slightly louder than normal voice in order to enhance diction and enunciation and try a distance of about 12 inches from the microphone.

ENHANCEMENTS.

General.

This section of the manual provides information on some modifications which can be done to allow the DVR-4 to be used in some other applications. Some of these are rather involved and require a good background in digital electronics to accomplish. We recommend that you only tackle them if you feel your background is sufficient, and even then, you should operate the unit in its standard setup as designed before attempting any modifications so it will be easier to solve problems which may occur.

The Theory Of Operation section gives some additional explanation of the operation of the recorder ic, which may allow you to do some other adaptations. If you develop an application you want to share with others, we invite you to let us know. If we can, we'll add it to the manual to make it available to future DVR-4 users.

Changing Tone.

The bass response of the recording circuit is controlled largely by the values of C8 and C9. You can increase the values of these capacitors to get more low frequency response or decrease them for less low frequency pickup. Both capacitors must be the same value. If you want to increase the value, it may be necessary to change to a different type of capacitor, such as polyester (mylar) capacitors, in order to get a large value.

Speaker Output.

Although not normally used in the DVR-4, two output pins from the voice recorder ic (connect at E7 and E8) can provide direct speaker drive capability of about 50 mW rms (100 mW peak) into a 16Ω speaker — enough to be clearly heard from the other side of a normal sized room.

Addressing More Than One Message.

The rest of the enhanced operation techniques all depend on the user having a good grasp of binary addressing. You should not attempt any of these modes unless you feel comfortable with the discussion that follows.

The ISD1420P ic can be operated in many different modes. The simplest is the "addressed" mode, in which the various 8-bit address lines marked "A0" through "A7" on the schematic diagram are used to set binary addresses for the starting points of various message storage areas in the chip.

The 1420 ic can be looked at as a miniature tape recorder with 20 seconds worth of tape. It has the ability to pre-position the playback/record head anywhere on this 20 second tape before we begin operation. The device has 160 valid addresses giving an address resolution of 0.125 seconds. This means 8 address counts equal 1 second of record time.

To determine what address to give the device, we must first convert sec-

Table 2. Address Line Binary Weighting.					
Address Pads	A7	A6	A5	A4	A3
Weight (sec.)	16	8	4	2	1

onds into binary counts. A 1-second resolution is adequate for our purposes. Since 8 counts equal one second and 8 is an even binary multiple, we can ignore all the counts less than eight. We do this by strapping A0, A1, and A2 to ground and just programming the 5 remaining bits. Using switches and diodes (for isolation), we can select any interval between 1 and 19 seconds for the start of record or playback.

To program addresses, we need to tie individual address lines to ground (logic 0) or +5Vdc (logic 1). Table 2 gives the binary address weight of each address line pad on the pc board.

Using normal binary numbering to do the addressing, following are examples to illustrate how to program at one second intervals. Not all addresses are given, only enough to give you the idea of how binary digits are added to yield the desired address.

Note that the address is the starting address of either record or playback message and must be set before the RECORD or PLAYBACK switch is pressed. Because we are addressing in one-second increments, the highest practical address is 19 seconds.

We mentioned earlier that there are other operational modes besides the addressing mode. These are enabled by tying both A6 and A7 high at the same time, which tells the ic that instead of using message starting addresses, we want the chip to operate in a special mode. These other modes are selected by pulling one of the A3-A5 lines high while the A6 and A7 lines are also high. For instance, tying lines A3, A6, and A7 high selects a special message looping mode, which was discussed earlier. There are other modes which we won't discuss because they are used for testing or in modes not suitable for our type of product. All these operational modes use a message space starting address of zero; the programming in these cases establishes a mode of operation and not the starting address of the message.

Multiple Messages.

Using addresses, you can record and playback multiple messages, depending on the starting addresses being properly set before record or playback is initiated. When a message is recorded, the recording starts and runs until you release the RECORD switch. At the end of the message, the ic embeds an "EOM" (end of message) marker, which controls where the playback will automatically stop.

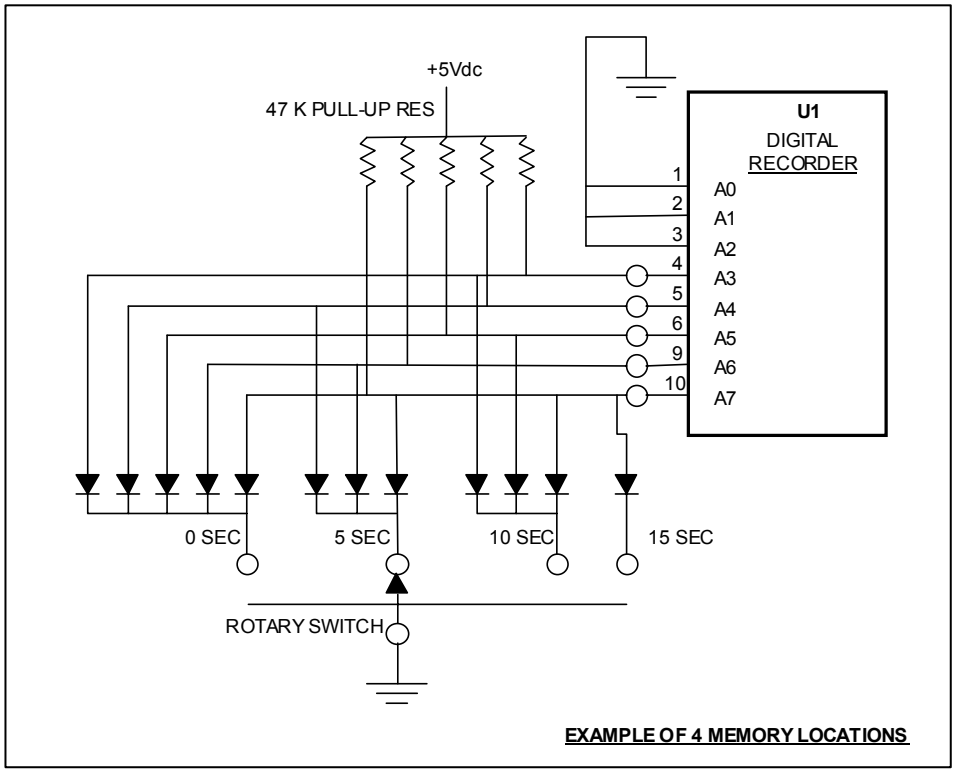
Keep in mind when recording a new message that if you record a message longer than the address space you have reserved for it, you will begin erasing the next message in the series (or run over the end of the 20 second capacity of the chip). If you then try to select the message you just erased part of, you will get the end of the new message starting at the message address of the message you just corrupted. *Whenever you play a message, the ic starts at the selected address, whether or not that coincides with the start of a message, and it runs until it sees an EOM marker.* If you want to record a message longer than its allowed message space, just go ahead and do it; but remember that the next message just isn't available any more.

The schematic diagram below shows how multiple message addressing is implemented in a simple system with four 5-second message spaces starting at 0, 5, 10, and 15 seconds into the recording space. You can easily set up any number of spaces at whatever addresses you want; these are just used as an example. The spaces don't need to be evenly divided as in the case.

Table 3. Address Examples.					
Start Address	**Address Pads**				
Location (sec)	A 7	A 6	A 5	A 4	A 3
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
15	0	1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1

The five resistors are used to pull up the address lines to +5Vdc when they are not grounded through the diodes. For simplicity, we depict a rotary switch in a straight line format. Note that any type of switch can be used. The only thing that matters is which lines are grounded *at the start* of a record or playback cycle. It doesn't even matter if you change an address setting in the middle of a cycle; that would be ignored. You can devise any sort of switching scheme you like as long as you set the starting address as defined earlier.

Remember that the diodes are installed for those address lines that are to be programmed lo (ground), not hi (+5Vdc). The pull-up resistors provide the logic hi voltage for those address lines which are not grounded through diodes.



Remote Control of Multiple Messages.

If you want to be able to control which of several messages is used, and do it by remote control, you can use a unit, such as our TD-2 DTMF Decoder/Controller to select a particular group of diodes, as shown in the schematic for multiple message addressing. Just make sure that you don't turn on remote control latches for more than one address at once or the address will be mixed up.

THEORY OF OPERATION.

General.

Following is a thorough discussion of the operation, first of the digital voice recorder ic, and then of the support circuitry. You will need a background in digital electronics to understand some of it, although it isn't too complicated.

Recording Technology.

The ISD-1420P ic is an analog sampled data system, with on-chip microphone preamp, agc, anti-aliasing and smoothing filters, storage array, speaker driver, control interface, and internal precision reference clock. This system uses eeprom technology to directly record analog signals so no d-a and a-d converters are required.

The ISD-1420P ic uses a sampling rate of 6.4 kHz for 20 seconds of storage time, and it has an anti-aliasing filter which cuts off at 2700 Hz. If the frequency response was higher, the recording time would be less, because at least two samples per cycle are required to reproduce any frequency.

Audio Recording Circuits.

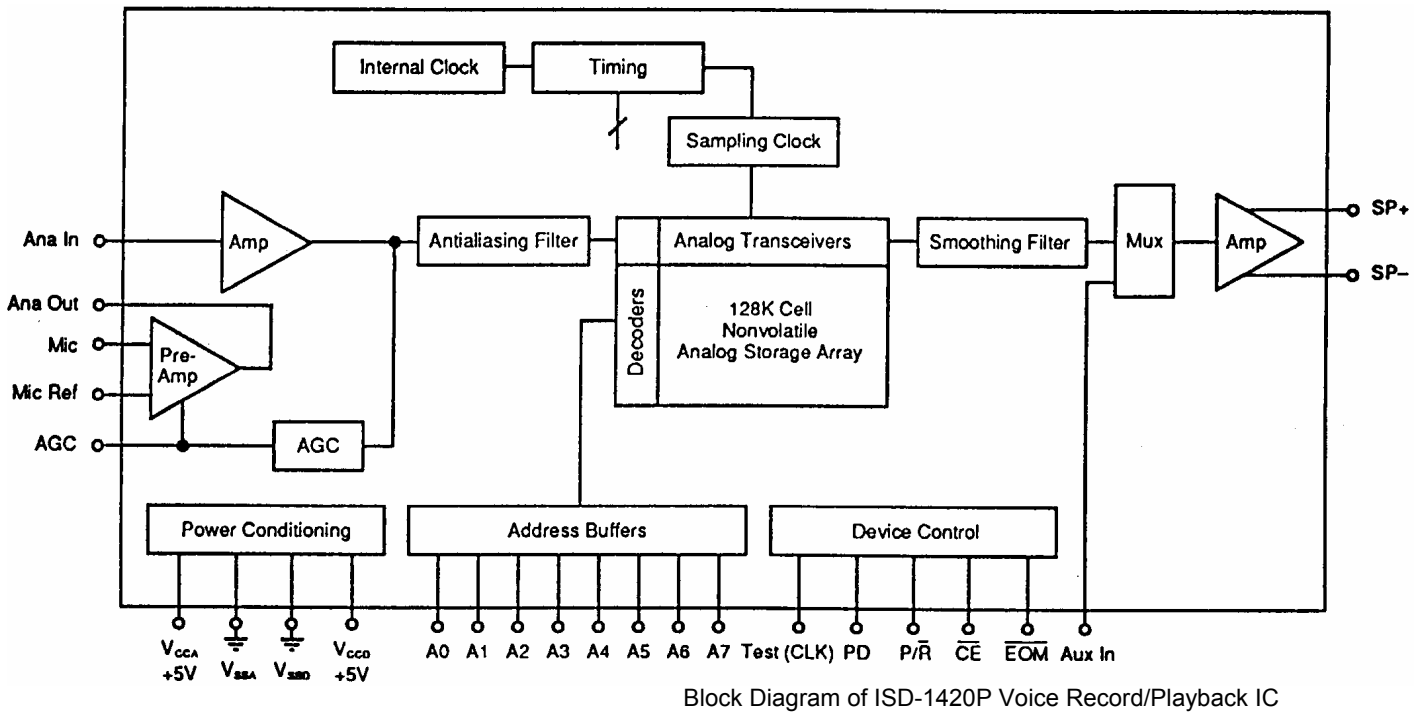
Refer to schematic diagram at the rear of the manual and the block diagram of the ic below. The DVR-4 records audio from the microphone on the pc board. R6 and R7 is a voltage divider to provide the proper level to recorder ic U1 at pin 17. Pin 18 of the ic provides an reference input to the input op-amp. This is connected to the ground plane of the board to cancel any hum or noise pickup. The analog preamp output at pin 21 is coupled through blocking capacitor C6, which also serves to tailor the frequency response and level to match the repeater audio input.

During recording, the 1420P chip performs several stages of signal conditioning before the actual storage operation takes place. The first stage is the amplification of the input signal to a level optimized for the dynamic range of the storage circuits. This is done by the preamplifier, amplifier, and agc circuits in the chip. Amplification is done in two steps — initially by the input preamplifier and then by a fixed gain amplifier. The signal path between the preamplifier and the fixed gain amplifier is completed by a blocking capacitor, which allows the fixed amplifier to be connected to a line input instead in some applications.

The preamplifier has automatic gain control, with the attack/release time constants set by R10/C12. The 20 dB or so of gain compression range on the preamp compensates for variations in voice characteristics and levels of speech volume.

The next stage of signal conditioning is done by the input filter. Although analog storage of the instantaneous voice level does not require an a-d converter, digital sampling is done in the time domain; so an anti-aliasing filter is required to limit any speech components to frequencies less than one-half the sampling rate. This is a primary requirement of any digital audio processing technology.

The processed waveform is then passed into the analog transceivers to be written into the analog storage array. Because the storage process takes longer than the sampling period, several samples are written at one time, and then another group of samples is written, and so on. The eeprom cells work similar to digital eeproms you are familiar with, but these eeprom cells actually store an analog voltage and not a digital signal (0's and 1's). The recording is



Block Diagram of ISD-1420P Voice Record/Playback IC

non-volatile; it has a useful life of at least ten years even if no power is applied during part or all of that time.

Audio Playback Circuits.

During playback, the recorded analog voltages are sequentially read from the storage array, thereby reconstructing the sampled waveform. The smoothing filter on the output path removes the sampling frequency component and the original waveform is restored. The output of the smoothing filter is connected through an analog multiplexer into the output power amplifier.

Although not normally used in the DVR-4, two output pins (14 & 15) can provide direct speaker drive capability of about 50 mW rms (100 mW peak) into a 16Ω speaker — enough to be clearly heard from the other side of a normal sized room. An external audio signal can also be applied to the speaker driver through the AUX IN at pin 11.

Normal audio output for external use is derived from one line of the speaker driver. This audio is coupled through potentiometer R8, which allows for level adjustment, and R9/C10, which provides the proper output impedance and dc blocking.

U1 Control Circuits.

There are several control lines on the ic, of which we only use two.

The PLAY E (edge triggered playback) line, does two things when taken low momentarily. First, it resets the internal address pointer to zero. Second, it puts the ic in a power down state in which it draws very little current (for idling).

The REC line records a message up for as long as it is held low, but not exceeding 20 seconds.

S2 Record Switch Circuit.

Now that you know the functions of the control pins on the U1 chip, we can discuss how the external control circuits operate. *Refer to the schematic diagram.*

In order to record a message, S2 (or an external switch performing the same function) is depressed. The switch works in conjunction with pull-up resistor R2 to apply either +5Vdc or ground to playback/record pin 27 on the U1 chip. When recording is necessary, S2 is depressed, and pin 27 is held low, in the record mode. Pressing S2 causes the ic to be in record mode and to run, i.e., for the clock circuits to step through a message.

At the end of the recorded message, releasing S2 stops the record cycle and causes the chip's internal control circuitry to put an "end of message" marker at the point in memory where the message ends. On playback, this marker controls where playback stops.

In order for the ic to play back, S1 (or an external switch performing the same function) is depressed momentarily. This switch works in conjunction with pull-up resistor R1 to apply either +5Vdc or ground to the PLAY E line on the U1 chip. This is an edge triggered command line, which means only a momentary ground is required to start the playback operation.

Addressing.

There are two types of addresses used in the U1 chip. The first is an internal address pointer, which at any given time, keeps track of which memory cell is next to be read or written. At the beginning of a record or playback cycle, it starts at a starting location and cycles through until the end of the message and remains there until the PD line is brought high, which resets it to the starting address again.

The starting address normally is set by the address control lines on the upper left side of the pc board. As the board comes from the factory, these lines are all strapped to ground by pc board traces; so the starting address is zero. If one or more of these lines is raised to +5Vdc, the starting address for a given record or playback cycle is changed to some other location in memory. There is an extensive discussion of memory addresses earlier in this manual, under *OPERATION,* in a subsection titled *Addressing More Than One Message.*

Power Distribution.

+5Vdc operating voltage for the module is derived from the 12Vdc input through voltage regulator U2.

There are two separate +5Vdc busses on the DVR-4 board and separate sets of Vcc and Vss pins on the recorder ic for digital and analog power supplies. Because noise from the switching and clock circuits in the chip could affect the quality of the recording and playback audio, these two power paths are carefully separated and filtered from each other at various frequencies from audio up through the vhf range. This is also the reason a special microphone reference line is used to carefully establish the reference point used for the op-amp microphone preamp to suppress any noise from affecting the recording. It is important to maintain these features if you make any modifications to the circuits.

TROUBLESHOOTING.

General.

Tracking down trouble is fairly straightforward. The *Theory of Operation* section describes the signal path and what each circuit does.

Remember that the ic's are static sensitive. You don't want to further damage the board while troubleshooting. A ground wrist strap should be worn when handling the ic's.

Significant logic voltages are high's (near +5V) and low's (near ground). Following is a stage-by-stage description of other voltages which should be present under various conditions.

A logical troubleshooting procedure would be to start by checking for expected operation with the manual playback and record switches, S1 and S2. If you can't hear any audio or the transmitter does not key when S1 is pressed momentarily, then check various voltages and logic levels. An oscilloscope may be necessary to check audio levels. If the unit works manually but the timer and external trip circuits do not respond as expected, then trace those signals through the circuit, referring to the schematic diagram and information in the *Theory of Operation* section of the manual.

Digital Recorder U1.

All analog circuits in 1420P ic U1 are referenced to an internally generated bias of approximately 1.5Vdc. This voltage can be measured at the mic input (pin 17), mic ref (pin 18), ana input (pin 20), and ana output (pin 21), but only in the record mode. In playback mode, these pins measure near ground. The audio output pins (14 and 15) should each measure about 1.5 Vdc to ground in playback mode.

The agc line at U1 pin 19 rests at about 1.5Vdc in record and peaks up just a little bit if you apply loud au-

dio to the audio input to make the agc take action.

Here are some typical ac voltage measurements. In record mode, the mic input voltage at pin 17 should be about 20 mVp-p. The analog input voltage at pin 20 should be about 50 mVp-p. In playback mode, the audio output between pins 14 and 15 should be about 3Vp-p (1.5Vp-p ref ground).

The control signal pins on U1 are at logic levels noted on the schematic.

Power Supply Circuit.

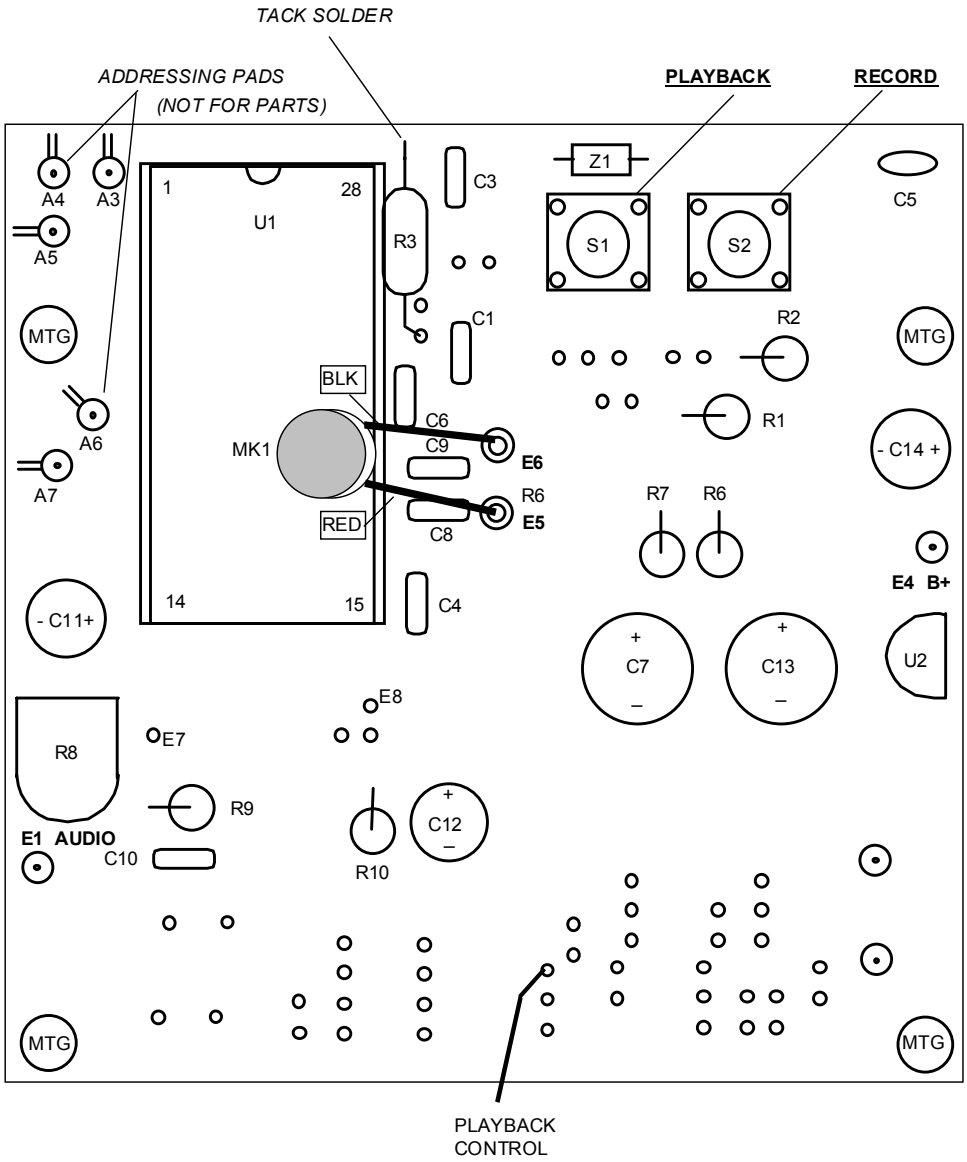
The acceptable range of operating voltages is +4.75 to +5.25 Vdc. Current drain normally is about 4 mA at idle and 22 mA in playback mode.

It is very important, though, to protect the entire board from voltage transients and reverse polarity, which will cause damage. Be careful, especially if any relays are powered from the same line. Any relay coils or other inductive devices must have diodes connected across them to absorb transients generated when current to the coil is switched off.

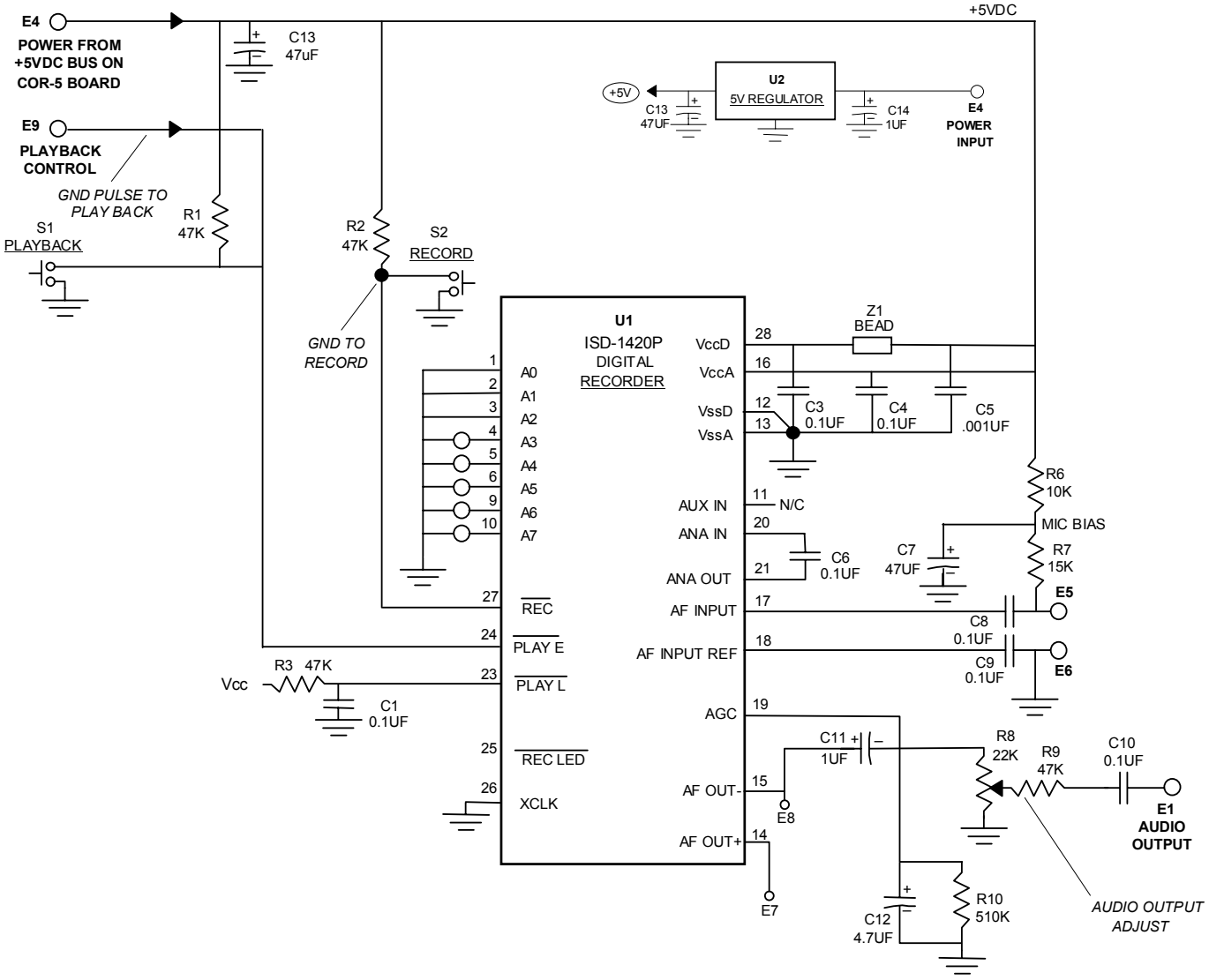
PARTS LIST.

* Indicates this part is surface mounted under pcb.

Ref Desig	Description
C1*	0.1µf
C2	not assigned
C3-C4*	0.1µf
C5*	.001µf
C6*	0.1µf
C7	47µf electrolytic
C8-C10*	0.1µf
C11	1µf electrolytic
C12	4.7µf electrolytic
C13	47µf electrolytic
C14	1µf electrolytic
MK1	Electret Microphone
R1-R2*	47k
R3	47k
R4-R5	not assigned
R6*	10k
R7*	15k
R8	22k or 20k pot
R9*	47k
R10*	510k
S1-S2	pushbutton switch, spst
U1	ISD-1420P recorder ic
U2	78L05 regulator ic
Z1	ferrite bead, prestrung



DVR-4 DIGITAL VOICE RECORDER MODULE, COMPONENT LOCATION DIAGRAM



DVR-4 DIGITAL VOICE RECORDER MODULE

