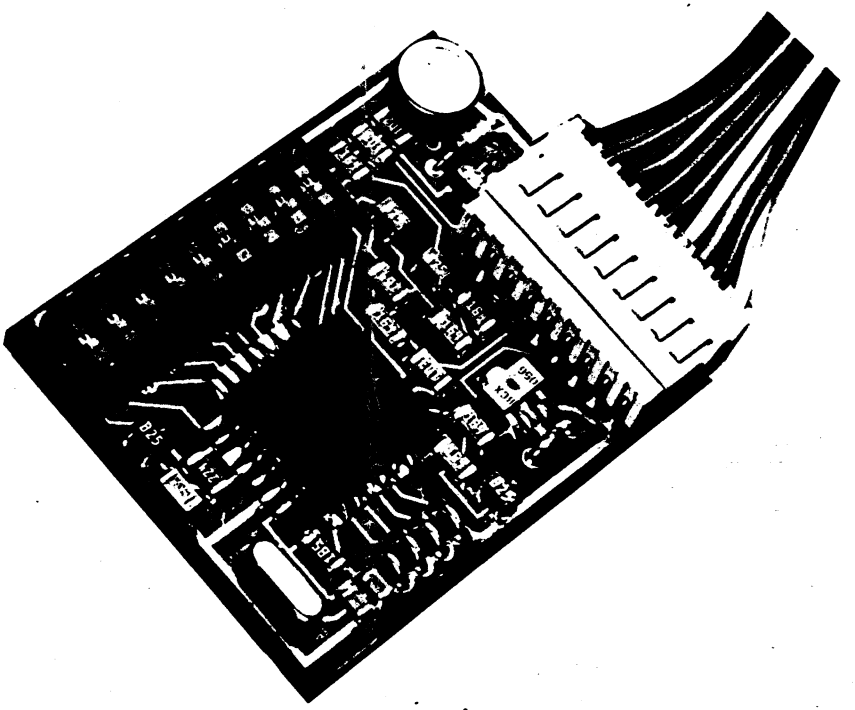
# FERRITRONICS

# DE33

## DIGITAL CODED SQUELCH ENCODER / DECODER




**United States:**
1319 Pine Avenue
Niagara Falls, N.Y. 14301
(716) 282-7470
(800) 828-6884
(800) 462-7242 N.Y.

**Canada**
222 Newkirk Road
Richmond Hill, Ontario
Canada, L4C 3G7
(416) 884-3180
Telex: 06-966680



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# DE33 DIGITAL CODED SQUELCH
# FERRITRONICS ENCODER/DECODER

## FEATURES

The Ferritronics Model DE33 is a Digital Coded Squelch (DCS) Encoder-Decoder board, that is designed to encode and decode a continuous 23 bit digital codeword. The DE33 is compatible with mobile radio digital signalling formats such as "Digital Private Line" and Digital Channel Guard".

This second generation product uses surface mount technology, resulting in a very compact and highly reliable circuit. The DE33 is engineered to retrofit into mobiles, portables, and base station radio sets, that utilize a direct FM modulator circuit. The microprocessor based product uses CMOS components for very low power consumption. This makes the DE33 ideal for portable radio applications that utilize DCS signalling.

1. Fully field programmable via 9 position dip switch allows selection of any one of 110 digital codes.
2. Jumper selection of receive code polarity, transmit code polarity, audio mute polarity and PTT polarity.
3. Squelch tail elimination via 'Turn off Code'.
4. Audio highpass filter eliminates all digital noise from receive audio.
5. Delayed PTT circuitry allows transmitter to stabilize before code is sent. Open collector outputs capable of sinking 150mA maximum or sourcing 100mA maximum.
6. Receive mute output: Open collector output capable of sinking 50mA maximum.

## SPECIFICATIONS

| | |
|---|---|
| **ENCODER** | |
| ENCODING | 23 bit digital coded word (dcs) transmitted at 134.4 hz. data rate |
| TURN OFF CODE | 134.4 hz square wave for 180 ms. |
| OUTPUT Z | 1.5 k ohms ac coupled |
| OUTPUT AMPLITUDE | 0 to 4.0 v. adjustable |
| **DECODER** | |
| INPUT Z | 50 K ohms AC coupled |
| INPUT SIGNAL LEVEL | 20 mVrms to 1.7 Vrms |
| SIGNAL TO NOISE | Better than 4 Db. Sinad |
| SQUELCH TAIL ELIMINATION | by turn off code detection |
| DECODE TIME | 170 Ms. Maximum (1 word length) |
| FADE TIME | 750 Ms. |
| **GENERAL** | |
| DCS PROGRAMMING | by 9 position DIP switch |
| DCS CODE REFERENCE | 3 digit number 000-777 |
| SIGNAL POLARITY | by PCB wire jumper |
| MICROPHONE HAND-UP INPUT | Ground to mute, open to monitor |
| RX MUTE OUTPUT | Open collector @ 50 Ma. |
| PTT INPUT | Ground or +V to transmit |
| DELAYED PTT OUTPUT | Open Collector pull to ground @ 150 Ma. or pull to +V @ 100 Ma. |
| RECEIVE AUDIO FILTER | 3 pole High-pass |
| TEMPERATURE RANGE | -30 C to +65 C |
| SUPPLY VOLTAGE | 6.0 to 18.0 VDC |
| CURRENT REQUIREMENTS | 10 Ma. @ 12.0 V |
| SIZE | 1.61" X 1.27" X 0.31" |

## INSTALLATION

Installation of the DE33 should be done by a qualified two-way radio technician. All connections to the DE33 are made at the nine pin PCB connector, P1. The cable assembly supplied with the DE33 should be used for interfacing the unit to the FM transceiver. Installation of the DE33 is very similar to the installation of a CTCSS encoder-decoder. Be sure that all power is removed from the transceiver prior to interfacing the DE33. The DE33 may be mounted in any location where space permits. Please refer to the Typical Mobile Installation Diagram for a typical installation. When programming the DCS code, or changing jumper options, be sure to remove the power from the DE33. Permanent damage may result if the DE33 is modified with power applied.

IMPORTANT NOTE

Please note that not all FM transceivers are specifically designed to be compatible with encoding digital data signals. The transmitter MUST have a DIRECT FM MODULATOR to encode DCS data. A phase modulated transmitter does not have the proper frequency response for DCS data, and is not normally designed to pass the low frequency components inherent in DCS transmissions. The use of the DE33 with a radio not designed for DCS transmission, such as a phase modulated transmitter, may not provide satisfactory performance. Under some circumstances, a phase modulated radio can be modified for direct FM operation. Consult the manufacturer of your radio set to determine it's interface capability with DCS signalling.

Use the following information for all wire connections to the DE33:

| PIN # | DESCRIPTION |
|---|---|
| P1-1 BLACK | GROUND. Connect this wire to a convenient location in the radio, which will supply a DC ground return to the DE33. |
| P1-2 ORANGE | DELAYED PTT OUTPUT. This wire should be connected to the PTT line inside the transmitter. Connect the wire removed from the microphone connector, inside the transceiver, to this wire. This wire keys the transmitter, and holds the transmitter on the air for 150 ms. after the microphone PTT switch is released. If a relay is driven by this output, be sure to install a protection diode across the relay coil. As shipped from the factory, jumper J5A is installed, and provides a ground potential to key the transmitter. If a pull to +V is required to key the transmitter, then move jumper J5A to J5B. |
| P1-3 RED | +VDC. This wire must be connected directly to any sourse of +DC voltage. The best place to find the positive voltage is inside the radio set AFTER the powerswitch. This connection will then activate the DE33when the radio set is turned on, and disable the DE33 when the radio set is turned off. If a regulated source of voltage is available, it may also be used. |
| P1-4 YELLOW | RX MUTE OUTPUT. This wire must be connected to a location in the receiver circuit that will mute the recieve audio upon the application of a ground potential. This location is usually the collector of the squelch switch transistor. This wire is normally at ground with the microphone on-hook, and mutes the receiver when no signal is decoded. When the microphone is off-hook, or a DCS signal is decoded, Q6 unmutes the receiver, and appears as an open circuit. If a reverse polarity signal is required to mute, and unmute the receiver, then remove the MUTE POLARITY Jumper, J3, on the DE33 circuit board. |

P1-5 BROWN — DCS OUTPUT. This wire outputs the DCS data to the radio for transmission. This wire should be connected to the sub-audible modulator input on a direct FM transmitter. The use of shielded cable may be required if the modulator input on the transmitter is susceptable to high RF interference levels, or if the DE33 is mounted some distance from the modulator circuit. Any series capacitors in the DCS signal path should be changed to at least 3.3 uf. in order to preserve the low frequency response necessary for the transmission of DCS data. The DE33 encodes the Turn-Off Code when in the idlestate. When the PTT INPUT is keyed, the DE-33 will encode the DCS data.

P1-6 BLUE — MICROPHONE PTT INPUT. This wire should be connected to the PTT switch inside the microphone. This wire tells the DE33 when to key the transmitter, and when to start encoding the DCS data. Disconnect the PTT line from the microphone connector on the transceiver, and connect the MICROPHONE PTT INPUT wire to the microphone connector. The PTT wire removed from the microphone connector will be re-connected in the next step. If the PTT line from supplies +V to key the transmitter, then remove the PTT POLARITY JUMPER, J3, on the DE33 circuit board. Also, be sure to modify Jumper J5, in the next step, if necessary.

P1-7 WHITE — MICROPHONE HANG-UP. This connection must be wired directly to the microphone hang-up switch. When the microphone is on-hook, a ground should be applied to the MICROPHONE HANG-UP Input on the DE33. When the microphone is off-hook, an open circuit should be seen at the MICROPHONE HANG-UP Input. This connection is used to control the RX MUTE OUTPUT on the DE33.

P1-8 GREEN — RX AUDIO INPUT. This wire must be connected DIRECTLY to discriminator output on the receiver. If there are any series capacitors in the signal path, they must be changed to at least 3.3 uf. The frequency response of the DCS signal path must be kept very low in order for the DCS signal data to pass un-distorted to the DE33 decoder circuit.

P1-9 GREY — HP FILTER OUTPUT. This connection is optional. This output filters out the DCS signal from the receive voice audio. Break the receive audio signal path after the RX AUDIO INPUT connection, and connect the HP FILTER OUTPUT in series with the audio path.

## DC OUTPUT LEVEL ADJUSTMENT

The DE33 requires only one level adjustment - the DCS OUTPUT level. During this adjustment procedure, it is very important to use a service monitor that has a "deviation scope" when setting the deviation level on the DCS OUTPUT. The deviation scope MUST be used to properly set the system deviation. A standard deviation "meter" may give an improper deviation level reading due to the low frequency spectrum used in DCS signalling. In addition, some of the older service monitors do not have the low frequency response necessary for DCS deviation measurements. The deviation scope will also indicate if any distortion is present in the transmitted DCS signal. Use the following procedure for setting the level of the DCS OUTPUT:

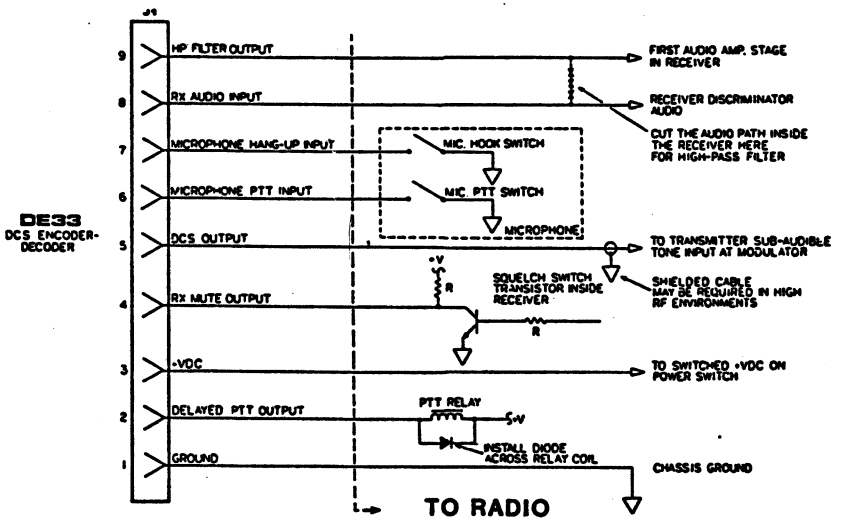
STEP 1. To set the level on the DCS OUTPUT, first verify that all of the DIP switches on the DE33 are set to "ON". When all switches are turned ON, the DE33 will generate a low frequency digital square wave on the DCS OUTPUT when the MICROPHONE PTT INPUT is keyed.

STEP 2. Apply power to the transceiver, and set your service monitor to the RF channel of the transmitter.

STEP 3. Now press the PTT switch on the microphone, and while watching the deviation level on the service monitor, adjust the DCS Level Pot, R25, with a small alignment tool, for .75 Khz. of peak to peak deviation. Please note that the encoded signal should look like a square wave with the corners rounded off. If the DCS OUTPUT tends to overdrive the transmitter, then a 47K ohm resistor can be placed in series with the DCS OUTPUT to reduce the drive.

STEP 4. Release the PTT switch, and remove power from the transceiver. This completes the level adjustment.

## TYPICAL MOBILE INSTALLATION




## ADJUSTMENT

The DE33 is typically used in conjunction with an FM radio transceiver. User operation of the DE33 is identical to the operation of a typical CTCSS encoder-decoder.

The DE33 will mute the receive audio when the transceiver microphone is "On-Hook", and if a properly encoded signal is not present. The receive audio may be unmuted for monitoring, by lifting the microphone "Off-Hook". The receive audio may be muted by placing the microphone back On-Hook.

When properly interfaced to an FM transceiver, the DE33 will unmute automatically the receive audio upon recognition of the correct digital codeword, and allow the receive audio to pass. The DE33 will hold the receiver audio open for as long as the DCS signal is present. The DE33 will also hold the receiver unmuted for 750 ms. during signal fade conditions, but will immediately mute the receive audio upon detection of the "Turn-Off-Code" that is received at the end of every DCS transmission. The detection of the Turn-Off-Code eliminates the squelch tail that would otherwise be heard at the end of a transmission.

When the microphone PTT switch is pressed, the DE33 will key the associated transmitter, and generate a continuous 23 bit digital codeword for transmission. This unique 23 bit codeword, known as the DCS signal, will be transmitted for as long as the microphone PTT switch is pressed. When the microphone PTT switch is released, the Turn-Off-Code will be generated, and the transceiver will revert back to the receive mode in 150 milliseconds.

## PROGRAMMING THE DE33B

The DCS Code can be easily field programmed by the 9 position DIP switch (SW1-SW9) on the DE33B circuit board. The DCS code consists of a three digit number ranging from 000 to 777. The leading digit of the DCS code is programmed by SW1, SW2, and SW3, the middle digit is programmed by SW4, SW5, and SW6, and the least significant digit is programmed by SW7, SW8, and SW9. Remove power from the DE33B and program in the DCS code number using the DIP switches according to the following table:

| DCS # | SW 1,4,7 | SW 2,5,8 | SW 3,6,9 |
|---|---|---|---|
| 0 | ON | ON | ON |
| 1 | ON | ON | OFF |
| 2 | ON | OFF | ON |
| 3 | ON | OFF | OFF |
| 4 | OFF | ON | ON |
| 5 | OFF | ON | OFF |
| 6 | OFF | OFF | ON |
| 7 | OFF | OFF | OFF |

For example, to program the DCS code number 152, set the DIP switch as follows:

| SW1 | SW2 | SW3 | SW4 | SW5 | SW6 | SW7 | SW8 | SW9 |
|---|---|---|---|---|---|---|---|---|
| ON | ON | OFF | OFF | ON | OFF | ON | OFF | ON |
| | 1 | | | 5 | | | 2 | |

The maximum number of DCS codes available is 512. However, less than 100 of these codes are useable. When selecting a DCS code for a new system, be sure to select a valid code.

## POLARITY JUMPERS

Now that the DCS code is programmed, the final step is to verify that the DE33B will encode and decode the proper data polarity signal for your two-way radio system.

Apply power to the transceiver, and have a mobile radio on the receiver channel generate a DCS signal for decoding. If the DE33B does not decode the DCS signal, disconnect power from the transceiver, and remove the RX POLARITY Jumper, J1. Now re-test the DE33B for DCS decoding. If the DE33B still does not decode the DCS signal, then either the DCS code is not programmed correctly, or the DCS signal from the receiver discriminator is not interfaced properly to the DE33B.

To test the DCS encode signal polarity, apply power to the transceiver, key the PTT on the microphone, and check to see if the transceiver will access your radio system properly. If proper decoding does not result, disconnect power from the transceiver, and remove the TX POLARITY Jumper, J2, from the DE33B circuit board. Now re-test the DCS encoding. If the DE33B still does not access your radio system, then either the DCS code is not programmed correctly, or the DCS encode signal is not interfaced properly to the transceiver.

## THEORY OF OPERATION

### GENERAL

The main controller of the DE33B is the CMOS microprocessor chip, IC2. All control, encoding, and decoding functions are derived from within IC2. Interface components such as the transistor circuits, isolate and protect IC2 from any transient voltages that might exist on any connecting wires to the DE33B. Op-amp circuitry provides the transition from the outside analog world, to the internal digital world of the circuit. The critical system clock is derived from a 3.579 Mhz. quartz crystal.

A DIP switch and PCB jumpers on the DE33B allow for codeword programming, data polarity inversion, and other field programmable options. A 3 pole high-pass filter circuit removes audible frequencies below 350 Hz, and allows the voice frequency spectrum to pass unattenuated. The filter roll-off rate is at approximently 24 Db/octave.

### DECODER

The DCS signal is applied to P1-8 on the DE33B. This signal is fed into a 3 pole low-pass filter which eliminates the voice signal from the 23 bit digital codeword. This filtered signal is fed into a 1 pole passive low-pass filter, and then into a zero-crossing detector. This zero-crossing detector squares up the signal, and filters out the noise components. The processed signal is then fed directly into the microprocessor circuit for DCS word decoding.

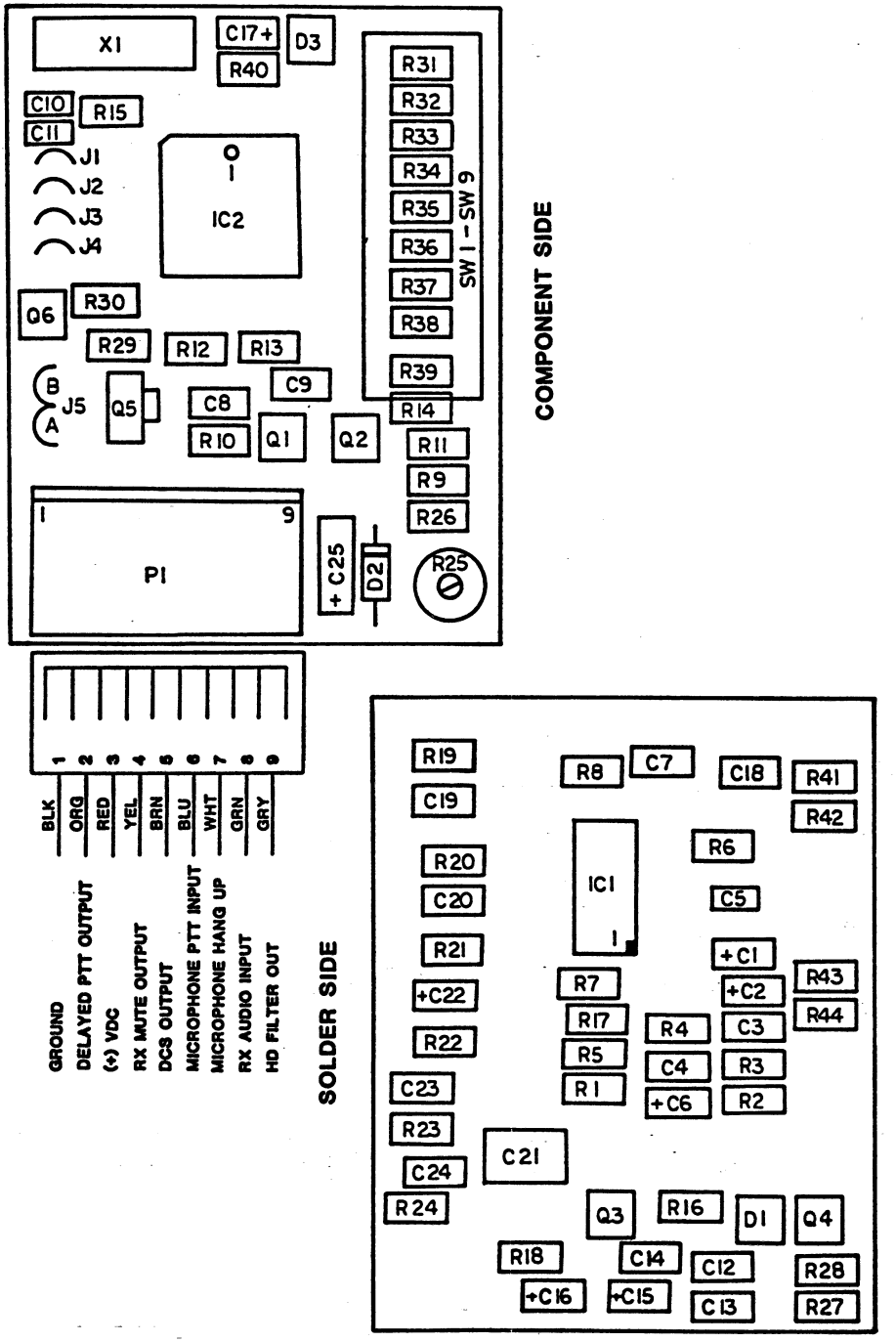
### ENCODER

The DCS encode signal is generated by the microprocessor chip, IC2, pin 10. The output from this chip is fed into a 2 pole low-pass filter which removes the high frequency components from the square wave output. The level of the DCS signal can be adjusted by R25, and the DCS output is available at P1-5.

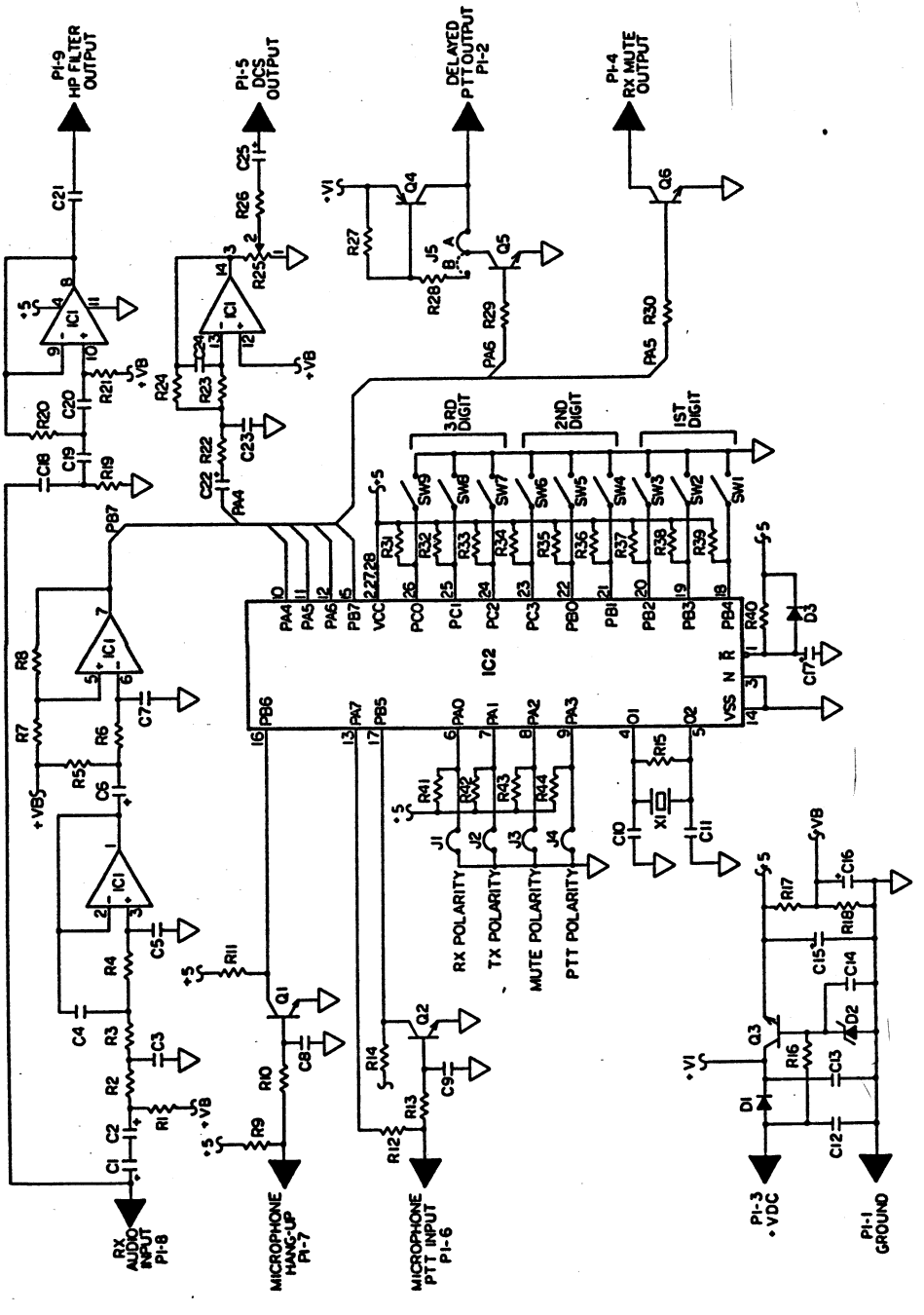
### POWER SUPPLY

The regulated voltage for the op-amp, IC1, and the microprocessor chip, IC2, is derived from a voltage regulator circuit consisting of Q3, D2, and associated circuitry. The input voltage is regulated down to +5.5 Volts by Q3. Bias voltage for the op-amp is derived from R17, and R18. C16 stabilizes and filters out any noise components that may exist on the virtual ground of the op-amp circuitry. The DE33B circuit is designed with CMOS integrated circuits for very low power dissipation.

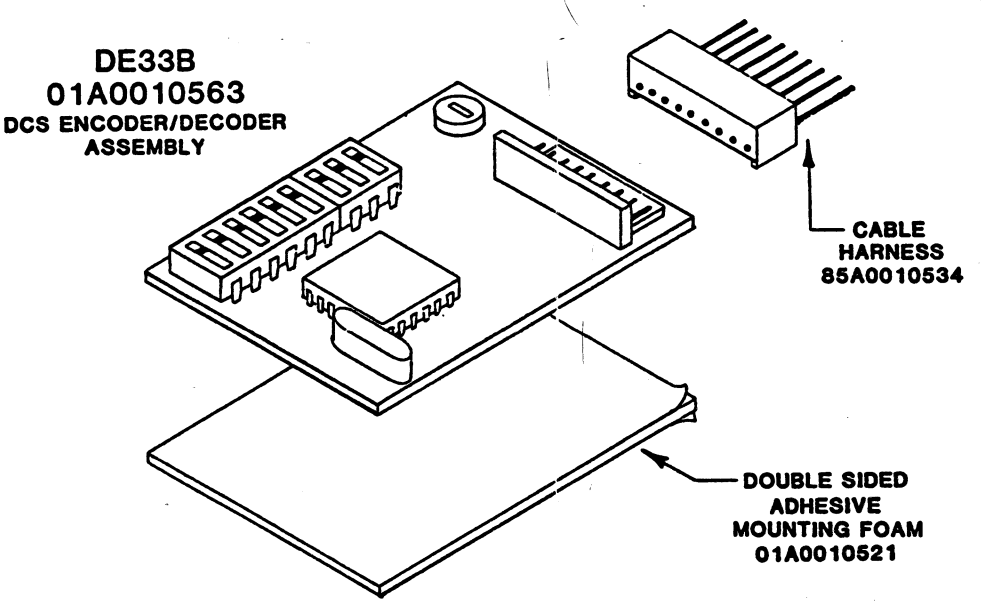
# DE33B ENCODER/DECODER BOARD



# DE33B DCS ENCODER / DECODER UNIT



# DE33 DCS ENCODER / DECODER UNIT
# 01A0010533




## PARTS LIST

## 01A0010533 DE33 DCS ENCODER / DECODER UNIT

| DESIGNATION | DESCRIPTION | PART # | QUANTITY |
|---|---|---|---|
| DE33B | DCS UNIVERSAL ENC. DECODE | 01A001563 | 1 |
| J2 | 9 PIN FEMALE CABLE ASS'Y | 85A0010534 | 1 |
| | ADHESIVE FOAM TAPE | 01A0010521 | 1 |
| | ANTI STATIC BAG | 89-3247 | 1 |
| | INSTRUCTION SHEET | 98A0010533 | 1 |

## PARTS LIST

## 01A0010563 DCS UNIVERSAL ENC/DECODE BOARD

| DESIGNATION | DESCRIPTION | PART # | QUANTITY |
|---|---|---|---|
| | PRINTED CIRCUIT BOARD | 18B0010563 | 1 |
| IC1 | CMOS QUAD OP-AMP SO-14 | TLC274ID | 1 |
| IC2 | CMOS MICROP. 28 PIN PLCC | MC146805F2CFN | 1 |
| Q1,Q2,Q6 | NPN TRANSISTOR SOT-23 | MMBT3904 | 3 |
| Q3 | NPN H.V. TRANSISTOR SOT-23 | MMBTA06 | 1 |
| Q4 | PNP H.V. TRANSISTOR SOT-23 | MMBTA56 | 1 |
| Q5 | NPN TRANSISTOR SOT-89 | BCX56 | 1 |
| D1,D3 | SILICON DIODE SOT-23 | BAS29 | 2 |
| D2 | 6.2 V 1/2 WT. 5% ZENER | 1N753A | 1 |
| X1 | 3.579 MHZ XTAL HC-43U | 49U4H3.579M | 1 |
| C16 | 10 UF TAN CHIP 20% 4V | NTC10M4VT | 1 |
| C25 | 6.8 UF TAN CHIP 20% 20V | NTC6.8M20VT | 1 |
| C1,C2,C6,C15,C17,C22 | TAN CHIP 20% 16V | NTC1M16VT | 6 |
| C21 | .22UF CHIP X7R 1812 20% 50V | 1812X224M2B | 1 |
| C4,C7,C12,C13 | .047UF CHIP X7R 10% 50V | 1206X473K2B | 4 |
| C23 | .018UF CHIP X7R 10% 50V | 1206X183K2B | 1 |
| C3,C8,C9,C14,C18 C19,C20,C24 | 5600PF CHIP X7R 10% 50V | 1206X562K2B | 8 |
| C5 | 68PF CHIP NPO 10% 50V | 0805C680K2B | 1 |
| C10,C11 | 27PF CHIP NPO 20% 50V | 0805C270M2B | 2 |
| R25 | 10K POT RND TOP ADJ. | 82PR10K | 1 |
| R26 | 1K 5% 1206 CHIP RESISTOR | | 1 |
| R10,R13,R16,R28 R29,R30 | 2.2K " " " " | | 6 |
| R18 | 3.6K " " " " | | 1 |
| R17,R20 | 5.1K | | 2 |
| R7,R9,R12,R27 | 10K | | 4 |
| R6 | 18K | | 1 |
| R11,R14,R19,R31-R39 R41-R44 | 33K | | 16 |
| R23 | 82K | | 1 |
| R24 | 150K | | 1 |
| R5 | 200K | | 1 |
| R22,R40 | 220K | | 2 |
| R1 | 390K | | 1 |
| R2,R3,R4 | 680K | | 3 |
| R21 | 1.3 MEG | | 1 |
| R8,R15 | 1.8 MEG | | 2 |
| SW1-SW9 | 9 POS. SEALED DIP SWITCH | 51D-0901 | 1 |
| | MAIN PCB | 18B0010563 | |
| P1 | 9 PIN MALE PCB HEADER | 10-32-1093 | 1 |
| J1,J2,J3,J4,J5A | PCB WIRE JUMPERS | | 5 |

NOTES