Motorola

I-50 Controller

Owners / Service Manual

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GENERAL SPECIFICATIONS

All specifications apply over the specified operating temperature range, duty cycle, voltage range, and humidity unless otherwise stated.

DC input voltage:
10.5 to 15VDC

DC input current:
less than 400mA

Weight:
3 pounds maximum

Dimensions:
9⅜" W x 7½" D x 2¼" H

Telephone line conn.:
Modular plug

Operational Temp. Range:
-25°C to +55°C

Humidity range:
<95% relative humidity at +50°C

Input level from phone line:
+5dBm max
autolevel threshold -35dBm ± 3dB

Output level to phone line:
-9dBm max (time averaged over 3 seconds)

Input level from receiver:
280mVRMS nominal
autoleveled ± 10dB from nominal
differential input impedance >180k
Max DTMF twist (hightone/lowtone)
-8dB to +4dB

Output level to transmitter:
165mVRMS ± 1.5dB into 600Ω

Audio frequency response:
± 3dB, 300–3000Hz from 1kHz reference
(-45dBm input, phone to repeater path)
(280mVRMS input, repeater to phone path)

Hum and noise:
-45dB from 1kHz reference using 30kHz LPF
(-30dBm input, phone to repeater path)
(280mVRMS input, repeater to phone path)

Audio distortion:
3% max., 1 kHz tone
(-10dBm input, phone to repeater path)
(280mVRMS input repeater to phone path)

Phone line busy detect threshold:
-10V ± 2V (or -20V ± 2V with 48V threshold jumper, JU2, in)

Logic level inputs:
>4 volts is logic high, <1 volt is logic low.
Input impedance >90kΩ (inputs pulled up through 100kΩ to +5V bus)

II. DESCRIPTION

1. GENERAL DESCRIPTION

The phone patch allows telephone service to be extended to mobiles and portables. Conversations are "half-duplex" with the mobile able to interrupt the land-line party. Mobiles answer, originate, and disconnect calls by sending Touch-Code tones with their Touch-Code encoder.

The phone patch can be programmed to signal the land-line with regenerated DTMF or dial pulse, inhibit long distance calls (0 or 1 leading digit), and allow 3, 10, or 20-minute calls (if allowed by regulations). If no mobile activity is detected for 3 minutes, the patch is disconnected. Signal "ticks" are sent for 15 seconds prior to a disconnect. An "over" beep signal is sent to the land-line party when the mobile unkeys.

Self-diagnostic tests are included in the phone patch firmware to assist in installation and troubleshooting.

2. MOBILE OPERATOR INSTRUCTIONS

a. To Initiate a Call

1.) Press the push-to-talk button and send a Touch-Code star (*) (or pound-star (#*), if so programmed).

2.) Release the push-to-talk button and listen for a dial tone. (If the telephone line is in use and the patch is so programmed, a busy signal will be heard. The mobile operator may then release the patch with a pound (#) or wait for a dial tone.)

3.) Press the push-to-talk button and dial the desired telephone number, ending with a star (*). (Cuts through mobile audio immediately on completion of land-line signalling. If the number is not terminated with a star, the patch will wait 3 seconds for additional numbers from the mobile and then cut through mobile audio.)

4.) When the land-line party answers, press the push-to-talk button to speak and release it to listen. The land-line party will hear an "over" beep when you release the push-to-talk button, signifying it is his turn to talk.

5.) 15 seconds prior to disconnecting a call due to time out or mobile inactivity, the patch sends a "tick" signal every two seconds.

6.) To disconnect a call, press the push-to-talk button and send a Touch-Code pound (#).

b. To Answer an Incoming Call (3-second ring signal sent)

1.) Press the push-to-talk button and send a star (*) (or pound-star (#*), if so programmed).

2.) Say "Hello" and release the push-to-talk button.

3.) Carry on the conversation as described above in "To Initiate a Call."

III. INSTALLATION

1. SWITCH AND JUMPER PROGRAMMING

Determine the system requirements and set switch SWA as appropriate.

Switch SWA Section	
8	Connect command on = star (*) off = pound-star (#*)
7	Telephone line signalling on = DTMF off = rotary dial
6	Long distance inhibit (1 or 0 leading digit) on = inhibited off = allowed
5	3-Minute Access timer on = 3 minutes (regardless of section 4) off = 3-minute timer off
4	10-Minute Access timer on = 10 minutes (if section 5 off) off = 10-minute timer off
Note: If both section 5 and section 4 off, 20 minutes allowed.	
3	Initiate ring signalling to mobile; on = after 4th ring off = after 1st ring
2	Phone line busy detect (when mobile attempts to access phone patch) on = mobile access denied and busy returned when line in use (low voltage on line) off = mobile access allowed any time
1	Ring detect defeat on = land-line to mobile alert signalling defeated off = land-line to mobile alert signalling allowed

Jumper Descriptions	
JU2	48-volt telephone line threshold in (shunt in) = normal 48-volt idle telephone line out (shunt parked) = 24-volt idle telephone line
JU4	620Ω test load **Must be out for normal operation**
RT	Ring sensitivity in (default) = normal ring sensitivity out = increased ring sensitivity

2. LEVEL CONSIDERATIONS

The phone patch automatically compensates for varying telephone line levels and repeater receiver levels. Therefore, the patch has no internal audio level adjustments. Reference levels and autolevel performance can be verified through use of the internal diagnostics. Refer to the "Internal Diagnostics" section for details.

IV. INTERNAL DIAGNOSTICS

The patch has built-in test procedures to assist in setup and troubleshooting. These tests are invoked through use of the TEST and RESET buttons on the circuit board. Pressing the TEST button once will start test 1 and cause the "MODE" LED to flash once. Pressing it again will start test 2 and cause the "MODE" LED to flash twice and so forth through test 5. Each time a new test is selected, a test timer is set to 15 minutes. If this timer reaches zero, the patch resets itself to idle, ready to process telephone calls. The following describes each test and the various indications.

1. TEST 1

Keys the radio transmitter, accesses the telephone line, and sends a Touch-Code star (*) to the transmitter and switched network at a level of about -11dBm (600Ω load) to the switched network and about 165mV (600Ω load) to the transmitter. This test can be used to check transmitter deviation and telephone line access. While in this test, the "MODE" LED indicates the level of the alert inhibit input (on when pin 9 of P1 is grounded, off when ungrounded). The "STATUS" LED indicates the level of the patch disable input (on when pin 10 of P1 is grounded, off when ungrounded).

2. TEST 2

The transmitter is keyed and the switched network is accessed. The patch generates the 12 Touch-Code tones at six different levels. These tones are sent to the switched network and looped back to the DTMF decoder. The "STATUS" LED illuminates on data valid from the DTMF decoder, indicating that it is receiving its own DTMF codes. The tones are on for 100 milliseconds and may be slowed down to 500 milliseconds by pressing the RESET button. Pressing the RESET button again will freeze the test at the current DTMF tone and level. Pressing the RESET button again will allow the test to continue at the fast rate. The highest level is adequate to overdrive the radio transmitter and exceed the maximum input specification on the DTMF decoder. This procedure may be used to test the patch DTMF encoder/decoder and most of the audio paths in the patch. During this test, the "MODE" LED indicates the level of the manual connect input (on when pin 11 of P1 is grounded, off when ungrounded).

3. TEST 3

The switched network is accessed and land-line signalling is enabled. A mobile can dial a phone number in DTMF or dial pulse, as programmed. When not land-line signalling, receive audio is routed to the phone line with autoleveling. This test allows exercise of the repeater to switched network path, with autoleveling. While in this test, the "STATUS" LED is on while receiving a valid DTMF tone pair. The "MODE" LED indicates the level of the unsquelched input (on when pin 12 of P1 is grounded and off when ungrounded).

4. TEST 4

The transmitter is keyed and the switched network is accessed. Switched network audio is routed to the transmitter with autoleveling enabled. This test allows exercise of the phone line to transmitter audio path, with autoleveling. The "MODE" LED is on when the audio level on the switched network is adequate to cause autoleveling. The "STATUS" LED is on when a valid DTMF tone is being sent to the switched network.

5. TEST 5

This test exercises the non-accessed functions of the patch. The "MODE" LED illuminates when off hook (phone line voltage below threshold) and extinguishes when on hook (voltage above threshold). The "STATUS" LED flashes on when ringing is received on the phone line. The "MODE" LED also flashes since ringing will cause the off hook thresholds to be exceeded.

VI. THEORY OF OPERATION

The phone patch functions are controlled by the unit microprocessor. The patch can be broken down into functional blocks as follows:

1. DIGITALLY CONTROLLED AUDIO GAIN

Stage consisting of IC's U15, U14, U12A, U12C, U9A and U9B. The processor can select the gain stage input by control lines PC0 and PC1 controlling U15, an integrated double pole, four-throw analog switch. When one input to the gain stage is selected, a source for the DTMF decoder is also selected (pins 1, 5, 2, and 4 of U15). The inputs to the gain stage are:

a. Switched network on 0X
b. Repeater receiver on 1X
c. DTMF encoder and/or processor "beep" tone on 2X and 3X

The processor can control the overall gain of the functional block by changing digital lines P10–P17 to the analog multiplier IC U14, allowing a 1 to 255 gain change (gain numbers limited by firmware to 10–250). The current output of U14 is converted to a voltage by U9A and amplified by U9B. The output of the gain stage is routed to the phone line through analog switch U12C and/or to the transmitter through analog switch U12A.

2. PEAK READING VOLTMETER CIRCUIT

The voltmeter circuit consists of gain switch U12B, U10, U13, and U17. The voltmeter input is always from the variable gain stage. Two levels of gain are controlled by digital line PA5. High gain is used to indicate when a signal is present (VOX) and low gain to measure its present level. The output of the gain stage U10A is fed to the precision rectifier circuit U10D and U10C. The peak of this rectified signal is compared with the voltage generated by counter U17 and the 1R-2R resistance ladder in comparator U10B. If the rectified signal peaks are higher than the voltage from the ladder, oscillator U13C is gated on to increment counter U17, raising the ladder voltage until it is greater than the rectified input or the maximum counter count of 15 is reached. The processor periodically resets the counter and reads its output to determine proper gain numbers for the various path configurations.

3. DTMF ENCODER/DECODER

The DTMF encode/decode circuitry consists of U16, U9D, and U5A. The microprocessor clock is buffered by U5A and supplied to U16, the DTMF encoder/decoder. The decoder receives it input from switch U15 as described above. When the decoder sees a valid DTMF tone pair, it asserts DV (pin 22). This line is sampled every 5 milliseconds by the processor. When a data valid is seen, the processor takes data enable (DE, pin 5) low causing U16 to output the decoded number on digital lines PB0–PB3. The outputs are then turned off. When a DTMF tone is to be generated, the processor places the digital number on PB0–PB3 and then takes data latch low (LCH pin 17), then back high. To turn the tone off, the processor takes reset (pin 16) high. The generated DTMF tone is buffered by amplifier U9D and sent to the analog switch U15 for routing. When a beep or tick is required, the processor sends a 949Hz square wave from P22 through C38 to switch U15.

4. PHONE LINE LIMITERS AND FILTERS

Audio from the phone line is fed through high pass filter U8D to filter out low frequency hum and noise. Audio to the phone line is routed through low pass filter U8C which provides the rolloff characteristics required for FCC registration. Limiters Q6 and Q7 limit the instantaneous voltage that can be applied to the phone line. Surge protectors S1 and S2, in conjunction with chokes L6 and L7, provide a very high degree of surge protection to the phone patch, provided that the frame ground connections are made as described in the installation section.

5. OFF HOOK AND RING DETECT CIRCUITRY

In normal telephone systems, one of the telephone lines is grounded at the central office or PBX location and a negative voltage is applied to the other line. The off hook circuitry of U11 detects this voltage and informs the processor via PC5. Note that the power ground (and therefore radio ground) must be at approximately the same voltage as the grounded phone line in order for the circuitry to work. Large voltage excursions on the phone line are detected by opto-isolator U18 and sent to the processor on digital line PC4. The processor times and counts these pulses to differentiate between dial pulses, ring, etc.

6. DIFFERENTIAL RECEIVER INPUT

Amplifier U8B has differential instrumentation input with fairly small RC time constants to minimize hum and noise pickup. This signal is amplified by U8A and sent to the analog switch U15.

7. MICROPROCESSOR BUS

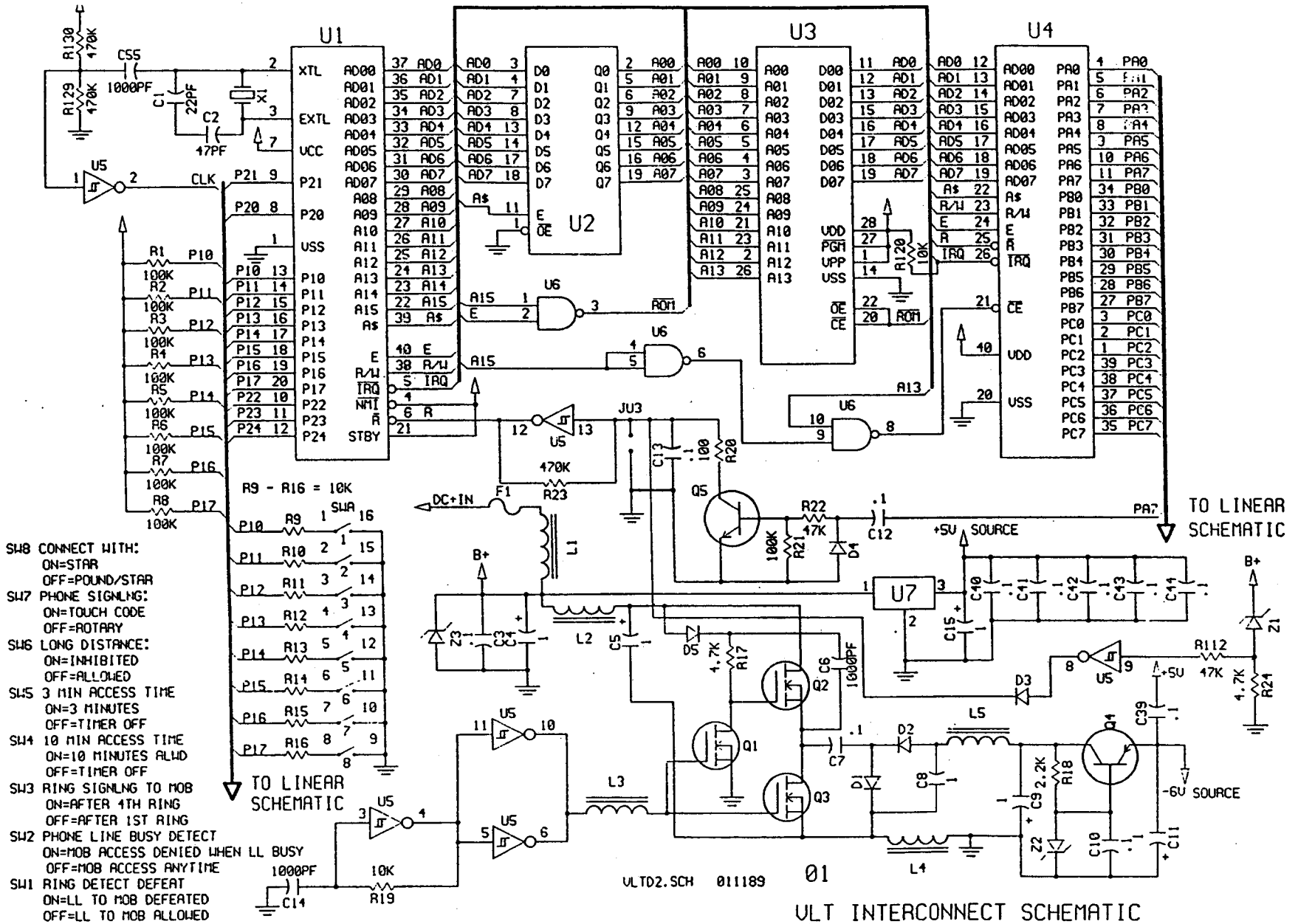
Microprocessor U1 puts out multiplexed address and data on AD0–AD7. These signals are demultiplexed by address latch U2 which provides the low order address bits to ROM U3. ROM U3 contains the patch firmware. Peripheral interface adapter U4 provides 24 input/output lines for operating the various functions in the patch.

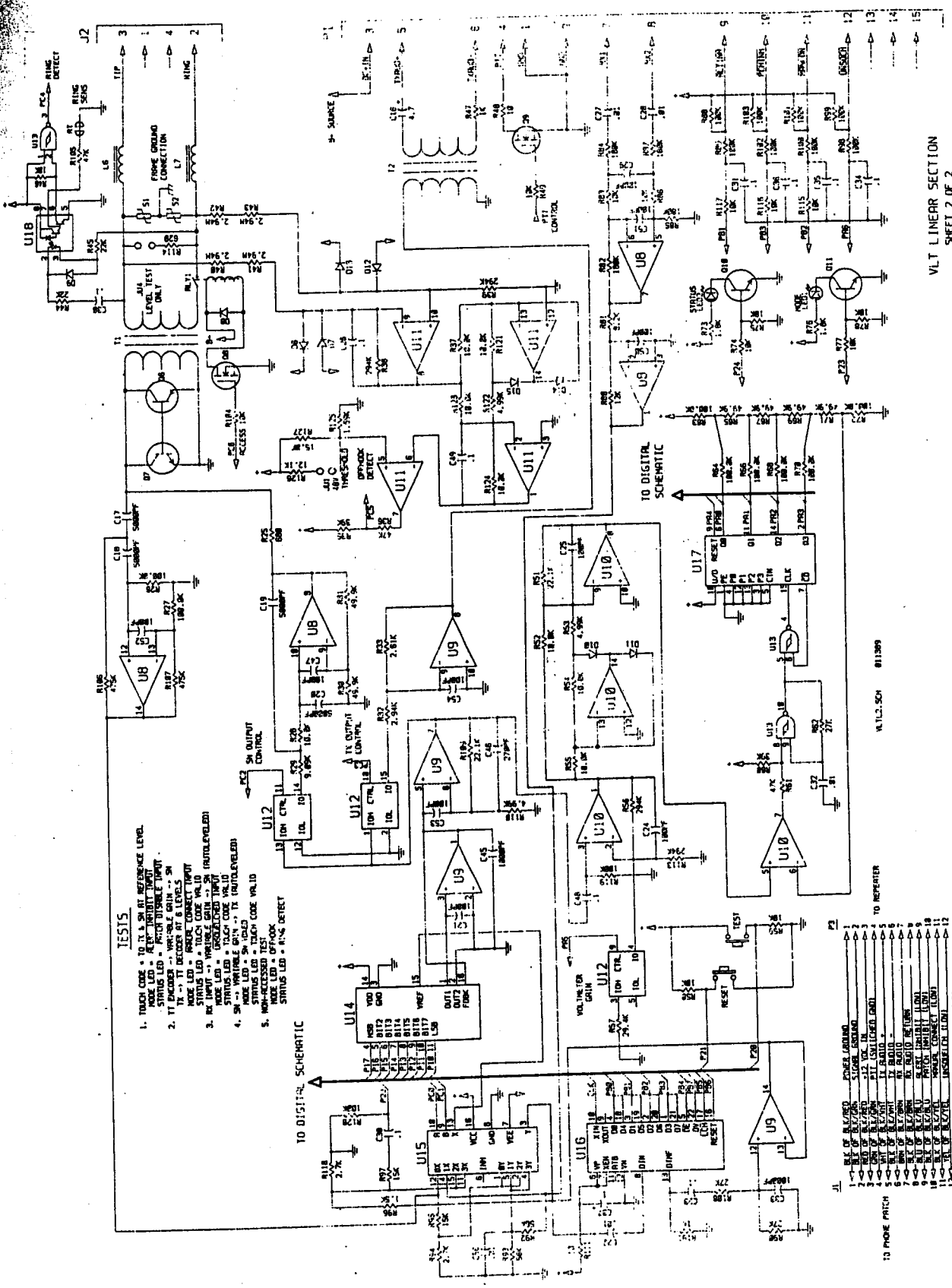
8. POWER SUPPLY

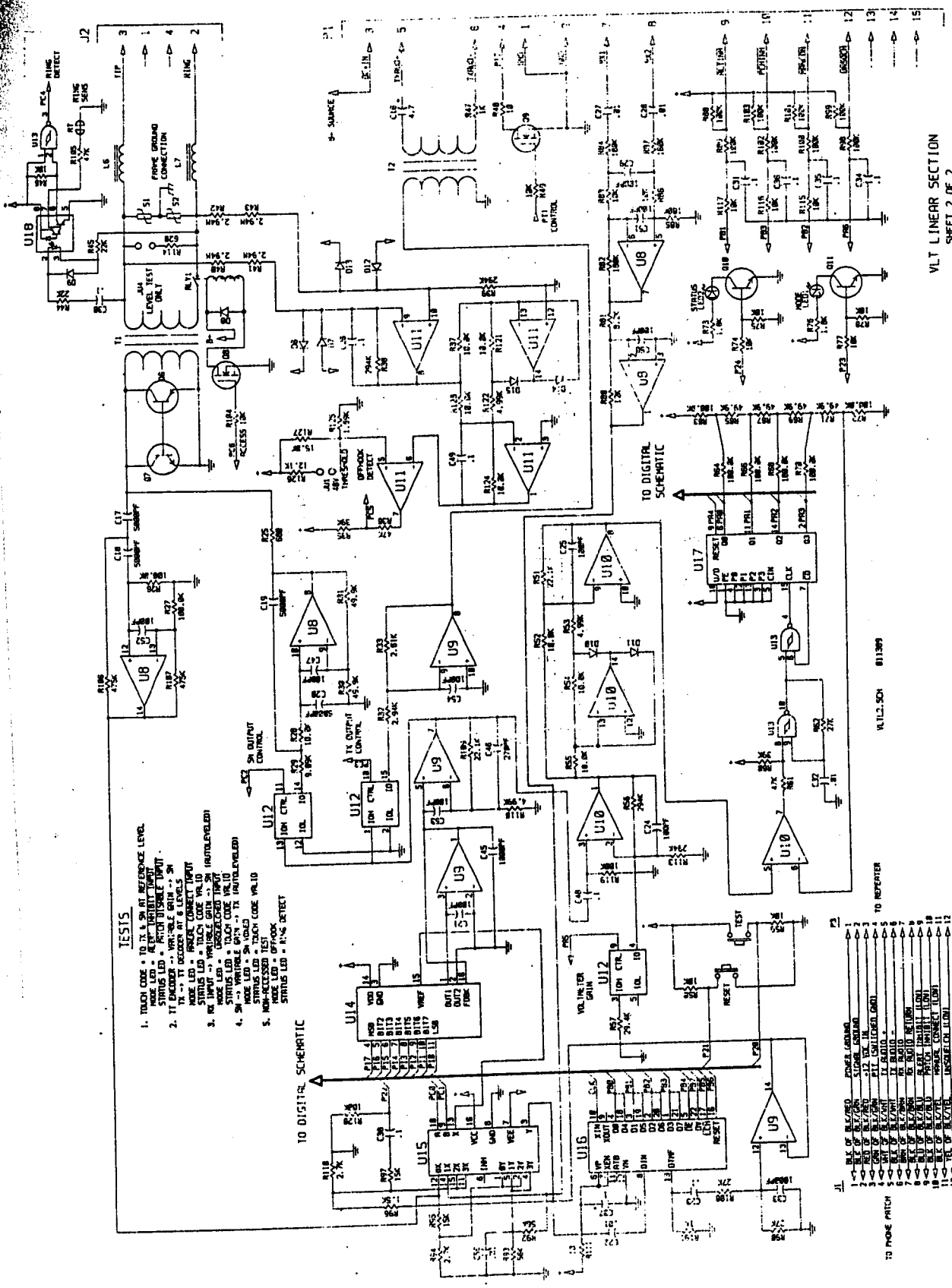
Input voltage is fused, filtered, and sent to 5 volt regulator U7 which supplies most of the patch power. Oscillator U5B generates about 100kHz which is buffed by U5C and U5E and fed to VFET's Q1, Q2, and Q3. These FET's provide a push-pull, full B+ swing output. This signal is AC coupled and rectified by high speed diodes D1 and D2. This voltage is filtered and regulated to about -6 volts for the various analog devices.

9. POWER FAIL/RESTART

When the patch is first powered up, microprocessor reset is held low until B+ reaches about 9 volts (Z1, R24) which removes the high through D3 to C13. Reset is then allowed to go high after C13 discharges through R23. Once the processor is running, running pulses are generated at PA7, keeping C13 discharged and preventing reset. If these pulses are lost due to program malfunction or if power falls below the Z1–U5D threshold, reset is again asserted. JU3 is for system emulation use only.


U1
U2
U3
U4
U5
U6
U7
R130 470K
R129 470K
CS5
1000PF
C1 22PF
C2 47PF
X1
CLK
R1 100K
R2 100K
R3 100K
R4 100K
R5 100K
R6 100K
R7 100K
R8 100K
R9 - R16 = 10K
SW8 CONNECT WITH:
ON=STAR
OFF=POUND/STAR
SW7 PHONE SIGNLNG:
ON=TOUCH CODE
OFF=ROTARY
SW6 LONG DISTANCE:
ON=INHIBITED
OFF=ALLOWED
SW5 3 MIN ACCESS TIME
ON=3 MINUTES
OFF=TIMER OFF
SW4 10 MIN ACCESS TIME
ON=10 MINUTES ALWD
OFF=TIMER OFF
SW3 RING SIGNLNG TO MOB
ON=AFTER 4TH RING
OFF=AFTER 1ST RING
SW2 PHONE LINE BUSY DETECT
ON=MOB ACCESS DENIED WHEN LL BUSY
OFF=MOB ACCESS ANYTIME
SW1 RING DETECT DEFEAT
ON=LL TO MOB DEFEATED
OFF=LL TO MOB ALLOWED
TO LINEAR SCHEMATIC
DC+IN
F1
L1
L2
L3
L4
L5
JU3
470K R23
R22 47K
R21 100K
R20 100
C12 .1
C13 .1
C5 1
C6 1000PF
C7 .1
C8 1
C9 2.2K
C10 .1
C11 .1
C14 1000PF
R19 10K
R112 47K
R24 4.7K
R17 4.7K
+5V SOURCE
-6V SOURCE
PA7
VLTD2.SCH 011189 01
VLT INTERCONNECT SCHEMATIC
DIGITAL SECTION
SHEET 1 OF 2


VLT LINEAR SECTION
SHEET 2 OF 2
TO DIGITAL SCHEMATIC
TO REPEATER
TO PHONE PATCH
RADIO CABLE DETAIL
TESTS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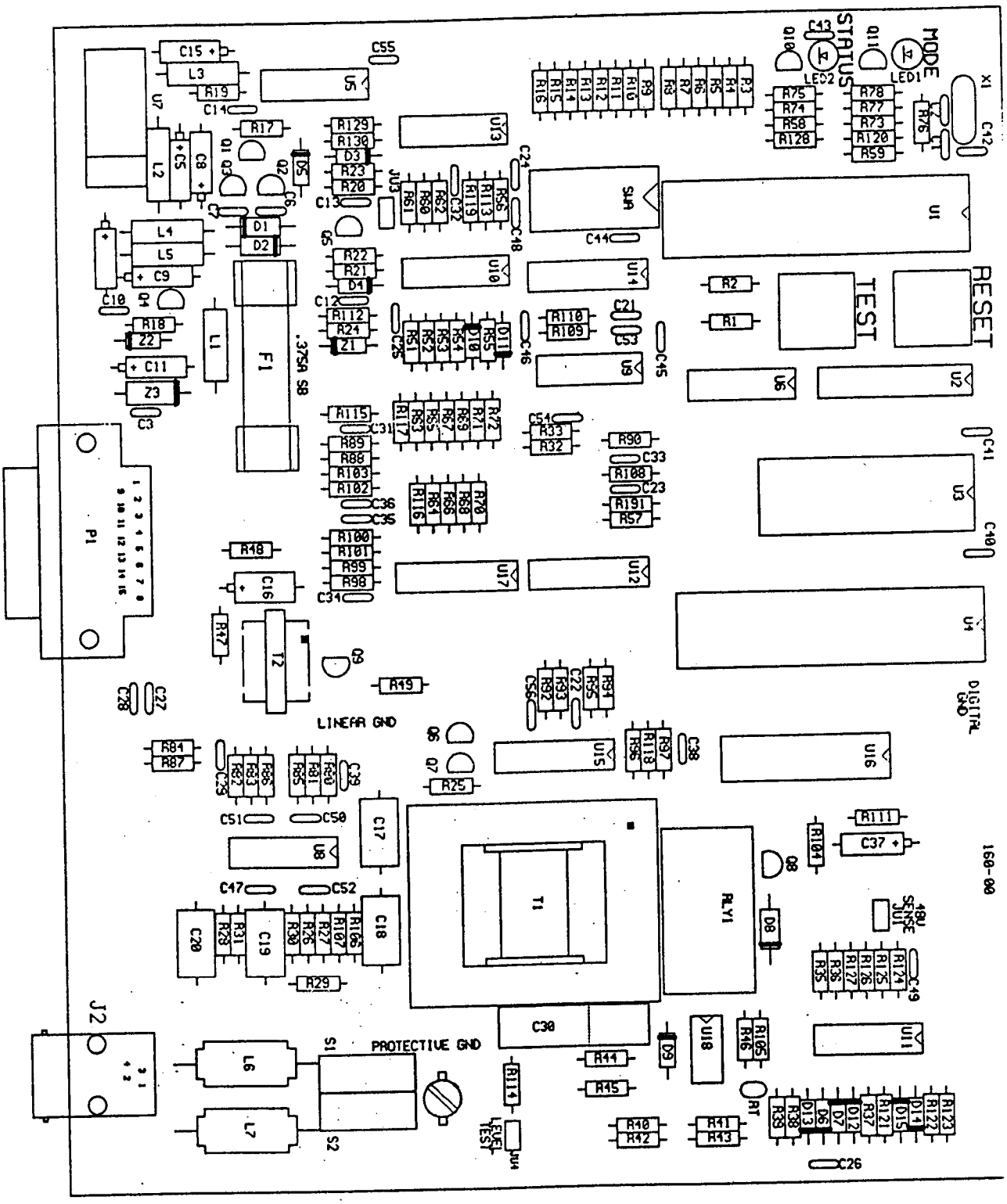
SHEET 2 OF 2
TESTS
RADIO CABLE DETAIL
TO DIGITAL SCHEMATIC
TO REPEATER
TO PHONE PATCH



Component Layout for VLT Circuit Board