HANDHELD RADIATION DETECTOR

MODEL HHD-440A

OPERATING AND SERVICE MANUAL

VERSION 1.01

TSA systems ltd.

1. INTRODUCTION

1.1. SCOPE AND PURPOSE OF MANUAL

This manual is designed to enable operating and service personnel to properly operate and care for the HHD-440A. Since applications are necessarily site-specific, operation procedures are given in general terms. Service and repair are covered to the board or assembly level. Anything more complex than this requires that the instrument or assembly be returned to TSA.

1.2. GENERAL DESCRIPTION

The TSA Model HHD-440A Radiation Detector is a portable, hand-held unit designed to detect gamma radiation. It is also somewhat neutron-sensitive. Uses include Special Nuclear Material (SNM) searches at material accesses and in protected areas, background monitoring, and contamination measurement. The HHD-440A is a microprocessor-based instrument with self-test capability, using a solid organic scintillator in the detector assembly. It is powered by an internal rechargeable nickel-cadmium "sub-C" cell battery pack.

1.2.1. Operation

The unit continuously monitors the background count and calculates a statistical function based on that count. The results of the function calculation are used to determine whether any detected increase in the background is significant. If the increase is significant, the count rate is displayed and an audible alarm is triggered. In the FIND mode the alarm pitch increases as the amount of detected radiation increases. The HHD- 440A has four operating modes:

- BACKGROUND Monitoring (slow count)
- SEARCH (fast count)
- FIND (fast count)
- VARIANCE ANALYZER (provided for verification of proper counting statistics by service personnel)

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1.2.2. Controls and Indicators

The top panel of the HHD-440A (Drawing 1) has a five-digit Liquid Crystal Display, a SEARCH/FIND mode switch, an LED to indicate low battery conditions, an ON/OFF power switch, a headphone jack and a control knob for headphone volume. The handle contains a pressure sensitive switch to actuate the SEARCH/FIND and VARIANCE ANALYZER modes and a red LED which indicates that the instrument is operating in one of these modes.

1.3. SAFETY PRECAUTIONS

Cautions and warnings related to specific procedures are cited at those places in the manual. A summary is given here.

WARNINGS: THE HHD-440A USES HIGH VOLTAGE DURING OPERATION. CARE MUST BE TAKEN DURING SERVICE PROCEDURES. THEY SHOULD ONLY BE DONE BY QUALIFIED PERSONNEL.

CAUTIONS: THE HHD-440A IS WATER RESISTANT, BUT CARE SHOULD BE TAKEN TO AVOID IMMERSION IN WATER.

THE UNIT SHOULD NOT BE OVERCHARGED, AS THIS WILL SHORTEN THE BATTERY LIFE. NOR SHOULD IT BE CONSTANTLY SHALLOW CHARGED (SEE OPERATING INSTRUCTIONS FOR DETAILS).

AS WITH ANY SENSITIVE ELECTRONIC INSTRUMENT, THE HHD-440A SHOULD NOT BE DROPPED OR SUBJECTED TO SEVERE MECHANICAL SHOCK.

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1.4. SPECIFICATIONS

Power:	5 cell nickel-cadmium battery pack 1.4 Amp/hr @ 6.0 volts nominal
Battery Life:	Minimum of 16 hours between charges with fully charged batteries
Charging Rate:	140 milliamps at 7.95 volts for 11 hours for full charge
Display:	5 digit Liquid Crystal Display
Dimensions:	5.5" wide x 7" long x 5". deep
Weight:	6.25 pounds (basic instrument, without options)
Detector:	Plastic scintillator, 35 cubic inches nominal
Temperature:	0 to 50° C (operating)
Humidity:	≤ 95%, non condensing
Serviceability:	Unit can be serviced in the field by replacing modular components
Sensitivity:	Will detect with greater than 50% probability a spherical test source of not more than 10 grams of ^{235}U in uranium metal, of at least 93% enrichment, containing at least 99.75 weight percent uranium, or a test source of 1 gram of ^{239}Pu in plutonium metal, containing at least 99.50 weight percent plutonium, and having a minimum density of 19.44 g/cm. The Pu239 content shall be at least 93.5% and the Pu240 content shall be less than 6.5%.

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1.5. OPTIONAL COMPONENTS

Headphones are available for use in a high noise environment. A headphone jack and a volume knob are located on the front of the HHD-440A.

An **external amplifier** with a larger speaker provides a louder alarm signal in high noise environments.

A **printer** can be added as a separate unit to provide hard copy of the instrument's background readings. The printer interfaces with the HHD-440A via a 6-pin MS connector on the back of the case (if installed).

Beta sensitive detectors are also available. Consult with TSA's engineering staff for detailed information on these detectors.

2. INSPECTION AND SET-UP

2.1. INSPECTION

2.1.1. Incoming Inspection

Immediately inspect the instrument for mechanical damage, scratches, dents or other defects. It should be examined for evidence of concealed, as well as external damage.

2.1.2. Damage Claims

If the instrument is damaged in transit or fails to meet specifications upon receipt, notify the carrier and TSA Systems immediately. Shipping cartons, packing materials, waybills and other such documentation should be preserved for the carrier's inspection. TSA will assist in providing replacement or repair of the instrument if necessary.

2.1.3. Storage

If the instrument is to be stored for any length of time, disconnect power to the instrument and remove and store any batteries separately in a cool place. If batteries are to be stored for any length of time, they should be inspected, and, if necessary, charged to full value, at least once a month. Care should always be taken to avoid subjecting the instrument to severe mechanical or environmental shock. The instrument should be stored in a dry, temperature controlled location.

2.1.4. Shipping

Before returning the instrument for any reason, notify TSA Systems of the difficulty encountered, giving the model and serial numbers of the equipment. TSA will furnish specific shipping instructions.

2.2. SET-UP

"Set-up" refers to the procedure by which the HHD-440A is adjusted and checked for proper operation at a specific site. The instrument is fully calibrated at the factory, and should not need recalibration or tuneup unless it has been serviced or in storage for a long period.

2.2.1. Initial Set-up

Put the instrument into the Read/Set-up mode. With the unit in the normal position, open the top. A small black pushbutton switch will be visible near the center of the plastic barrier plate which covers the board. Hold this button down while turning the instrument on with the power switch. Continue to hold the button down until the beeper signals that the power-up sequence is finished. When the self-test check is over, the unit will begin a sequence of readings which will appear on the display. Use the Press switch on the handle to step through the sequence.

Go through the following sequence of settings, using the internal Dipswitches (described at the end of this section) to change settings when necessary. In most cases, the factory settings (shown in **bold** type) will be adequate.

2.2.1.1. Low Alarm (LA): comes up on the display in counts per second (cps). This setting controls the radiation level at which the HHD-440A will go into low alarm. This setting is used primarily as a trouble indicator for the HHD-440A, as the natural background is almost always greater than the value selected. If LA is set to zero then the unit will never go into Low Alarm. The factory setting is **32** and the range is 0 to 96.

2.2.1.2. High Alarm (HA): also comes up on the display in counts per second (cps). It controls the radiation level at which the HHD- 440A will go into high alarm. This setting is used to prevent artificial raising of the background and thus lowering the sensitivity. It will only activate in BACKGROUND mode. It is generally set at least twice the average background. The high alarm can also be disabled (see section 2.3 Dipswitches for settings). Factory setting is: 8192 cps.

2.2.1.3. Counts per micro-Rem: This setting is done at the factory and in most cases will not need to be changed. However, if any of the assemblies in the HHD-440A has been replaced or serviced then it must be checked (see section 5.1 Tune-up and Calibration Procedures). If the HHD-440A is to be used only in cps mode then it can be ignored, unless the set point is used. Factory setting range is: **16 to 23.**

2.2.1.4. Background Time: controls the amount of time in seconds that the HHD-440A uses for a background count. The allowed settings are 5, 10, 15, and 20 seconds. In general, the longer the background count, the more accurate it is. In situations where the unit will be turned off between uses it may be desirable to have a shorter background time as this will reduce the waiting time during power-up. Factory setting is: **20 seconds.**

2.2.1.5. Set-point Alarm: provides an absolute level at which the HHD- 440A will alarm and provides a distinctive alarm sound. One application is measuring possible contamination to insure that it is below release levels. This alarm will work in μr during SEARCH/FIND mode and can be used during normal security searches. It can be turned on or off and the level at which it works can be set. Factory setting is: **Disabled.**

2.2.1.6. Display: controls the display. The radiation measured by the HHD-440A can be displayed in milli-Rem or counts per second. In general, the milli-Rem (m-Rem) setting is used for Health Physics and/or contamination measurements, and the counts per second (cps) setting is used for security work. The factory setting is: **Counts per second** (cps).

2.2.1.7. Number of Intervals: determines how many 200 milli-second time periods are checked for an alarm condition while in SEARCH/FIND mode. When using the HHD-440A to search, a longer interval will allow for greater sensitivity, while a shorter interval will result in faster response and speed searching. The factory setting is: **5**.

2.2.1.8. Sigma (N): adjusts the sensitivity of the unit. It controls one of the variables in the alarm threshold equation (see section 2.3 Dip Switches). If it is set to a low value then the unit will alarm in SEARCH mode with a small increase in background. If set to a high value, then it will take a larger increase in background to produce an alarm. Factory setting is: **4.0**, and the range is from 2.0 to 5.0.

2.2.1.9. The next three settings are for informational purposes only. They identify the software type, version and revision date. When calling TSA for information or service it is very helpful to have this information. For the HHD-440A the only standard factory setting is **01** for the type. The other numbers will change.

2.2.1.10. The last setting is a reference point to signal the end of the sequence. It does not change. The factory setting is **9.9.9.9.9.**.

The following is a reference table of the **READ SETUP LOOP**:

LED	SETTINGS SEQUENCE
ON	LOW ALARM LEVEL (cps)
OFF	HIGH ALARM LEVEL (cps)
ON	COUNTS/μR
OFF	BACKGROUND TIME (SEC)
ON	SET POINT ALARM LEVEL (μR)
OFF	DISPLAY: 0 = cps; 1 = mr
ON	NUMBER OF INTERVALS (200ms)
OFF	N*SIGMA
ON	SOFTWARE TYPE: (01 = HHD)
OFF	SOFTWARE VERSION NUMBER
ON	REVISION DATE (MM YY)
OFF	9.9.9.9.9 (REFERENCE POINT)

2.3. DIPSWITCHES

The Dipswitches are located on the circuit side of the HHD- 455 board. To access them, open the case by releasing the two side clamps. When the case is open they will be seen on the

upper portion at the edge (see Drawings 2, 3). To change the settings on the switches use a small screwdriver or pencil and make sure that the switch is all the way open or closed.

NOTE: A "ONE" IN THE TABLE CORRESPONDS TO THE DIPSWITCH IN THE "OPEN" POSITION.

DIPSWITCH 1

OFF ON

[--]	1	Low Alarm + 32 cps
[--]	2	Low Alarm + 64 cps (range=0-96)
[--]	3	High Alarm + 2048 cps
[--]	4	High Alarm + 4096 cps(range=2048+sum switches)
[--]	5	cps/μR + 1
[--]	6	cps/μR + 2
[--]	7	cps/μR + 4
[--]	8	cps/μR + 8 (range=16+ sum of switches)

DIPSWITCH 2

OFF ON

[--]	1	Background Time + 5 seconds
[--]	2	Background + 10 sec (range=5+sum switches)
[--]	3	High Alarm Disable (ON= Disable)
[--]	4	Set point .100 mr Alarm Level
[--]	5	Set point + .200 mr
[--]	6	Set point + .400 mr
[--]	7	Set point + .800 mr
[--]	8	Set point + 1.600 mr (range=0-3.100mr)

DIPSWITCH 3

OFF ON

[--]	1	cps or μR Display (ON=μR)
[--]	2	Number of Intervals + 1
[--]	3	Intervals + 2
[--]	4	Intervals + 4 (range=1+sum of switches
[--]	5	N-Sigma + .2 (Search Mode)
[--]	6	N-Sigma + .4
[--]	7	N-Sigma + .8
[--]	8	N-Sigma + 1.6 (range=2.0+ sum of switches)

2.4. INITIAL SET-UP CHECKLIST

___ Incoming inspection performed.

___ Battery charge checked (Low Battery LED not lit).

___ Background mode in operation area; count = _____

___ All modes operational.

___ High alarm test. Source used: _____

___ Dipswitch settings: ___ unchanged ___ new values:

Low alarm: _____

High alarm: _____

Counts per micro-Rem: _____

Background count: _____

Set point alarm: _____

Display: _____

No. of intervals: _____

Value of Sigma (N): _____

___ List sources and sizes used:

_____

___ Variance analyzer test; variance = _____

___ Checked operation of optional components

Performed by: _____ **Date:** _____

3. OPERATING INSTRUCTIONS

This section assumes that the initial set-up procedure has been completed. If not, see section 2. Inspection and Set-up for directions.

The instrument comes factory-set to display readings in cps. However, the software supplied with the HHD-440A can display the measured radiation in either millirem or cps (counts per second). Other than the display, there is no difference in the operation of the unit between the two types of display. Usually, the millirem display is used for Health Physics and contamination applications, and the cps display is used for security applications. In the descriptions of the operating modes the cps display will be shown in **bold** print.

3.1. POWER-UP AND SELF-TEST

Turn on the POWER switch located on the lower left of the top of the instrument (Drawing 1). The unit will then go through a series of self-tests. All segments and decimal points on the display, the low battery indicator and the LED in the handle will come on until the tests are finished or until one fails. The self-tests take approximately two seconds to complete. Then the decimal points will "walk" across the display for 7 seconds, while the high voltage comes up and stabilizes. After the unit has completed the self-tests and high voltage warm-up period it will go into BACKGROUND counting mode.

If the unit gives an error signal or if the beeper fails to sound the low pitch READY signal, the unit is malfunctioning and must be checked out. See section 4.2 Self-Test for explanations of each of the error signals.

3.2. BACKGROUND COUNTING

The unit automatically enters the BACKGROUND counting mode after completing the self-tests and high voltage warm-up. This is the default mode for the instrument, and it will go to this mode whenever you turn the unit on or exit from another mode. The background count interval is set by internal Dipswitches (see section 2.3 Dipswitches), and is variable from 5 to 20 seconds. The display will count down in seconds from the selected background time interval to zero, then display the current background in millirem or cps. The background is a sliding count which will up-date every five seconds (see section 4.3 Background Counting for more details).

3.3. SEARCH MODE

3.3.1. Put the SEARCH/FIND switch in the SEARCH position.

3.3.2. Press and release the switch on the handle, marked PRESS. The red LED in the handle will turn on. This indicates that the unit is now in the SEARCH mode. The display will now be updated every second in millirem or cps.

3.3.3. While in this mode, if the unit detects an increase in radiation that exceeds the alarm threshold calculation (see section 4.5 Find for details) a 1 kHz tone will sound for at least .2 seconds or until the radiation level falls below the alarm threshold level.

3.3.4. To exit this mode, press the handle switch again. The LED in the handle will turn off and the unit will return to the BACKGROUND Counting mode, with the last background count displayed. It will then take a new 5 second background interval before updating.

3.4. FIND MODE

3.4.1. Move the SEARCH/FIND switch to the FIND position.

3.4.2. Press and release the switch on the handle, marked PRESS. The red LED in the handle will turn on. This indicates that the unit is now in the FIND mode. The display will now be updated every second in millirem or cps.

3.4.3. While in this mode, if the unit detects an increase in radiation that exceeds the alarm threshold calculation (see section 4.4 Search for details), a tone will be heard. The frequency of this tone is dependent on the intensity of the radiation detected. At one Sigma over background it will be 1kHz. From there it goes up (in pitch) in approximately 94 Hz steps up to 4kHz.

3.4.4. To exit this mode, press the PRESS switch in the handle. This will return the unit to the BACKGROUND COUNTING mode.

3.5. DISPLAY

The display is used to show the intensity of gamma radiation either in BACKGROUND mode or SEARCH/FIND mode. It gives a digital readout in millirem or cps. In Variance Analyzer mode it displays the variance, and in Read Setup mode it displays information on current settings.

3.6. VARIANCE ANALYZER MODE

3.6.1. When the instrument is first turned on, depress and hold the switch in the handle until the LED in the handle turns on. Continue to hold the switch until the power-up self-tests are finished and the beeper sounds.

3.6.2. After the diagnostics are complete, the display will count down from 15 to 0.

3.6.3. The unit will then display the variance and update this every 15 seconds. Prior to each update, the beeper will sound for one half second (for acceptable variance values see section 4.6 Variance Analyzer).

3.6.4. To exit from the VARIANCE ANALYZER mode, simply turn the instrument off, then back on.

3.7. SET-POINT ALARM

The set-point alarm can be set to measure absolute levels of gamma radiation and sound an alarm when a predetermined level is reached (see section 2.2.1.5. Set-point Alarm). The set-point alarm sounds a distinctive alternating tone.

3.8. ALARM AND LOW BATTERY

There are three different alarm tones, each associated with a particular function; a 1kHz tone sounds for SEARCH, HIGH ALARM and LOW ALARM, a 1kHz to 4kHz variable tone for the FIND function, and an alternating tone for SET-POINT alarm. The HIGH ALARM (HA) shows that the radiation level is greater than a pre-set level, and will only sound when the unit is in BACKGROUND mode. The LOW ALARM (LA) occurs when the radiation level falls below a pre-set level. It can occur during BACKGROUND or SEARCH/FIND mode.

The low battery LED is located on the upper right hand corner of the front panel of the HHD-440A. It illuminates when the Ni-Cad batteries have reached a low level, at which time the unit should be plugged into its charger and the batteries recharged completely.

NOTE: USE OF THE HHD-440A WHILE LO-BAT LED IS ON IS NOT RECOMMENDED,AS THE READINGS OBTAINED MAY NOT BE ACCURATE!

3.9. READ SET-UP MODE

With the instrument in the normal reading position, open the top. A small black pushbutton switch will be visible near the center of the upper plastic barrier plate (see drawing 2). Hold this button down while turning the instrument on with the power switch. Continue to hold it until the beeper signals that the power-up sequence is finished. When the self-test check is over, the unit will begin the following sequence of readings, which will appear on the display. Use the PRESS switch on the handle to step through the sequence.

	HANDLE LED	SEQUENCE VALUE
1)	off	Low Alarm value in cps
2)	on	High Alarm value in cps
3)	off	Counts per micro-Rem
4)	on	Background time (sec)
5)	off	Set point Alarm in micro-Rem
6)	on	Display mode: millirem or cps
7)	off	Number of intervals
8)	on	Sigma (N)
9)	off	Software type
10)	on	Software version
11)	off	Software revision date.(MM,YY)
12)	on	9.9.9.9.9 (reference point)

The sequence repeats from here. To return to normal functioning, turn the unit off and then power-up again. For more information on the Setup values see section 2.3 Dipswitches.

3.10. TYPICAL SEARCH PROCEDURES

Refer to your site regulations and Operating Procedures first, and follow those directions for search procedures. If there are no specific guidelines, the following may serve as a general guide for search procedures.

Searches using the HHD-440A are generally conducted to locate contamination or for security purposes. In either case, the general principles are the same. The person doing the searching must be careful to do a thorough job, without taking too much time and slowing traffic.

PERSONNEL: With the instrument in SEARCH/FIND mode, have the person being searched set aside or hold out any articles they may be carrying for separate search. Hold the HHD about 2-3 inches away from the person, and move the instrument slowly up and down the front and then the back of the person. Be sure to check head and feet. Then scan any briefcases, handbags, packages, etc. With practice, it should not take more than about 15 seconds to do a careful search.

VEHICLES: With the instrument in SEARCH mode, have the driver turn the engine off, open the hood, trunk and all doors, and have all passengers get out and stand to one side. If there are two search personnel, one can scan the occupants while the other checks the vehicle. Since there are a number of complicated surfaces in and around a vehicle, it is important to take the time to do a thorough search. If there is an area you can not reach, search it from the outside, through glass if possible.

Holding the HHD about 2-3 inches away from the surfaces, check every area under the hood that you can reach, and the hood itself. Search the inside of the trunk in the same way. Scan each door, and the inside of the vehicle, moving the HHD over every surface and into every open area. Then search the outside, including the wheel wells, bumpers, and as far under the vehicle as you can reach. For larger vans or trucks, it may be helpful to use a small stepladder or stool to gain access to the bed and upper surfaces.

CONTAMINATION: When searching an area or object for contamination, allow enough time to do a thorough sweep of the entire area. Plan the search pattern ahead of time to be sure no section is missed. When the general area of contamination is located, switch the HHD

to FIND mode to further localize the contamination.

If contamination or suspect material is located, follow site regulations.

* These search techniques are drawn from examples given in the Los Alamos National Laboratories User's Manual, Hand-Held Search Monitor for Special Nuclear Materials, by Paul E. Fehlau (1984).

4. THEORY OF OPERATION

4.1. COMPONENTS

4.1.1. The **HHD-455 microprocessor control board** is the computer board for the system. Its program runs the HHD-440A and processes the incoming five volt pulse from the HHA-457 board. The pulses are counted and analyzed, and, depending on the result, the board will output information to the display and beeper. The board also accepts input from the various switches and outputs to the display, LED's, and beeper.

4.1.2. The **HHV-454 high voltage power supply** supplies regulated high voltage to the dynode assembly to power the photo-multiplier tube (PMT).

4.1.3. The **HHA-457 single channel amplifier** receives the negative pulse from the dynode string. It inverts and amplifies this signal, then turns it into a constant width five volt pulse with the frequency dependent on the incoming pulse rate. The lower level discriminator is set to eliminate low-level signals (noise).

4.1.4. The **Detector Assembly** consists of the organic plastic detector with a prism glued to one face. The PMT is glued onto the prism. The whole assembly is wrapped in light-tight materials. The detector assembly converts gamma or neutron radiation into a negative voltage pulse which can be counted and analyzed.

4.1.5. The **Dynode Assembly** is made up of the tube socket and dynode string (resistors and signal capacitors). It divides the incoming high voltage for the plates in the PMT, and separates the signal from the high voltage.

4.1.6. The **Battery Pack** consists of 5 sub-C cells wired in series. This allows the HHD-440A to operate without an external power source.

4.1.7. The **enclosure and wiring harness** includes the blue case, all of the wiring, and the switches.

4.2. SELF-TEST

When the instrument is first turned on, it enters the power-up diagnostics routine. The program runs the following tests. With the exception of the Display and Beeper test, if a diagnostic fails, an ERROR display is shown:

Display - Prior to starting the diagnostic tests, all segments and decimal points on the display and the low battery indicator are turned on. They remain on until the tests are completed or until one fails. If all pass, this display remains on for a few seconds before clearing.

RAM - All RAM locations used by the program are tested by a complementary bit pattern test. If a RAM failure occurs the display will show:

--0--

Prom Checksum - A two byte checksum of the prom is calculated and compared against a stored checksum. Prom failure display:

--1-- = PROM failure

Real Time Clock - The clock is checked to see if it is running and to compare its frequency to that of the CPU clock. Timer 1 of the NSC-800 is used as the real time clock. RTC failure display:

--2--

After completing the diagnostics self-tests, the unit will pause for seven seconds to stabilize the high voltage, then signal by sounding the beeper for one-half second. It is then in the BACKGROUND Counting mode, from which either SEARCH or FIND modes may be selected.

4.3. BACKGROUND COUNTING

After the seven second pause, the display counts down from the background time selected to zero, then displays the background obtained. It will then update the background every five seconds. The background is a "sliding count". This means that the oldest five second background interval is discarded and the new five second background interval is summed with the remaining ones to produce the background number displayed. The number of intervals remaining will depend on the background time selected.

In BACKGROUND mode the instrument compares the latest count with the High and Low Alarm values selected by the Dipswitches. If the background count is outside these settings, the instrument will sound the audible alarm and the display will read -LA- for a low alarm or -HA- for a high alarm.

4.4. SEARCH

If the SEARCH/FIND switch is in the SEARCH position and the handle switch is depressed, the red LED in the handle comes on to indicate that the instrument is now in SEARCH mode. In this mode, the instrument sums a preselected number of 0.2 second counts and displays this sum in counts per second. It also compares this count to the N*SIGMA function. If the count exceeds this function, the alarm sounds and the current count rate is displayed. When the switch in the handle is pressed again, the LED is turned off, and the unit returns to

BACKGROUND Monitoring mode, displaying the latest (time selected) background count.

```
Alarm level =  BG + N * Sigma, and:

N  = a constant selected by internal
     dipswitches


BG = background found by the last four
     5 second intervals

Sigma =  √BG
```

4.5. FIND

When the SEARCH/FIND switch is in the FIND position and the handle switch is depressed, the instrument displays the total count in counts per second and also emits an audible tone when the count is above background plus one SIGMA. The frequency of the tone varies as follows:

$$\text{Freq.} = 1000 + 93\,(X - 1)$$

where: $X = \frac{\text{Excess}}{\text{Sigma}}$

Thus, the tone will rise in frequency (pitch) as the instrument is brought closer to the source of radiation. The display is updated every second and the tone is updated every 0.2 seconds. The tone range is between 1kHz and 4kHz with the 4kHz occurring at alarm rates greater than 20 sigma.

4.6. VARIANCE ANALYZER

In this mode, the unit takes 75 0.2 second background counts and stores them. After this reading is finished, the program calculates the following function:

$$R = \frac{s^2 - \bar{C}}{\bar{C}}$$

where:

R = the quality factor

s^2 = variance $\frac{\Sigma (C - \bar{C})^2}{N - 1}$

C = each of the individual counts

$\bar{C}$ = the mean of the counts = $\frac{\Sigma C}{N}$

N = number of counts taken

$\bar{R}$, the running average value of "R", is displayed every 15 seconds. In an undisturbed background environment, the R values should be 0.1000 or less, after three cycles.

The variance analyzer mode is used to check whether the counts seen by the controller are actually from the proper distribution. If the distribution approaches normal, the resulting number will approach 0. Any significant deviation from the normal distribution will result in a larger number.

There are several excellent texts available on counting statistics, including Dixon & Massey's "Introduction to Statistical Analysis", which should be consulted by those interested in a more in-depth look at the mathematical facets of radiation monitoring.

4.7. BEEPER

The beeper is sounded as a test at power-up, as an alarm for power-up test, as an alarm during operation, and to alert the operator for a new ratio in the Variance Analyzer mode. The beeper sounds at 1 kHz and continues to sound until the error condition is removed, or until a new mode is entered. The exceptions are:

- During power-up diagnostics, it sounds at 1kHz for two seconds.
- At failure of a diagnostic, it sounds at 1kHz continuously.
- In VARIANCE ANALYZER mode, it sounds at 1kHz for one-half second.
- In FIND mode, the frequency is variable.

If a high or low alarm sounds while in BACKGROUND Counting mode, the beeper will persist until the end of the next five second interval. This is an unusual condition, but if it does occur, the alarm condition may be forced off by momentarily toggling the SEARCH/FIND switch.

4.8. GENERAL OPERATING PRINCIPLES

While in the BACKGROUND mode the HHD-440A constantly updates the background count to reflect changes in the environment. The background is accumulated in 5 second increments, with the current background reading equal to the one-second average of the user selected number of 5-second intervals. This update is sliding and will drop the earliest interval out. Thus a new background will occur a maximum of every 20 seconds. The use of a sliding background allows the unit to up-date and respond to shifts in background faster.

The HHD-440A collects its counts in 200 millisecond (0.2 sec.) intervals. For example, if the number of intervals is set to 4, the alarm comparison will be based on 0.8 second counts. This sum of counts is then compared to an alarm level which is corrected for that number of intervals.

While the HHD-440A is in SEARCH or FIND mode it makes an alarm comparison every 200 milliseconds, based on adding together the number of user selected 200 millisecond intervals. The intervals are stored continuously, so that as soon as the HHD-440A is placed in SEARCH or FIND mode it waits for the current interval to end, then adds up the selected number of intervals and makes an alarm comparison. This means that if the HHD-440A is set to add five intervals, it is effectively using a one second time period for its alarm comparisons.

5. MAINTENANCE

Except for regular recharging of the batteries and occasional Variance Analyzer checks, the HHD-440A should need no further maintenance after initial setup. Check site regulations for required calibration schedules.

5.1. TUNE UP AND CALIBRATION PROCEDURE FOR C.P.S. VERSION

The instrument comes factory tuned and calibrated, and should not need further adjustment unless it has been serviced or stored for a long period. A Checklist is included at the end of this section. It is recommended that a copy of this be filled out whenever the HHD-440A is put into service after tuning and recalibration.

EQUIPMENT REQUIRED:

- Oscilloscope
- Digital Volt Meter
- Radioactive Source: ^{137}Cs 5 - 10 μCi

PROCEDURE:

Unit must be operational. Adjust the discriminator setting of the HHA-457 board to 75 $\pm$ 5 millivolts, by using R11 and taking the reading from TP1.

Place the ^{137}Cs under the center of the unit. Connect the oscilloscope to TP2 on the HHA-457 board. Adjust R5 on the HHV-454 board to achieve a 2 volt pulse amplitude. Refer to drawing 13 for a "typical pulse profile".

5.2. CALIBRATION FOR MICROREM VERSION

Before starting the calibration procedure, ensure that the HHD-440A has been tuned up properly. "Calibration" refers to the process of checking the HHD-440A's readings against a known gamma radiation field. The HHD-440A is linear from 0 to 2 milli-Rem, and so the calibration is done in this range. The calibration procedure relates a known field intensity of ionizing radiation to the display (in milli-Rem) shown on the HHD-440A.

At the TSA facility several different gamma field intensities are used. The gamma fields are generated by ^{226}Ra sources of the following sizes 0.021 μCi, 0.27 μCi and 1.21 μCi. These sources will produce 21 μR, 270 μR and 1.21 mr per hour at the surface of the source. This gives a range of intensities from the lower end to the mid-point of the linear range of the HHD-440A. If desired, a source near the upper end of the range may also be used (approximately 2.0 μCi).

The following steps should be done in a background constant area (i.e.: not in a place where sources are present or being moved). It is also recommended that the calibration procedure not be done in an area where the background exceeds 25 μR per hour. The test sources should be shielded from the HHD-440A except when in actual use.

EQUIPMENT REQUIRED:

- Oscilloscope
- Digital Voltmeter
- High voltage probe (100:1; 1000 megohms Impedance)
- Radioactive Sources: ^{226}Ra approx. 0.021 μCi
  approx. 0.27 μCi
  approx. 1.21 μCi

PROCEDURE:

Open the HHD-440A and set the Dipswitches as follows: switch 1-5 off, 1-6 on, 1-7 on, 1-8 off and switch 3-1 off. The other Dipswitches should already be properly set (refer to the operating instructions for factory settings). When this has been done, the "K" factor is set to 22. Set the display to cps.

Turn the HHD-440A on and let it run a background. Record this number.

Take the source (1.21 μCi at TSA) and place against the bottom of the HHD-440A as shown in Drawing 12. The HHD-440A may have to be operated in either SEARCH or FIND mode to avoid a high alarm status with this source. An alternate method is to disable the high alarm. To do this, set switch 2-3 to on. Record the number of counts.

Subtract the background number from this number. The result is then divided by the field intensity of ionizing radiation to give the "K" factor. An example is given below.

Background = 450 cps

Counts per second with 1.21 μCi ^{226}Ra source = 25860
Minus background of 450 cps - 450

Counts per second from source = 25410

25410 divided by 1210 μrem per hour = "K" factor of 21

Change the switch settings from the starting point to: 1-5 on, 1-6 off and 1-7 on, to give the newly calculated "K" factor, 21 in the above example.

Change switch 3-1 to ON (changes display to milli-Rem) and take a background count. Record this number. Then place the middle range source against the detector, as in step 4 above, and observe the reading. It should be the background plus the amount of the source. Using the above example, the background is 21 μrem per hour and the source is 1210 μrem per hour, so the combined reading should be 1231 μrem per hour $\pm$ 10%, shown as 1.231 milli-Rem on the display.

Repeat steps 3 through 5 for the other sources without changing the "K" factor setting. These readings are used to check the range and linearity. The setting should be made using the middle range source. If the readings are off more than 10%, refer to the Troubleshooting Section of this manual.

5.3. TUNE-UP AND CALIBRATION CHECKLIST

TUNE UP

___ High voltage set; level: _____

___ Detector checked

___ ^{137}Cs pulse height set

___ Discriminator set; level: _____

___ Background level: _____

___ Variance level: _____

CALIBRATION

___ Dipswitch settings: ___ unchanged ___ new values:

Low alarm: _____

High alarm: _____

Counts per micro-Rem: _____

Background count: _____

Set point alarm: _____

Display: _____

No. of intervals: _____

Value of Sigma (N): _____

___ List sources and sizes used:

_____

Performed by: _____ **Date:** _____

6. TROUBLESHOOTING

6.1. COMPONENT ACCESS

The **HHD-455** board is located in the top section of the case. To access, open the case, remove the four screws holding down the plastic barrier plate, and lift this plate off. To remove the board from the case, remove the four standoffs and the front cap nut from the power switch. The board can then be taken out far enough to remove the connectors that attach it to the wiring harness.

To replace the board, attach the connectors from the wiring harness and place the board on the standoffs in the upper part of the case. Replace the four standoffs and the cap nut on the power switch. Attach the plastic barrier plate with the four screws previously removed.

The **HHV-454** board is located under the aluminum barrier plate in the bottom of the case. To access it, open the case and remove the four Phillips screws holding the plate to the side rails. Lift this plate up, taking care not to damage the wiring harness. The board is then visible. To remove it, disconnect the wiring harness connectors and take out the screws holding the board to the stand-offs.

To replace the board, attach to the stand-offs with the screws previously removed and re-attach the wiring harness connectors.

The **HHA-457** board is also located under the aluminum plate. To access it, open the case and remove the four Phillips screws holding the plate to the side rails. Lift this plate up, taking care not to damage the wiring harness. The board is then visible. To remove it, disconnect the wiring harness connectors and take out the screws holding the board to the stand-offs.

To replace the board, attach it to the stand-offs with the screws previously removed and re-attach the wiring harness connectors.

The **detector assembly** is located in the bottom of the HHD-440A. To access it, follow the steps above for board removal, then lift the battery out. Disconnect the wiring harness connectors, and the detector can then be lifted out of the case. Do not remove the foam if it is glued in.

To replace the assembly, connect the wiring harness connectors and set the detector in the bottom of the case. Replace the foam around the detector if it has shifted or come loose and set the battery in its place. Install the aluminum barrier plate and screws that hold it in place. Close the case.

The **dynode assembly** is secured on to the end of the PMT by black electrical tape. To access it, follow the steps above for the detector assembly. To remove the dynode assembly, take some of the black electrical tape and pull it off gently. It should come loose from the photo-multiplier tube. Then un-plug the wiring harness connector.

CAUTION: DON'T REMOVE ANY MORE TAPE THAN NECESSARY AS LIGHT LEAKS CAN RESULT.

To re-install, push the assembly gently onto the PMT and secure with black tape. Connect the wiring harness connectors and follow the steps for replacement of the detector assembly.

The **battery pack** sits on top of the detector assembly. To access it, remove the aluminum barrier plate. To remove it, disconnect the wires running to the battery pack and lift it out.

To replace the battery, connect the wires running to the battery and position the battery on top of the detector in its original position. Re-install the aluminum barrier plate.

The **wiring harness** is not considered a user-serviceable part. It runs throughout the HHD-440A and so can not be removed. If service is attempted then it should be done by qualified personnel only.

6.2. TROUBLESHOOTING GUIDE

The following tools and equipment are needed for these procedures:

Digital Volt Meter
High voltage probe (1000 megohms or better)
Oscilloscope

The troubleshooting guide is designed so that on site personnel can effect minor repair and keep the HHD-440A operational. It covers repairs and troubleshooting down to the board or assembly level only. If further repairs are needed the unit must be returned to TSA or TSA must be contacted for further instructions.

The first step in any troubleshooting procedure is to verify that the problem suspected is actually present. Inspect the exterior of the unit for damage (dents, broken handle or missing parts) which could indicate that the unit has been abused, then follow these procedures.

6.2.1. Turn the unit on; if the Low Battery LED is illuminated, or the unit fails to complete the normal countdown sequence/and/or self-check routine, check the battery.

NOTE: THE HHD-440A IS EQUIPPED WITH A SELF RESETTING SOLID STATE FUSE IN LINE WITH THE BATTERY. IF A SHORT CIRCUIT EXISTS IN THE SYSTEM THERE WILL BE NO VOLTAGE OR CURRENT FLOW.

6.2.2. To check the battery condition, open the case and remove the aluminum barrier plate (see section 6.1 Component Access). Disconnect the in line connector between the battery and the main wiring harness. Measure the voltage present at the battery side of the in line connector. This must be at least 6.0 volts; if the voltage is less, reconnect the in

line connector and charge the unit for at least 6 hours. If the voltage remains low after recharging, replace the battery.

6.2.3. When the proper voltage is present, reconnect the in line connector, and measure the voltage at J3 pins 1(+) and 2(-) on the HHA-457 board with the unit turned on. No voltage indicates a short in the wiring harness or a board problem.

6.2.4. If proper voltage is noted at Step 6.2.3, check other system voltage as follows: J2 on the HHD-455 board, pin 9, should be the battery voltage and pin 8 should be a regulated 5 volts using Pin 4 as a ground. J3 on the HHA-457 board, pin 3, should be 12 volts and Pin 4 ground. Failure at any point indicates a board component failure.

6.2.5. No failure at Step 6.2.4 indicates a possible high voltage problem. Measure by attaching a high voltage probe to J2 on the HHV-454 board, Pin 1, and ground at Pin 3. The voltage should be at least 800 and not more than 1300 volts. Adjust as required (see tune-up procedures). If the high voltage cannot be adjusted to the proper value, replace the board.

6.2.6. Check the 5 volt signal pulse coming from the HHA-457 board by attaching a scope probe to J2 pin 1 and placing a source next to the detector. The pulse seen should be at least 3 volts and at least 2 micro-seconds wide. The signal should be present at J2 pin 3 on the HHD-455 board.

6.2.7. If no problems are apparent, attach a 10-times scope probe to TP2 on the HHA board and set the scope as follows:

Vertical Deflection	:	0.5V/division
Horizontal Deflection	:	1μsec/division
Triggering	:	Normal, positive edge

Adjust the trigger level to get the pulse profile shown in Drawing 12, Figure #2.

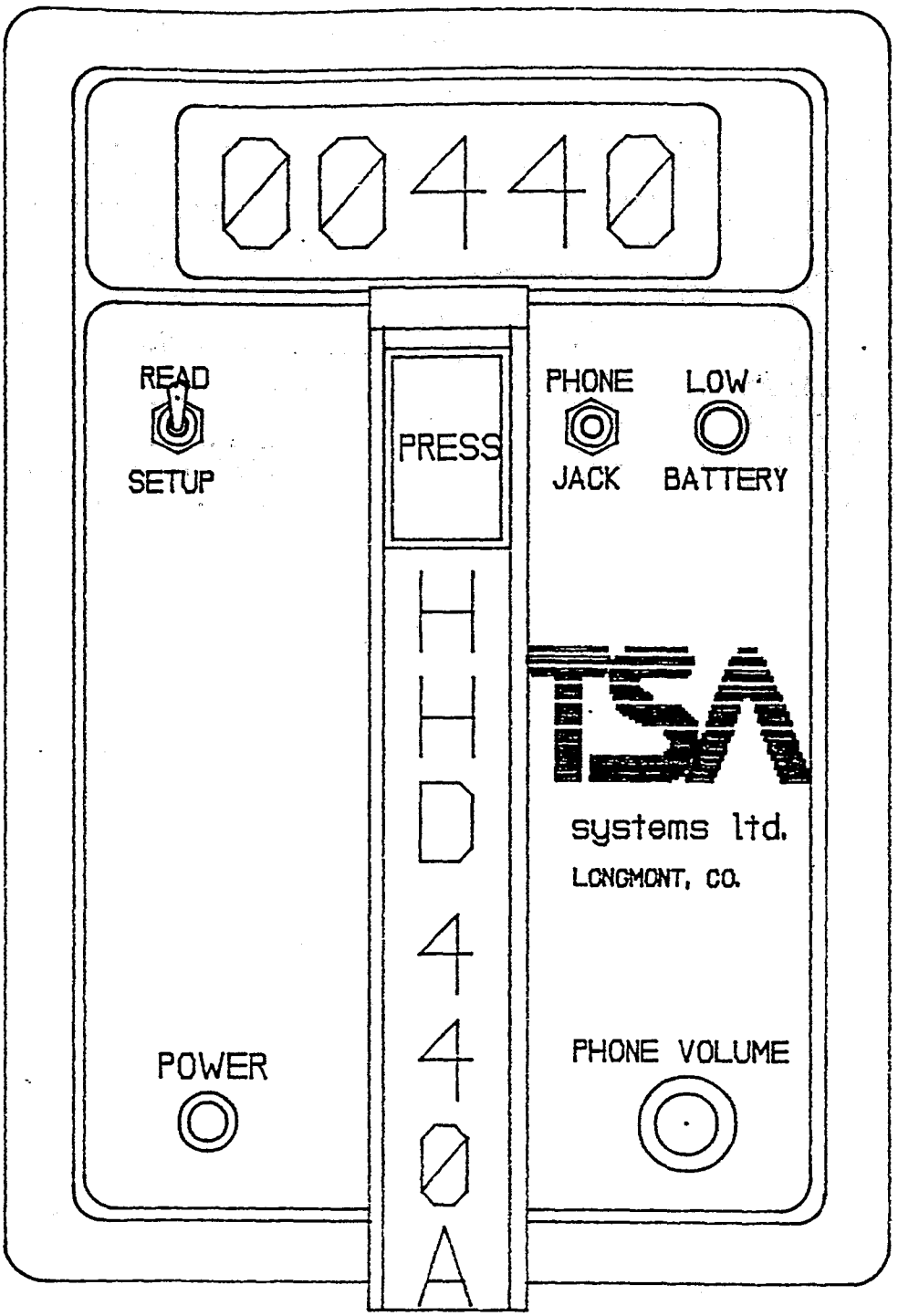
IF THIS PULSE IS NOT SHOWN, it is probable that the HHA-457's FET (Q1) has been destroyed. Disconnect the input coax and attach the scope onto it with maximum vertical deflection and negative edge triggering to see that the negative going pulses are present. They will be very small and hard to see, typically less than 50 mV, but if present, replace the HHA-457 board.

IF A LARGE NUMBER OF PULSES ARE SHOWN, similar to extremely large amplitude noise of 0.2 volts heights or better, a light leak may be suspected. Cover the detector with a sheet of black felt or solid black, non-conducting material. If the number of pulses shown decreases dramatically, there is a light leak which will have to be sealed with black electrical tape or the detector replaced.

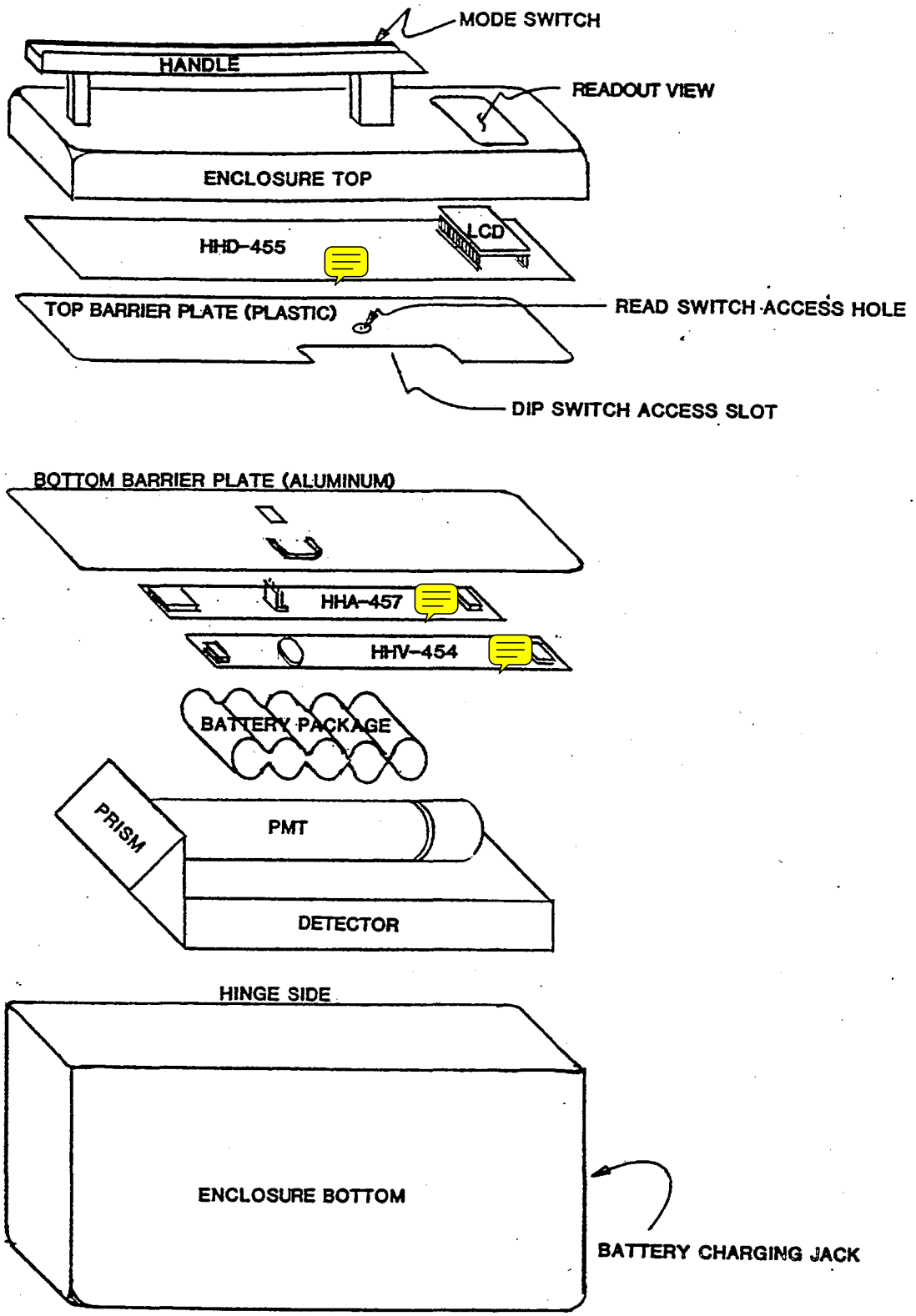
6.2.8. Perform the set-up procedure, including the read/set-up mode and check the settings, testing each one. For example, if the high alarm is set to 8192 counts per second, place a source of sufficient intensity near the detector and check that the unit goes into high alarm. If any of the settings fail, replace the HHD-455 board.

6.2.9. This completes the field test procedures. If the unit is still inoperative, the TSA staff is available to provide assistance by telephone, or the unit may be returned to the factory for repair.

7. LIST OF DRAWINGS

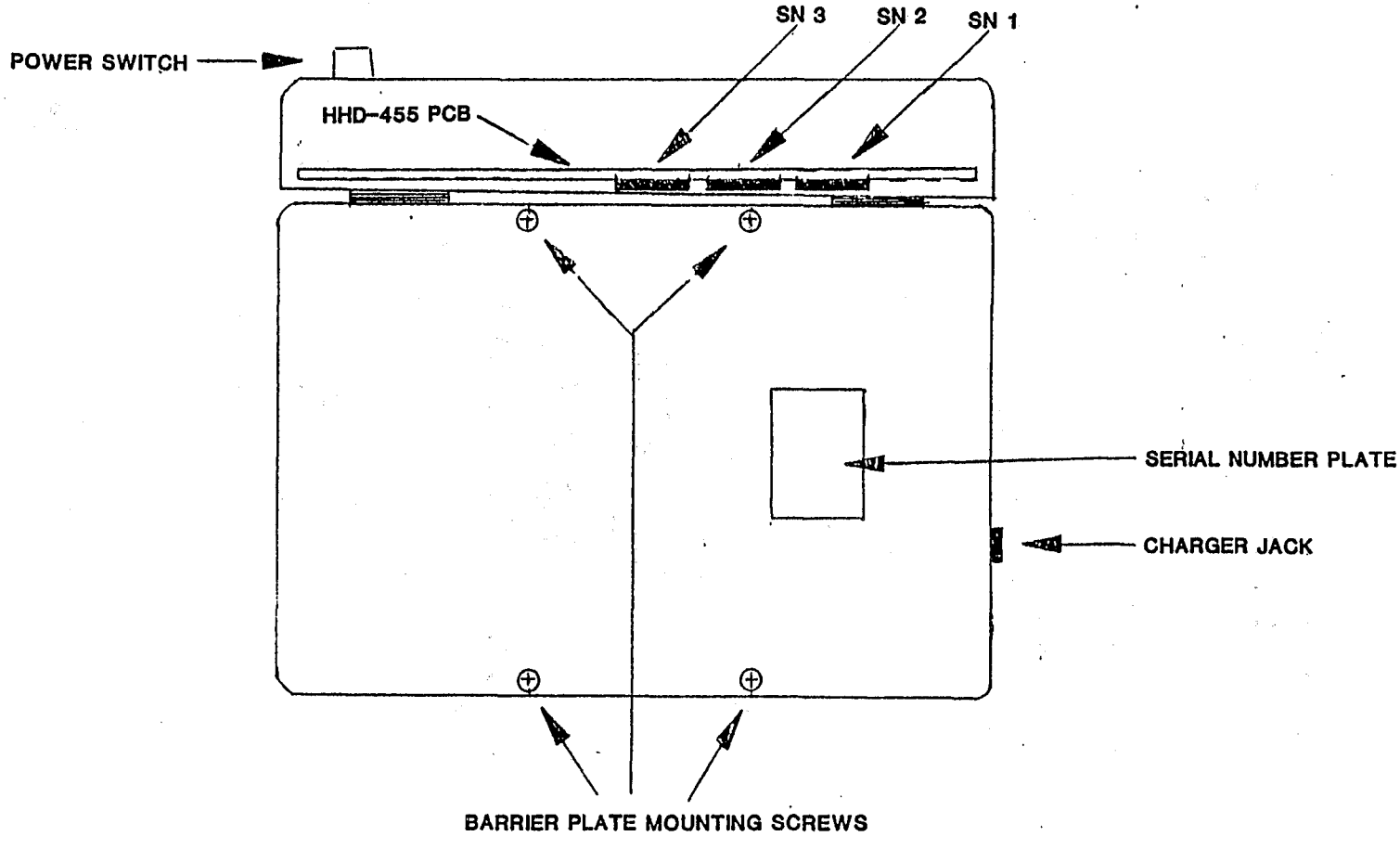


HAND-HELD DETECTOR
MODEL HHD-440A



HHD-440A
COMPONENT EXPLODED VIEW

HHD-440A



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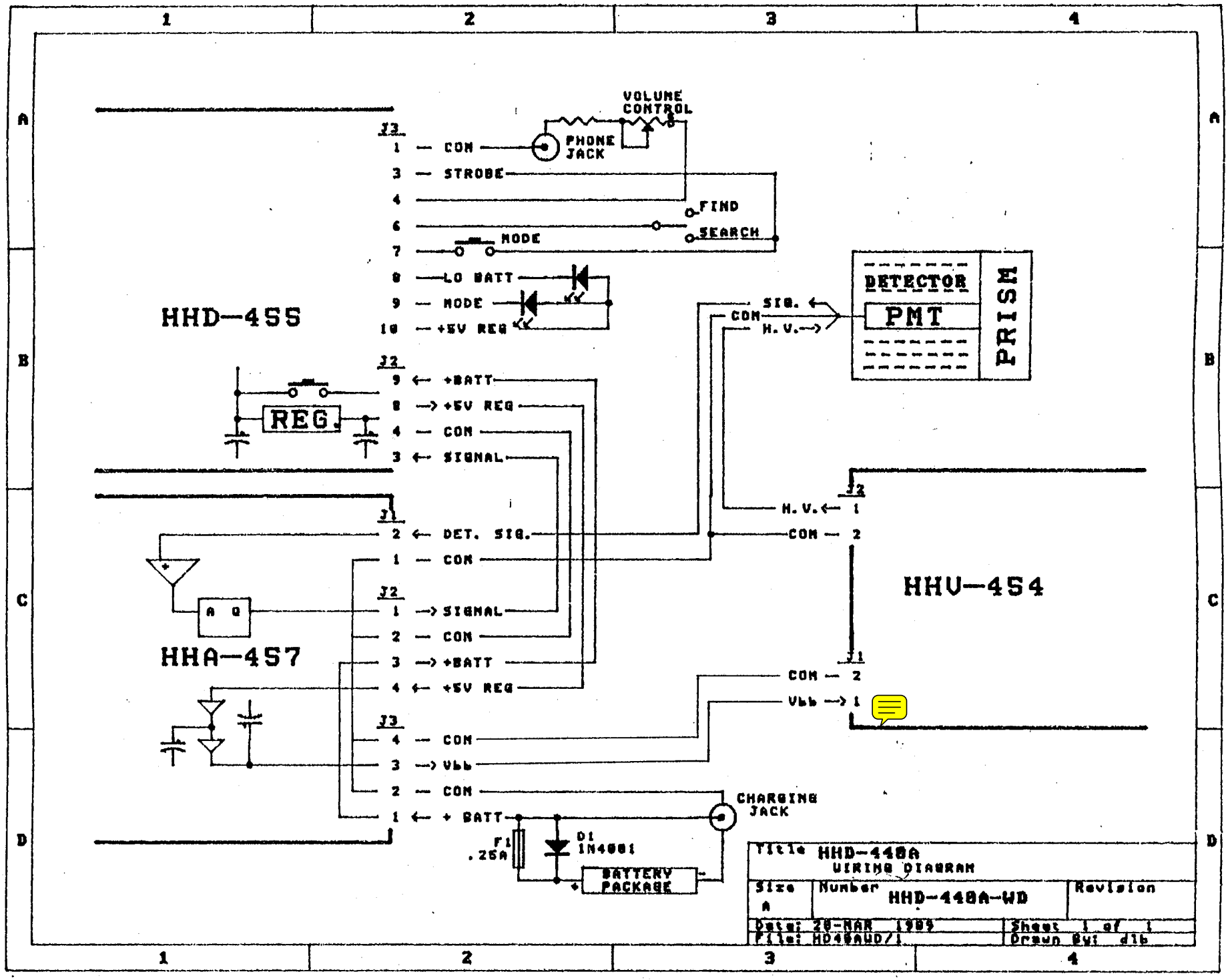
VOLUME CONTROL
PHONE JACK
J3
1 — COM
3 — STROBE
4
6
7 — MODE
8 — LO BATT
9 — MODE
10 — +5V REG
FIND
SEARCH
HHD-455
DETECTOR
PMT
PRISM
SIG.
COM
H.V.
J2
9 ← +BATT
8 → +5V REG
4 — COM
3 ← SIGNAL
REG
J1
2 ← DET. SIG.
1 — COM
J2
1 → SIGNAL
2 — COM
3 → +BATT
4 ← +5V REG
HHA-457
A Q
J2
H.V. ← 1
COM — 2
HHV-454
J1
COM — 2
Vbb → 1
J3
4 — COM
3 → Vbb
2 — COM
1 ← + BATT
CHARGING JACK
F1
.25A
D1
IN4001
BATTERY PACKAGE
Title HHD-448A
WIRING DIAGRAM
Size A
Number HHD-448A-WD
Revision
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Sheet 1 of 1
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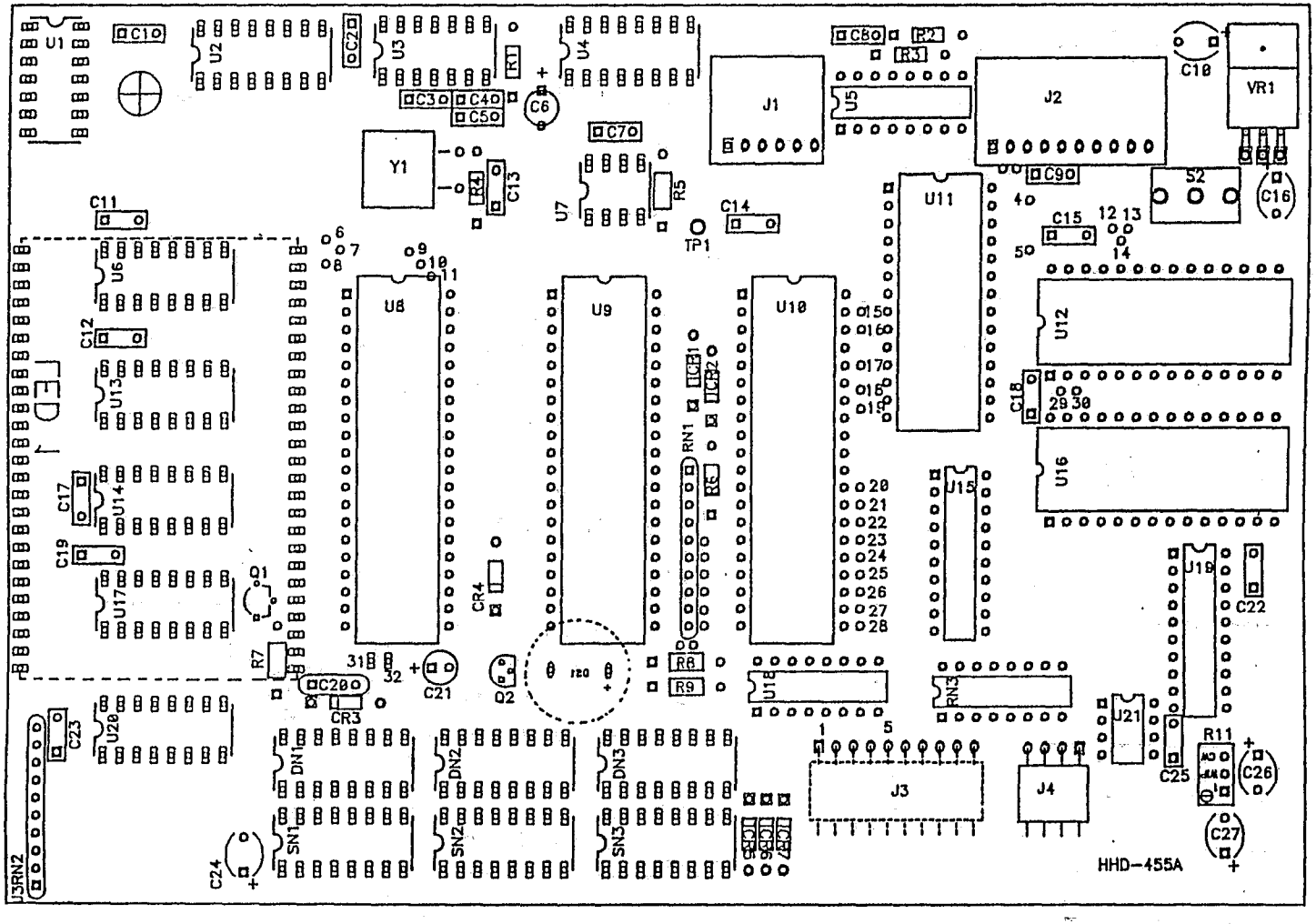
2
3
4
A
B
C
D

DWG 4



TSA Systems ltd.

Rev.	Date	
		Engineering Approval
		Checked by

Document Control No. CD8404A — Surf. Fin.

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COMPONENT DESIGNATOR

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Date	Scale	Sheet of	Drawn By
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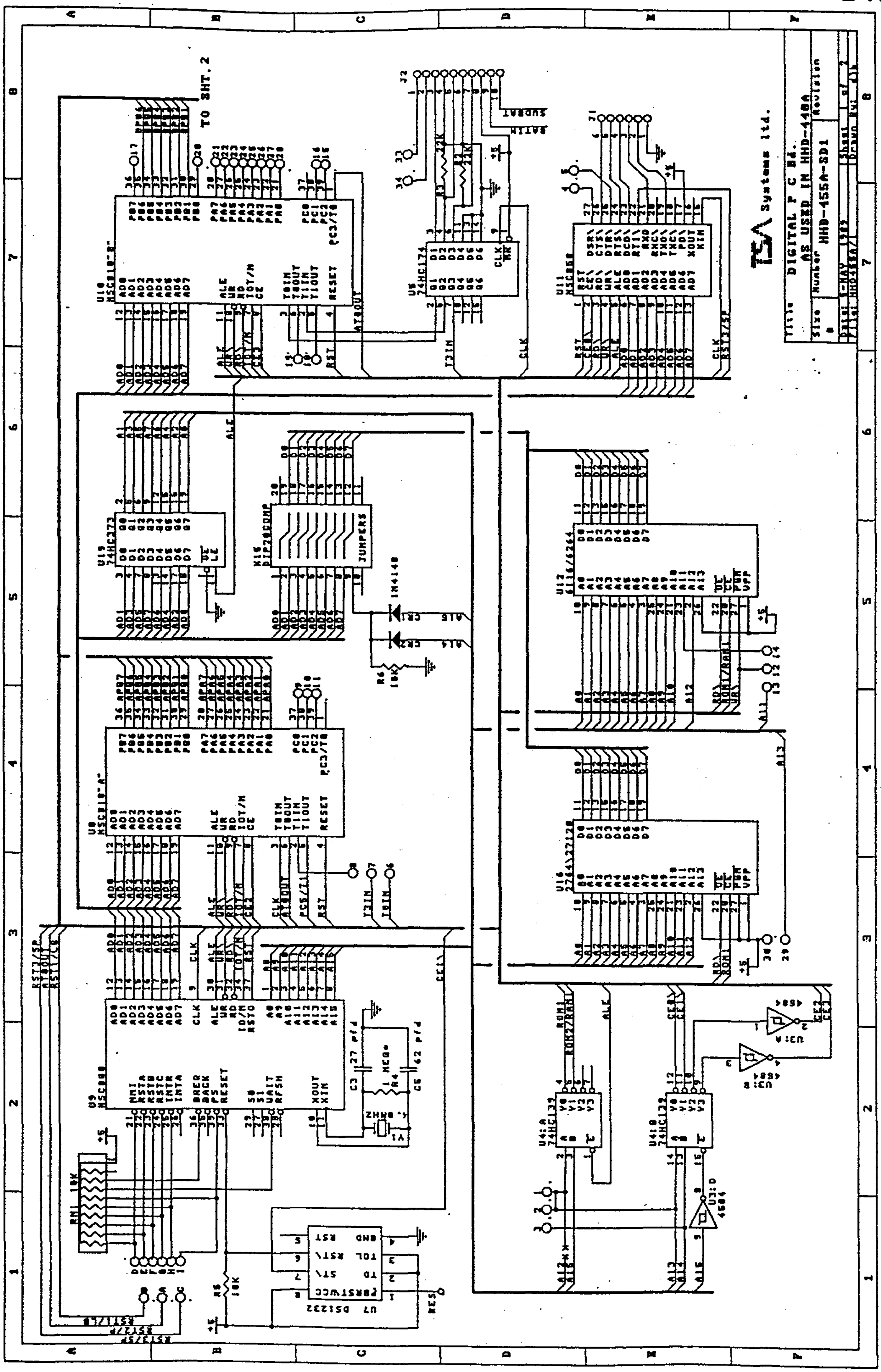
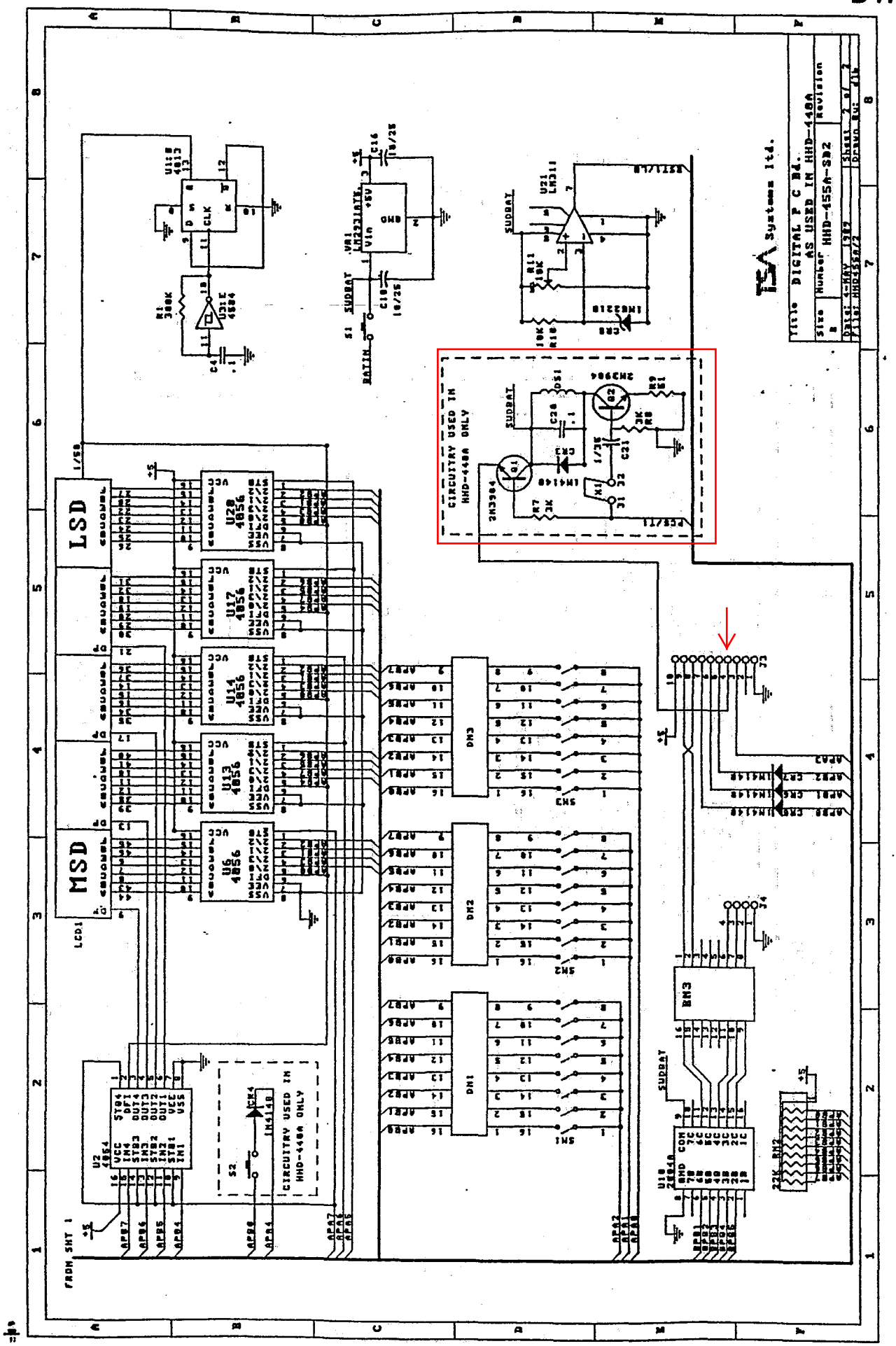
File Name — Layer


TO SHT. 2
DIGITAL P C Bd.
AS USED IN HHD-440A
HHD-455A-SD1
Systems ltd.

DWG 7


LSD
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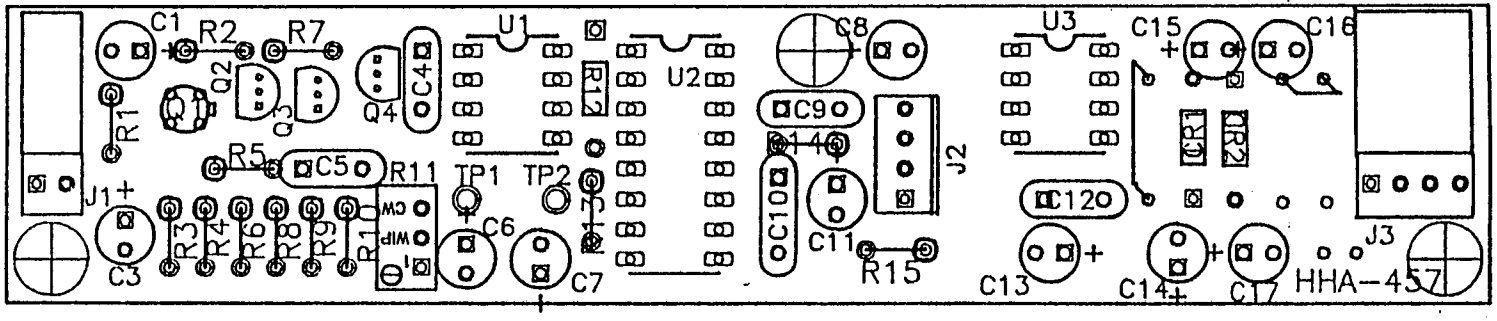
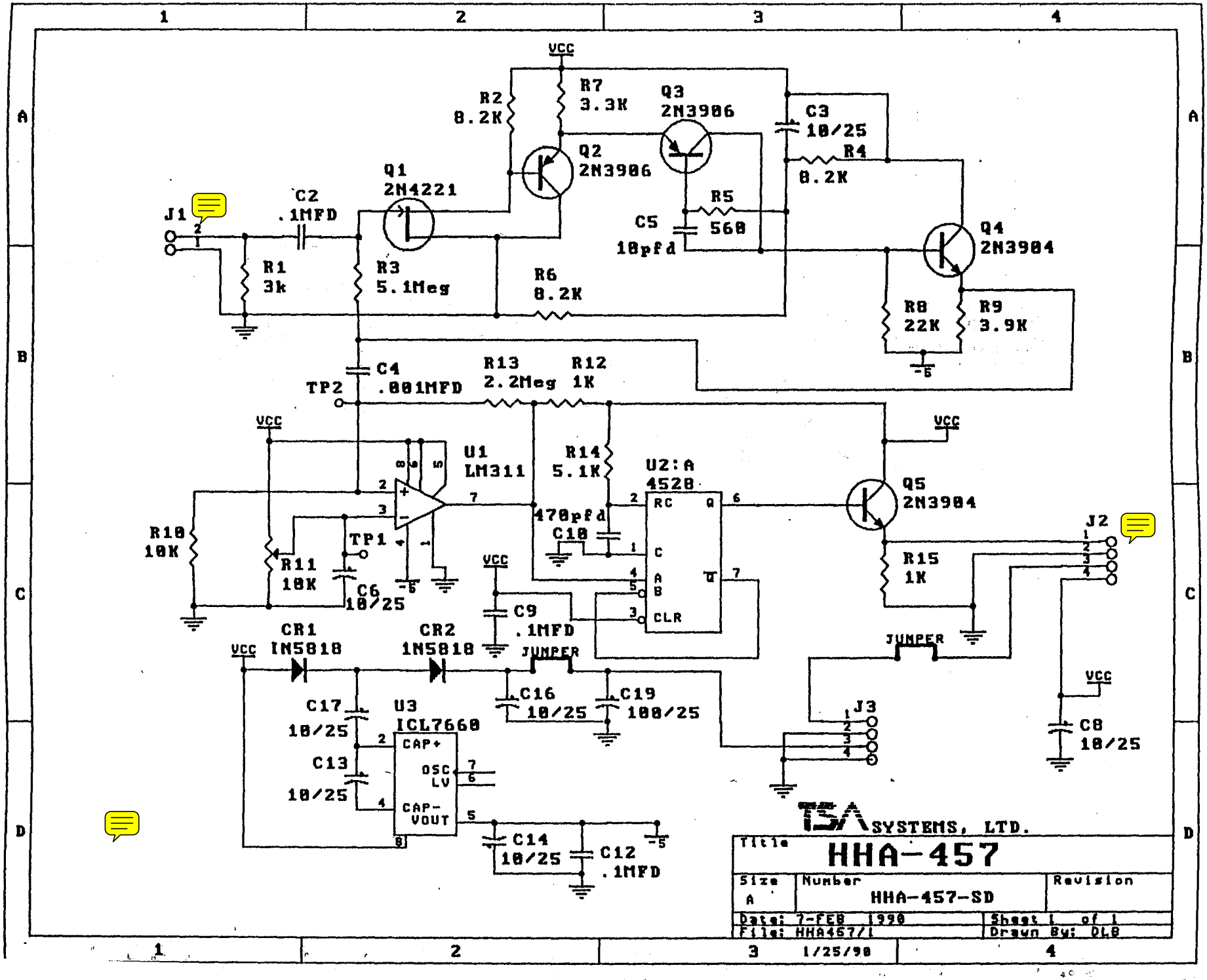
Number HHD-455A-SB2
Revision
Systems ltd.



HHA-457 P C Bd. 8/23/90 T S A Systems ltd.


VCC
R2
8.2K
R7
3.3K
Q3
2N3906
C3
10/25
R4
8.2K
Q2
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Q1
2N4221
J1
C2
.1MFD
R5
560
C5
10pfd
Q4
2N3904
R1
3k
R3
5.1Meg
R6
8.2K
R8
22K
R9
3.9K
C4
.001MFD
TP2
R13
2.2Meg
R12
1K
U1
LM311
R14
5.1K
U2:A
4528
Q5
2N3904
R10
10K
R11
10K
TP1
C6
10/25
470pfd
C10
J2
R15
1K
C9
.1MFD
CR1
IN5818
CR2
1N5818
JUMPER
C16
10/25
C19
100/25
C17
10/25
U3
ICL7660
C13
10/25
C14
10/25
C12
.1MFD
J3
C8
10/25
TSA SYSTEMS, LTD.
Title
HHA-457
Size
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Number
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Revision
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Sheet 1 of 1
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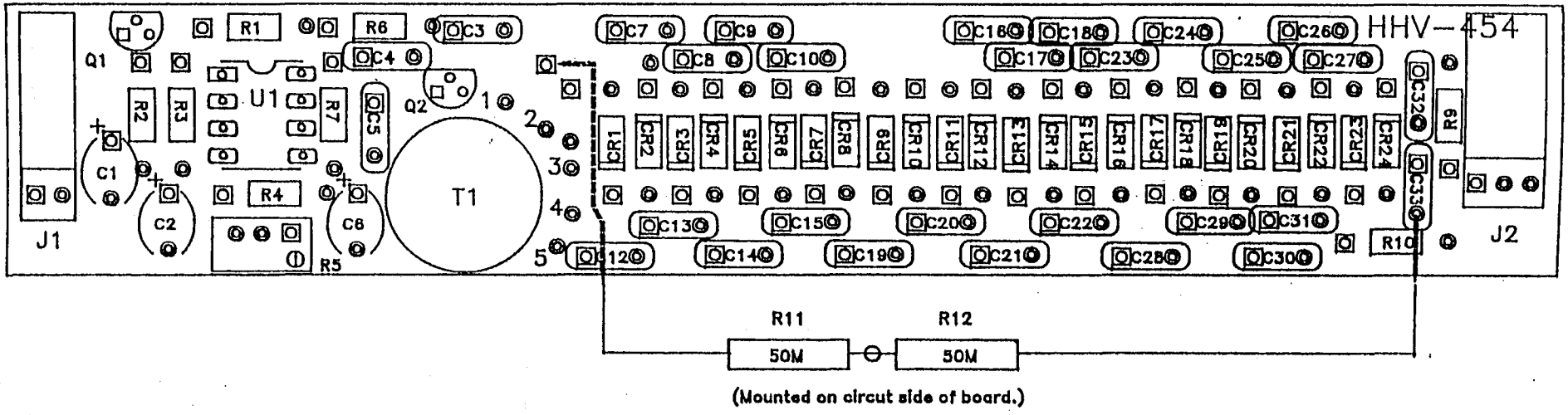
1/25/90



(Mounted on circut side of board.)

TSA Systems ltd.

ECO 94-2-3-94 RLR

Rev.	Date.	Engineering Approval	
		Checked by	
Document Control No,	CD8411	Surf. Fin.	
Title	High Voltage PC Bd. HHV-454		
Size	Dwg. Number HHV-454-CD	Revision	
Date 1-10-94	Scale NONE	Sheet of	Drawn By RLR
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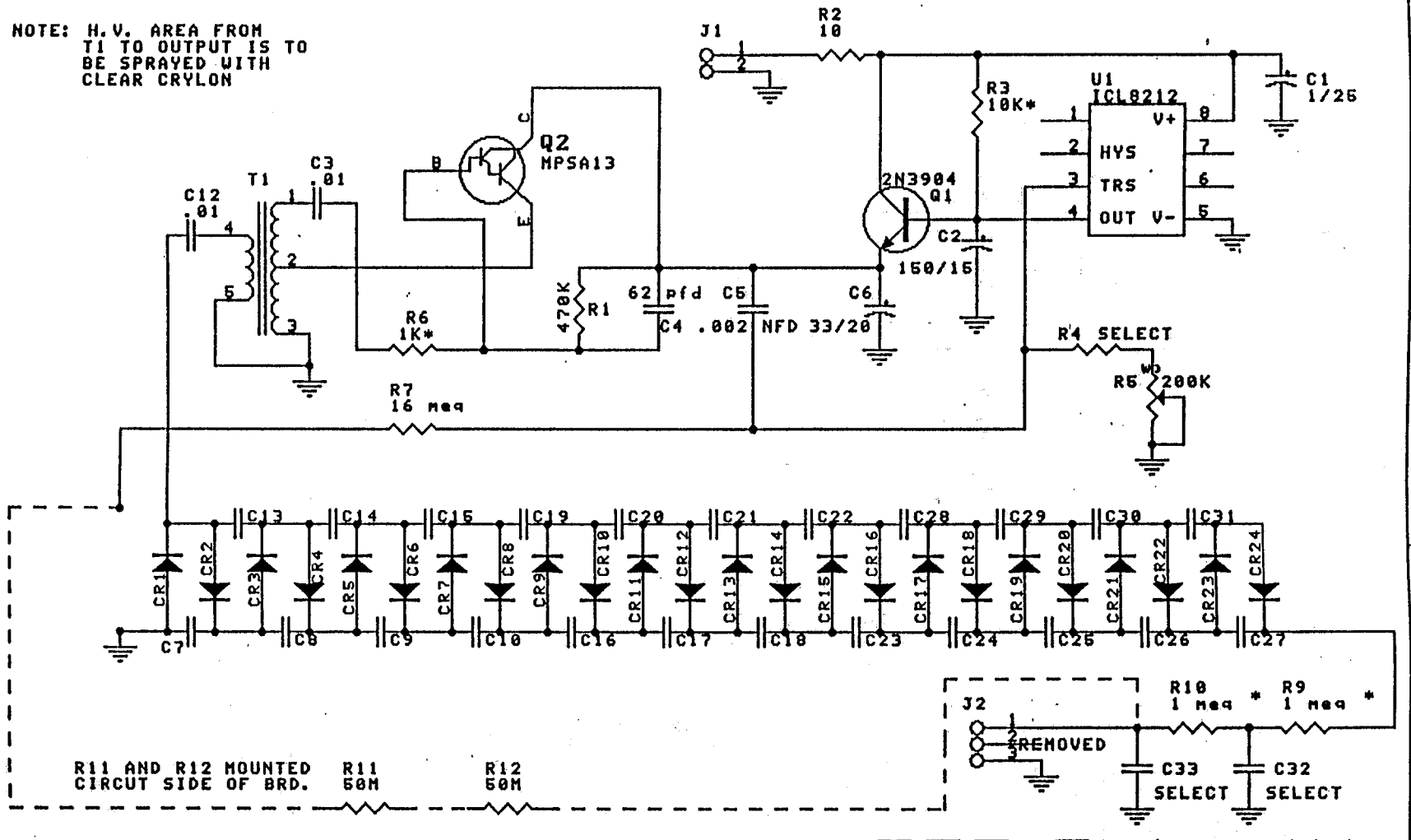
DWG 10



NOTE: CR1 - CR24 = 1N4937

C3, C7 - C31 = .01 MFD CK05BX103K

SELECT

	(8410) HHD/TPM	(8411) PRM/NNV
R4	75k	130K
C32	.01/1KV	.001/3KV
C33	.01/1KV	.001/3KV

TSA Systems ltd

Rev.	Date	
		Engineering Approval
		Checked by

ECO 94-2 1/7/94 RLR

Document Control No. SCH8411

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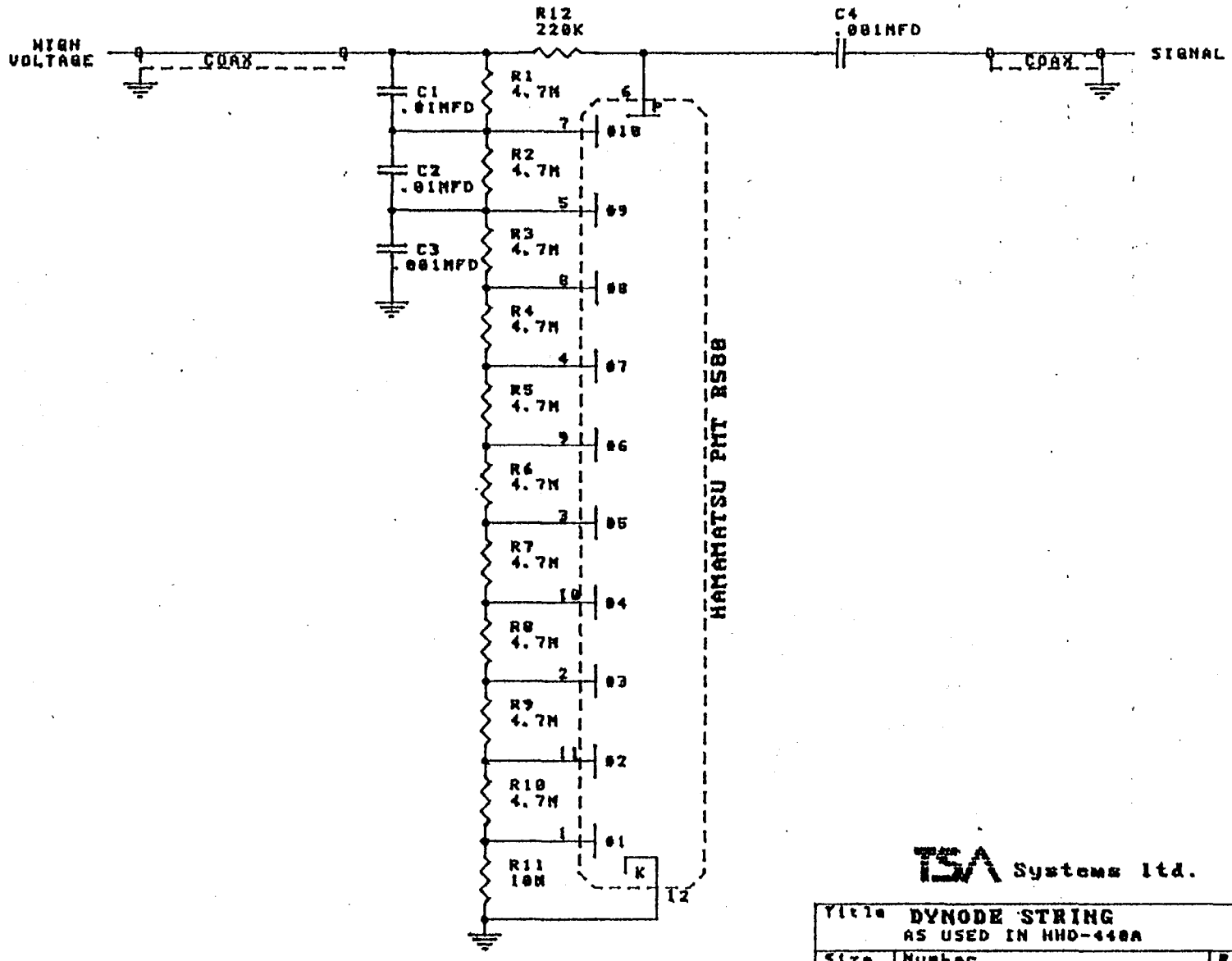
Date: 16-FEB 1996 | Sheet 1 of 1

File: a:sch8411/1 | Drawn By: RLR

DWG 11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COAX
C1 .01MFD
C2 .01MFD
C3 .001MFD
R12 220K
R1 4.7M
R2 4.7M
R3 4.7M
R4 4.7M
R5 4.7M
R6 4.7M
R7 4.7M
R8 4.7M
R9 4.7M
R10 4.7M
R11 10M
C4 .001MFD
COAX
SIGNAL
HAMAMATSU PMT R580
DYNODE STRING
AS USED IN HHD-440A
Size A
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Revision
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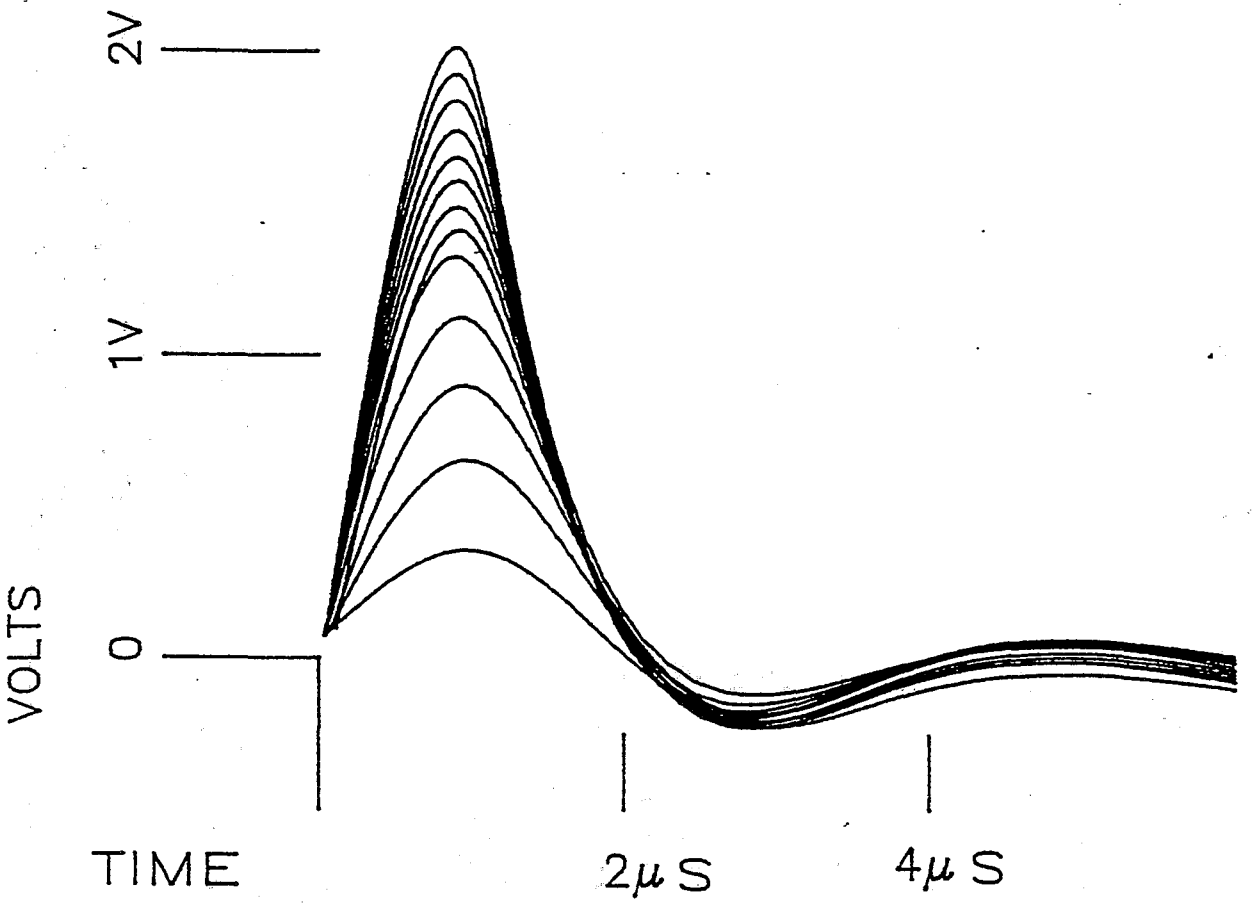
ISA Systems ltd.

DWG 12



TSA Systems ltd.

Rev.	Date.	Engineering Approval
		Checked by
Document Control No.		Surf. Fin.
Title 2 Volt Pulse Profile w/Cs 137		
Size	Dwg. Number	Revision
Date 2-4-94	Scale NONE	Sheet of Drawn By RLR
File Name 2VOLTPP.DW2		Layer

HHD-440A SYSTEM

TSA #	DESCRIPTION	MANUFACTURER/SUPPLIER #
9050A	HHD-440A SYSTEM	TSA 9050A
8850	WIRE HARNESS ASSEMBLY	TSA 8850
8413	HHA-457 ASSEMBLY	TSA 8413
8410	HHV-454 ASSEMBLY	TSA 8410
8404A	HHD-455A ASSEMBLY	TSA 8404A
8204A	DYNODE ASSEMBLY PB4.7M	TSA 8204A
8204	DETECTOR ASSEMBLY DA5.75PP	TSA 8204
8110	BATTERY PACK ASSEMBLY	TSA 8110
7815A	SWITCH, DRESS CAP & NUT	C&K 8025-2
7809	MEMBRANE SWITCH	BRADY/ZYMOX 14144 W/BERG
7284	KNOB, 1/8"SHAFT BLK	ALCO/SWITCH PKG50B-1/8"
7076D	ENCLOSURE, MACHINED	TSA 7076D
7076B	HDW D-RING PLATE	ZERO 924
7076A	HDW D-RING	ZERO 563
6757	LED RED PANEL MOUNT	IEE BD362R
6468	CHARGER 140mA	TSA 6468
3551	OVERLAY INSIDE CPS/MR	TSA 3551
3511	OVERLAY FRONT PANEL	TSA 3511
3501	OVERLAY HANDLE	TSA 3501
3420	HANDLE COMPLETE	TSA 3420
3410	AL MOUNTING RAILS 1/4"	TSA 3410
3406	PLASTIC DIVIDER PLATE	TSA 3406
3401	AL BARRIER PLATE	TSA 3401

8. PARTS LISTS

SPARE PARTS ORDERING INFORMATION

To facilitate the processing of spare parts orders the following information is required.

Product Number
Product Serial Number
TSA Stock number
Part description (from parts list)

When ordering programmed proms, the software version is required. This can be found on the prom label.

NOTE: MODEL NUMBER SUFFIXES ARE GENERALLY NOT INCLUDED IN THE TEXT OF THE MANUAL. HOWEVER, THE SUFFIXES IN THE PARTS LISTS MUST BE INCLUDED ON ORDERS FOR SPARE PARTS.

FOR ASSISTANCE CALL:

TSA SYSTEMS, LTD.
1820 Delaware Place
Longmont, CO 80501
Phone# 303/651-6147
Fax # 303/651-6823

HHA-457 ASSEMBLY

TSA #	SYMBOL	DESCRIPTION	MANUFACTURER/SUPPLIER #
8413	SUB	HHA-457 ASSEMBLY	TSA 8413
2084	C1,3,6-8,11,13-17	CAP, TA 10 μF 25V	SPRAGUE 199D106X0025CAI
2038	C2,9,12	CAP, SMF .1 μF 100V	PANASONIC ECQ-V1104JM
2020A	C10	CAP, CER 470 pF 200V	MALLORY CKO5BX471K
2101	C19	CAP, TA 100 μF 20V	SPRAGUE 199D107X9020FE4
2025	C4	CAP, CER .001 μF	KEMET CKO5BX102K
2001A	C5	CAP, CER 10 pF 200V	KEMET CKO5BX100K
6185	CR1,2	CR, 1N5818	MOTOROLA 1N5818
2688W	J1	CONN, 2 PIN R/ANGLE	MOLEX G-22-12-2024
2688Y	J2	CONN, 4 PIN STRAIGHT	MOLEX G-22-11-2042
2688V	J3	CONN, 4 PIN R/ANGLE	MOLEX G-22-12-2044
6025	Q1	TRN, ECG456	PHILLIPS ECG456
6018	Q2,3	TRN, 2N3906	MOTOROLA 2N3906
6017	Q4,5	TRN, 2N3904	MOTOROLA 2N3904
1051	R1	RES, 3K	
1064	R10	RES, 10.0K	
1427	R11	POTENTIOMETER, 10K 22 TURN	BOURNS 3299W-1-103
1040	R12,15	RES, 1K	
1124	R13	RES, 2.2M	
1057	R14	RES, 5.1K	
1062	R2,4,6	RES, 8.2K	
1133	R3	RES, 5.1M	
1031	R5	RES, 560 OHM	
1052	R7	RES, 3.3K	
1072	R8	RES, 22K	
1054	R9	RES, 3.9K	
5166A	U1	IC	NSC LM311N
5073	U2	IC	NSC CD4528BCP
5255	U3	IC	SILICONIX ICL7660CPA
7722	X1,3	SOCKET 8 PIN	SPC ICD-8-2T
7724	X2	SOCKET 16 PIN	SPC ICD-16-2T

HHD-440A WIRE HARNESS ASSEMBLY

TSA #	DESCRIPTION	MANUFACTURER/SUPPLIER #
8850	WIRE HARNESS ASSEMBLY	TSA 8850
7774	SWITCH, TOGGLE, SPDT	ALCOSWITCH MTA-106D
6759A	PLS LED HOLDER	TSA 6759A
6759	LED RED	HEWLETT PACKARD HLMP-1700
2747	CONN, PHONE JACK	SWITCHCRAFT 142A
2741	CONN, POWER PLUG JACK	SWITCHCRAFT 712A
2691	CONN, 2 PIN JACK	MOLEX 03-06-2023
2688E	CONN, 2 PIN HOUSE	MOLEX 22-01-2027
2688C	CONN, 3 PIN HOUSE	MOLEX 22-01-2037
2688A	CONN, 10 PIN HOUSE	MOLEX 22-01-2107
2686B	CONN, 4 PIN HOUSE	MOLEX 22-01-2047
1452A	POT, 10K, 1 TURN	CLAROSTAT 381N-10K
1013	RES, 100 OHM	

HHD-455A ASSEMBLY / HHD-440A VERSION

TSA #	SYMBOL	DESCRIPTION	MANUFACTURER/SUPPLIER #
8404A	SUB	HHD-455A ASSEMBLY	TSA 8404A
2038	C1,2,4,7-9,11-15,17-20	CAP, CER .1 μF 50V	KEMET CKO5BX104K
2038	C22,23,25	CAP, CER .I μF 50V	KEMET CKORBX104K
2160E	C3	CAP, MICA 27 PF	CDE CD15ED270JO3
2162C	C5	CAP, MICA 62 PF	CDE CDI5ED620J03
2084	C6,10,16,24,26,27	CAP, TA 10 μF 25V	SPRAGUE 199D106X0025CAI
2071	C21	CAP, TA 1 μF 35V	SPRAGUE 199D105X0035BB1
6140	CR1,2,3,4-7	DIODE IN4148	PHILLIPS IN4148PH
6166	CR8	DIODE IN5221B	MOTOROLA IN5221B
6191	DN1,2,3	DIODE ARRAY	SPRAGUE TND921
6447	DS1	AUDIO TRANSDUCER	INTN'L CC BRT 1615P-12
2688P	J1	CONN, 6 PIN R/ANGLE	MOLEX 22-05-3061
2688	J2,3	CONN, 10 PIN R/ANGLE	MOLEX 22-12-2104
2688V	J4	CONN, 4 PIN R/ANGLE	MOLEX 22-12-2044
6758	LCD1	DISPLAY	SEIKO SP538PR
6017	Q1,2	TRANSISTOR	MOTOROLA 2N3904
1103	R1	RES, 300K	
1072	R2,3	RES, 22K	
1311	R4	RES, 1.0M, 1%, 1/4W	
1064	R5,6,10	RES, 10.0K	
1051	R7,8	RES, 3K	
1006	R9	RES, 51 OHM	
1427B	R11	POT, 10K, ADJ 1 TURN	BOURNS 3352T-1-103
1463	RN1	RESISTOR NETWORK 10K 10 PIN SIP	BOURNS 4310R-101-10K
1464D	RN2	RESISTOR NETWORK 22K 9 PIN SIP	DALE CSC09A-01-223G
1473	RN3	RESISTOR NETWORK 220 OHM DIO	BOURNS 4116R-001-221
7764	SN1-3	SWITCH, DIP 8 POSITION	GRAYHILL 76SB08S
7815	SW1	SWITCH PB SPDT	C&K 8161SHZ3QE
7835	SW2	SWITCH PB NO MOM	ALCOSWITCH APB1FG-PC
5050	U1	IC	NSC MC14013BCP
5228	U2	IC	SGS CD4054BE
5230	U3	IC	MOTOROLA MC14584BCP
5207	U4	IC	NSC MM74HC139N
5206	U5	IC	NSC MM74HC174N
5263	U6,13,14,17,20	IC	SGS CD4056BE
5277	U7	IC	DALLAS DS 1232
5242	U8,10	IC	NSC NSC810AN-3I
5241	U9	IC	NSC NSC800N-3I
5264	U12	IC	SGS MK6116N15
7737	U15	SOCKET 18 PIN HEADER	AUGAT 1118-3G1
5019	U18	IC	SPRAGUE ULN2004A
5287	U19	IC	NSC MM74HC373E
5166A	U21	IC	NSC LM311N
4998	VR1	VOLTAGE REGULATOR	NSC LM2931AT-5.0
7741	XDS1,2	SOCKET 25 PIN SIP	RN WB-25-55-TG
7724	XSN1-3,XDN1-3	SOCKET 16 PIN	WELCON 802-0161642
7717	XU11,12,16	SOCKET 28 PIN MC	AUGAT 528AG11D
7723	XU1,3	SOCKET 14 PIN	WELCON 802-0141642
7724	XU2,4,5,6,13,14,17,18,20	SOCKET 16 PIN	WELCON 802-0161642
7722	XU7,21	SOCKET 8 PIN	WELCON 802-0081642
7733	XU8,9,10	SOCKET 40 PIN MC	AUGAT 540AG11D
7725	XU15,19	SOCKET 20 PIN	WELCON 802-0201642
6656A	Y1	CRYSTAL, 4.0 MHZ	FOX F0X040

HHV-454 ASSEMBLY

TSA #	SYMBOL	DESCRIPTION	MANUFACTURER/SUPPLIER #
8410	SUB	HHV-454 ASSEMBLY	TSA 8410
2071	C1	CAP, TA 1 μF 35V	SPRAGUE 199D105X0035BB1
2101A	C2	CAP, TA 150 μF 16V	SPRAGUE 199D157X9016TE4
2032	C3,7-10,12-31	CAP, CER .01 μF 100V	KEMET CKO5BX103K
2162C	C4	CAP, MICA 62 PF	CDE CDI5ED620J03
2089	C6	CAP, TA 33 μF 25V	SPRAGUE 199D336X0025EE2
2173	C32,33	CAP, MTL POLY .01 μF 1KV	ILLINOIS CAP. 103MSR102K
6203	CR1-24	DIODE	DIODES, INC. IN4937
2688W	J1	CONN, 2 PIN R/ANGLE	MOLEX 22-12-2024
2688X	J2	CONN, 3 PIN R/ANGLE	MOLEX 22-12-2034
6017	Q1	TRANSISTOR	MOTOROLA 2N3904
6040	Q2	TRANSISTOR	MOTOROLA MPSA13
1108	R1	RES, 470K	
1000	R2	RES, 10 OHM	
1270	R3	RES, 10.0K, 1%, 1/8W	
1089	R4	RES, 75K	
1431C	R5	POT, 200K, 22 TURN	BOURNS 3299W-1-204
1194	R6	RES, 1K, 1%, 1/8W	
1145	R7	RES, 16.0M	
1311	R9,10	RES, 1.0M, 1%, 1/4W	
1327	R11,12	RES, 50M 1% 100PPM	HY-MEG CORP HV-65-50M
7885	TX1	TRANSFORMER	TSA 7885
5258A	U1	IC	INTERSIL ICL8212CPA
7722	XU1	SOCKET, 8 PIN	WELCON 802-0081642