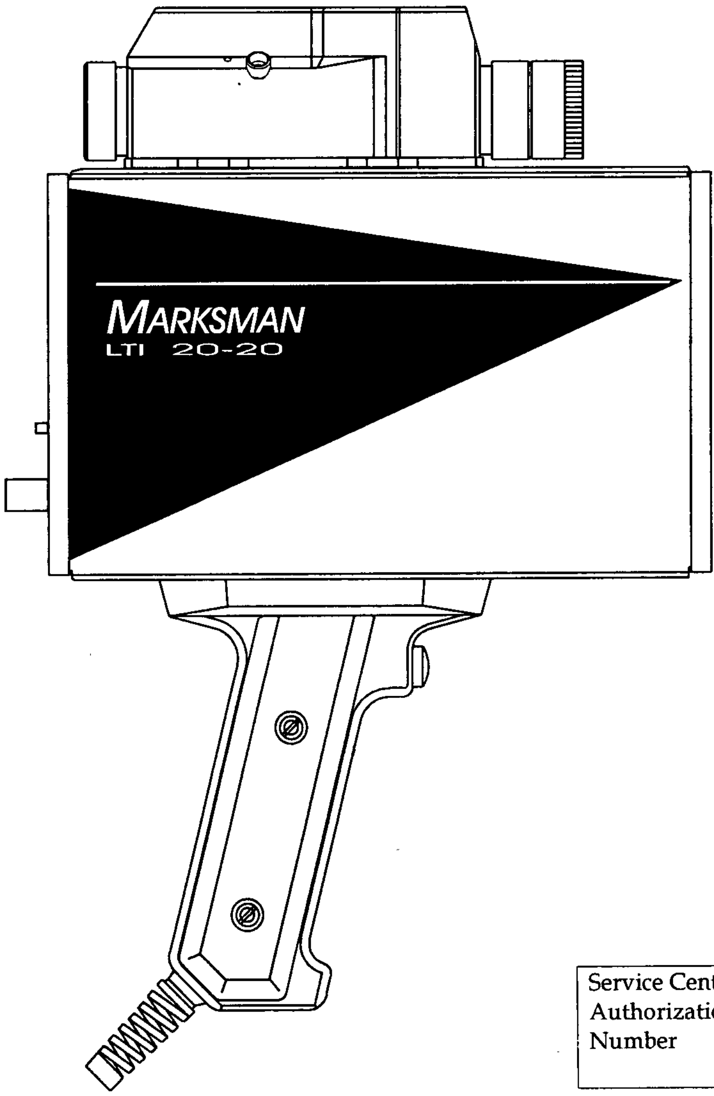
LASER INC TECHNOLOGY

Redefining ways to measure your world.

Marksman / LTI 20 -20

Laser Speed Detection System

Service Manual



Service Center Authorization Number MMSV0040

Marksman/LTI 20-20®
Service Manual

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Information in this document is subject to change without notice and does not represent a commitment on the part of Laser Technology, Inc.

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This product is covered by pending patent applications and/or one or more of the following issued patents:

5,359,404
5,521,696
5,617,199
5,715,045

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PART 1: INTRODUCTION

Scope of this Manual

The purpose of this manual is to provide service information to enable an experienced technician to perform repairs on the Marksman/LTI 20-20 Speed Detection System. The information contained within is designed to encompass the most common repairs encountered with standard field usage. All of the service procedures covered can be completed utilizing readily available tools and equipment. Repairs requiring specialized fixtures and/or technical knowledge should be referred to Laser Technology, Inc.

Safety Precautions

The Marksman is designed to meet stringent FDA eye safety requirements and is classified as eye-safe to class one limits. That means that it is nonhazardous to directly view the laser output for a continuous period of up to 10,000 seconds. As with any laser device, however, it is recommended to avoid looking directly into the transmit aperture for prolonged periods of time while firing the laser.

DO NOT ATTEMPT TO DISASSEMBLE ANY PORTION OF THE TRANSMIT OR RECEIVE MODULES - REFER ALL MODULE SERVICE TO LASER TECHNOLOGY, INC.

⚠ **Caution**: To reduce the risk of electrical shock, please read this manual thoroughly, noting highlighted precautionary warnings, before removing instrument side covers or performing any service repairs.

Replacement Parts

Replacement parts can be ordered directly from Laser Technology, Inc. When ordering, please supply the part number, quantity required, and a part description. You may also be asked to provide your Service Center Authorization Number (refer to front cover of this manual). Phone, mail, fax or E-mail to place orders. Please address your requests to the Service Department.

Service Returns

In the event that the Marksman cannot be repaired with the information supplied in this manual, it may be necessary to return the unit for manufacturer service. It is recommended that you contact the service department before returning any equipment. The Service Representative may be able to suggest a solution to the problem and eliminate the need for a return. If it is determined that the instrument must be returned, the Service Representative will note the serial number, and supply you with a Return Merchandise Authorization (R.M.A.) Number for your reference. Please be sure to supply all the necessary information regarding the nature of the return so that the equipment can be serviced efficiently.

Service Documentation

It is recommended that a log be kept of any service that is performed on a Marksman. This record will be useful as a reference for any further repair to that instrument, be it either by you or by Laser Technology, Inc. A repair log may also be essential in any court proceedings in which the unit is involved. A standard repair log format should include: instrument serial number, date of manufacture, date of service, name of service technician, symptoms of the problem, repairs completed, and any results of any post service testing.

Product Warranty

Laser Technology, Inc., warrants the Marksman to be in good working order for a period of one year from the date of purchase from LTI or an authorized LTI product dealer. Should the product fail to be in good working order at any time during this one-year warranty period, LTI will, at its option, repair or replace this product at no additional charge except as set forth below. Repair parts and replacement parts and products become the property of LTI. This limited warranty does not include service to repair damage to the product resulting from accident, disaster, misuse, abuse or non-LTI modification of the product.

Limited warranty service may be obtained by delivering the product during the one-year period to Laser Technology, Inc. Service Center: 7070 South Tucson Way, Englewood, Colorado 80112, and provide proof of purchase date. If this product is delivered by mail, you agree to insure the product or assume the risk of loss or damage in transit, to prepay shipping container or equivalent.

LTI hereby disclaims all other express and implied warranties for this product, including the warranties of merchantability and fitness for a particular purpose. Some states do not allow the exclusion of implied warranties, so the above limitations may not apply to you.

If this product is not in good working order as warranted above, your sole remedy shall be repair or replacement as provided above. In no event will LTI be liable to you for any damages including any lost profits, lost savings or other incidental or consequential damages arising out of the use or inability to use such product. Further more, LTI shall not be held responsible if an LTI authorized dealer has been advised of the possibility of such damages, or for any claim by any other party.

Marksman Overview

The Marksman is a hand-held, laser-based speed detection system. LASER is an acronym that stands for "Light Amplification by Stimulated Emission of Radiation". Laser light sources can take many forms, having lasing mediums which are solids, liquids, or gases. No matter how a laser is constructed, its light energy output can be characterized as being of a single frequency (ideally), and having a wavefront which is " in-phase" or coherent. The type of laser used in the Marksman is an infrared semiconductor laser diode, which has several properties that make it ideal for use in a hand-held speed measuring device.

Laser diodes are typically small, similar in size to a light emitting diode, and can operate with a low power source, such as a battery. These diodes emit a narrow cone of radiation from a very small source area, allowing the light to be collimated into a narrow beam with pinpoint targeting accuracy. The Marksman is what is known as a **pulse** laser, using the ability of the laser diode to turn on and off in less than a billionth of a second. This rapid transition speed gives the instrument its superior accuracy in both range and speed velocity measurements. As mentioned above, lasers emit light in a narrow band of frequencies, this allows a detector to be "tuned" to a particular wavelength and thus ignore background radiation given off by other light sources. This is why the Marksman can operate during the daytime when there is background light from the sun. The laser diode in the Marksman emits light in the infrared electromagnetic spectrum, meaning that it is invisible to the naked eye and cannot be a distraction to drivers or operators.

The Marksman determines speed by measuring the time of flight of a series of short pulses of light. Since the speed of light is a constant, the time it takes a laser pulse to travel to a target and return is directly proportional to the distance to the target. By firing two pulses a known time apart, two distances can be calculated. The change in distance, divided by the time interval between the two pulses, gives the speed of the target. In theory, it is possible to make a speed measurement using only two pulses, however, due to a limited amount of data; this simple method would be prone to errors. To minimize errors and maximize accuracy, the Marksman uses multiple pulses to accumulate data for a single speed measurement. It then uses a mathematical process known as Least Squares Analysis to find the "best fit" line for the individual data points. This line is a direct representation of the motion of the target, and its slope is the average speed of the target during the measurement period. It can be seen that speed determination by laser is a direct measure of the distance traveled by a target, not an inferred calculation based on a Doppler frequency shift as with radar.

It is important to keep in mind that the Marksman is a line-of-sight instrument. You must be able to see the target to acquire a speed or range. Although laser light is a form of electromagnetic radiation, much the same as that of a radio wave emitted from a conventional radar unit, the two have very different characteristics. The laser light has a frequency some 13 thousand times higher than K-band radar. The laser light beam is not affected by diffraction and re-radiation the way that a radar beam is, and is also immune to interference or errors caused by rotating or vibrating objects. Therefore, it does not bend around corners or experience strong returns due to secondary reflection off unwanted targets. Virtually none of the laser beam goes beyond the targeted vehicle, allowing virtually no possibility of advance warning by a "Laser-buster" device. The Marksman can discriminate between approaching and departing targets, and gives an accurate zero speed for a stationary target. When gathering information on symptoms of problems, always remember that the Marksman "sees" a target just as your eyes see light reflected from objects around you.

PART 2: OPERATION OF THE MARKSMAN

Normal System Operation

Plug the power connector of the Marksman into a suitable 12-volt power source. Using the On/Off switch on the back panel of the instrument, turn the unit on. When the instrument is initialized, it puts itself through a self-check. The instrument's microcontroller interrogates each circuit board and lights all of the segments on the LED display. During initialization, three mid-frequency beeps are sounded. If everything tests positive the instrument display will go from " 8.8.8.8." to dashes, and a high tone will sound. If the instrument does not test positive, an error message will be displayed.

After the power-up sequence, the Marksman defaults to the "Speed/Range" mode and is ready to take a speed measurement. Take a test reading by aiming the instrument at a stationary target that is within the standard operating range (30 to 1500 feet). The laser must be held steady during target acquisition or an error message will be displayed. The trigger can be held continuously while attempting to acquire a target, during which time a low tone is sounded. When the laser locks and completes a measurement, a short high tone will sound if the reading is valid. If the trigger has been released before target acquisition, or an invalid measurement has occurred, the instrument will emit a low tone and display an error message. Some versions of software support a feature called "Retry on Error". By continuing to keep the trigger depressed on an invalid measurement response, the instrument will retry target acquisition until a valid target is acquired or until a maximum number of retries has occurred. The speed reading of a stationary target should be 0 mph (+/- 1 mph) or 0 kph (+/- 2 kph). Pressing the "Speed/Range" button will toggle the display between target distance and target speed when the instrument is in "Speed/Range" mode.

The "Test Mode" button on the rear plate can be used to select four different test functions. If the "Test Mode" key is pressed and immediately released, the instrument is put into test tone mode and "tt" will be displayed. This function is used to verify or adjust the sighting scope alignment (see the section on scope alignment for further explanation). By holding the "Test Mode" button down for approximately one half of a second, an operator can initiate the power-up display test that lights all the LED display segments. If any segment of the display is not functioning properly, a flaw will be evident in one of the numbers displayed. If the "Test Mode" key is released during the first five seconds of the display test, the Delta Distance verification mode is initiated and "d1" is displayed. See the section on Calibration Verification for further information on this function. Releasing the "Test Mode" button after more than five seconds will display a software verification code (this function was not available on early models). The verification code is used when contacting the factory for any detailed information regarding system function or operation.

The "Timing Mode" key on the rear plate is used to put the Marksman into a time-over-distance speed measurement mode. If the instrument is equipped with a Speedscope, pressing the "Timing Mode" key and releasing it immediately, will bring up the Speedscope's digital brightness control (see the section on the Speedscope Digital Brightness Control). Depressing the "Timing Mode" key for more than 0.5 second will access the timing mode feature and a "d1" will be displayed. The operation of the "Timing Mode" is discussed in a section to follow.

If the mode of operation has been changed from the default "Speed/Range" at power up, this mode can be initiated by pressing the "Speed/Range" key. Any time this mode is entered, the display will switch to dashes and will default to show speed when a measurement is taken. Pressing the "Speed/Range" key again will toggle the display to show distance. Note that a displayed speed will show solidly, while a displayed range will flash. The "Display Intensity" control varies the brightness of the display and the red dot inside a Red-dot scope. A Speedscope uses the Digital Brightness Control to control its internal intensity. With the control turned all the way clockwise, the display should be at maximum brightness. Turning the control all the way counterclockwise will cause the display to be completely blank, even during power-up initialization.

Trapping of Erroneous Readings / Error Messages

The Marksman has the ability of detecting errors in both the system hardware and in the measurement process. Hardware errors are those having to do with actual operation of the system circuitry, such as self-calibration errors or memory checksum errors. Measurement errors are those that would create an erroneous speed or distance calculation, such as an unstable aiming point or a beam obstruction during target acquisition. Hardware errors have a fairly straightforward explanation, although it may not be simple to locate the problem component. In order to understand measurement errors, however, one needs a grasp of how the instrument acquires and processes measurement data.

As mentioned earlier in the text, the Marksman accumulates data from multiple laser pulses to calculate a speed or range measurement. The data from each individual laser pulse must pass three separate tests to insure its quality before it is included in the aggregate data set. Of the total number of pulses used for a given measurement, at least 75 percent of them must pass these initial raw data integrity tests before any other calculations are performed. If this 75 percent criteria is not met, "E-02" will be displayed for that measurement. If the quality of the data set is deemed acceptable, the instrument then determines a "best fit" line for the individual points using least squares analysis. The data line must then pass three additional tests, which check, for velocity discontinuities and acceleration or deceleration limits. If the data makes it this far, but fails any of the curvature tests, "E-03" will be displayed. It should be noted that error trapping criteria used in the Marksman was established by analyzing data obtained from actual moving vehicles. Therefore, the instrument has been optimized to trap errors, which would occur in practical use.

A summary of error codes is listed below, with an explanation of the probable causes. Measurement errors could occur frequently for an inexperienced user, but with a little practice, consistent target measurement is attainable. System errors (hardware related) may occasionally occur due to noise fluctuations in the instrument circuitry. This does not indicate that the unit has questionable performance, but rather that the error trapping algorithms are operating correctly. A system error message that happens once, but is never seen again, should be noted but is not a great concern. If an instrument consistently shows system errors, it will require service and may need to be returned to the manufacturer.

System Error Codes

E-50	Internal self calibration error 1
E-51	Internal self calibration error 2
E-52	Instrument temperature too low
E-53	Instrument temperature too high
E-54	Internal self calibration error 3
E-60	Program checksum mismatch. Unauthorized changing of the instrument program IC
E-61	External EEPROM checksum mismatch error 1
E-62	External EEPROM checksum mismatch error 2
E-63	External RAM test failure
E-70	Back panel key depressed on start-up

Measurement Error Codes

do	Display overflow
Lob	Low Battery
E-01	Never acquired a target because the target was out of range or the target was too close
E-02	Lost the target due to an obstruction or the target goes out of range
E-03	Unstable reading due to poor aiming or panning off the target
E-04	Insufficient time allotted to determine speed in the timing mode. The minimum time of measurement is one second.
E-05	Excessive time allotted to determine speed in the timing mode. The maximum time of measurement is 99.99 seconds.
E-07	Optical interference detected. Indicates the possible use of a laser jamming device. Accompanied by a warble tone.

Ranging with the Marksman

The Marksman has ranging capabilities that can be used for a variety of applications. The ranging accuracy of the instrument is +\- 6 inches. The maximum range of the instrument depends upon the reflectivity of the target. The maximum range to the rear of an automobile, for example, is more than 4,000 feet: the range to the front of that same automobile is only about 2,000 feet. The reason for the difference is that the tail lights on the rear of a vehicle are usually more reflective than anything on the front of the vehicle.

There are many factors that affect the reflectivity of a target. Surface finish, size, shape, and color all effect reflectivity and range. The brighter the color, the longer the range. Red is very reflective and will allow longer ranges than the color black, which is the least reflective color. A shiny finish provides more range than a dull one. A small target with rounded corners and sloping surfaces is more difficult to range to than a larger target with square corners and flat faces.

The angle to the target also has an effect. Shooting a target at a 90-degree angle, such as a wall, will provide a good range. Trying to acquire a target at a shallow angle will result in poor range. All of the target characteristics will have an impact on the maximum range achievable.

In speed enforcement use, noting the target distance along with the speed and direction, may solidify a violation. Other uses of the ranging function could include accident reporting and reconstruction, swat team sniper ranging and investigation for false compartments for drug interdiction. Numerous other situations may come up where an accurate distance measurement may prove useful.

Use of the Timing Mode

In addition to measuring velocity directly, the Marksman can operate in "timing mode". In timing mode, the Marksman determines a vehicle's speed by measuring the time it takes the vehicle to travel over a measured distance.

Timing mode uses the formula: Speed = Distance ÷ Time

To see how the equation works, imagine that an officer has determined the distance between two fixed points as one-half mile, and has clocked a vehicle traveling that distance in 20 seconds. The vehicle's speed is determined as follows:

$$\text{Time} = \frac{\text{20 seconds travel time}}{\text{3600 seconds per hour}}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{0.500}{\frac{20}{3600}} = 0.500 \times \frac{3600}{20} = 90 \text{ mph}$$

Measurement Methods

There are three different methods for using timing mode. In all of them, the underlying principle is the same: to determine the distance between two reference points, and to use the Marksman's precise timing to clock vehicles as they traverse that distance.

The difference among the methods is the manner in which the enforcement distance is determined. In method 1, you use the instrument to measure the speed enforcement distance directly. In method 2, you use the instrument to measure the distances to the beginning and ending points of the enforcement section, and to calculate the enforcement distance. In method 3, you manually enter an enforcement distance that was previously determined.

Regardless of which method you use, it's important that the distance entered into the instrument, by whatever means, is equal to the distance target vehicles will travel over the measured time. Using method 1 or 2, for example, the section of road used for enforcement must be straight. Using method 3, however, you can clock vehicles traveling over curved sections of road as long as you know the actual distance from the beginning of the enforcement section to the end.

Using Method 1

In method 1, you sight the instrument on a reference point and determine its distance, and then clock vehicles as they travel that distance. You may station yourself on an overpass, for example, and measure the distance to a sign up the road. Then you would stay on the overpass and clock vehicles to see how long it takes them to travel between the sign and the overpass.

Method 1 requires the following procedure:

1. Press the Timing Mode button on the back panel, and keep the button depressed for 0.5 seconds. The screen displays "d1", which stands for *distance 1.*

2. Sight on your chosen reference point down the road and squeeze the trigger. The screen displays a number, which is the distance to the reference point.

3. Press Timing Mode again. The screen displays "d2", which stands for *distance 2.*

4. Press Timing Mode once more. (This bypasses distance 2; method 1 doesn't use it.) The screen displays "tod", which stands for*Time Over Distance*.

You have now established your vehicle as one reference point, and the point you selected down the road as the other reference. To measure speed, squeeze and release the trigger when the target vehicle passes one reference point; squeeze and release again when the vehicle passes the other reference point. The instrument calculates the speed and displays it on the screen.

Using Method 2

In method 2, you determine the distance between two remote points and clock vehicles as they travel that distance. If you are stationed on an overpass, for example, you can shoot to a sign up the road, acquiring its distance. Then shoot to a utility pole even farther up the road, acquiring *its* distance. The Marksman uses the two measurements to calculate a distance between the sign and the utility pole. You can then drive to any convenient viewpoint to clock vehicles as they pass between the utility pole and the sign.

Method 2 requires the following procedure:

1. Press the Timing Mode button on the back panel, and keep the button depressed for 0.5 seconds. The screen displays "d1", which stands for *distance 1.*

2. Sight on your first chosen reference point down the road, and squeeze and release the trigger. The screen displays a number, which is the distance to that point.

3. Press the Timing Mode button again. The screen displays "d2", which stands for *distance 2.*

4. Sight on your second chosen reference point down the road and squeeze the trigger. The screen displays a number, which is the distance to *that* point.

5. Press Timing Mode once more. The screen displays a number. That number is the distance between the first point and the second.

6. Press Timing Mode yet again. The screen displays "tod", which stands for *time over distance*.

You have now established your two reference points. To measure speed, station yourself at any position convenient for observing both reference points. Squeeze and release the trigger when the target vehicle passes one reference point; squeeze and release again when the vehicle passes the other reference point. The instrument calculates the speed and displays it on the screen.

Using Method 3

Method 3 allows you to manually enter a specific distance over which to measure the elapsed time. To do that, you use the timing mode "edit" function. The procedure is as follows:

1. Determine the actual on-road distance between the two reference points you will be using for enforcement.

2. Press the Timing Mode button and keep it depressed for 2.5 seconds. The display reads "Ed 2".

3. Press Timing Mode again to display the edit screen. The first digit of the number is flashing, indicating that the instrument is ready for you to edit that digit.

4. Press Speed/Range to advance the digit from 0 to 9, then press Test Mode to select the next digit. Go through the entire number in that fashion, selecting each digit in turn and resetting its value.

5. After you have reset the last digit, press Timing Mode again. The display flashes so you know the distance measurement you have entered.

6. Press Timing Mode yet again. The screen displays "tod".

You are now ready to proceed with speed measurements. Station yourself at any position convenient for observing both reference points. Squeeze and release the trigger when the target vehicle passes the first point; squeeze and release again when it passes the second. The instrument calculates the speed and displays it on the back panel screen.

Notes on Using Timing Mode

- Timing mode determines the average speed of a vehicle over a measured distance; it does not capture peak speed.

- The time between trigger pulls must be a minimum of 1 second, and may be a maximum of 99.99 seconds.

- A reference point can be any visually detectable and stationary mark on or near the roadway. A flat surface, such as a road sign, provides the greatest reflection of the laser beam and the longest range between reference points.

- It's important that you use the same part of the vehicle to start and stop the clock. If you start the clock when the headlights hit the first reference point, for example, stop the clock when the headlights hit the second point. In that way, your response time squeezing the trigger assures a consistent measurement.

- When you start the clock, the instrument begins to tick so you know the clock is running. The ticking noise continues until you squeeze the trigger to stop the clock.

- Once the speed is displayed, you can display the elapsed time— the time it took the vehicle to travel the distance— by pressing the Timing Mode button. Press Timing Mode again to toggle back to the speed display.

- Once timing mode is activated ("tod" is displaying on the screen), you may continually clock vehicles between the chosen reference points. The distance originally determined is used to calculate the speed of each vehicle.

- To set up for a different pair of reference points, exit timing mode by pressing one of the other mode buttons. Then re-enter timing mode and set up the new reference points.

PART 3: TESTS, CHECKS AND ADJUSTMENTS

Scope Alignment

The most common cause of field problems is a mis-aligned sighting scope. Reported symptoms for this 'fault' include: "short maximum range", "erroneous distance readings", "erroneous speed readings", "excessive error messages", or "no target acquisition". Scope alignment is set at the factory, and should remain set unless the instrument receives a heavy blow. Because verification of proper alignment is critical to instrument operation, a test has been incorporated into the instrument to verify that the instrument's light beam is hitting the sighted target.

Scope Alignment Test

This test ensures the accuracy of the Marksman's targeting mechanics, and should be performed periodically.

1. Put the instrument in test tone mode. Press and quickly release the Test Mode button on the back panel of the instrument. The display reads "tt", which stands for *test tone*. When test tone mode is active, pressing the trigger generates an audible tone. The tone's pitch is related to the strength of the laser pulse returned to the instrument: a high tone indicates a strong return, a low tone indicates a weak one.

2. Select a target. Choose a prominent target with definitive horizontal and vertical edges. The target's reflective qualities and distance from you should be such that you can clearly hear a change in the pitch of the test tone when you pan the instrument over the edges of the target. (A telephone pole is an excellent choice.) Make sure there is nothing behind the target the instrument might detect, so you know without doubt that any change in pitch is due strictly to the target.

3. Scan the target. Press and hold the trigger while panning the instrument across the target. The tone changes pitch when the instrument acquires the target. The highest pitch—the "on target" tone—should occur when the scope's red aiming dot is centered on the target.

Scan the target both horizontally and vertically, making certain the pitch decreases evenly off each side of the target. If there is any discrepancy between the "on-target" tone and the position of the red aiming dot, perform the following realignment procedure.

Realignment Procedure:

1. Steady the instrument on a solid base. Rest the instrument against a solid support that will help keep the aiming dot steady on the target.

2. Expose the adjustment screws. Remove the turret caps from the elevation and windage adjustment screws (Red-dot scope) or remove the two cover screws that angle out of either side of the scope body (Speedscope).

3. Put the instrument in test tone mode. Press, and quickly release, the Test Mode button on the instrument's back panel. The display should read "tt".

4. Select a target. The target should be at least 700 feet (200 m) away. It should be a prominent target with definitive horizontal and vertical edges that will cause a clearly perceivable change in the pitch of the test tone. (A telephone pole is an excellent choice.) Make certain there are no background objects that the instrument might detect.

5. Locate the target. Press and hold the trigger while panning the instrument across the target. When the tone achieves its highest pitch, the laser light beam is hitting the target.

6. Adjust the scope. Adjust the alignment screws to make the red aiming dot converge with the center of the target.

   - If you have a Red-dot scope, use a flathead screwdriver or coin to adjust the elevation and windage screws. Those screws move the aiming dot along the horizontal and vertical axes of the scope's field of view.

   - If you have a Speedscope, use the supplied Allen wrench to adjust the alignment set screws. Those set screws move the aiming dot along the diagonals of the field of view.

7. Check the alignment. Use the test procedure, above, to double check the alignment. If the instrument doesn't pass, repeat the alignment procedure.

8. Secure the instrument. When the instrument passes the alignment test, replace the turret caps or cover screws.

Scope Filter

Both the Red-dot scope and the Speedscope have polarizing filters that allow you to adjust the brightness and contrast of the scope view. The filter's adjustment mechanism is the ring on the front of the scope. When lighting conditions are extremely bright, for example, turn the ring to darken the scope's view. When lighting conditions are poor, adjust the filter ring to admit more light. At night, adjust the scope to soften the view and eliminate headlight glare. This gives the operator maximum versatility during extreme light conditions.

Note: THE LASER SHOULD NEVER BE AIMED DIRECTLY INTO THE SUN. Aiming the laser into the sun could melt the laser diode and injure the operator's eyesight.

The Red-dot Scope

The Red-dot scope is a zero magnification scope with a internal red aiming dot.

The Speedscope

The optional Speedscope greatly enhances the use of the Marksman, as follows:

- The Speedscope also has an internal red aiming dot, but also provides an in-scope display of speed and range. The display remains in sight in the scope for two seconds and then disappears. The reading remains in the main display until you take another reading.
- The Speedscope provides 2x magnification, which enhances long range targeting while providing a field of view comparable to the red-dot scope.

Display Brightness Control

You control the brightness of the back panel display with the Display Intensity knob. Unless your instrument has a Speedscope with the digital brightness control option, that same knob controls the brightness of the in-scope display.

The digital brightness controls the brightness of the Speedscope's in-scope display. Access the option by pressing the Timing Mode button and releasing it immediately. The display reads "br" followed by a number. That number represents the in-scope display brightness setting. There are 41 settings numbered 0 to 40, with 40 being the brightest. Use the Speed/Range button to increase the setting, Test Mode to decrease it. Press Timing Mode to return the instrument to normal operation.

Calibration Verification

The Marksman Laser Speed Detection System calculates speed by measuring the actual distance that a target has traveled over a known period of time. Therefore, unlike radar instruments, the accuracy of the speed measurement does not depend on the absolute frequency of the output signal. Speed accuracy is determined by the instrument's ability to correctly measure the time-of-flight of an individual laser pulse, and its ability to transmit subsequent pulses at precise time intervals. The speed calculations are referred to a crystal controlled time base which is guaranteed to have less than 100 parts per million (PPM) error over the full operating temperature of the instrument. Therefore, additional calibration is not necessary, but if verification of calibration is desired, the following steps can be followed to verify proper calibration of the instrument's range and timing accuracy. These two functions are the key elements used to calculate a speed measurement and can be verified by two different procedures: the fixed distance / zero velocity test and the delta distance test.

Fixed Distance / Zero Velocity Test

In a convenient location establish a permanent known distance between two stationary points. For uniformity the distance used should be 175 feet. If space is not available, this distance is not a absolute requirement. However, the distance between the target and the shooting mark must be a multiple of one foot: a fraction will not do. To ensure the accuracy of the fixed distance, use a metal tape to measure your test site. The target should be a sign, pole, wall or other permanent structure. On the target, paint a bull's-eye or mark to aim at. Measure 175 feet from the target and mark the designated point with an X, painted on the pavement. This painted X is where the laser operator will always stand to test for verification of calibration. The orientation of the target surface should be perpendicular to the laser beam. To verify calibration, a horizontal distance should be used. A slope distance, depending on the angle, will create a longer distance. A distance measured to the base of a 30-foot light pole of 175 feet is a horizontal measurement. The distance measured from the same point to the top of the 30-foot light pole is a slope measurement, and would be 2.5 feet longer than the ground or horizontal measurement.

Check laser accuracy by having the operator stand on the painted X and aim at the target. Pull the trigger and acquire the target. A 0 miles per hour speed measurement should be displayed. Pressing the "Speed/Range" button will switch to the range mode and will display the correct distance, plus or minus 1 foot. There are two causes of the plus or minus one-foot result. Holding the instrument at different locations, either in front of, or behind, the painted X and by the rounding of the displayed ranges. If a precise measurement is needed, carefully position the instrument over the painted X.

Verifying the ranging and timing accuracy of the instrument with the above test, checks the two elements used to measure velocity. A 0 miles per hour speed measurement shows verification of instrument timing accuracy. A 0 mile per hour reading of a stationary target is identical in nature to an accurate speed reading of a moving vehicle at all speeds. Therefore, calibration verification is complete.

Delta Distance Velocity Check

The delta distance test requires two targets. For uniformity, the first target should be 150 feet from the shooting mark, and the second should be 175 feet from the mark. To ensure that the distances are accurate, use a metal tape to measure them. (If there is insufficient space available, those specific distances are not crucial. However, the distance between the two targets and the distances from the targets to the shooting mark must be multiples of 1 foot; a fraction of a foot will not do.) One way to get the elements positioned is to first install the farther target. Then measure 175 ft to the shooting point and mark the spot. Finally, measure from the shooting mark 150 ft to the second target. Mark that spot and install that target.

The test procedure is as follows:

1. Stand on the shooting mark.
2. Press the Test Mode button on the Marksman's back panel and keep it depressed until "8.8.8.8." displays.
3. Release the button. The screen displays "t d1", which stands for *test distance 1.*
4. Shoot to the near target. The screen displays the distance to that target, plus or minus one foot. (If the near target is 150 feet away, the display should read 149, 150, or 151.)
5. Press Test Mode again. The screen displays "t d2", which stands for *test distance 2.*
6. Shoot to the far target. The screen should display the distance to the far target, plus or minus one foot. (If the far target is 175 feet away, the display should read 174, 175, or 176.)

   Note: The manner in which you stand and the manner in which you hold the instrument both affect the measurements. For exact readings, carefully hold the instrument so it is directly over the middle of the X.

7. Press Test Mode again. A number begins flashing on the screen.

The flashing number represents a simulated speed based on the distance between the two targets. The speed simulated reflects the distance traveled by a vehicle over the one-third of a second measurement time of the instrument—about six inches for each mile-per-hour. If the first target is 150 feet away, for example, and the second is 175 feet away, the two targets are 25 feet apart, and the speed reading should be -50. The expected accuracy is ± 1, so a reading of -49 or -51 is also acceptable. If the targets are shot in reverse order, the number flashing in the display is the same, but is unsigned.

This test includes a check of the instrument's ranging accuracy and its timing accuracy, which are the two elements that calculate velocity. When the instrument is measuring distances correctly and the time clock in the instrument is functioning properly, then the instrument will accurately measure velocity.

Moving Confidence Check

If additional verification is desired, the instrument can be checked against a calibrated speedometer by shooting a stationary target from a moving vehicle and comparing the speedometer of the vehicle against the Marksman reading. The stationary target is subject to the normal cosine error limitations and must be within a 10-degree angle off the road.

Note: For obvious safety reasons, this method is not recommended unless a passenger is available to operate the laser.

Reference Frequency Test

The final calibration verification test that can be performed is the reference frequency test, which measures the actual timing accuracy of the Marksman with a frequency counter. This procedure was developed to comply with the testing requirements of the National Institute of Standards and Technology (NIST - formerly the National Bureau of Standards) of the United States Government. Depending on individual state regulations, you may be required to conduct this test using a frequency counter that has had a NIST traceable calibration. Refer to the section on service tools for required frequency counter specifications.

1. Remove the four Phillips, flat head screws from the left side cover (looking from the rear of the instrument), and remove the side cover itself.

2. On the backside of the rear-most pc board (the display board); at the lower exposed corner is a four pin, right angle connector header. Plug the test cable connector into the header, with the white label on the connector facing towards the rear of the instrument. Plug the BNC end of the test cable into the high impedance input of the frequency counter, and set the mode of the counter to measure period.

3. Turn on the Marksman. After the initialization and segment tests have been completed, press the "Test Mode" button and hold down for at least six seconds. Upon releasing the button, a verification code will appear on the display and the output test signal will activate. If the "Test Mode" button is released too soon, "t d1" will show on the display. If this occurs, press and release one of the other two buttons to exit from the test distance mode, then repeat the "Test Mode" button procedure. You may measure either the frequency or the period of the output signal. It may be more practical to measure the period in order to obtain the proper measurement resolution. The output from the gun will be a 12.500 Hz RS232 level signal (period = 80.000 milliseconds +\- 100 ppm).

4. After the test signal has been verified, turn off the Marksman, remove the test cable and replace the side cover (note the orientation of the silkscreen graphics). Replace the four Phillips, flat head screws, tightening each to a torque of approximately 10 inch/pounds.

Note: The above procedure requires a test cable made by Laser Technology, Inc., part number 7051057.

Standard Maintenance

The Marksman is self-calibrating. There are no moving parts or radio frequencies to go out of alignment. Standard power surge protection eliminates any concern over use of the vehicle's 12 volt source. With the laser optics inset and interconnecting aluminum extrusion, the Marksman can withstand the roughest treatment and most extreme environments. These features provide operators with virtually no user maintenance.

Proper care and maintenance of the Marksman is as follows:

1. The type 3AG quick blow 1.6 amp fuse is easily replaceable in the power cord connector.

2. When the instrument gets wet during use, towel off any excess moisture and air dry the instrument at room temperature before returning to a closed case.

3. It is recommended that the instrument be cleaned before it is stored in the case.

4. Be extremely careful when cleaning the front LASER lens.

   The lenses should be moistened with a lens cleaning solution or by providing condensation by breathing on the lens and wiping with a soft cloth or lens tissue. If the lens becomes excessively scratched, the range of the instrument will be reduced. The lenses in the scope should be treated in a similar fashion. Damage to the lens surface will make it difficult to see your intended target.

5. The Marksman should be stored in a dry room that remains at a relatively constant temperature.

PART 4: SYSTEM ELECTRICAL HARDWARE

Marksman Hardware Description

The electrical hardware in the Marksman consists of five major printed circuit boards (PCB's), the transmit module, the receive module, and associated wiring interconnects. Each of the above mentioned PCB's performs a specific function in the operation of the Marksman. During a single speed measurement cycle, a complex interaction of data transfer between these individual circuits occurs. The boards are named for their primary function and are as follows: CPU, Core, Reference, Power Supply, and Display.

Attention: **Each Marksman is calibrated and aligned for a specific set of circuit boards. Swapping boards between units will invalidate the calibration of all instruments involved. The exception to this rule is the display board, which may be replaced without re-calibrating the instrument. Also note that the frame of the Marksman is connected to the system electrical ground. Grounding integrity is an important characteristic for proper instrument operation.**

CPU Board

The CPU board in the Marksman is essentially the supervisor or controller of the system. This board contains the micro-controller integrated circuit (IC), which executes the firmware program that has been "burned" into its on-board memory (component U1 on the CPU layout). The architecture of the CPU board dictates the manner in which data is transferred throughout the system. Since some components require a serial interface, while others a parallel "buss" interface, the CPU circuit has been designed to accommodate both. Serial communication is initiated by first selecting a device using one of the individual serial enable lines, then data is transferred on either the serial-out or serial-in line (depending on the direction of the data flow). Serial data transfers are synchronized with the serial-clock signal. Parallel devices are selected via the parallel enable lines, and parallel data is transferred on the 8-bit data buss. Besides the serial and parallel byte manipulation, there are also many single line control, and/or flag bits. These individual signal paths are used to monitor or control various functions throughout the system (note that extensive address decoding is required to avoid any data contention problems).

In addition to the data decoding components, the CPU board also contains additional memory IC's as well as some hardware interrupt circuitry. U8 is a volatile RAM used as a "scratchpad" by the microcontroller for on-the-fly calculations and temporary data storage. U9 is an erasable / programmable ROM used to store semi-permanent system parameters. Several other components are used to "condition" various interrupts lines feeding the microcontroller. These interrupt lines signal high-priority events that must be monitored, such as a low-battery condition or a trigger pull.

Note: The only socketed components in the Marksman are U1, U8, and U9 listed above. If an instrument receives an unusually heavy blow, it is possible for these components to become dislodged from their sockets, causing a system failure. In the event this occurs, these components can be re-inserted in their sockets using the CPU board layout as a guide (note pin 1 orientation of each IC). **DO NOT SWAP U1, U8, OR U9 BETWEEN UNITS AS THIS WILL INVALIDATE THE CALIBRATION OF EACH INSTRUMENT INVOLVED.**

Core Board

The Core circuit board contains the timing logic that allows the Marksman to precisely measure ranges and calculate speeds, thus it is the "core" of the entire system. In basic terms, the Core circuit measures the time-of - flight of the laser pulse from the moment it leaves the instrument to when it returns from the target. The timing logic is driven by a precise quartz-crystal timebase that is specified to an accuracy of +/- 100 ppm over the operating temperature range of the instrument.

At the start of a measurement cycle, the laser 'fire' signal is sent from the CPU to the Core, where it is synchronized with the timing logic and output to the transmit module. When the laser diode fires, the reference pulse is generated and the time-of-flight counters are started. These counters continue until the return pulse is detected. Three separate signals are output from the receive module, allowing the logic to analyze the characteristics of the receive pulse itself. This analysis helps the Marksman to throw out any measurement readings that may be erroneous due to poor quality data. The fire, reference, and receive signals are connected to the backside of the Core pcb using shielded, coaxial wires. Be sure to attach these wires in the correct order (see diagram), making certain that each is properly locked into position.

Reference Board

The primary function of the Reference board is to generate the reference signal needed to fire the time-of-flight counters. A photosensitive detector mounted on the backside of the board is used to pick-off a small portion of the transmit beam. The signal created by this detector is amplified, then sent to the Core board via coax line. This configuration insures that the counters are started at the instant the light pulse leaves the instrument, eliminating any timing variables introduced by the transmit electronics. In addition to the reference pulse section, several other system functions are resident on the Reference board. A temperature sensing circuit is used to obtain a current temperature reading of the instrument. Temperature information is necessary to compensate for changes in component characteristics. Several analog control voltages are generated through a digital-to-analog converter on the Reference board. These control signals are needed on the Power Supply board and the Receive module. Speedscope control is also generated on the Reference board. The circuitry, located on the lower section of the Reference board, controls the Speedscope's digital brightness and supplies the data that is displayed in the scope. There is also a jumper within this circuitry that is connected to the pin marked 'D' (for digital control). If the Marksman is supplied with a Red-dot scope, then this circuitry is not needed and the Reference board may not even contain these components. The Reference board has also been used as a general interconnect between the CPU board and other components including the power supply, the Receive module, the Speedscope, and the trigger switch.

Power Supply Board

The Marksman Power Supply board converts the 12 volt (nominal) input voltage to the various supply voltages required by the system components. A total of nine different voltage "rails" are generated by the Power Supply board. These rails include: **+ 5v logic, - 5v logic, + 5v analog, - 5v analog, + 6.25v, TX voltage 1, TX voltage 2, RX voltage, and the reference detector bias.** Each of the separate supply voltages has been designed for a specific function with appropriate capabilities. The +/- 5v logic rails supply power to a majority of the logic IC's in the system, having a medium amount of current drive and noise isolation. The +/- 5v analog rails power the more noise sensitive components in the Marksman. These rails have low current drive capability , with a high amount of noise suppression and isolation. The +6.25v supply is primarily used to drive the high current circuits, such as the LED display and the audio beeper. The TX and RX voltage supplies have been designed to optimally drive the appropriate circuitry in the TX and RX modules. The reference detector bias supplies the detector circuit on the Reference board with the proper bias voltage.

Attention: **Use caution when testing any voltages on the Power Supply board while the instrument is turned on. The upper section of the Power Supply board outputs high voltage levels that are supplied to the Transmit and**

Receive modules. Proceed carefully when testing in the high voltage area, keeping in mind that the frame of the instrument is connected to system ground.

Incoming power from the handle connects to the Power Supply, where it passes through noise filtering and spike suppression circuitry. The supply voltage is then routed to the power switch connector, through the switch ribbon cable, to the switch itself on the rear plate. When the switch is turned on, the filtered power is returned back down the switch ribbon to the Power Supply, bringing up the supply for operation. The incoming power is monitored for two separate low voltage trip points. The first level, approximately 9.75v at the power cord connector, initiates a software interrupt which displays a flashing "L ob" message. The second trip level, approximately 8.75v at the connector, forces a hardware reset condition which shuts down the microprocessor on the CPU board. It should be noted that there are hysteresis effects associated with the low voltage trip points. The exact trip voltage varies depending on if the point is approached from a higher voltage level or a lower voltage level.

A diagram showing recommended test points to measure the key Power Supply voltage is included in Appendix A, along with a list of the typical voltage ranges for each supply rail. Monitoring the various output voltages may prove useful in tracking down a particular fault. The Power Supply is treated with a conformal coating which will need to be penetrated to make a good contact to any test point (do not damage the coating unless necessary). The main ribbon connector at the Power Supply can be disconnected to measure any loading effects caused by the Core, CPU, or Display boards. **Make sure the Marksman is turned off before disconnecting any system cables.** All of the Power Supply output rails are protected against momentary shorts to ground.

Display Board

The display board is basically the input / output section of the Marksman. The LED display, the audio beeper, the function keys, and the serial input/output driver are all resident on the Display board (see Diagram schematic in Appendix A). The display controller, U1, receives serial display data from the CPU on pin 22. The output driver signals, OB1 through OB32, connect to the individual segment pins on the LED displays, M1 and M2. The double digit LED displays are common-anode types; thus a low level voltage at a segment pin will turn on that segment. Voltage levels at the anode or cathode of an individual digit will vary depending on the number of segments lit. The typical voltage drop for a single segment is 1.5 volts, with a forward current of 10 to 15 milliamps, depending on the brightness setting. The display brightness is controlled by pin 19 of U1, which is driven by the circuit consisting of U5, Q1, and the 10K ohm panel mount potentiometer. The brightness circuit is designed to deliver an input current of 0 to 0.75 milliamps to the brightness control pin. The Blanking line is an active low signal that allows the CPU to blank the display by forcing the brightness current to zero. The sighting indicator in the Red-dot scope is also driven by U1 (some early instruments had scopes with external batteries), having the same intensity control as the LED display. If the connector is removed from the Display board, make sure it is reconnected with the proper orientation, having the red wire from the Red-dot scope going to the positive terminal on the scope drive connector.

Note: The Speedscope has separate digital control as explained in the Reference board section.

The tone generating beeper on the rear plate is driven by the timer circuit of U4 and Q2. The 555 timer is used in a monostable configuration, with the trigger input controlled by the tone line. By varying the time between pulses on the tone signal, the CPU can control the pitch of the beeper output. The function keys, S1, S2, and S3 are scanned and read by IC U2. When a key is pressed, U2 logs the key and activated the dav- line which is detected by the CPU (a dash following the signal name indicates it is active low, i.e. Dav "not"). Upon receiving the dav- request, the CPU activates the output enable of U2 (pin 14) and reads the keypress code on buss lines D0-D4. U2 has a built in hardware debounce circuit, with debounce time determined by capacitor C15. Serial I/O to and from the Marksman is level-translated by component U3. Having both receivers and drivers, U3 converts the TTL logic levels from the CPU to RS232 levels (approximately + / - 9 volts) for communications with external devices. Capacitors C16-C19 are used for the dual charge pump circuits in U3, allowing it to generate + / - 9 volts from the single + 5 volt supply.

Transmit and Receive Modules

The Transmit and Receive modules are separate, enclosed housings which contain the electronics that allow the Marksman to send and receive laser light pulses. Both modules are precisely aligned and rigidly mounted to the main optics tubes, with the receive unit having an additional secondary optics tube. The aluminum module enclosures are designed for noise screening, each being grounded to the instrument frame. This shielding helps to keep electrical noise from entering the sensitive receive circuitry, and attenuates any noise generated by the high-speed transmit electronics. To further maximize the system noise immunity, sensitive signal lines to and from the modules are connected using shielded coax cables. Each module also has a group of multi-colored wires entering it, which supplies power from the Power Supply board.

Caution: **Several of the power lines feeding the Transmit and Receive modules are at high voltage levels. Turn the instrument off before connecting or disconnecting the module power harness at the Power Supply board. The yellow, purple, and brown wires entering the modules carry the high voltage signals.**

The Transmit module contains the laser diode and the associated circuitry required to generate the short duration laser light pulses. The signal that controls the actual firing of the laser is sent from the Core board through the coax cable that enters the top of the module. The Transmit module is optically aligned along the axis, which passes through the center of the optics tube. This positional alignment is secured with the clamp ring on the end of the optics tube.

As stated above, the Receive module has sensitive electronics that enable the Marksman to distinguish the short duration laser pulse from the background noise. The heart of the receiver is a photosensitive diode with very low intrinsic noise characteristics. The auxiliary optics tube attached to the Receive module contains a narrow bandwidth optical filter that further assists in eliminating stray optical energy. The receiver has three separate coax cables that connect to the back of the Core board (see diagram in Appendix A for proper orientation), allowing the hardware to obtain a comprehensive analysis of the return pulse quality. The Receive module is precisely aligned in three different axes in order to obtain the strongest possible return pulse. To insure that the receiver does not lose its positional alignment, four screws fasten it to the auxiliary optics tube, which in-turn is secured to the main optics tube with a clamp ring.

Attention: DO NOT tamper with the alignment of the Transmit and Receive modules. If either module requires realignment, the instrument must be sent to Laser Technology, Inc. Special fixtures and procedures are necessary to properly align the modules. Please note, that if for any reason the Transmit and / or Receive module in the Marksman is knocked out of alignment, SPEED AND DISTANCE MEASUREMENT ACCURACY WILL NOT BE COMPROMISED. A mis-aligned instrument will suffer only a loss in maximum range capability.

Wiring Interconnects

The hardware components in the Marksman are linked together with a complex network of interconnects. The block diagram in Appendix A shows a simplified version of the instrument cabling (note the key showing the various signal types). Following below is a list of the system connections with a description of the signals carried in each.

Main Ribbon Cable

Carries power from the Power Supply to the Core, CPU and Display. Carries the data buss and control signals from the CPU to the Core and Display. Also carries serial data lines from the CPU to the Display.

Reference to CPU Ribbon Cable

Carries serial interface and miscellaneous control lines from the CPU, which go to the Power Supply, Receive module, and trigger switch from the Reference board.

Reference to Power Supply Ribbon Cable

Carries the Power Supply analog control voltages from the digital-to-analog converter on the Reference. Supplies power for the Reference board circuitry from the Power Supply.

Receive Module to Reference Ribbon Cable

Has control lines from the CPU, via the reference board, to the Receive module. Carries the Receive module analog control voltages from the digital-to-analog converter on the Reference board. Also carries the signal from the temperature sensor in the receive module, to the Reference board for processing.

Handle / Trigger to Reference Ribbon Cable

Carries the trigger switch signal from the handle to the CPU via the Reference board.

Handle / Power to Power Supply Ribbon Cable

Carries incoming power from the power cable to the Power Supply board.

Power Supply to Power Switch Ribbon Cable

Carries filtered incoming power from the Power Supply to the On/Off switch. Returns the incoming power to the Power Supply when the On/Off switch is in the "On" position.

Serial Port Operation

The Marksman can be equipped with a serial port connector on the rear plate. This port is used to download speed and distance data from the instrument to a computer. Measurement data can be used for various applications such as statistical analysis or accident reconstruction.

The serial port has a five-wire interface, consisting of the following signals: ground (GND), transmit data (TX), receive data (RX), request to send (RTS), and clear to send (CTS). Handshaking with the RTS and CTS lines is currently not implemented, therefore, a typical laser-to-computer interface will require only three of the serial signals; GND, TX, and RX. Voltage levels at the serial port follow the standard RS232 format, with mark and space voltages of approximately +/- 9 volts respectively. The serial bit stream is configured to follow the following format: **9600 baud, 8 data bits, 1 stop bit, no parity.**

Speed and range data is transmitted at the end of each laser measurement cycle, but only when the instrument is in the "Speed/Range" mode of operation. A single transmission is initiated by each trigger pull. No handshaking or data delay is available through the serial interface. Data output is in the following fixed field formats:

Case 1: A valid speed and distance measurement is made.(The units depend on if the gun is programmed for English or Metric measurements)

Data output: **SXXX,YYYY[.Y]CrLf**

S	=	Speed sign: "-" for negative departing speed, no sign for positive approaching speed.
XXX	=	Speed: 000 to 199 in mph or kph units.
,	=	Speed and Range field separator.
YYYY	=	Range: Unsigned 0000 to 9999 in whole feet (if in English mode).
YYYY.Y	=	Range: Unsigned 0000.0 to 9999.9 in tenths of meters (if in Metric mode).
CrLf	=	Each output is terminated with a carriage return and line feed.

Case 2: A measurement error occurs.

Data output: **EXXCrLf**

E	=	"E" character: designating error condition.
XX	=	A two digit error code (ie. 01) : The error codes are the same ones displayed for measurement errors on the LED display (refer to the section on error trapping).
CrLf	=	Each output is terminated with a carriage return and line feed.

Examples:

000,0050CrLf	=	0 mph @ 50 feet.
075,1230CrLf	=	75 mph approaching @ 1230 feet.
-125,0900CrLf	=	125 mph departing @ 900 feet.
058,856.5CrLf	=	58 kph approaching @ 865.5 meters.
E01CrLf	=	Error code 01.

Note: No data should be echoed or transmitted to the Marksman. Serial input is used for factory setup access only. Input data may disrupt serial 0operation and/or return data and error codes not described in the above format.

PART 5: SYSTEM MECHANICS

Marksman Mechanical Assembly/Disassembly

The Marksman has been mechanically designed to withstand the roughest conditions of field use. At the same time, the instrument is configured for ease in manufacturing and service. The unit consists of a number of subassemblies and modules, allowing segmented assembly/disassembly procedures and troubleshooting techniques.

The sections that follow are laid out in step-by-step instructions for each procedure. Please note that some procedures require the completion of previous sections as a prelude. It is recommended to read through this entire part before attempting any repairs. A list of required service tools is included at the end of this section.

⚠ Caution: **The PC boards in the Marksman are subject to static damage. Board removal should be done at a static proof station. Place removed boards in static bags while awaiting reinstallation.**

Attention: **It is recommended that assembly/disassembly be conducted on a soft, non-abrasive surface to avoid scratching the optics and metalwork of the instrument.**

General Rear Plate Repairs

Rear Plate Removal

1. Remove both side covers using a #2 Phillips screwdriver.
2. Using a 3/32" Allen wrench, loosen the cap screws securing the Power Supply board and the Reference Board.
3. Using a flat blade screw driver, carefully disconnect the main ribbon cable from the Display board using a gentle prying force on one side then the other until the cable connector is clear of the Display board header. Bend the cable out of the way.
4. Place the unit lens-side down on a non-abrasive surface. Remove the socket-head cap screws from the rear plate by using a 7/64" Allen wrench. Once the cap screws and lock washers are removed, the rear plate cleats can also be removed.
5. The rear plate has a natural tight fit to the top and bottom extrusions.

6. By carefully pulling the extrusions apart from each other, the rear plate should become loose enough to remove. While lifting the rear plate from the unit, be mindful of the wiring still connected to the Display board. While holding the rear plate in one hand, the Power Switch ribbon cable and the scope drive wires (red and black) can be disconnected with the other hand. The scope drive wiring that connects to the rear plate is for the Red-dot scope only, while the Speedscope wiring attaches to the Reference board only.

*** From this point all specific rear plate repairs can be performed.**

<u>Rear Plate Installation</u>

1. In the grooves of the top and bottom extrusions, where the side covers seat, can be found the white gasket material that serves to help seal the system from the elements. Notice that the gasket material is hollow. By using a pointed object, such as a pencil or toothpick, put the point of the object in the end of the gasket and pull about two inches of the gasket out of the groove. Repeat for all four gaskets.

2. Position the rear plate near enough to where it attaches to the extrusions to allow the cables to be reconnected. If the instrument has a Red-dot scope, then first connect the scope drive wires (red and black) to the two pin header making sure the red scope drive wire is connected to the positive terminal (see Display board diagram in Appendix A). Second, connect the power switch ribbon cable to the power switches printed circuit (p.c.) board, being sure that the connector pins and holes are properly aligned and that the ribbon cable exits from the bottom of the p.c. board.

   Note: Sometimes it is necessary to pull the power switch ribbon cable up even with the extrusion in order to have enough cable to work with in reconnecting it.

3. Center the rear plate over the top and bottom extrusions. Angle the rear plate into position by seating the bottom edge first. By pushing the rear plate against the bottom extrusion and gently pulling the top extrusion in the opposite direction, the top of the rear plate should pop into place. While doing this step, be sure the main ribbon cable connector is out of the way of the Display board header coming into position. Notice the white gasket material that encircles the rear plate. After the rear plate is seated, make sure the gasket isn't pinched or trying to roll out of its groove. If it is, try gently pulling the extrusion away from the gasket that is pinched. Then allow the extrusion to relax back into position.

4. Put the rear plate cleats in the top and bottom extrusions making sure the holes in the cleats are aligned with the holes in the rear plate.

5. Put one lock washer and cap screw in each hole in the rear plate. Using a 7/64" Allen wrench, tighten the cap screws until they are snug. If the Red-dot scope has a rubber eye piece, it must be removed during this step. Compress the top and bottom extrusions against the rear plate with a bar clamp. The bar clamp should be positioned as close to the rear ends of the extrusions as possible. Set the torque driver for 20 inch/pounds and torque the rear plate cap screws. Remove the bar clamp and replace the scope's rubber eyepiece.

6. Carefully reconnect the main ribbon cable to the Display board header, being sure the connector pins and holes are properly aligned. Special care is necessary since the pins can be easily bent.

7. Before proceeding, plug the unit into a power source and turn it on to verify proper re-connection. If the instrument doesn't turn on, check the main ribbon cable and power switch ribbon cable for improper alignment or bent pins.

8. Lay the unit on its left side (Power Supply board side up). Using a flat blade screw driver, gently push the gasket back down into their grooves, starting at the point where they are already seated in the groove and working back toward the rear plate.

9. Torque the cap screws securing the Power Supply board to 8 inch/pounds using a torque driver with a 3/32" bit.

10. Repeat steps 8 and 9 for the Reference board side of the instrument.

11. Replace the side covers. Set the torque driver to 10 inch/pounds and use the #2 Phillips head bit to tighten the screws to the side covers.

Specific Rear Plate Repairs

The following procedures assume the Rear Plate has been removed.

Power Switch Replacement

Removal:

1. Using a 3/32" Allen wrench, remove the cap screws and lock washers from the Display board. This step allows the Display board enough movement to be out of the way of the procedure. No wire disconnection is necessary.

   Note: If the instrument has a serial port connector with a p.c. board interface, take care in sliding the display board out from under the metal grounding tab soldered to the serial connector pc board.

2. If the rotary knob is still in place on the power switch shaft, use a .050" Allen wrench to loosen the set screw and remove the knob.

3. Using a 3/8" socket or nut driver, remove the nut and lock washer that secures the power switch assembly to the rear plate. The power switch assembly can now be removed.

   Note: A flat rubber gasket is between the power switch and the rear plate. When the switch is removed, the gasket may stick to one surface or the other. Be sure this gasket is transferred to the new power switch if a new gasket is not supplied with the replacement.

Installation

1. Installing the power switch assembly is a reversal of the above steps.

Items to note:

- Make sure the power switch header is located near the bottom edge of the rear plate.

- Take care not to over tighten the power switch shaft nut.

Set the torque driver to 8 inch/pounds and use a 3/32" Allen bit to tighten the Display board cap screws. Align the rotary knob set screw with the flat side of the power switch shaft. Use a .050" Allen wrench to tighten the set screw. Do not over tighten.

<u>Display Potentiometer Replacement</u>

Removal

1. Un-solder the wires from the pins on the potentiometer. Remove the cap screws that secure the Display board using a 3/32" Allen wrench if the board is interfering with the procedure.

2. Using a .050" Allen wrench, loosen the set screw in the rotary knob and remove the knob from the shaft.

3. Remove the nut and lock washer that secure the potentiometer to the rear plate using a 5/16" deep socket or nut driver. Remove the potentiometer from the rear plate.

Installation

1. Installing the new potentiometer is a reversal of the above steps.

Items to note:

- Make sure the tabs on the potentiometer align with the holes in the rear plate.
- Do not over tighten the potentiometer shaft nut.
- Solder the wires to the pins of the potentiometer as near to the body as possible, taking care to trim the excess of the pins as short as possible.

If the Display board cap screws and washers were removed, replace them and tighten to 8 inch/pounds using a torque driver with a 3/32" Allen bit.

Display Board Component Replacement

Display board removal

1. Remove the cap screws and lock washers that secure the Display board to the rear plate. If the rear plate has a serial port connector with a p.c. board interface, be careful in removing the Display board out from under the metal grounding tab.

2. If there is a serial port on the rear plate, disconnect it from the Display board. If the port has a p.c. board interface, unplug the ribbon cable from the serial port header. If the serial port is soldered in point-to-point, un-solder the wires from the display board.

3. Un-solder the brightness control potentiometer wires from the display board.

4. Un-solder the beeper drive wires from the Display board.

    - From this point all Display board component replacements can be performed.

Display Board Installation

1. Re-connection of the Display board is a reversal of the above steps.

Items to note:

- Pay careful attention to wire orientation. When securing the Display board to the rear plate, make sure no wires become trapped in areas where the board and rear plate touch or come close to each other.

- Refer to the drawings in Appendix A for wiring diagrams of rear plate-to-display board connections.

- When tightening the Display board cap screws, set the torque driver to 8 inch/pounds and use a 3/32" Allen bit.

Handle Repairs

<u>Handle Grip Replacement</u>

1. With the unit lying on its left side, use a #2 Phillips head screwdriver to remove two of the screws holding the handle grips together (Re-assembly is a reversal of this step).

   - **Handle grip removal is the first step in all handle related repairs.**

2. Remove the two screws and metal stand-offs from the opposite handle grip and re-assembly the handle grips to the unit.

   Note: Whenever the screws from the handle grips are removed it is recommended to apply a small amount of 242 "Loctite" to the threads of the screws on the left side grip before tightening the stand-offs onto the grip.

The following repair procedures assume that handle grip removal has been completed.

Power Cord and/or Strain Relief Replacement

<u>Power Cord Removal</u>

Note: Step 4 has two different versions depending on if the instrument model is equipped with power cable quick-disconnects in the handle.

1. Lay the unit on its left side. Remove the right side cover screws using a #2 Phillips screw driver. Remove the side cover.

2. Using a 3/32" Allen wrench, remove the cap screws that secure the Power Supply board. Be careful not to drop the screws or the lock washers inside the instrument. If one should drop inside, it is imperative that it is removed since it could cause electrical damage (removal of the opposite side cover may be necessary).

3. By carefully lifting the Power Supply board by the edge that's nearest to the front of the unit, the ribbon cables connect to the underneath side of the board should become accessible. Disconnect the handle power ribbon cable from the Power Supply board (see diagram in Appendix A for connector identification).

4a FOR A CABLE WITHOUT QUICK-DISCONNECTS
The power cable feeds through the handle and into a hole in the bottom extrusion. By pulling the cable out of this hole with one hand and feeding the cable inside the unit down through the hole with the other hand, the ribbon cable end of the power cord can be manipulated out of the unit.

4b. FOR A CABLE WITH QUICK-DISCONNECTS
The quick-disconnect connectors can be pulled apart using a small channel lock pliers and a stubby needle noise pliers.

⚠ **Caution:** The connectors in the handle can suddenly separate. If care is not taken, a connector may get pulled off the end of a wire.

5. Place the instrument lens side down. Using a small channel lock pliers, squeeze the part of the strain relief that is inside the handle while using the free hand to grasp the power cable from the outside. Work the cord up and down, pulling it outward at the same time. It may be necessary to apply heavy pressure to the channel lock pliers. Once the strain relief is free of the handle, the cable can be removed.

Strain Relief Replacement

Option A - FOR A POWER CORD WITHOUT QUICK-DISCONNECTS.

1. After noting connector orientation, cut the ribbon cable as close to the ribbon connector as possible.

2. Slide the old strain relief off the cord and slide the new one on, small end first.

3. Paying attention to proper orientation, re-terminate the ribbon cable with a new connector as close as possible to the cable end.

Option B - FOR A POWER CORD WITH QUICK-DISCONNECTS

1. Cut the black and red wires as close to the quick-disconnect connectors as possible.

2. Slide the old strain relief off the cord and slide the new one on, small end first.

3. Strip the red and black wires back approximately 1/4 inch.

4. Re-terminate the cord with new quick-disconnects connectors, crimping the female connector on the red wire.

Note: In order to separate the inner conductors enough to re-terminate, it may be necessary to strip a small portion of the black outer insulation of the power cord.

Power Cord Installation

All replacements will be completed using the quick-disconnect type of power cord.

Steps 1 - 3 are for instruments being upgraded with a quick-disconnect power cord. These steps describe the routing of the ribbon section of the cable, from the Power Supply board to the handle.

Place the unit on its left side. Carefully feed the ribbon connector end of the power cord ribbon cable through the hole in the bottom extrusion at the base of the handle. Continue to feed the cable through the hole until it can reach its connector on the Power Supply board. Be sure that the pins and holes of the connector are properly aligned and that the ribbon cable exits from the bottom of the connector when it is attached to the Power Supply board header.

1. Using a 3/32" Allen wrench, secure the Power Supply board with its cap screws and lock washers. Note that there are two lengths of cap screws used on the Power Supply. The longer screws go in the holes in the bottom extrusion, through the Power Supply heat sink. Torque the cap screws to 8 inch/pounds using a 3/32" Allen bit.

2. Fasten the side cover(s) in place using a #2 Phillips screwdriver and torque the screws to 10 inch/pounds using the #2 Phillips bit.

3. Fasten the side cover(s) in place using a #2 Phillips screwdriver and torque the screws to 10 inch/pounds using the #2 Phillips bit.

Steps 4 and 5 describe the installation of the coiled portion of the power cord, from the handle to the external connector.

4. Place the instrument lens side down. Using the strain relief installation tool, crimp the strain relief on the power cord at approximately three inches from the end of the quick disconnects connectors (on the black outer insulation). Make sure that the free-moving side of the strain relief is toward the rear of the instrument. While maintaining the crimping pressure on the strain relief, feed the power cord connectors through the hole in the bottom of the handle. Continue to hold pressure on the strain relief while forcing it into the hole in the handle. A rocking motion on the strain relief helps to work it into place. After the strain relief is seated, pull on it from side to side to make sure it won't dislodge. If it does, then it wasn't properly seated and requires reinstallation.

5. Connect the coiled portion of the power cable to the ribbon portion inside the handle. The connectors are polarized such that hooking the wires together incorrectly is almost impossible. If the instrument fails to power-up normally following power cord replacement, check the connectors in the handle for proper polarization.

Trigger Switch Replacement and Adjustment

Trigger Switch Removal

1. After removing the handle grips, place the instrument lens side down and remove the screws and nuts that secure the trigger switch to the handle.

2. Place the unit on its right side. Disconnect the trigger ribbon cable from the Reference board header (see diagram in Appendix A).

3. Remove the cap screws and lock washers that secure the Reference board using a 3/32" Allen wrench. By moving the board just outside the unit, there should be sufficient access to the inside without further disassembly (if necessary, disconnect the reference coax from the Core board. See diagram in Appendix A for correct coax signal orientation).

4. Carefully feed the ribbon cable down through the hole in the bottom extrusion to the handle. It may be easier to maneuver the ribbon connector through the hole using a needle nose pliers or a screwdriver.

Trigger Switch Installation

1. Installing a new switch is a reversal of the above steps.

   Replace the Reference board cap screws and lock washers, torquing them to 8 inch/pounds with a 3/32" Allen bit.

Trigger Switch Adjustment

1. Center the red button on the trigger switch with the trigger plunger in the handle. The two surfaces should almost touch when there is no pressure applied to the external trigger button.

2. Using a 3/16" socket or nut driver, tighten the screws and nuts that secure the trigger switch. Make sure the switch doesn't shift too much while being tightened.

   Note: It may be easier to adjust the trigger switch by tightening the bottom screw slightly, then pivoting the switch into position. Tighten both screws after positioning is complete.

3. Verify adjustment by pulling the trigger. There should be an audible "click" each time the trigger is pulled.

   Note: It is recommended that a small amount of 242 "Loctite" be applied to the screws that secure the trigger switch. This can be done after the nuts are tightened onto the screws.

Power Filter Board Replacement

The following procedure is for instruments equipped with input power filtering.

Removal

1. Remove the handle grips to expose the power filter board.
2. Mark the positive side of the powers supply ribbon cable, then un-solder it from the filter board.
3. **Note:** See Appendix A for the handle filter board diagram.
4. Un-solder the power cord wires from the filter board.
5. Using a 3/32 inch Allen key, remove the four socket head screws and washers that mount the board to the handle. The filter board can now be removed from the instrument.

Installation

1. Installing the power filter board is a reversal of the above steps.

Items to note:

- When connecting the power cable wires to the filter board leave enough wire length on the negative wire to wrap around the handle grip spacer, which will end up just under the filter board.
- Make sure that the power supply ribbon cable is positioned so that it does not get caught in the trigger switch assembly.

Scope Replacement

Red-dot Scope Removal

1. Remove the side covers using a #2 Phillips screwdriver.
2. With the unit placed on its side, use a flat blade screwdriver to work the main ribbon cable connector off the Display board header. Repeat this process for the CPU, Core and Power Supply, thus removing the main ribbon cable from the instrument.
3. On the left side of the unit, disconnect the Reference to CPU ribbon cable at the CPU board and bend the cable out of the way of the board.

4. With the instrument placed lens side down, disconnect the coaxial cables from the Core board. This is done by first separating each coax plug from its Core board socket using a flat blade screwdriver. Use a needle nose pliers to finish removing each connector. It is very important not to pull on the coaxial cable itself since it can be pulled out of the connector housing, forcing a factory service return.

5. Slide the CPU board out of the right side of the unit. Do the same with the Core board. If the scope wires are routed outside of the card guides, be sure they are out of the path of the boards as they are being removed.

   Attention: Take precautions against static damage when removing the instrument printed circuit boards.

6. Carefully pry the two card guides loose from the top extrusion and set them aside. Do not use extensive force.

7. Disconnect the scope wires at the back of the board.

8a. FOR A RED-DOT SCOPE WITH CLAMPS
Using a 3/32" Allen wrench, remove the cap screws and washers from the bands that secure the scope to the mount. When separating the scope from the instrument, carefully feed the scope wires out of the top extrusion.

8b. FOR A RED-DOT SCOPE WITH A DIRECT MOUNT
Using a #2 Phillips screwdriver, remove the four screws that secure the scope mount to the top extrusion. When separating the scope from the instrument, carefully feed the scope wires out of the top extrusion. Using the #1 Phillips screwdriver, remove the scope mount from the bottom of the old scope and transfer it to the new scope.

Speedscope Removal

1. Remove the side covers using a #2 Phillips screwdriver.

2. With the instrument placed on its right side and the Reference board facing up, disconnect the ribbon cables to the Reference board from the CPU, Power Supply, and Receive module. By bending the disconnected ribbon cables out of the way, the Speedscope's ribbon cable will be free to disconnect.

   Note: No removal of any the p.c. boards is necessary with a Speedscope as with the Red-dot scope.

3. Set the instrument lens side down. Using a #2 Phillips screwdriver, remove the four screws that secure the Speedscope to the top extrusion. When separating the Speedscope from the instrument, carefully feed the Speedscopes' ribbon cable out of the top extrusion.

Red-dot Scope Installation

1. Thread the wire of the new Red-dot scope through the hole in the top extrusion, pulling the wire back toward the Display board. With either scope mount version there is a o-ring between the scope and the top extrusion. Before seating the new scope, make sure the o-ring is in place.

2a. FOR A RED-DOT SCOPE WITH SCOPE CLAMPS
Use the bands from the old scope to secure the new scope. When installing the cap screws, use a 3/32" Allen wrench, being careful not to cross-thread the screws. Tighten the screws evenly, checking to see that the clamp bands meet the scope mount plate at each screw location. Do not over tighten the screws, as they can be broken.

2b. FOR A RED-DOT SCOPE WITH A DIRECT MOUNT
Using a #2 Phillips screwdriver, secure the scope mount to the top extrusion.

3. Connect the scope wires to the Display board header, aligning the red wire with the positive terminal on the connector (see diagram in Appendix A).

4. While holding the scope wires against the top extrusion, snap the two card guides back into place. Make sure the spring tabs on the card guides are pointed toward the right side of the unit. The scope wires should be under the card guides (be careful not to pinch the scope wires).

5. Insert the Core board from the left side of the instrument, into the card guide pair toward the front of the instrument. The coax sockets on the back of the board should be orientated near the power connector for the Receive and Transmit modules.

6. Using a needle nose pliers, connect the coaxial cables to the Core board, making sure each connector locks into position (see diagram in Appendix A for proper orientation).

7. Slide the CPU board into the remaining card guides with the component side facing the rear of the unit and the large header toward the right side.

8. Connect the ribbon cable from the Reference board to the CPU board. Connect the small connector of the main ribbon cable to the Power Supply board, then connect the cable to the Core board, CPU board, and Display board in order.

⚠ **Caution:** Be very careful when pressing the connectors in place. Misalignment can occur easily, bending the header pins on the circuit boards.

9. Plug the instrument into a power source and turn it on. If the instrument fails to turn on or displays an error message, double check all connections associated with this procedure. If the sighting indicator in the Red-dot scope does not operate, check the connector at the Display board for proper orientation and termination. If a problem with the scope connection exists, only the CPU board needs to be removed to gain access to the back of the Display board. To remove and reinstall the CPU board, refer to the steps above, disregarding irrelevant sections.

10. Put the side covers in place, torquing the screws to 10 inch/pounds with a #2 Phillips head bit.

11. Realign a newly installed scope by following the scope alignment procedure in Part 3.

<u>Speedscope Installation</u>

1. Thread the Speedscope's ribbon cable through the top extrusion, in the hole that is closest to the front plate. Work the cable end out the left side of the instrument toward the Reference board.

2. Using a #2 Phillips screwdriver, secure the scope to the top extrusion. Make sure the two o-rings seat correctly in the scope mount plate.

3. Reconnect the ribbon cables to the Reference board in the reverse order that they were removed.

4. Plug the instrument into a power source and turn it on. If the instrument fails to turn on or displays an error message, double check all connections associated with this procedure. If the Speedscope is not illuminating, check the scope's ribbon connector at the Reference board for proper orientation. Also check to make sure that the jumper on the lower section of the Reference is in the "D" location, and that the digital brightness control is not set at a zero setting.

5. Put the side covers in place, torquing the screws to 10 inch/pounds with a #2 Phillips head bit.

6. Realign a newly installed scope following the scope alignment procedure in Part 3.

Speedscope Objective Tube Replacement

<u>Speedscope Removal (See Appendix A)</u>

1. Remove the side covers.

2. Unhook the scope ribbon cable from the reference board.

3. Unscrew the scope from the top extrusion.

4. Carefully feed the ribbon cable through the hole in the top extrusion.

Objective Tube Replacement (See Appendix A)

1. Turn the Speedscope so that the bottom plate is facing up.

2. Remove the six Phillips head screws that hold the plate on. When removing the plate from the Speedscope, be careful of the prism assembly, which sits loosely inside on an anchoring pin.

   Note: The prism assembly will come out if the scope is tipped over. The prism is fragile and can break if dropped.

3. Use an .050 inch Allen wrench to remove the two set screws that lock the objective tube in place.

4. Unscrew the objective tube from the scope housing.

   Note: The set screws are tightened into the threads of the objective tube to anchor it in place. The threads on the tube may be damaged, making its removal difficult.

5. Install the new objective tube into the scope housing,

6. Screw the tube in until you see approximately 2 threads of the tube showing inside the scope housing.

   Do Not lock the set screws yet, the objective tube will need to be adjusted to minimize parallax.

Speedscope Parallax Adjustment (See Appendix A)

The parallax adjustment is an optical adjustment of the red-dot in the scope. A vertical target at least 300 meters away is needed to sight in the parallax adjustment. A light pole or the edge of a building will work well.

1. Lay the laser on its side with the reference board facing up with the scope still open.

2. Set the scope on the ribbon cables and connect the scope ribbon cable to the laser.

3. Power the laser to illuminate the scope red-dot. Looking through the scope, sight the red-dot on a distant vertical target.

4. Look at the red-dot on the target, move your head back and forth and watch for movement of the red-dot.

5. Screw the tube in or out of the scope body until the red-dot stops moving against the background.

6. Turn the set screws into the tube to anchor it in place when finished.

7. Re-assemble the scope and install it back on the laser.

    Note: A scope alignment will need to be done after the scope is mounted back on the unit.

Required Tools for Marksman Service Repairs

Hand Tools

Screwdrivers:	#1 Phillips #2 Phillips 1/14" X 4" Flat Blade 3/16" X 4" Flat Blade	
Allen Wrenches:	1/16" 3/32" 7/64" .050" 1.5mm 2.5mm	(All right-angle, ball driver types)
Nut Drivers:	3/16" 5/16" 3/8" 9/16"	
Miscellaneous:	Small Diagonal Cutters Small Needle Nose Pliers Combination Crimper/Stripper Tool Strain Relief Pliers (Heyco p/n R-29) Small Channel-lock Pliers (½" x 5") Soldering Iron Small Quick-Grip bar Clamp Small Screwdriver type torque driver - with 3/32" and 7/64" bits	

Test Equipment

Digital Multimeter	4 ½ digit display with Voltage, Current, and resistance measurement capability
Frequency Counter	Period measurement capability (resolution: 1 microsecond, 100 millisecond max. Period) High impedance input (1 M ohm) NIST traceable (if required)
Oscilloscope	Minimum 60 MHZ bandwidth

PART 6: TROUBLESHOOTING

System Troubleshooting

This section is designed to give a service technician some insight as to the nature of the service challenges associated with the Marksman. This guide covers the most common circumstances encountered with normal field use. In any instance where a symptom is not covered, or cannot be diagnosed with the information supplied, the faulty instrument may need to be returned for factory service. Contact Laser Technology, Inc. At (303) 649-1000 to speak to a Service Representative concerning a possible factory service return. The Representative may be able to suggest a solution that would eliminate the need to return the instrument.

I. Symptom: Instrument Fails to Power-up Correctly

Condition A. Absolutely no response

1. Verify that the power source is supplying 12 volts D.C.
2. Check the condition of the fuse. Test for continuity with an ohm meter. If the fuse is blown, ohm out the power cord to check for a short circuit.
3. Test for a faulty power cord. With a power source connected to the instrument and the power switch on, bend the power cord back and forth near the connector. Try the same thing on the cord where it comes out of the unit's handle. An instrument, which powers up intermittently usually is an indication of a broken wire connection. If the problem is in the portion of the cord near the handle, the whole cord will have to be replaced. If the fault is at the other end, or inside the cigarette plug connector itself, the cable can be repaired. Either repair the break inside the connector or reterminate the cord with a new cigarette plug.
4. With the instrument off and disconnected from any power source, remove the right side cover and handle grips. Connect the instrument to the power source and use a voltmeter to see if power is getting to the appropriate header on the Power Supply board. The power switch doesn't have to be on for this test. If the test is negative, disconnect the unit from the power source, separate the power cord from the ribbon cable inside the handle, and ohm out each of the two parts of the power cable (the red wire in the coiled portion of the power cable is connected to the center contact of the cigarette plug connector).

Condition B. Internal "click" only

1. The "click" is emitted from the beeper and indicates that the unit is turning on, but is being interrupted from completing initialization. Typically this indicates a more serious problem which may require factory service.

Condition C: Error messages

1. **E-50 thru E-53** can occur as a result of an internal cable being disconnected, or a cable being misaligned when reconnected. Check all connections for a secure fit and proper alignment.

2. **E-60 thru E-63** can occur if any of the three socketed IC's on the CPU board become partially or completely unseated. Check the IC's for complete insertion in the socket. If an IC comes out of its socket, see Appendix A for installation orientation.

3. **E-54** is an internal self-calibration failure, but can also be caused by a loose connection. Check for loose or incorrect coaxial connections to the Core board. Also check for a loose connection from the high voltage header on the Power Supply to the Transmit and Receive modules.

    Note: If all connections appear to be properly secured, the instrument may require factory service. Refer to the section on error messages in this text. Contact the factory and inform a Service Representative of the specific system error code. It is possible that the unit will not have to be returned.

II. Symptom: Unit Turns on Intermittently

Condition A: Inconsistent power switch response

1. Make sure the power switch ribbon cable is secure at both ends.

2. Remove the rear plate to gain access to the power switch. Use an ohmmeter to prove the integrity of the switch and replace it if necessary.

Condition B: Intermittent power regardless of function used

1. The most likely cause is a broken wire in the power cord. Refer to part I. A. 3 for the test procedure.

2. Visually inspect the internal cables to make sure they are secure.

III. Symptom: Improper Trigger Response

Condition A: No response

1. Check for an audible mechanical "click" when pressing the trigger button. If there is a "click", make sure the ribbon cable from the switch is securely plugged into its header on the Reference board. If the cable is secure, verify the integrity of the switch with an ohmmeter.

2. If there is no "click" when pressing the trigger button, try to realign the switch with the trigger plunger. Refer to the trigger switch replacement procedure in the previous section of this manual. If the switch is properly aligned, but is still difficult or impossible to obtain an audible "click", the switch may be faulty.

Condition B: Function intermittent

1. Check the switch for proper adjustment. Referring to the procedure on switch replacement and adjustment, adjust the switch as needed.

2. Test the electrical integrity of the switch, confirming the interaction of the normally open (no), normally closed (nc), and common terminals on the switch itself.

Condition C: Gets stuck in the "activated" position

1. Follow steps 1 and 2 from part III.B. above.

IV. Symptom: Malfunctioning Display

Condition A: No display response

1. Make sure the "Display Intensity" control knob is turned all the way clockwise.

2. Check the physical condition of the display potentiometer body. If the instrument receives a significant impact to the rear plate, the controls can be damaged.

3. If the display potentiometer has just been replaced, double check the wire configuration.

4. Check the display potentiometer to see if it varies the voltage properly.

Condition B: Intermittent display

1. Test the display controller IC (U1) on the Display board for proper signal characteristics.

2. Follow step 4 from part IV.A. above.

Condition C: Individual display segment missing

1. While testing for the voltage level on the line connecting the segment in question to the display controller, activate the "Test Mode" button to initiate the display test function (see the section on System Operation). The display controller or the double-digit display module may need replacement.

V. Symptom: Function Selector Showing Improper Response

Condition A: Little or no response from a specific function

1. Check the electrical integrity of the dome switch in question with an ohmmeter.

2. Test the signals at the keyboard encoder IC (U2) on the Display board. Verify that the key switch de-bounce capacitor (C15) is not faulty.

Condition B: Sporadic response (unstable selection results)

1. Refer to part V.A.2 above.

VI. Symptom: Serial Communication Trouble

Condition A: No serial communication

1. Verify the wiring in the serial cable at both connector ends. Test the cable for continuity and short circuits.

2. Check the voltage levels at the serial port IC (U3) on the Display board. Verify the RS232 voltage swing on approximately +/- 9 volts at the serial port connector.

Condition B: Intermittent download capability

1. Refer to part VI.A above.

VII. Symptom: Inconsistent Range and Speed Readings

Condition A: "E-01" message only

1. With the instrument in "Test Tone" mode, check for an audible tone response on any target. If there is no response at all, the instrument will require factory service.
2. Check the scope for proper alignment. Refer to the procedure in Part 3 for alignment testing and correction.

Condition B: Mixture of speed / range readings and error messages (e.g. E-01, E-02, E-03)

1. Carefully check the scope alignment. Refer to part VII.A.2 above.

Condition C: Stationary target returns a speed reading of greater than 1 mph (2 kph)

1. Check the sighting scope alignment.
2. Be sure to hold the instrument steady when targeting.

Condition D: Incorrect speed or range readings

1. This usually occurs during a calibration verification test. Verify the position of the test target with a metal tape.
2. Check the sighting scope alignment.
3. Make sure that the test distance is measured to the center of the instrument.

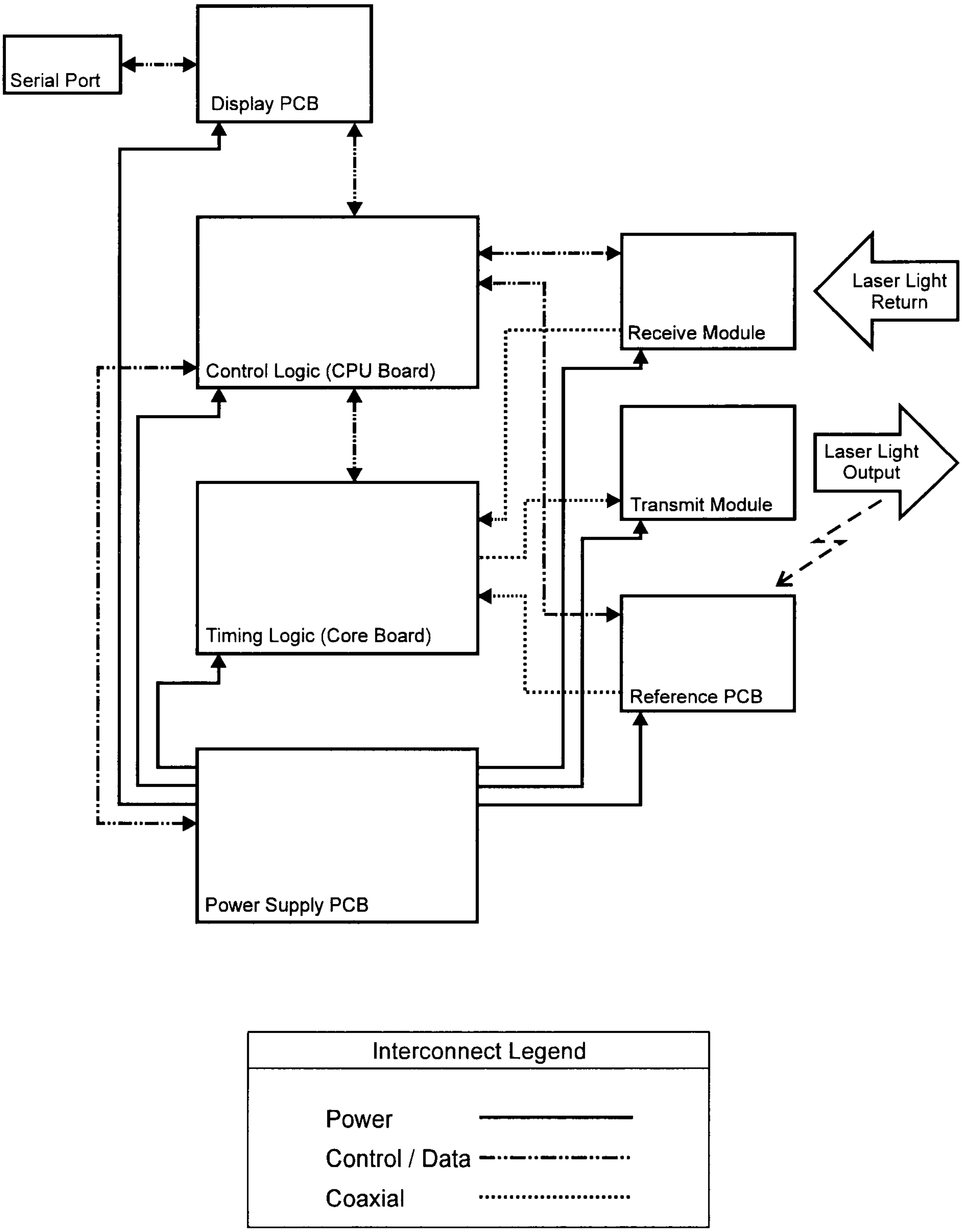
Condition E: Short maximum range

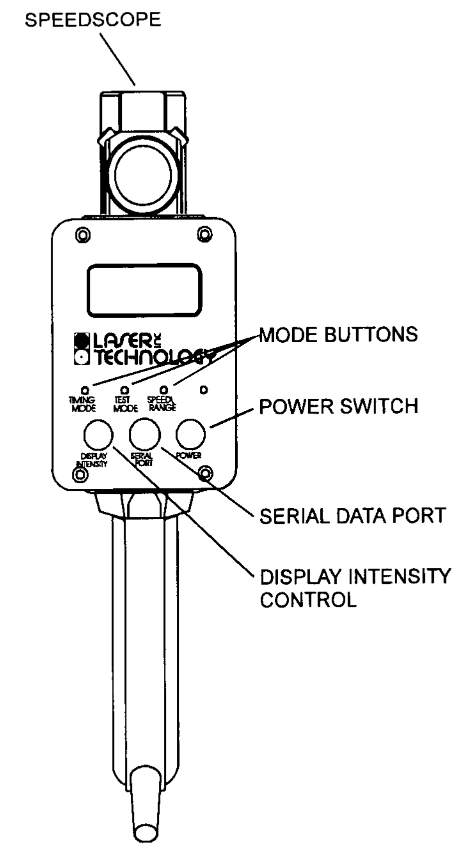
1. Check the sighting scope alignment.
2. Check the transmit and receive lens for excessive dirt and / or scratches

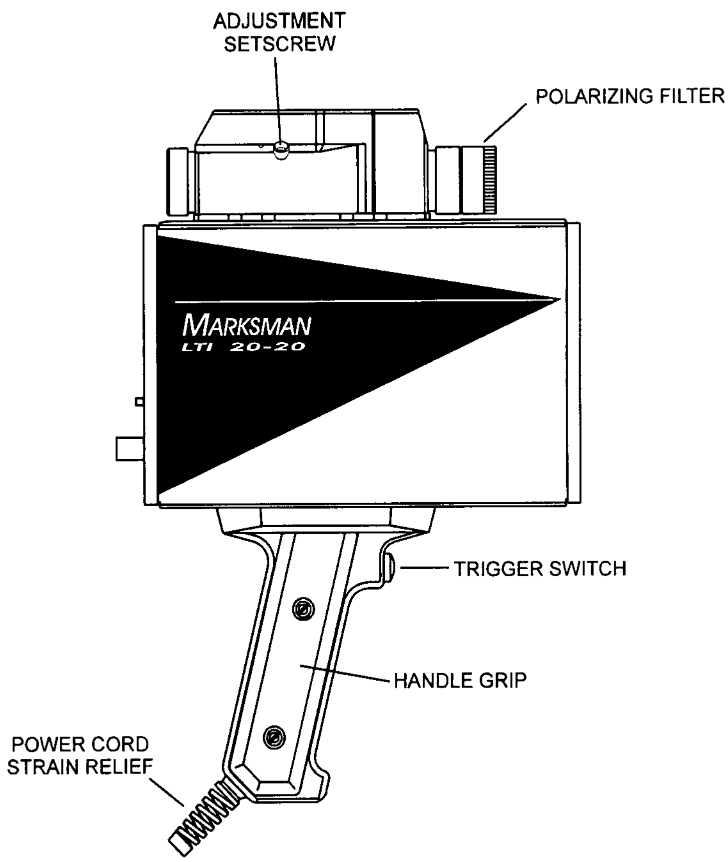
APPENDIX A:

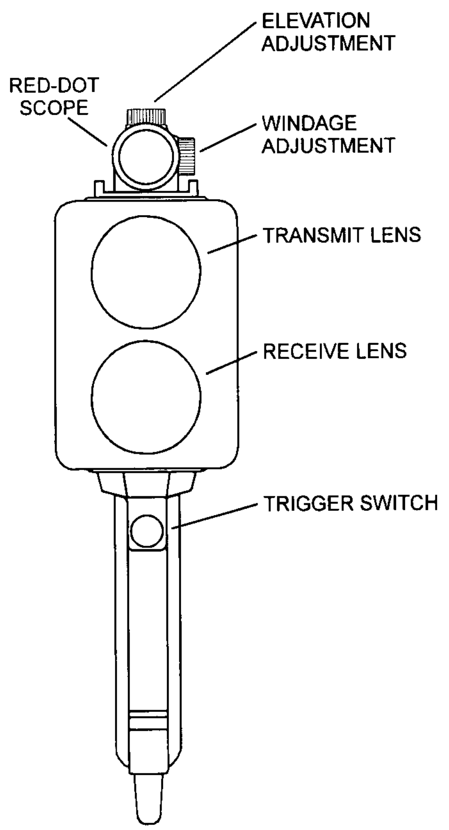
DIAGRAMS AND LAYOUTS

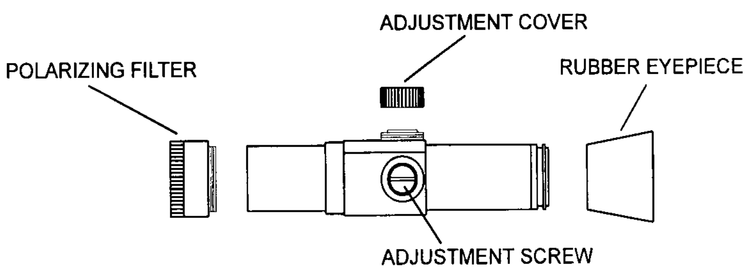
Marksman System Block Diagram





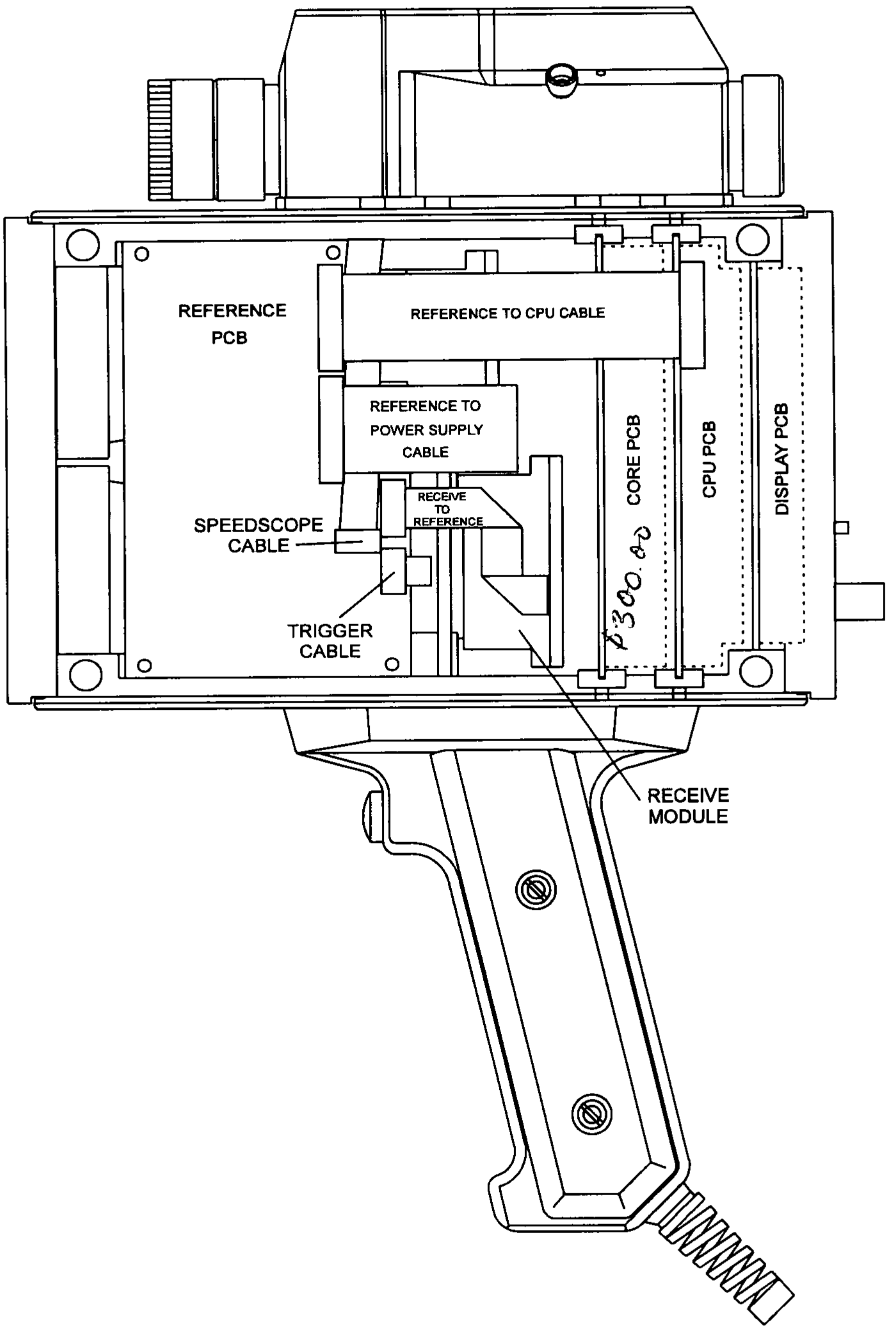






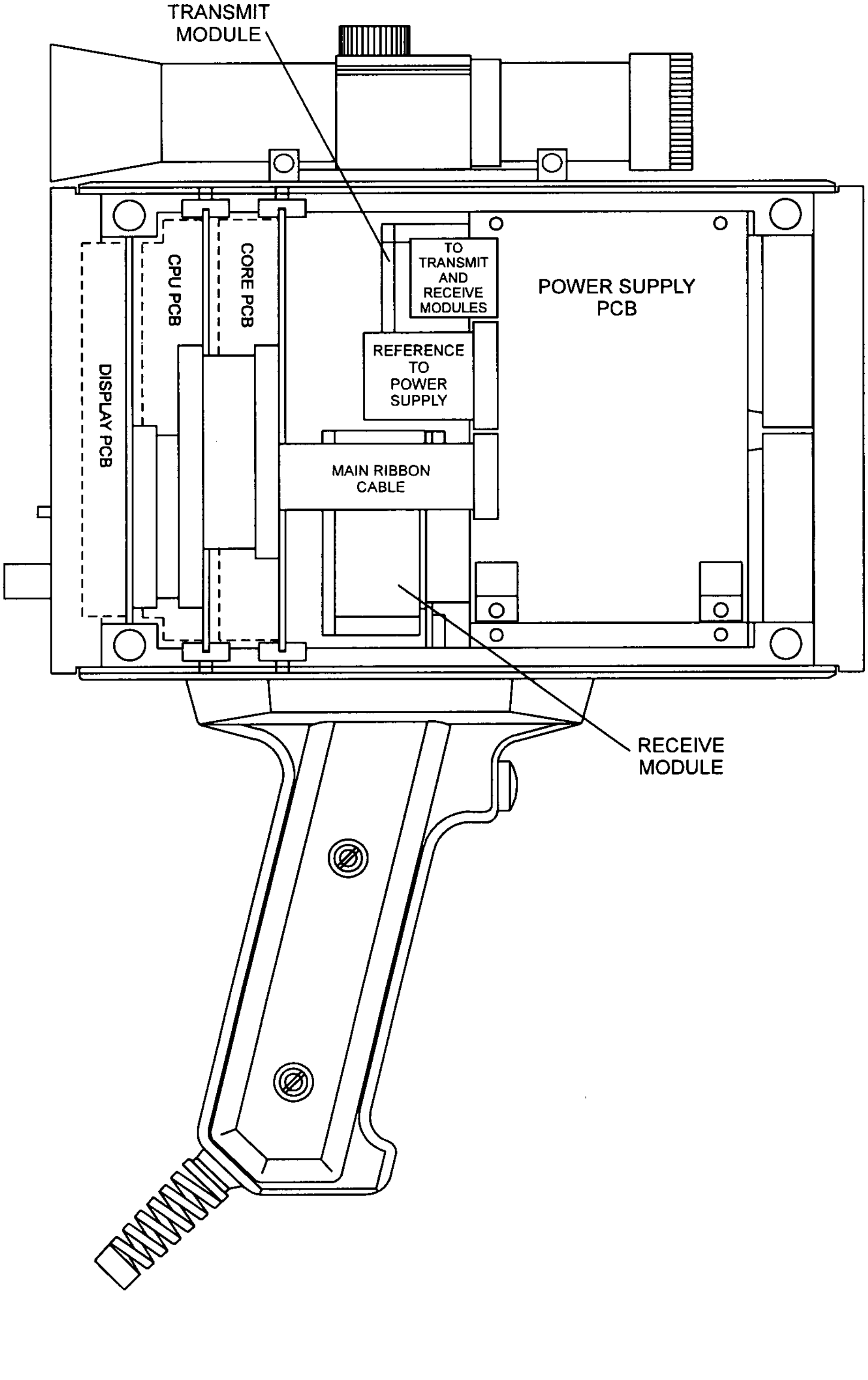
RED-DOT SCOPE

Left Side View



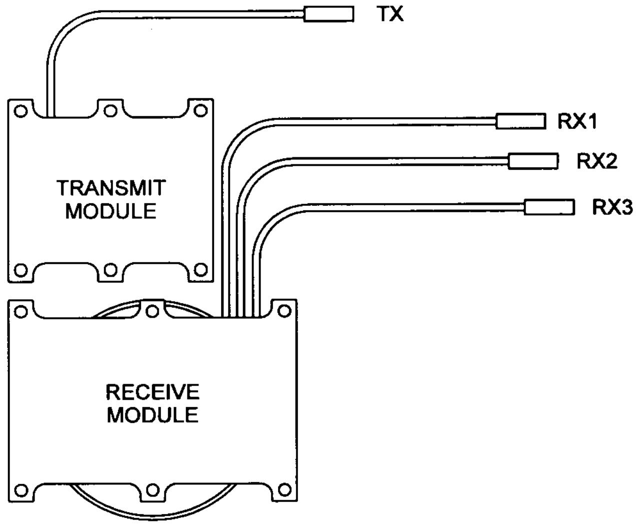
Error 50
damage Board core PCB

Right Side View

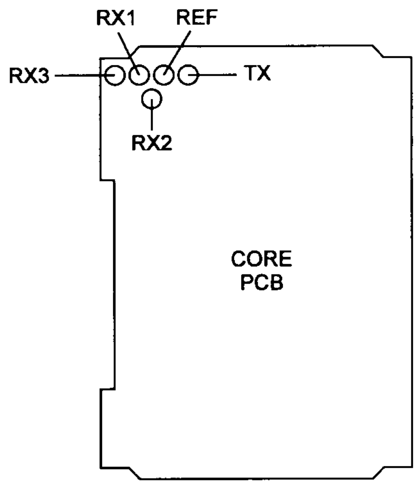


Coax Cable Connections

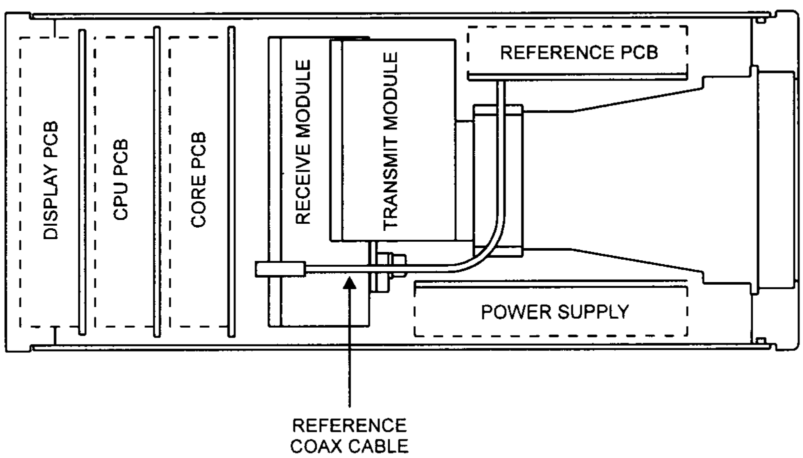
VIEW FROM REAR OF MARKSMAN



VIEW FROM BACKSIDE OF CORE PCB

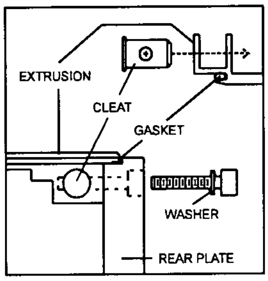


VIEW FROM TOP OF MARKSMAN

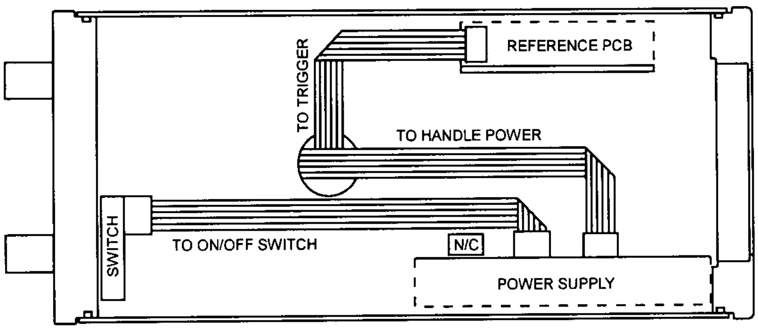


Mechanical Reference Diagrams

REAR PLATE ATTACHMENT
PART REFERENCE

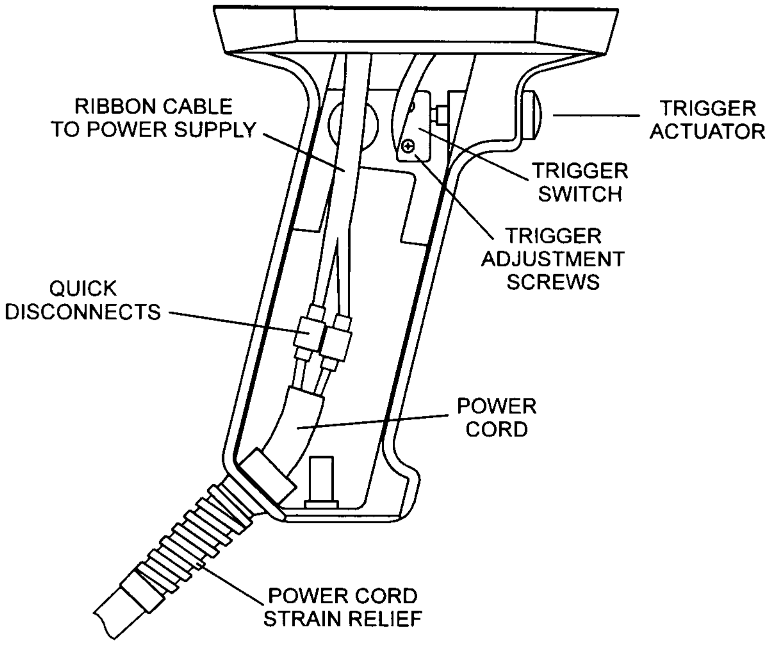


INTERNAL RIBBON CABLE ROUTING

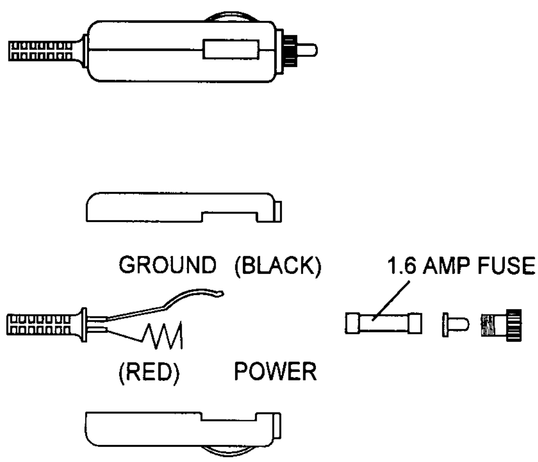


VIEW FROM TOP OF MARKSMAN

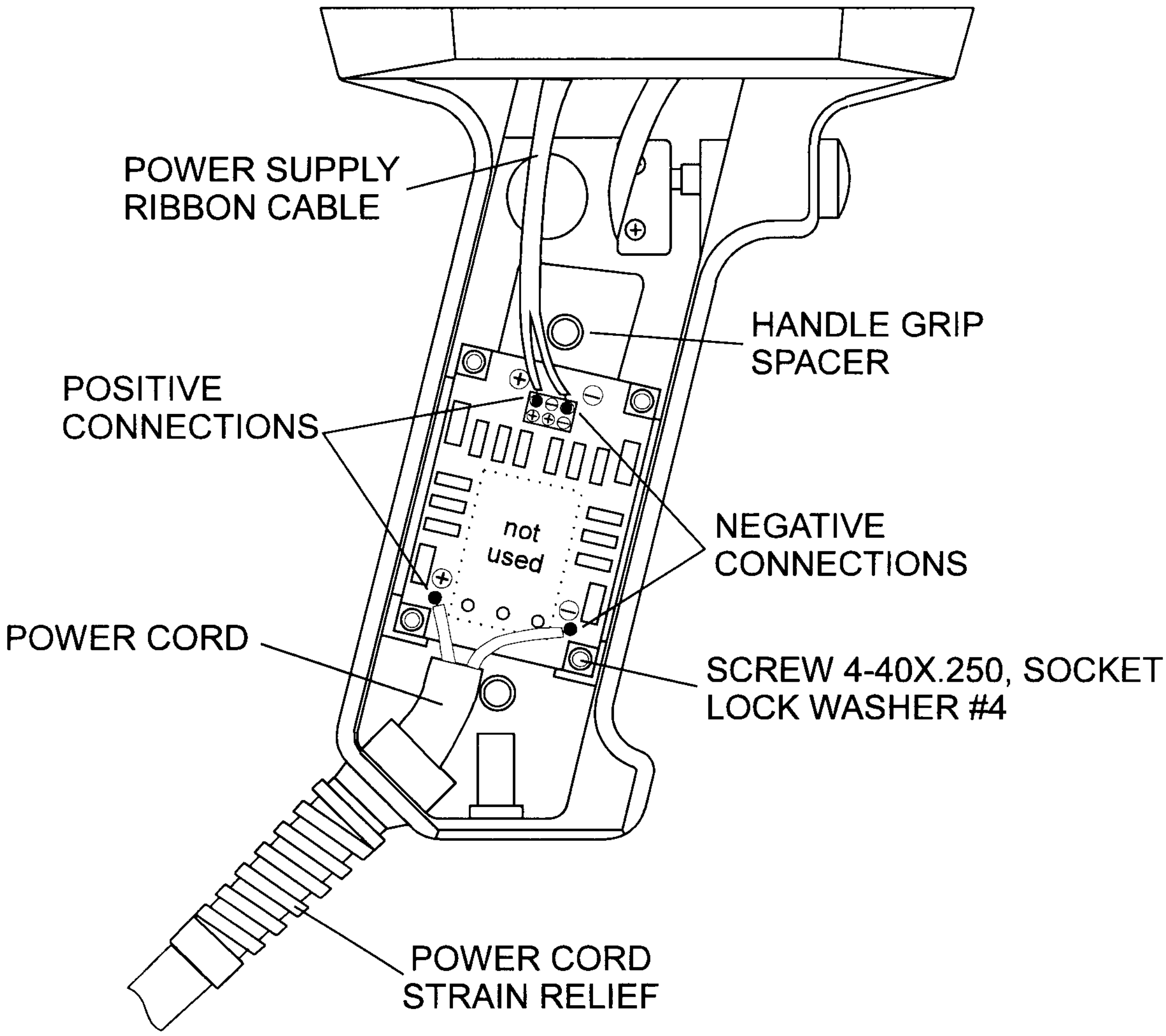
Handle Assembly



Power Plug

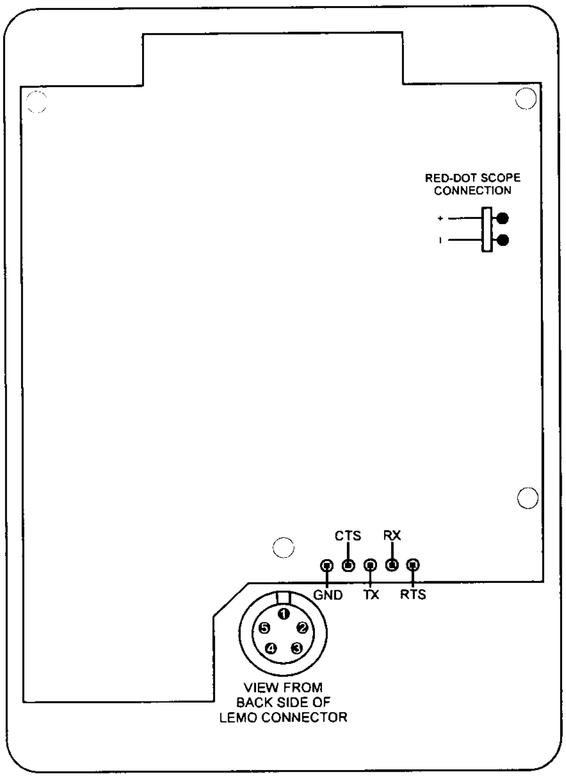


Handle Filter Assembly

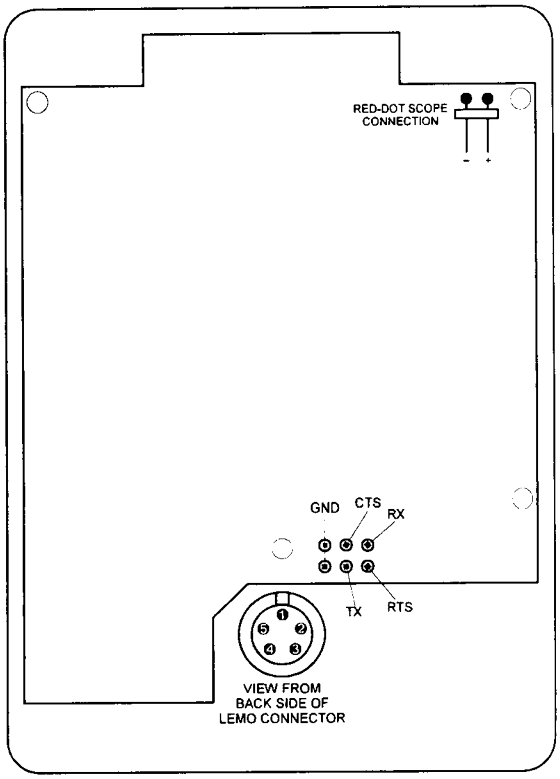


Display Board
Serial Port and Red-dot Scope connections

REV. 1



REV. 2



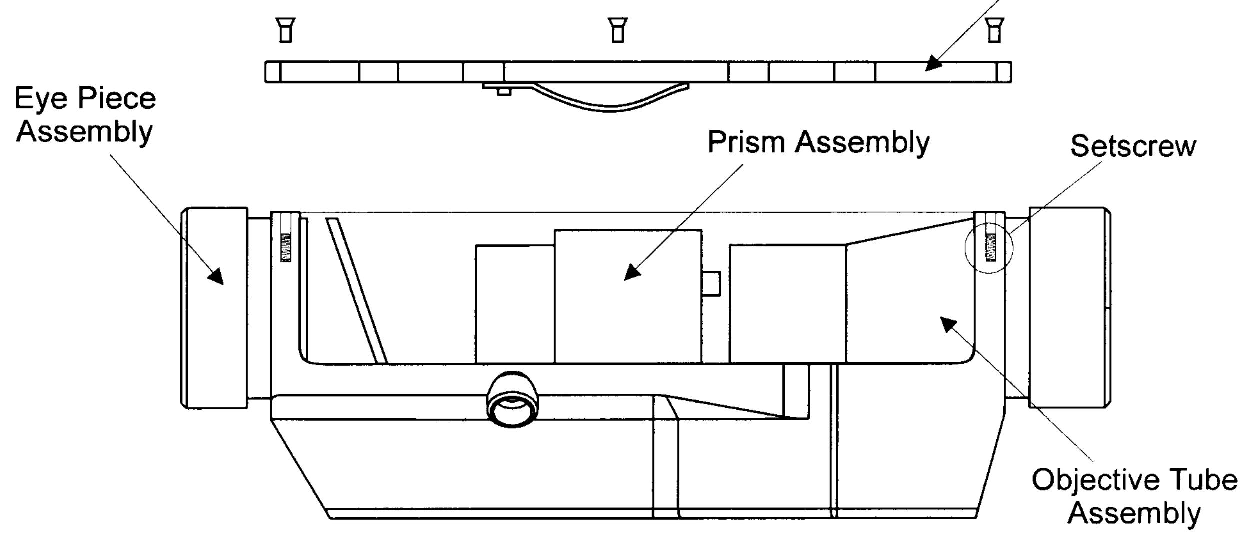
VIEW IS FROM BACKSIDE OF REAR PLATE ASSEMBLY

Signal Descriptions with Pinning

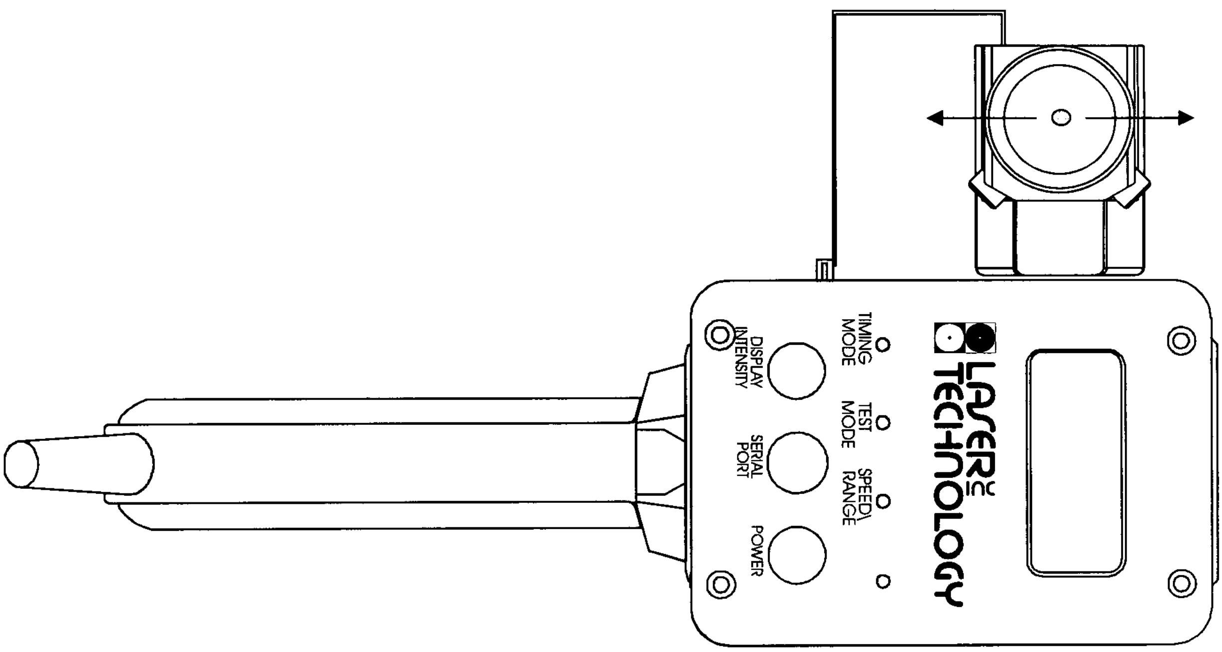
Lemo Pin Number	Signal	Color Code
1.	CTS	Black
2.	RTS	White
3.	RX	Red
4.	TX	Green
5.	GND	Blue

Speedscope Objective Tube Replacement

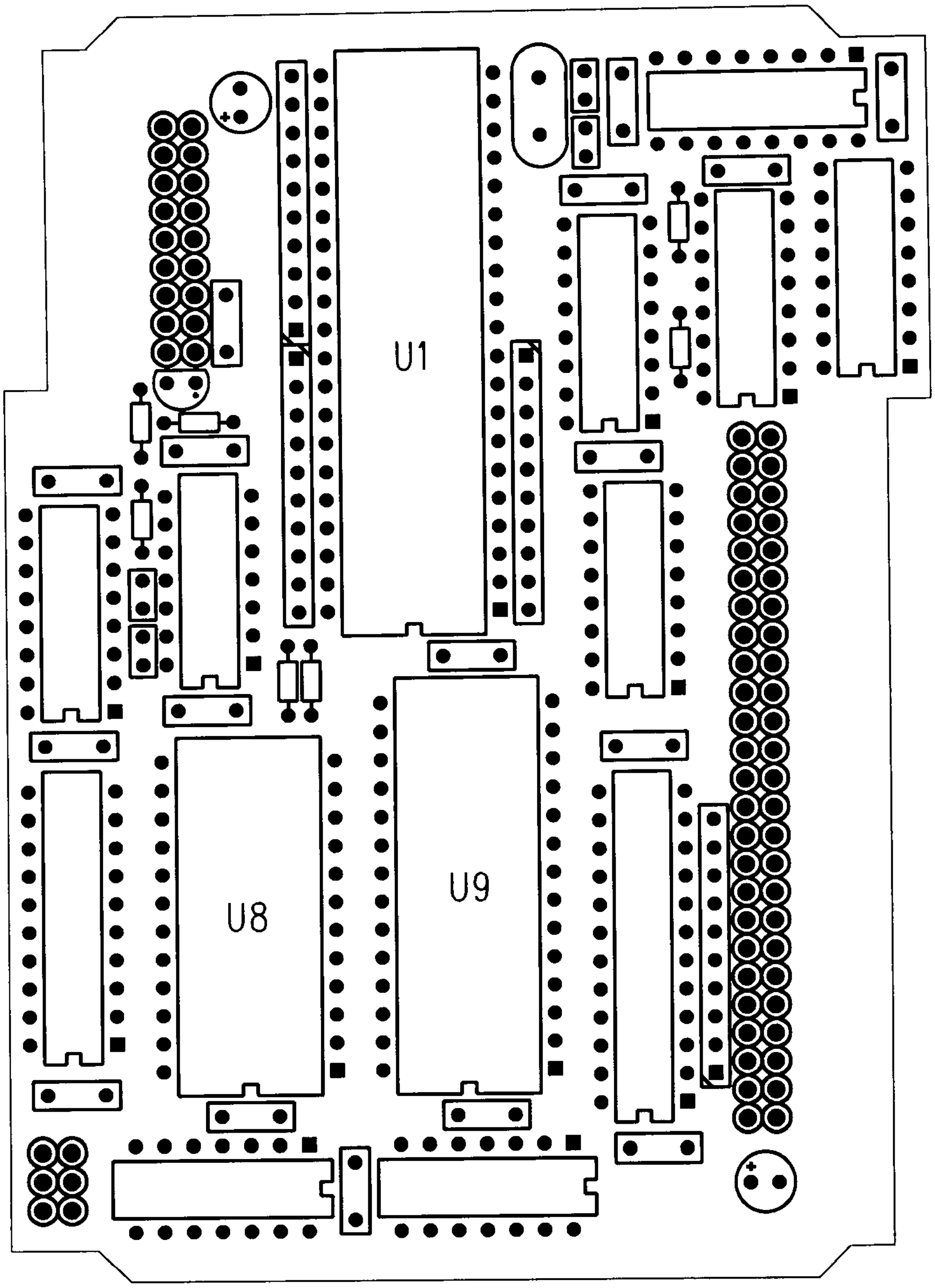
Speedscope Removal



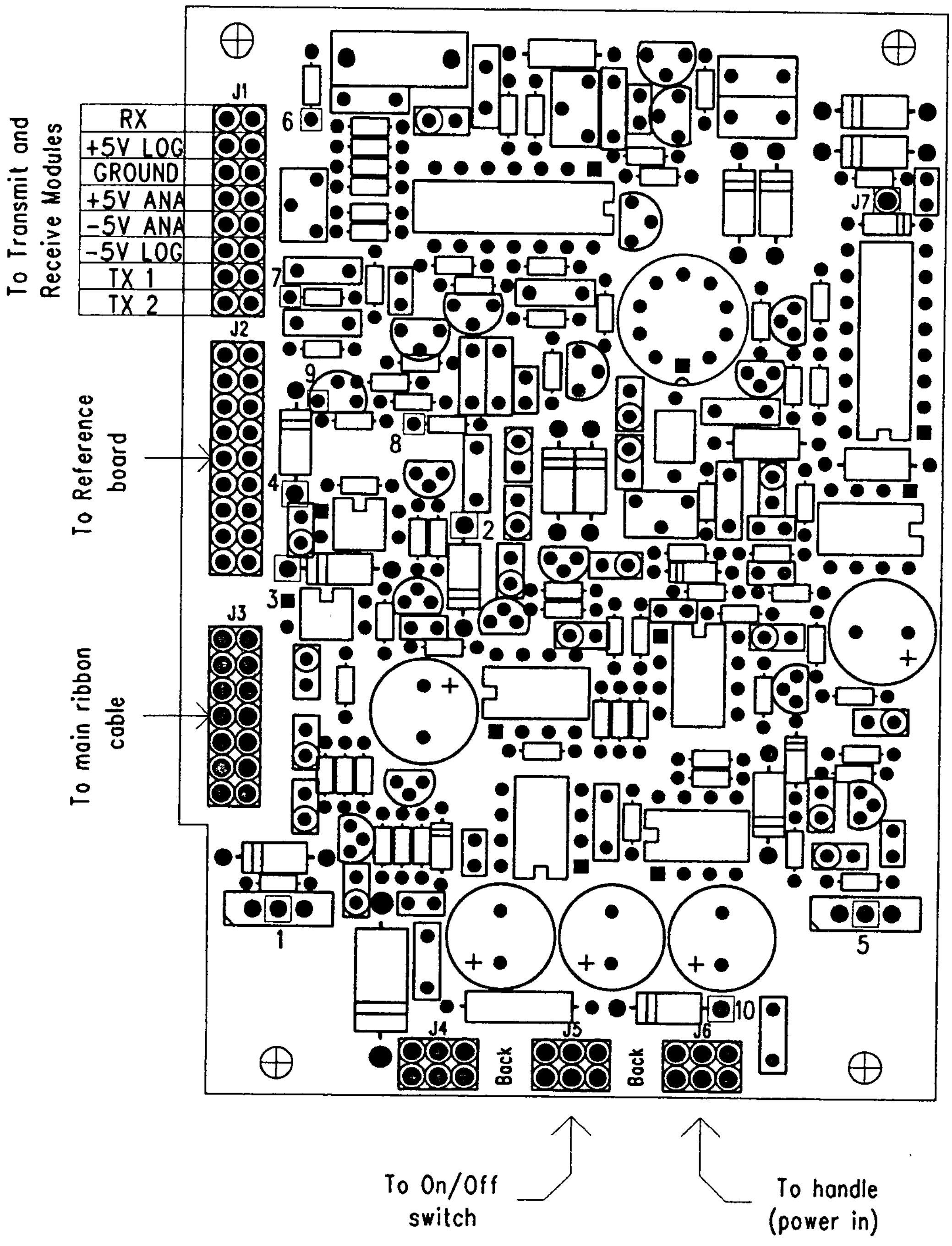
Speedscope Parallax Adjustment



CPU BOARD - REV1



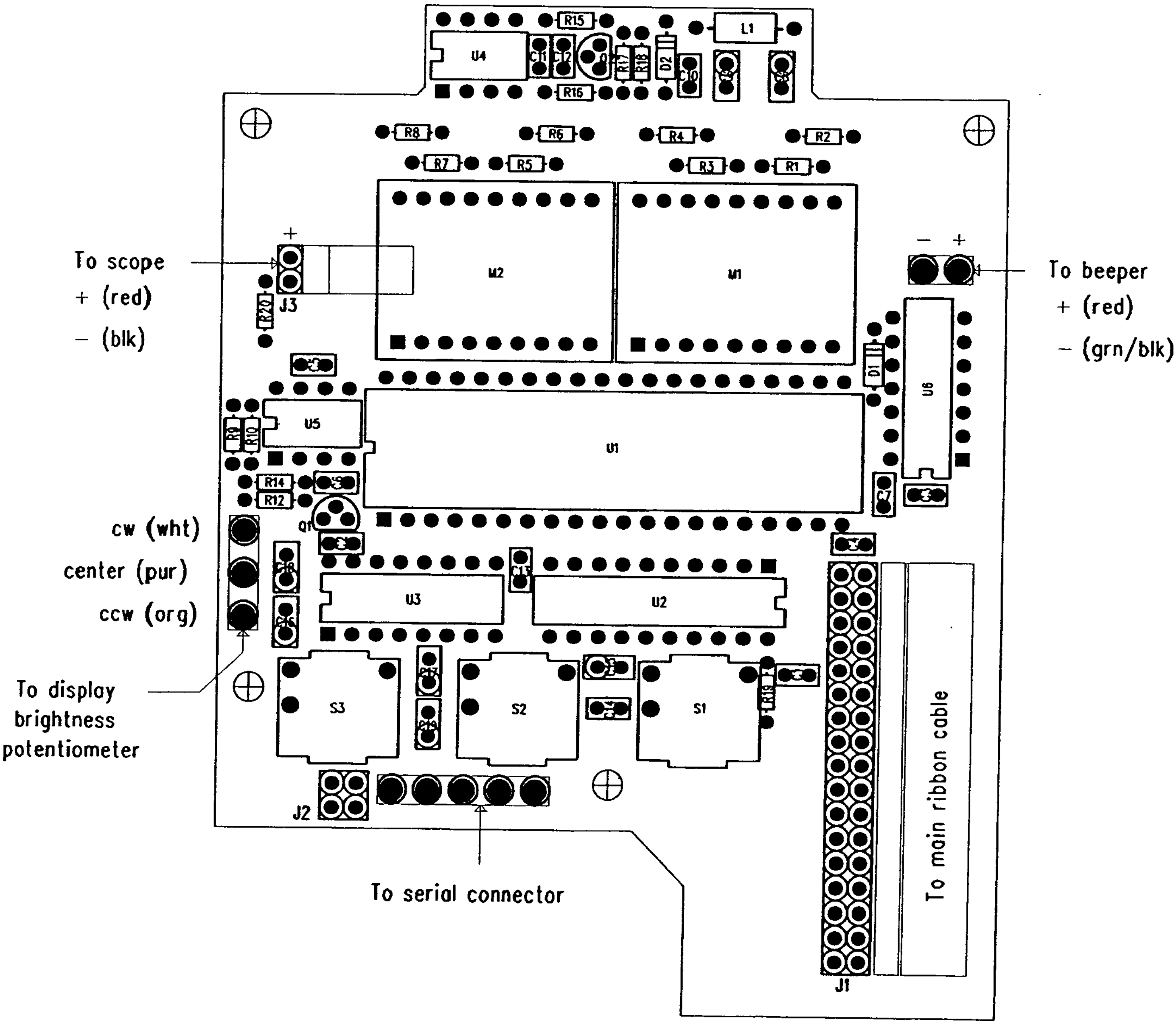
POWER SUPPLY TEST POINTS



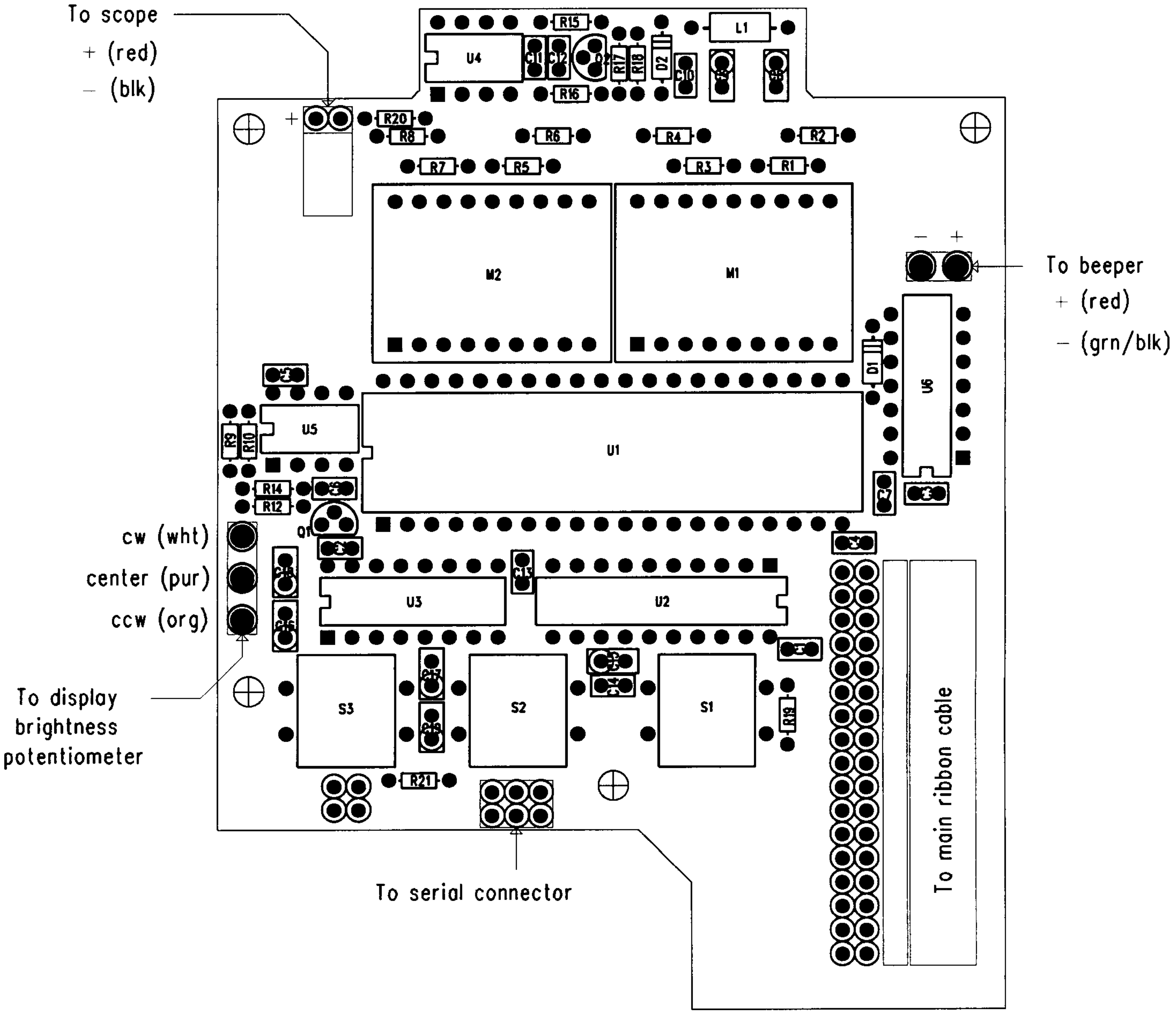
TEST POINTS AND TYPICAL VOLTAGE RANGES

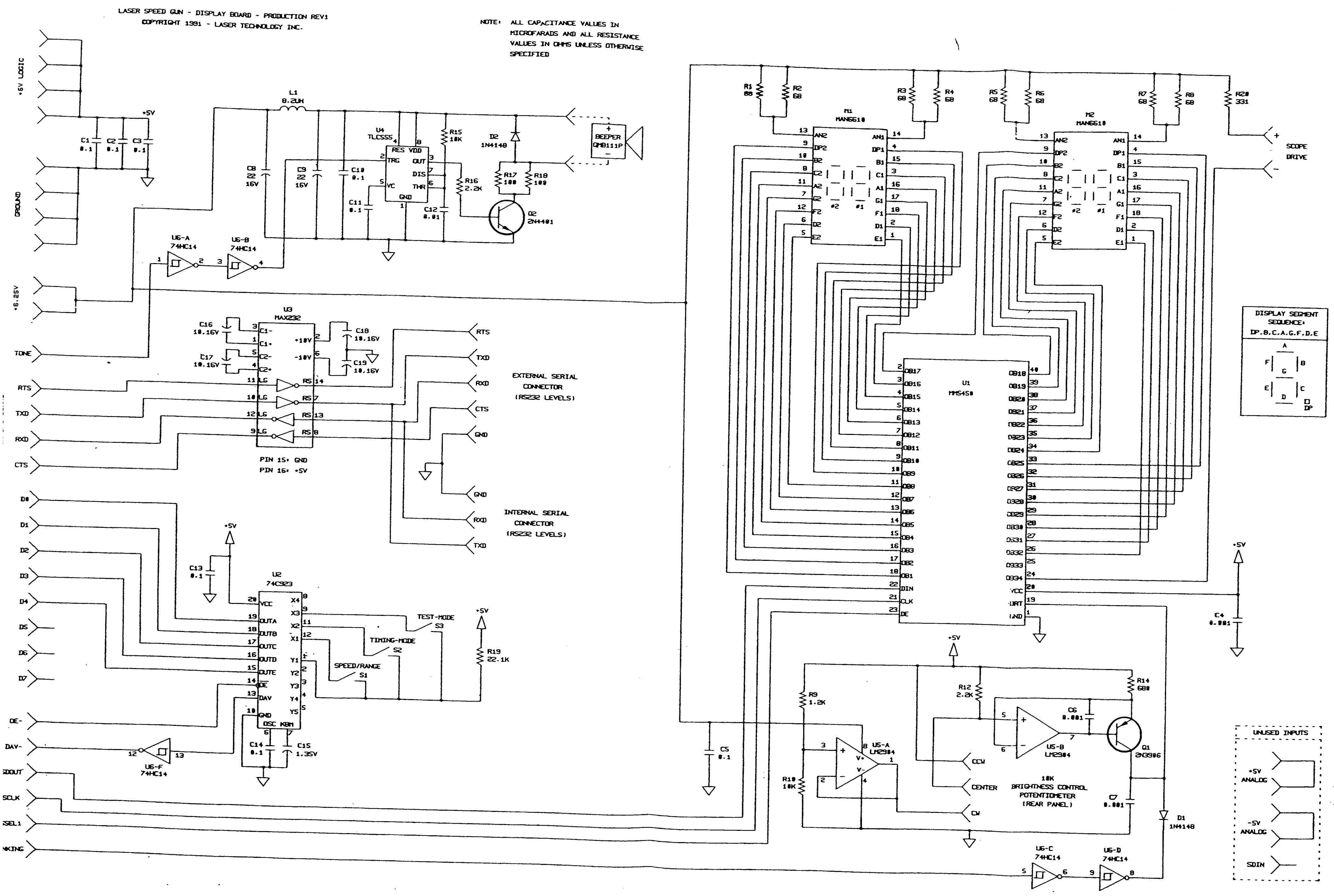
1. +5V LOGIC	4.98V TO 5.02V	6. RX VOLTAGE	190V TO 235V
2. -5V LOGIC	-4.96V TO -5.02V	7. TX VOLTAGE 1	65V TO 75V
3. +5V ANALOG	4.91V TO 4.95V	8. TX VOLTAGE 2	106V TO 107V
4. -5V ANALOG	-4.95V TO -5.00V	9. REFERENCE DETECTOR	36.5V TO 37.0V
5. +6.25V	6.21V TO 6.30V	10. INCOMING POWER	DEPENDANT ON SOURCE

DISPLAY BOARD - REV1



DISPLAY BOARD - REV2





LASER SPEED GUN - DISPLAY BOARD - PRODUCTION REV1
COPYRIGHT 1991 - LASER TECHNOLOGY INC.
NOTE: ALL CAPACITANCE VALUES IN MICROFARADS AND ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED
+5V LOGIC
GROUND
+6.25V
TONE
RTS
TXD
RXD
CTS
D0
D1
D2
D3
D4
D5
D6
D7
OE-
DAV-
SDOUT
SCLK
SSEL1
U3 MAX232
PIN 15: GND
PIN 16: +5V
EXTERNAL SERIAL CONNECTOR (RS232 LEVELS)
INTERNAL SERIAL CONNECTOR (RS232 LEVELS)
U2 74C923
TEST-MODE S3
TIMING-MODE S2
SPEED/RANGE S1
U4 TLC555
BEEPER QMB111P
M1 MAN6610
M2 MAN6610
U1 MM5450
SCOPE DRIVE
DISPLAY SEGMENT SEQUENCE: DP.B.C.A.G.F.D.E
U5-A LM2904
U5-B LM2904
10K BRIGHTNESS CONTROL POTENTIOMETER (REAR PANEL)
CCW
CENTER
CW
Q1 2N3906
Q2 2N4401
D1 1N4148
D2 1N4148
U6-A 74HC14
U6-B 74HC14
U6-C 74HC14
U6-D 74HC14
U6-F 74HC14
UNUSED INPUTS
+5V ANALOG
-5V ANALOG
SDIN

APPENDIX B:

PARTS LISTS

Replacement Parts

General Parts

Part Number	Description	Notes
3120365	Case	Carrying Case
3120366	Foam	Case Foam
7020359	Shoulder Rest	
1132561R	Side Cover	Right Side, Marksman
1132561L	Side Cover	Left Side, Marksman

Rear Plate Parts

Part Number	Description	Notes
7021096	Rear Plate Assembly	Complete Rear Plate Assembly
4910302	Potentiometer, 10K	Brightness Control Switch
7010308	Power Switch Assembly	On / Off Switch
6801371	Knob, Rotary	Switch Knobs
1810046	Display Window	
1810316	Gasket, Display Window	
1430060	Actuator	Push Button, 3 per Rear Plate
1500319	Gasket, Actuator	3 per Rear Plate
4600063	Beeper	
1500448	Gasket, Beeper	
1150030	Rear Plate, Raw	Rear Plate, painted
4811079	Serial Port	5 pin Lemo Connector
7011086	Filter Board, Serial Port	
7051175	Ribbon Cable	Serial Port Filter Board to Display Board

Replacement Parts

Sighting Scope Parts

Part Number	Description	Notes
7001156	Red-dot Scope Assembly	Complete ready to install
3251202	Rubber Eye Piece	Red-dot Scope
3251203	Polarizing Filter Speedscope and Red-dot Scope	27 mm., Red-dot Scope
5210519	Large O-Ring	Red-dot Scope
7031340	Speedscope Assembly	Complete ready to install
3251426	Polarizing Filter	30 mm., Speedscope
5211394	Small O-Ring	Speedscope and Red-dot Scope
3531284	Lens, Eyepiece	
6101477	Cap Screw, M3X4, Socket head	Adjustment Cover Screws
6301488	Nylon Washers	Cover Screw Washers

Handle Parts

Part Number	Description	Notes
7051364	Power Cable	
6800050	Strain Relief	
4811037	Power Plug	
1140793	Handle Grip, Left	
1140794	Handle Grip, Right	
7051176	Trigger Switch Assembly	
1140043	Actuator, Trigger	
6700356	Spring, Trigger	
6640048	E-clip, Trigger	
7011085	Filter Board	Handle, Power Filtering

Replacement Parts

Internal Parts

Part Number	Description	Notes
7050782	Main Ribbon Cable	
7050783	CPU to Reference Ribbon Cable	
7050784	Power Supply to Reference Ribbon Cable	
7050785	Power Switch Ribbon Cable	
3410360	Card Guides	PCB Mount

Hardware Kit - Part Number 7034534

Description	Notes
Screw,8-32X1/2, flat head, Phillips	Handle Grip Screw
Standoff, 1/4", 8-32X9/16	Handle Grip Standoff
Screw, 6-32X3/4, socket head	Rear Plate
Lock Washer, #6	Rear Plate
Screw, 2-56X7/16, pan head, Phillips	Trigger Switch
Nut, 2-56, hex	Trigger Switch
Cap Screw, ty123, 440 X .250	Power Supply, Reference Board & Display Board
Cap Screw, ty123, 440 X .3125	Power Supply, Heat Sink to Frame
Lock Washer, #4	Power Supply, and Reference Board
Screw, 6-32X5/16, flat head, Phillips	Side Cover & Scope Mounting

B4MER 703-4696 COMPLETE 25.00

Replacement Parts

PCA Display Board - Part Number 7010025

Description	Designator
Resistor, 68.1 ohm, 0.4, 1%	R1, R2, R3, R4, R5, R6, R7, R8
Resistor, 100 ohm, 0.4W, 1%	R17, R18
Resistor, 332 ohm, 0.4W, 1%	R20
Resistor, 681 ohm, 0.4W, 1%	R14
Resistor, 1.2K ohm, 0.4W, 1%	R9
Resistor, 2.21K ohm, 0.4W, 1%	R12, R16
Resistor, 10K ohm, 0.4W, 1%	R10, R15
Resistor, 22.1K ohm, 0.4W, 1%	R19
Capacitor, .001uf, 100V, X7R, +/- 10%	C6, C7
Capacitor, .01uf, 100V, X7R, +/- 10%	C12
Capacitor, .1uf, 50V, X7R, +/- 10%	C1, C2, C3, C4, C5, C10, C11, C13, C14
Capacitor, 1uf, 35V, TANT, +/- 5%	C15
Capacitor, 10uf, 16V, TANT, +/- 5%	C16, C17, C18, C19
Capacitor, 22uf, 16V, TANT, +/- 5%	C8, C9
Diode, 1N4148	D1, D2
Inductor, 8.2uh, 10%, axial	L1
Transistor, 2N3906	Q1
Transistor, 2N4401	Q2
KB Encoder, MM74C923N	U2
IC, MC74HC14AN, Schmitt trigger	U6
IC, LM2904N, Dual OpAmp	U5
IC, MAX232CPE, Dual RS-232	U3
IC, MM5450N, Display Controller	U1
IC, TLC555CP, Timer, Dip-8	U4
LED, 7 Segment	M1, M2
Switch, Momentary Trigger	S1, S2, S3