Laser Setup

Using lasers successfully requires attention to three main details:

- Laser placement
- Laser calibration
- Laser axis alignment

If the laser is incorrectly placed, has incorrect calibration, or is misaligned, the cost in time and money to fix any one of these problems can cause delays in completing a project.

NOTICE

Place the laser transmitter as recommended to ensure its availability.

NOTICE

Check the laser calibration daily to ensure correct grade control.

NOTICE

Align the laser to ensure correct slope.

NOTICE

Ensure that the laser grade axis matches the direction of slope on the area to be graded.

Laser Placement

The physical location of the laser on the jobsite should be outside the actual grading area, if possible. Topcon lasers feature a beam range from 500 to 2000 feet, making placement of the laser outside the grading area easier.

When choosing a location to place the laser transmitter, remember the following two recommendations.

1. Minimize the working distance from the laser.

   As the distance from the laser transmitter increases, grade accuracy decreases. The following factors affect grade at long distances:

   - Accuracy of individual laser instruments
   - Ground vibration from machinery working near the laser transmitter
   - Calibration error
   - Curvature of the earth
   - Laser movement from blowing wind
   - Atmospheric conditions

   For more information, see “Conditions Affecting the Laser Transmitter” on page 3-12.

2. Keep the laser transmitter as low as possible.

   Keeping the laser transmitter low, where you can reach it, will make setup and grade changing much easier. The transmitter and laser receiver on the machine will also be more stable. On windy days, you may need to anchor the tripod to keep the laser from moving.

   The laser transmitter does not need to be above the machinery on the job. The benefits of keeping it low far outweigh the momentary loss of the laser beam due to passing equipment.

Small Project Laser Transmitter Placement

On small projects, the laser transmitter can be placed off the working area (Figure 3-1). The working distance from your laser will indicate the type of project (small or large).

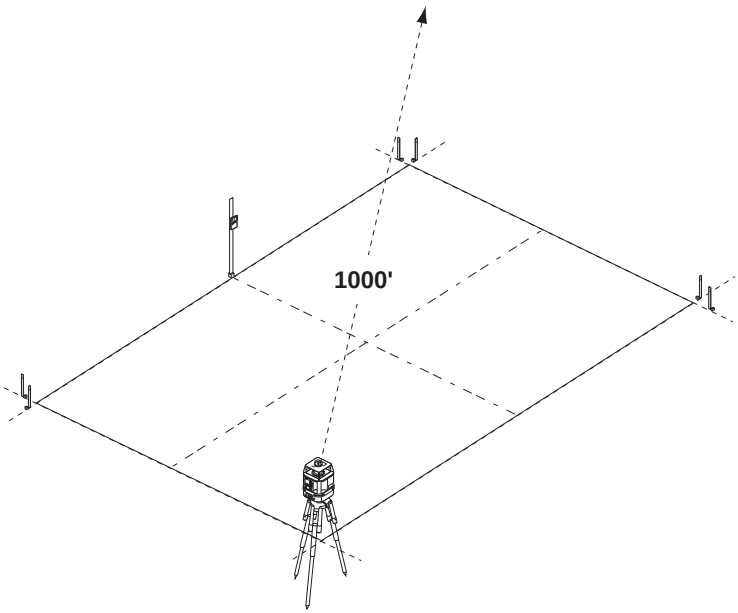

Figure 3-1. Laser Transmitter Placement – Small Project

Large Project Laser Transmitter Placement

On larger projects, place the laser in the center of the project to maximize the area you can grade, and minimize the distance from the laser (Figure 3-2). The working distance from your laser will indicate the type of project (large or small).

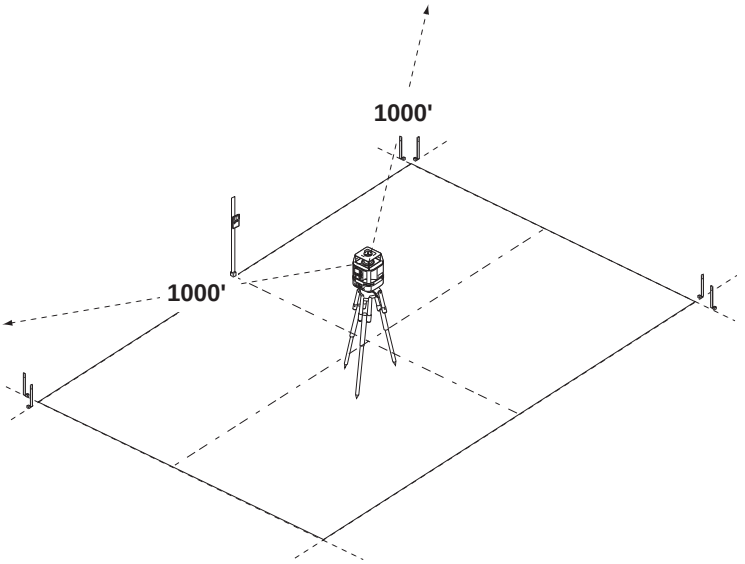

Figure 3-2. Laser Transmitter Placement – Larger Project

For particularly large projects, you may need to grade one section of the project, then move the laser to finish other sections.

Multiple Pads Laser Transmitter Placement

When grading multiple pads, place the laser in a location that allows you to grade several pads without moving the laser (Figure 3-3).

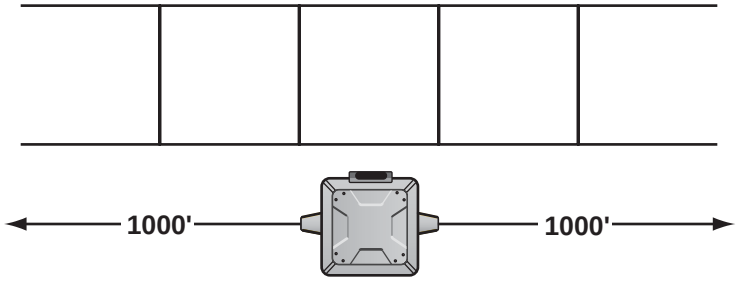

Figure 3-3. Laser Transmitter Placement – Multiple Pads Project

Hilly Pads Laser Transmitter Placement

When grading on a hilly project, place the transmitter so the elevation of the laser allows for maximum work to be completed before moving before moving it to another location (Figure 3-4).

1. Start at the top of the hill with the laser receiver on the machine at it's lowest position.
2. Adjust the height of the laser transmitter so the laser receiver picks up the laser.
3. As you work down the hill, raise the laser receiver to adjust for the difference in each pad elevation.

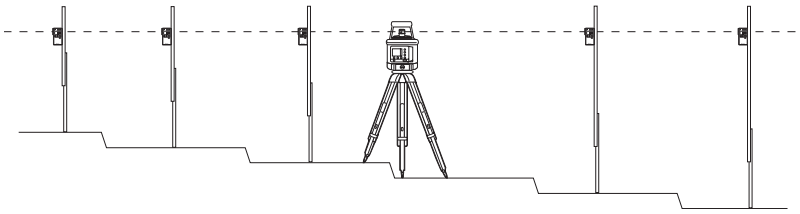

Figure 3-4. Laser Transmitter Placement – Hilly Project

4. If the receiver gets to it's maximum height, adjust it back down to the lowest position. Then move the transmitter down the hill until the laser receiver picks up the laser beam again, and continue grading.

Laser Transmitter Calibration

The laser transmitter is the grade control reference for your project. Check it daily to ensure correct calibration and make adjustments as necessary.

1. Set the laser on a tripod about 150' to 200' (45 to 60 meters) from the laser sensor and turn on the laser's power switch. Confirm that grades are set to 0% slope and the laser is in automatic level mode.
2. Set the laser sensor to "fine correction" mode, if applicable.
3. Raise or lower the sensor to get an on-grade signal (a solid tone) (Figure 3-5). Record or mark the position on the grade rod (X1).

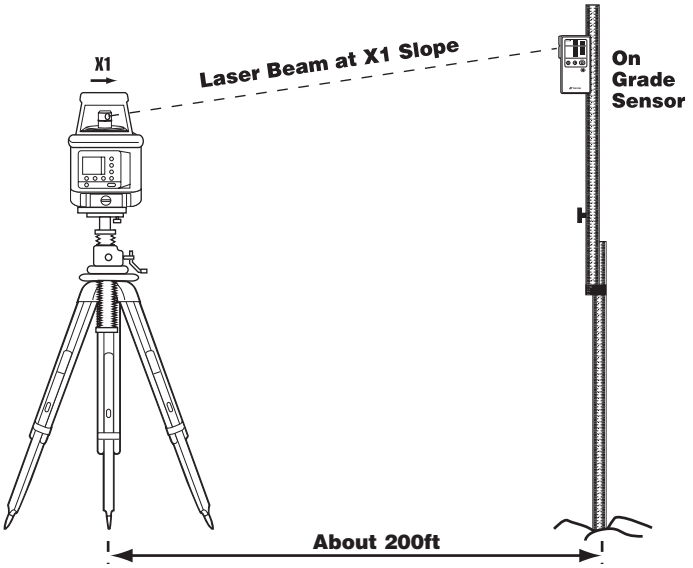

Figure 3-5. Raise Sensor

4. Rotate the laser 180° so that side two (the second X axis) points toward the grade rod (Figure 3-6).

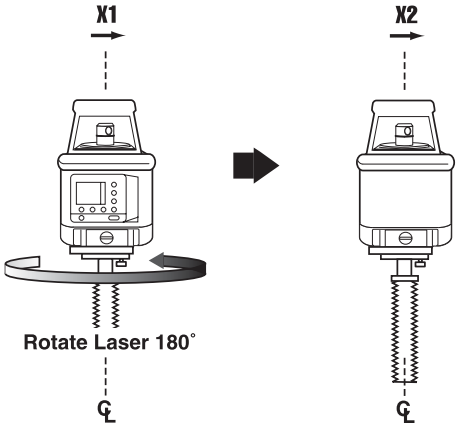

Figure 3-6. Rotate Laser

5. Raise or lower the sensor to get an on-grade signal (Figure 3-7). Record or mark the position on the grade rod (X2).

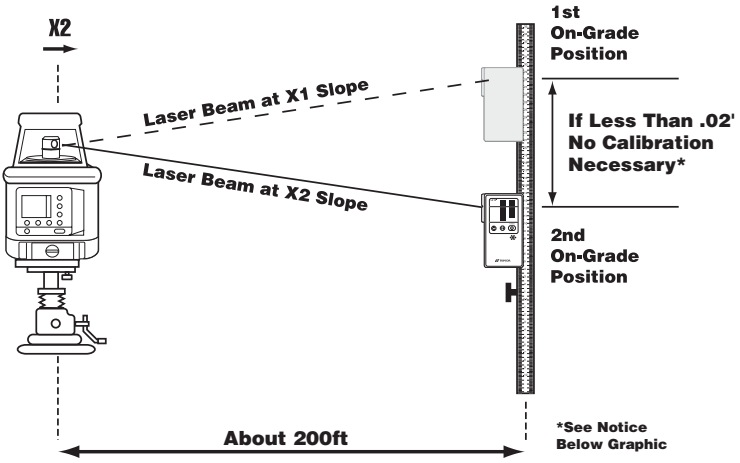

Figure 3-7. Note Laser Sensor's Second Position

The calibration error at the distance from the laser to the grade rod is half the amount between the first and second readings.

- If the calibration error is less than .015 ft., no calibration adjustments are necessary.

NOTICE

Laser transmitter models have different accuracy specification. Refer to your laser's documentation for accuracy specifications.

- If a calibration error over .015 ft. has been determined, a field adjustment can be made. See your laser's documentation for calibration adjustment procedures.

Laser Axis Alignment

When setting up the laser to grade a pad or an area with slope, correct laser alignment is critical. The laser transmitter must be aligned so that the laser slope is parallel to the desired slope of your project. Even slight rotation errors can cause significant error in the elevation of the cross slope axis. The steeper the slope, the more error you will have with an incorrectly aligned laser.

Automatic Alignment

For lasers with the automatic alignment feature (such as the RT-5Sa), follow these steps to correctly align the laser's axis:

1. Roughly align a laser's grade axis to within 10° of the true axis.
2. Position the alignment target:
   - on the true axis up to 328' (100 meters) from the laser,
   - so the "Up" arrow points up, and
   - with the reflective side facing the laser (Figure 3-8 on page 3-9).

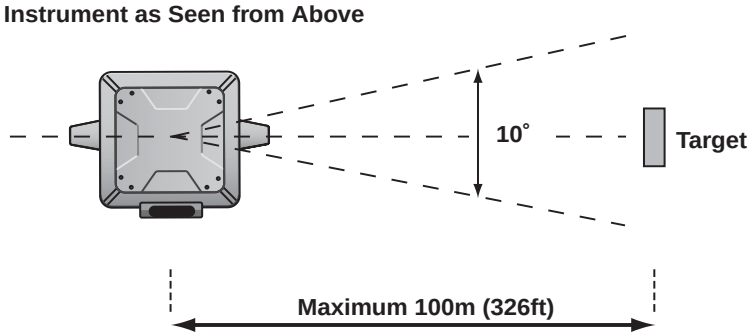

Figure 3-8. Automatic Alignment Positioning

3. Press **Automatic Alignment** on the laser's remote control or on the laser's control panel, then select the grade axis currently facing the alignment target.
4. Press **Enter** to begin auto-alignment.

Refer to your laser's documentation for further details.

Manual Alignment

For lasers with manual alignment, follow these steps to correctly align the axis of your laser.

1. Locate or place two hubs parallel to the slope of the project. The hubs should be approximately 300' apart, or completely across the project on small jobs.
2. Place the laser transmitter over one hub and dial in a 0% slope on both axis.
3. Align the laser by sight, pointing in toward the second hub.
4. Place the grade rod on the second hub and secure it to prevent movement.

   The laser transmitter and grade rod should now be positioned so they are parallel to the direction of slope.

5. Set the laser sensor to center the leveling bubble and get an on-grade signal, and lock it into position (Figure 3-9).

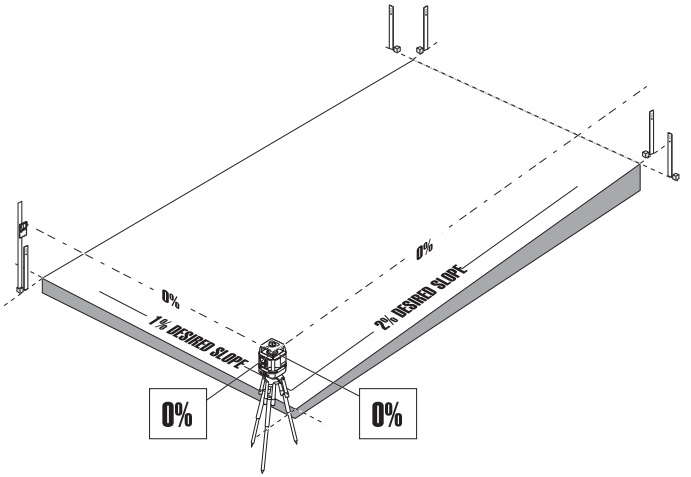

Figure 3-9. Laser and Grade Rod Positioning

6. Dial the slope into the laser transmitter on the axis facing away from the detector. Leave the slope on the axis facing the detector at 0%. If the laser is aligned properly, the grade on the 0% axis will not change at the second hub, and the detector will still have an on-grade signal (Figure 3-10 on page 3-11).

   If you do not have an on-grade signal, rotate the laser until you get the on-grade signal.

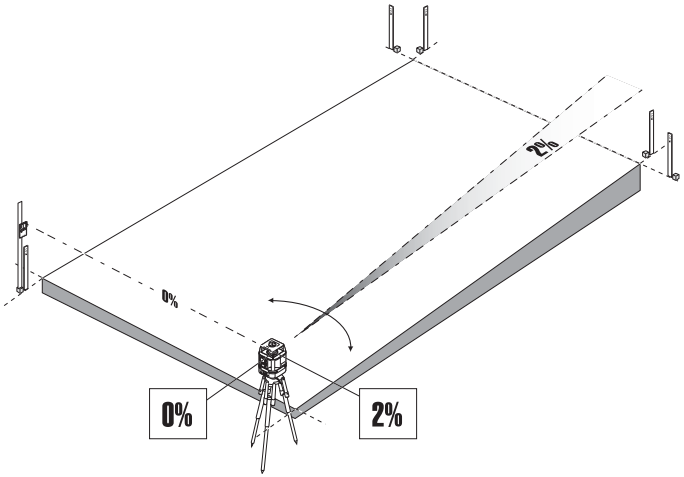

Figure 3-10. Larger Slope Set

7. Once you have an on-grade signal, the laser is aligned. Dial in the desired slopes for your project.

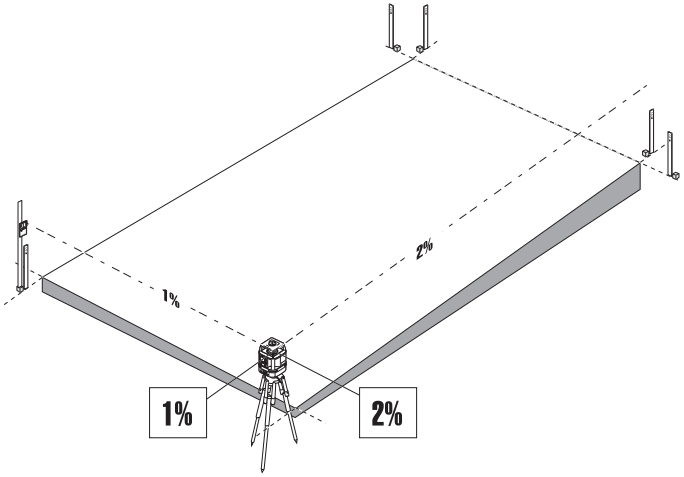

Figure 3-11. Laser Aligned to Project Slopes

Conditions Affecting the Laser Transmitter

The laser transmitter is the grade control reference for the job, and conditions that can affect the transmitter also affect the grade, or quality, of work. Once finish grade control reference points are in place (see “Setting Grade Reference Points” on page 3-14), continue to verify these points throughout the grading process. Succeeding day setups or conditions throughout the day (such as, laser transmitter drift, atmospheric conditions, wind, and other factors) can affect the accuracy of grade being cut or filled. Understanding and identifying these situations will help locate and fix the problem, allowing you to continue grading.

Laser Drift

Laser drift is caused as temperature changes affect the mechanical leveling system of the laser transmitter. Laser transmitters have a level sensor that acts like a precision carpenters level, allowing the transmitter to level to very accurate specifications.

As changes in temperature affect the mechanical leveling system, the laser will re-level to a new position. Although the laser “thinks” this new position is correct, it has induced an error in the grade. Many lasers have a separate level sensor for each axis, so the error may be different in each axis.

If grade increases on one side of the laser and decreases on the other side—or the implement cuts on one end of the project and fills on the other end—the laser beam has drifted and is at an incorrect position (Figure 3-12).

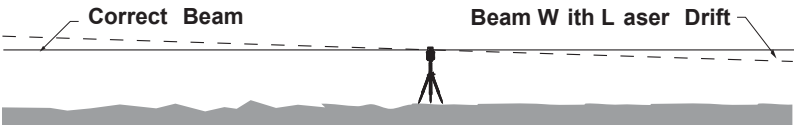

Figure 3-12. Laser Drift

To minimize problems associated with drift, Topcon has developed lasers with leveling systems that eliminate or greatly reduce laser drift. The RT-5S transmitter with it's five arc second accuracy and even less repeatability specification, has temperature compensation that automatically adjusts as the outside temperature changes. The RL-H2Sa laser has a five arc second repeatability specification due to the newly developed liquid compensated leveling system that has no mechanical parts to affect the level of the laser beam.

Atmospheric Laser Bending

Sometimes, atmospheric conditions can cause the laser beam to bend as it gets farther away from the transmitter. Different atmospheric layers cause this bending, and most frequently occurs in calm-air mornings and evenings in the spring and fall when rapid changes in temperature and humidity occur.

Since temperature and humidity changes also cause drift in some lasers, detecting atmospheric bending as well as drift can help reduce or eliminate grading problems.

Excluding laser drift, if the implement cuts (or fills) on all ends of the field, the laser is bent due to atmospheric bend (Figure 3-13).

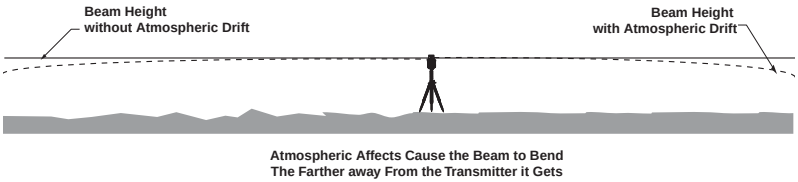

Figure 3-13. Beam Bending Due to Atmospheric Conditions

Atmospheric beam bending can be an inconsistent, increasing error the farther away from the transmitter. The beam bending may be undetectable or minimal at 500'/152m, and may bend down .05'/.015m or more at 1000'/305m from the laser.

Setting Grade Reference Points

Recognizing and measuring errors help to minimize problems and maintain productivity. Once errors are identified, they can be measured against pre-set benchmark hubs or finish grade spots. These grade control reference points can be used throughout the job to verify grade. Set up at least four reference points, one on each axis. On larger projects, use eight benchmarks, two on each axis.

When setting up control points, place the benchmarks 800–1000 feet/305 meters from the transmitter, or near the ends of the field for small projects (Figure 3-14).

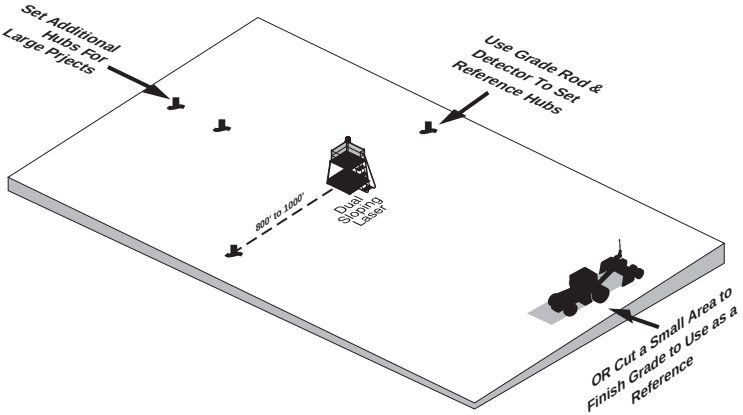

Figure 3-14. Set Grade References

If you suspect laser drift, atmospheric bending, or some other problem, use a grade rod on the benchmark hubs, or the implement on the finish grade spots, to measure the error. In most cases and with little or no drift, you can compensate for the small changes that occur from atmospheric bending.

- For 500’/152m to 700’/213m from the laser, there will be little change in grade.
- For 1000’/305m or more, elevation changes will be consistent for a given distance from the transmitter.

Once you have determined the errors and given points on the field, compensate for error due to drift or atmospheric conditions:

- Use elevation offsets in the Control Box to set an elevation for different areas of the field. See “Elevation Offset Button and Elev/Avg Button” on page 2-7 and “Elevation Offsets (Setpoints)” on page 2-34 for information.
- If grading throughout the night, the beam will most likely stay in that position until early morning, or until the wind mixes the layers of air. In this case, set the Control Box to compensate for this error.

NOTICE

Changing grade to match one end of the field to compensate for drift will cause double the error on the opposite side of the laser/field.

Therefore, only change grade on one side of the laser if working only on that side.

- If you measure transmitter drift, make an elevation adjustment to match the reference spot or hub, then work closely to that area. Wait for a time of day to work on other areas of the field when the drift is minimized.

Other Factors Affecting Quality

Along with laser drift due to mechanical and atmospheric drift, wind, dust, fog, and the curvature of the earth affect the accuracy and quality of grading.

Wind

To minimize the affects of wind:

- Secure and stabilize the tripod. Tie the tripod down in gusty wind conditions. In extreme conditions, build a mound and place the laser on a shorter tripod.
- Re-position vertical-mounted screw jacks on laser trailers to be at an angle.
- Four-legged trailers are sometimes difficult to get stable, especially in hard dirt. Wiggle the trailer until all legs are secure and have even pressure on the ground.
- Minimize the working distance from the laser transmitter. Use multiple lasers if needed.
- Increase the Averaging function on the System Five Control Box. If the implement then begins to “porpoise”—i.e., leaving long waves—lower the Averaging setting. See “Averaging” on page 2-25 for information on this setting.

Dust

Dust can block the transmission of the laser beam. A good rule of thumb in dusty conditions: if you can see the transmitter, the receiver can see the beam.

- Work haul paths in a cross-wind direction.
- In extreme dust conditions, try relocating the transmitter up-wind of the work area.

Fog

In fog, water droplets diffuse and refract the laser beam. In foggy conditions, the laser receiver will be unable to locate the beam, even if you can see the transmitter.

Curvature of the Earth

In theory, a transmitted laser beam will go forever in a straight line; however, the earth is round. Even if the laser has slope dialed in, the affects of a straight beam of light on the round earth are the same. Unless grading at extreme distances, the errors generated from the curvature of the earth are undetectable.

If leveling huge fields, use multiple transmitter setups due to the limitation of the laser distance. Since each laser transmitter levels itself using gravity, the total field distance will not cause compounding errors.

Table 3-1 shows the error's due to the earth's curvature at distances from the laser transmitter.

Table 3-1. Errors Due To Earth's Curvature

Distance From Laser	Curvature of Earth
500' / 152m	.006' / .00183m
1000' / 305m	.024' / .00732m
1500' / 457m	.054' / .01646m
2000' / 610m	.096' / .02926
2500' / 762m	.150' / .04572m
3000' / 914m	.215' / .06553m
4000' / 1219m	.383' / .11674m

Laser Accuracy and Repeatability

The accuracy and repeatability of a laser transmitter are measured in arc seconds. Arc seconds is an angle of measurement used when specifying the accuracy of a laser or other leveling instrument.

A circle is divided into 360°. A degree is divided into 60 arc minutes. An arc minute is divided into 60 arc seconds. Table 3-2 shows how arc seconds relate to elevation at a distance.

Table 3-2. Arc Seconds vs. Feet/Meters

	At 100’ /30m	At 500’ / 152m	At 1000’ / 305m
1 arc second =	.0005’ / .00015m	.0024’ / .00073m	.0048’ / .00146m
5 arc seconds =	.0024’ / .00073m	.012’ / .00366m	.024’ / .00732m
10 arc seconds =	.0048’ / .00146m	.024’ / .00732m	.048’ / .01463m
15 arc seconds =	.0072’ / .00219m	.036’ / .01097m	.072’ / .02195m

Grading

With System Five™ and a laser transmitter, you can make faster, fewer, and more consistent cuts to get to grade.

Grading allows the operator to move soil from high spots to low spots, cutting and filling the pad to achieve on-grade. With the use of a laser transmitter and receiver, you can set a specific grade value into the control box, then begin to grade. While you grade, the laser receiver tracks the laser beam, telling the hydraulic valves to move the blade or implement up or down, keeping it on-grade. The result is a smoother and more accurate grading job.

Grading Preparation

Before you begin to grade, you need to:

- Setup the laser transmitter.
- Enter an initial reference elevation.
- Set the cutting edge to grade.
- Set the working reference elevation.

See the following sections for grading preparation procedures.

Laser Transmitter Setup

Setup your rotating laser in the center of the field/pad or in a position within range of the area you intend to grade.

See “Laser Setup” on page 3-1 for general laser transmitter setup and calibration procedures. Refer to your laser’s documentation for more specific setup instructions.

Setting the Cutting Edge to Grade

Setting the cutting edge to grade with a machine control laser dramatically reduces the amount of time needed to set and check grade.

If the laser receiver looks like it rests too low on the mast/pole, raise the laser transmitter. Conversely, if the receiver seems too high on the mast, lower the laser transmitter.

1. Place the grade rod on a reference hub and move the detector up or down to get an on-grade signal (Figure 4-1).

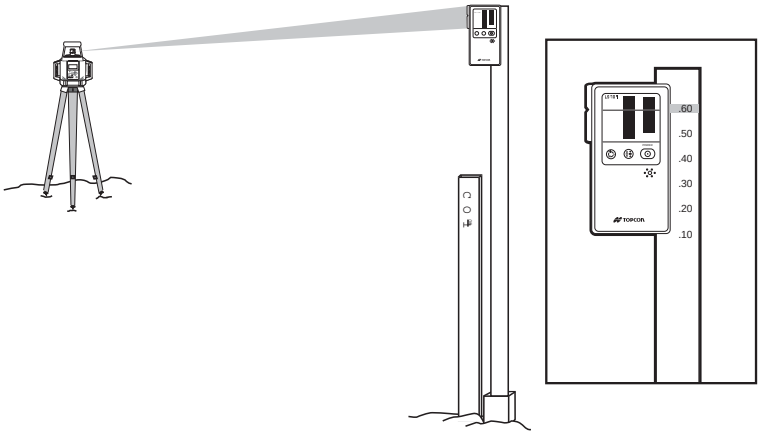

Figure 4-1. Detect Beam and Adjust Rod for On-grade

2. Adjust the rod for cut/fill or known elevation of the reference hub (Figure 4-1).
3. Set both sides of the cutting edge on the ground. Press the **Survey/Search** button to have the receiver search for and lock onto the laser transmitter for an on-grade reading (Figure 4-2 on page 4-3).

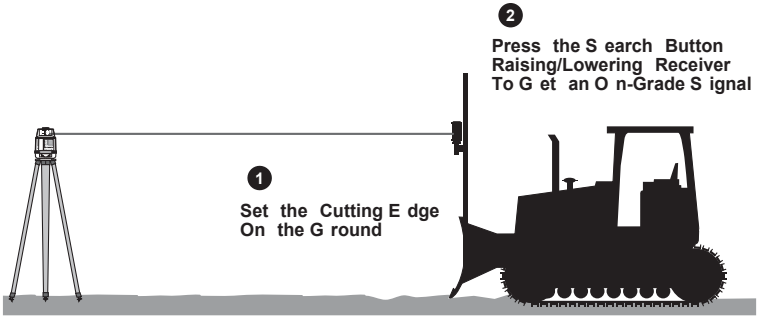

Figure 4-2. Adjust Laser Height to Center Receiver

4. Press the **Auto/Manual** button to set the System Five in automatic mode. Grade a short pass.
5. Using the grade rod and detector, check the grade cut behind the machine (Figure 4-3).

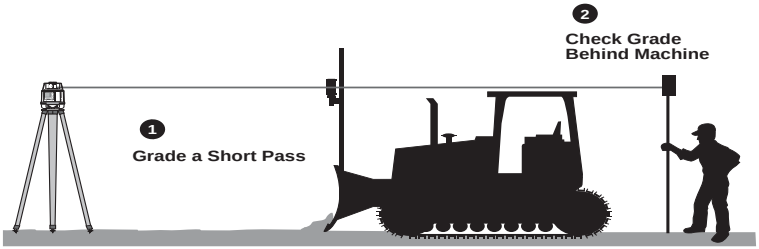

Figure 4-3. Grade a Short Pass, Then Check Grade

6. Raise or lower the laser receiver as needed to cut the correct grade, then begin grading the pad.

Setting the Elevation Reference Number

After using the grade rod to verify grade, set the Control Box display to reference “finish grade”. Typically, the reference hubs on the jobsite provide either a true elevation reference or a cut/fill value for the graded area. The Control Box can be set to read either the true elevation number or a cut/fill value.

Use a True Elevation Reference Number

Typically, you grade flat pads or dead level surfaces to a true or known elevation. After making a pass in automatic mode and verifying the grade using the grade rod, set that number into the display. For example, if the grade is cut at a known elevation of 325.65 feet, set the display to read 5.65.

1. Press and hold the **Set/Menu** button.
2. Dial in the desired value using the **Grade Adjustment Knob** (e.g., 5.65). Both the Grade Correction Indicator Lights and the Double Arrows light up.
3. Release the **Set/Menu** button to save the elevation reference value.

After setting the display, turn the Grade Adjustment Knob to the desired finished pad elevation and switch to automatic control. System Five will control the cutting edge to grade the pad to the desired elevation. This works well when grading multiple pads at different elevations.

Use a Cut/Fill Value (0.00 Grade Reference)

Jobs with sloped surfaces typically use a cut/fill value, or 0.00 grade reference; however, flat pads can also use a zero value. After making a pass in automatic control and verifying the cut/fill amount using the grade rod, set that cut or fill number into the Control Box. For example, if the cutting edge is .15 feet above finish grade, set the display to read .15 feet.

1. Press and hold the **Set/Menu** button.
2. Dial in the desired value using the **Grade Adjustment Knob** (e.g., 0.15). Both the Grade Correction Indicator Lights and the Double Arrows light up.
3. Release the **Set/Menu** button to save the elevation reference value.

After setting the display, turn the **Grade Adjustment Knob** to 0.00 and switch to automatic control. System Five will control the cutting edge to grade the pad to the desired finish grade.

Use Multiple Elevation Settings

The Control Box can be set for jobs with multiple elevation settings, or offsets, from one pass to another. You can set up to three different elevation offsets using the elevation offset switch and the performance menu. For example, if the job requires three different pad elevation settings, Pad #1, Pad #2 and Pad #3, set three different offsets/references.

1. In the Performance Menu, rotate the **Grade Adjustment Knob** to access the Setpoints (SPt) menu, and press the **Auto** button. See “Performance Menu” on page 2-15 and/or “Elevation Offsets (Setpoints)” on page 2-34 for information on using the Performance and Setpoints menus.
2. Rotate the **Grade Adjustment Knob** to select the number of offsets, from one to three, required for the job (e.g, 3).
3. Press the **Auto** button to save the selection, then the **Set/Menu** button to return to Control Mode.
4. Dial the **Grade Adjustment Knob** to set the display to the first desired pad elevation (for example, 5.50).
5. Press the **Offset** button for one second, to save the first offset/reference value and move to the next offset.

6. Repeat steps four and five until the desired number of offsets/references have been set (for example, 6.50 and 5.00).

Each time you press the **Offset** button for one second, the grade reference setting moves to the next offset, or elevation reference (for example, 5.50 to 6.50 to 5.00).

To change an elevation setting, turn the Grade Adjustment Knob; changing one setting will not effect other settings.

Grading with the System Five

Once the laser transmitter and Control Box have been set up, and the elevation reference entered or selected, begin grading passes.

1. With the laser receiver and cutting edge on-grade, press the **Auto/Manual** button to set the Control Box to Manual Control Mode.
2. Grade for several feet, then press the **Auto/Manual** button to set the Control Box to Automatic Control Mode. The Auto LED illuminates.
3. In the first 50 feet or so of grading, check the grade several times to make grade adjustments as necessary and/or ensure correct grade.

   Even if the pass is off a couple of hundredths, it will be consistently off those hundredths. Therefore, dial in a smaller cut amount on the first pass to determine the grading accuracy of the setup. Then, you can make grade adjustments as necessary to achieve the desired grade.

Troubleshooting

In general, as long as you follow the maintenance and safety instructions provided in this manual, you should have few problems with your System Five™ Control Box. This chapter will help you diagnose and solve some common problems you may encounter with your Control Box.

Before contacting your local Topcon Distributor, try the following:

- Check that all cables are securely and properly connected to the various components of the System Five (control box, TM-1 mast, laser receiver, valves, sensor, etc.).
- Disconnect cables and inspect them for damage or contamination. Clean all connections with an electrical contact cleaner.

Control Box Problems

This section lists possible System Five Control Box problems you may encounter. If you still have problems after trying the solutions listed here, contact your local Topcon Distributor.

Problem	
The Control Box LCD does not display.	
Causes	**Solutions**
The Control Box does not have power.	Check that the machine has power. Check the power cable fuse. Replace if necessary. Check that all cables are properly and securely connected to the System Five™ Control Box. Disconnect cables and inspect them for damage or contamination. Clean all connections with an electrical contact cleaner.
Problem	
Control Box LCD displays “Error”.	
Causes	**Solutions**
The Control Box cannot communicate with the laser receiver.	When turning on the Control Box, watch the lights on the laser receiver. The lights should flash, indicating the Receiver has power. Check that all cable are properly and securely connected. Check and/or clean all cables as described on page 5-1.

Problem	
Grade lights flash high and low and will not stay On-Grade.	
Causes	**Solutions**
If problem is only in automatic mode, then hydraulic Performance Settings are incorrect.	Valve Offsets are incorrect. See below. Check if the Gain setting is too high. Reduce the Gain setting as necessary. See “Gain (Elevation)” on page 2-19 or “Gain (Slope Control)” on page 2-20.
If problem is also in manual mode, then...	The laser transmitter is unstable, secure the laser. Check that the Deadband in Performance Menu is not less than 6mm. See “Elevation Deadband” on page 2-26 or “Slope Deadband” on page 2-28. Increase the Averaging setting using the Performance Menu. See “Averaging” on page 2-25.
Problem	
The valve is driving the hydraulic cylinder too far and overshooting grade.	
Causes	**Solutions**
Valve Offsets in Control Box are set too high.	Lower the Valve Offset value until the sensor no longer overshoots grade. See “Valve Offset” on page 2-22 for more information. For Servo and Solenoid valves, lower the value by 2 to 5 numbers, then check the hydraulic performance. For Proportional valves, lower the value by 10 to 15 numbers, then check hydraulic performances.

Problem	
The valve will not drive the hydraulic cylinder far enough to get the sensor On-Grade.	
Causes	**Solutions**
Valve offsets in Control Box are set too low.	Raise the Valve Offset value until the sensor is driven to grade. See “Valve Offset” on page 2-22 for more information. For Servo and Solenoid valves raise the value by 2 to 5 numbers, then check hydraulic performance For Proportional valves raise the value by 10 to 15 numbers, then check hydraulic performance.