BILL V'S
DERBY TIMERS

Arduino Based Drag Race Timer for RC Scale Model Cars Version 3

USER MANUAL

1 INTRODUCTION

The drag race timer discussed herein has been specifically designed for 1/10 scale Radio Controlled (RC) cars. This design has been tailored to mimic the features of an actual drag strip timing system including a functional light (i.e. Christmas) tree, start line sensors that support vehicle staging and reaction time measurement, 6 Ft and 66 Ft sensors to provide vehicle performance times as it races down the track, trap and finish line sensors to determine the vehicle speed, elapsed and overall time. This timer design is intended to be run from a PC running the author's race management software. It does however, have the capability to be controlled remotely by a single hand-held pushbutton tethered on a cable. The race management software controls the race timer, displays and saves race results and allows for printing of time slips at the conclusion of each race as is done in actual drag strip timing systems. The software provided with this version has been tailored for a 1/10 scale quarter-mile (132 Ft) track with speed indications in Miles-Per-Hour (MPH).

The drag race timer design supports seven sets of optical sensors positioned down the track as follows:

1. **Pre-Stage Beam/Sensors**: Positioned 2" aft of the stage beam/sensors to support vehicle staging
2. **Stage Beam/Sensors (Start Line)**: Positioned at the start line to indicate when a vehicle is staged
3. **Guard Beam/Sensors**: Positioned 1" forward of the start line to indicate when a vehicle has left the start line.
4. **6 Foot Sensors**: Positioned 6 feet down track from the guard beam and provide a time when the vehicle has traveled 6 feet down track.
5. **66 Foot Beam/Sensors**: Positioned 66 feet down track from the stage beam and provide a time when the vehicle has traveled 66 feet (half way) down track.
6. **Trap Beam/Sensors**: Positioned 5.28 feet prior to the finish line. Work in conjunction with the finish line sensors to determine the vehicle speed at the end of the run.
7. **Finish Beam/Sensors:** Positioned at the finish line. Measure vehicle race finish time.

The Christmas tree can be set to function as either a RCDRL (Radio Controlled Drag Racing League) "Standard" tree (AKA "sportsman" or "full" tree), a RCDRL "Professional" (Pro) tree or as a "street outlaw" tree. The timer can be set to either start the race manually or automatically. The timer can also be set to handle one or two racers. This version of the timer does **not** support bracket racing or provide a 60 second staging timeout feature (to be added in a future upgrade).

Note: Many RC cars do not have adequate chassis/ground clearance to permit start line staging based on front wheel position. Hence, this version uses the car's body to detect its position for pre-stage and stage indications. A "guard" beam positioned about 1" forward of the stage beam is used to detect when the car leaves the start line.

The Arduino MEGA™ micro-controller board used in this timer provides the interfaces to the optical lane sensors, Christmas tree and hand-held race start pushbutton and executes the software that drives the Christmas tree lights, monitors the track sensors, performs the timing and sends the race results and track status to the PC for display and post-race processing. Data is transferred between the Arduino based timer and the PC via its USB port.

The race management software running on the PC (see Fig. 11a & 11b) provides display of the race start reaction time, 6 Foot marker time, 66 Foot marker time, trap speed (in MPH), elapsed time, overall time (elapsed time + reaction time) and racer's status (win, draw, disqualified). Race times are displayed down to three decimal places (0.001 seconds or 1 millisecond). The race results can also be printed on a thermal receipt printer to provide a hardcopy Time Slip to the race participants. All race results are saved to a comma-

delimited data file that can be read by MS Excel or other spreadsheet software. The race management software also provides the ability to view and print prior race results and continue a race from a previously saved race event. Mouse clickable buttons allow the user to (1) enter racer ID numbers, (2) ready the timer for the next race, (3) start the race, (4) manually print time slips, and (5) as previously mentioned, view race results from previously run races. A message box at the bottom of the race management screen provides for the display of timer and track status messages. Additionally, keyboard function keys F1, F2, F3 and F5 are utilized to (1) select Christmas tree operation between “Standard”, “Professional” or “Street Outlaw” mode, (2) select between auto start and manual start, (3) select single or dual vehicle race mode and (4) perform a Christmas tree lamp test.

2 GETTING STARTED

2.1 Timer Components

The drag race timer consists of the components listed in Table 1 below.

Table 1. Timer Components

Component	Description / Function
Infrared Lane Sensors each consisting of 1 infrared transmitter module and 1 infrared receiver module. Qty=14 (7 per lane) Note that the transmitter modules are separate units powered by a 12 volt battery pack to provide for portability and ease of setup.	The infrared sensors sense and report when its invisible infrared beam is interrupted (broken) by an object. They are positioned along the track as follows: • Pre-Stage line – Positioned 2" aft of the start line. • Stage line – Positioned at the start line. Used to support staging. • Guard line – Positioned 1" forward of the start line. Used to measure start of Elapsed Time (E.T.) and Reaction Time. • 6 Ft line – Positioned 6 feet down track form the guard line. • 66 Ft line – Positioned 66 feet down track form the guard line. • Trap line – Positioned 5.28 feet before the finish line. Used in conjunction with the finish line sensors to calculate vehicle speed (aka Trap speed). • Finish line – Positioned at the finish line. Used to measure total elapsed time.
Main Timer Unit	Contains all the electronics including the Arduino microcontroller for: • Monitoring the lane sensors and hand-held pushbutton • Driving the Christmas tree • Performing the timing and timing calculations • Sending race results to the PC.
Hand-Held Race Start Button	Provides a means to start the race from a location other than the PC. Typically this is done by the same person who is assisting with staging the cars at the start line.
Light (Christmas) Tree	Houses the staging, countdown sequence and disqualification lights.
PC (Laptop)	Computer that runs the race management software.
Optional: Time Slip Printer	Thermal (receipt/point-of-sale) printer that prints the time slips at the end of each race.
Cable Assemblies	Provide for the electrical connection of the timer components.

2.2 Component Setup

It is assumed the end user has already measured and laid out the 2-lane track. Figure 1 provides the suggested locations of the timer components. This configuration eliminates the need for any electrical cables to cross the racing lanes.

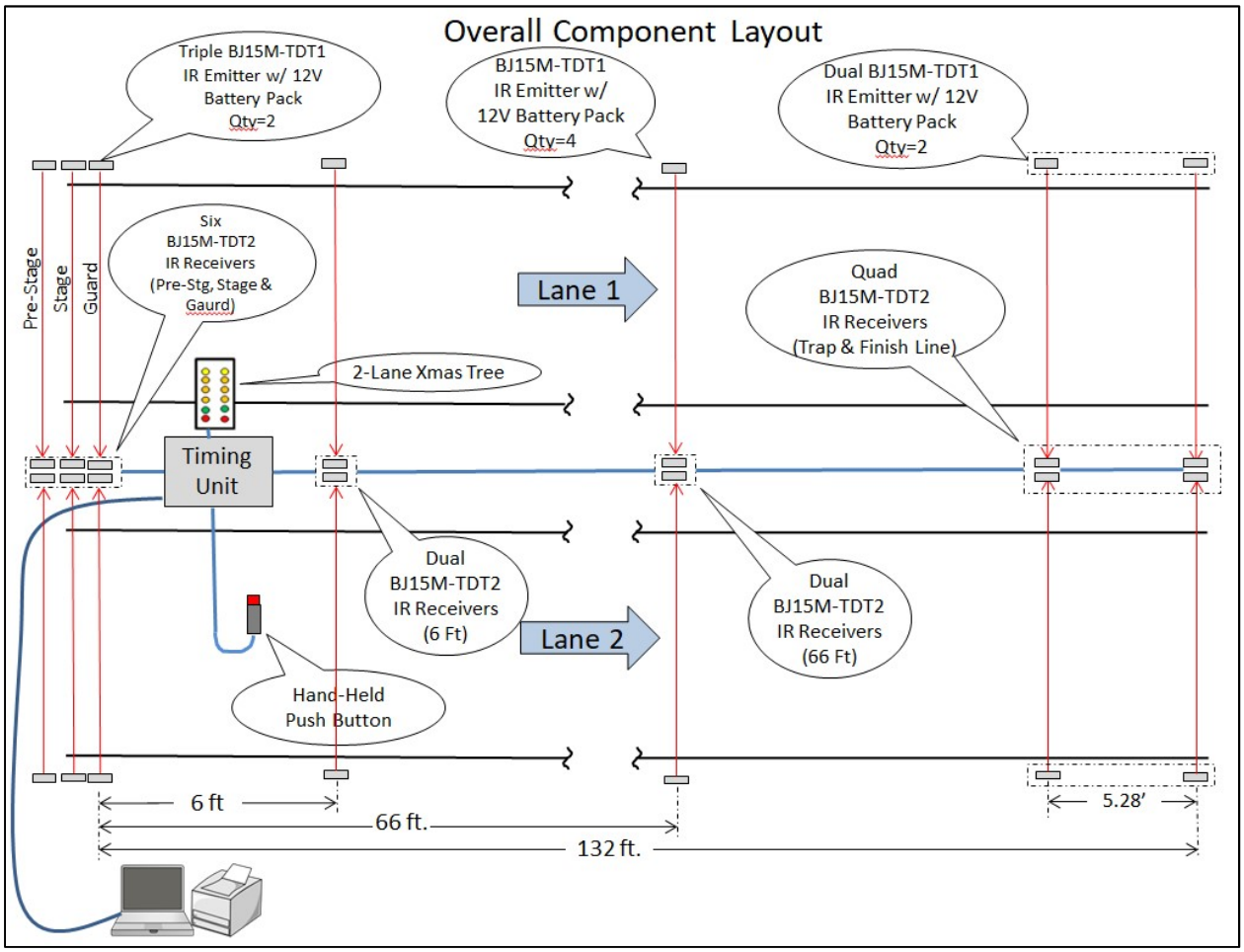


Figure 1 – Timer Component Layout

2.3 Timer Software Installation

All required software except for the Arduino Integrated Development Environment (IDE) and the Processing Integrated Development Environment (IDE) is provided as part of the design package. It is assumed the end user will select and acquire a suitable thermal receipt (aka Point-of-Sale) printer to be used as the Time Slip printer and install/setup the drivers required for it. Access to the Internet is required to download and install both the Arduino and Processing IDEs. The race management display software is JAVA based and was developed using a free software package called "Processing3" which is downloadable from the WEB at the Processing.org website (https://processing.org).

2.3.1 Race Management/Display Software Installation

With connection to the internet established, go to https://processing.org and follow the instructions to download and install the Processing Integrated Development Environment (IDE). The WEB site also provides tutorials and step-by-step instructions to help you every step of the way.

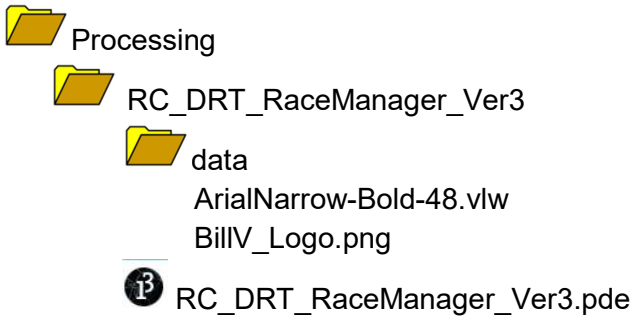
For Windows machines:

- Use File Explorer to view the contents of the Processing zip (e.g. processing-3.5.4-windows64.zip) file you downloaded. It should contain a folder called 'processing-x.x.x'.
- Drag the 'processing-x.x.x' folder into your C:\Program Files\ folder.
- Double click 'processing.exe' to launch the program and cause it to install. If everything goes right it should create a Processing folder under your Document folder and start with the Processing IDE screen displayed.
- Exit Processing.

Once you have the Processing IDE installed, perform the following:

1. Create a subfolder called 'RC_DRT_RaceManager_Ver3' under the "Processing" folder.
2. Copy the file 'RC_DRT_RaceManager_Ver3.pde' from the source to the 'RC_DRT_RaceManager_Ver3' folder just created.
3. Now create a subfolder called 'data' under the 'RC_DRT_RaceManager_Ver3' folder.
4. Copy the files 'ArialNarrow-Bold-48.vlw' and 'BillV_Logo.png' from the source into the 'data' folder.
5. Update the Time Slip file path per Section 2.3.3.4 to match your PC's folder hierarchy (IMPORTANT).
6. Review Section 2.3.3 and make any desired changes to the User Modifiable Parameters.

The folder/file hierarchy should look like this:

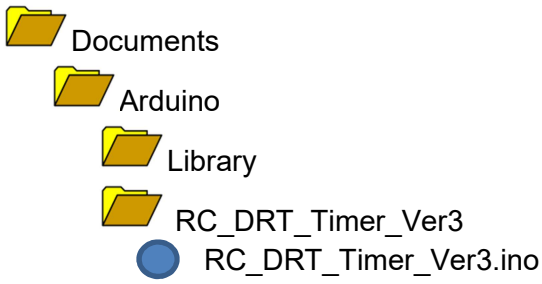


2.3.2 Arduino Integrated Development Environment Software Installation

With connection to the internet established, go to https://www.arduino.cc/ and follow the instructions to download and install the Arduino Integrated Development Environment (IDE). The WEB site also provides tutorials to help you every step of the way.

Once you have the Arduino IDE installed, create a subfolder called 'RC_DRT_Timer_Ver3' under the "Arduino" folder (same folder containing the Arduino Library folder). The "Arduino" folder was created during the install, usually under your Documents folder. Now copy the file 'RC_DRT_Timer_Ver3.ino' from the source to the 'RC_DRT_Timer_Ver3' folder you just created.

This is a typical folder/file hierarchy but may vary:



NOTE: Installation of the Arduino Integrated Development Environment (IDE) also installs the necessary USB drivers for your PC to communicate with the Arduino via a serial RS-232 type (i.e. COM1, COM2, etc.) communication link. These drivers are also used by the race management/display software discussed in Section 2.3.1.

2.3.2.1 Uploading the timer code to the Arduino

Perform the following steps to upload the timer code to the timer unit's Arduino microcontroller.

Step	Action	Comments
1	Ensure your PC is powered up and ready.	N/A
2	Apply power to the track timer unit. **- - Note - -** Track Timer should always be powered up before connecting it to your PC.	N/A
3	Connect the track timer (Arduino MEGA 2560 board) to your PC USB port via the USB cable.	N/A
4	Double click on the 'RC_DRT_Timer_Ver3.ino' file to launch the file and bring up the Arduino integrated development environment.	Arduino integrated development environment window is displayed with the RC_DRT_Timer_Ver3 source code listing.
5	Select the 'Tools/Board' pull-down menu to select/verify the "Arduino MEGA or MEGA 2560" board is selected.	N/A
6	Select the 'Tools/Port' pull-down menu to select/verify the COM port selection (i.e. COM1, COM2, etc.).	Arduino COM port is selected / verified.
7	Select "→" (upload) to start the compile and upload process.	The program will compile and automatically upload to the Arduino board.

Refer to the Arduino website for more in depth instructions if problems are encountered. Note that once the software has successfully been uploaded to the Arduino board, it is there permanently, unless overwritten by another upload. Hence, you only have to perform these steps once. Future use of the Arduino timer during your race events does not require an upload. Just connect the Arduino timer to your PC, launch the Display software and you should be ready to go.

2.3.2.2 Time Slip Printer Setup

It is assumed the end user will provide the Time Slip printer and install/setup its drivers. During the driver setup the user must set the Time Slip printer as the "Default" printer. Additionally it may be required that a custom paper size be created/selected to avoid excessive amounts of paper to form feed at the end of each print out. Other settings, depending on the make & model of printer, may also be required including default font size and margins. This can be done in the printer properties menus. Note that when a time slip is generated, it is saved to a text file (Timeslip.txt) that can be manually printed with a regular printer using Notepad or other word processing software. This file is overwritten each time a new time slip is generated.

2.3.3 User Modifiable Parameters

The race management/display software has a handful of settings that can be modified by the user as follows:

- Display Title: Text displayed at the top of the screen
- Time Slip Header Line 1: 1'st line of user modifiable text printed at the top of the Time Slip
- Time Slip Header Line 2: 2'nd line of user modifiable text printed at the top of the Time Slip
- Time Slip Footer Line 1: 1'st line of user modifiable text printed at the bottom of the Time Slip
- Time Slip Footer Line 2: 2'nd line of user modifiable text printed at the bottom of the Time Slip
- Auto Print Copies: Number of Time Slip copies to automatically print at completion of each race
- Time Slip file path: File folder in which the Time Slip text file is saved.

These settings are made prior to program startup and once saved; do not need to be re-entered each time the program is started. Figure 2 shows the section of source code that contains these modifiable user defined parameters.

```
/* * * * * * * * * * * * * * * * * * * * USER DEFINED PARAMETERS * * * * * * * * * * * * * * * * * * * * * * * * */
String Disp_Title = "Organization Name Goes Here";  //Text string to hold display title
String TS_Header1 = "DFW Winternationals";          //Time Slip header line 1 (33 Char Max)
String TS_Header2 = "RC Car Drag Racing";           //Time Slip header line 2 (33 Char Max)
String TS_Footer1 = "Thanks for racing with us";    //Time Slip footer line 1 (33 Char Max)
String TS_Footer2 = " ";                            //Time Slip footer line 2 (33 Char Max)
int Autoprintcopies = 0;                            //Number of copies to automatically print after race
//Set the file path for printing the Time Slip file
String File_Path = "C:/Users/Bill/05-RC_TenthScale_Timers/RC_DRT_Ver1_New/RC_DRT_RaceManager_Ver1/Timeslip.txt";
/* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * */
```

Figure 2 - Screenshot of User Defined Parameters Code

2.3.3.1 Modifying the Display Title

The race management software source file (RC_DRT_RaceManager_Ver3.pde) is delivered with a generic heading of "Organization Name Goes Here". The heading text can be easily changed to suit your needs. To change the heading, perform the following:

- In the Processing Display Environment scroll down to the "USER DEFINED PARAMETERS" section of the code (See Fig. 2) and find the line: *String Disp_Title = "Organization Name Goes Here"; //Text string to hold display title*

- Edit the text within the double quotes as desired. Do NOT change any other part of the line. Note that the text will automatically center on the screen when the program is run so you don't have to worry about adding extra spaces.
- Select save (Ctrl S) to permanently save your changes.

2.3.3.2 Modifying the Time Slip Header and Footer Text

The race management software source file (RC_DRT_RaceManager_Ver3.pde) is delivered with example text for the two Time Slip header lines and the two Time Slip footer lines. The header and footer text can be easily changed to suit your needs. To change the header and footer text, perform the following:

- In the Processing Display Environment scroll down to the "USER DEFINED PARAMETERS" section of the code (See Fig. 2) and find the lines starting with: *"String TS_Header1…", "String TS_Header2…", "String TS_Footer1…", "String TS_Footer2…"*
- Edit the text within the double quotes as desired. Do **not** exceed 33 characters and do **not** change any other part of the line. Note that the text will automatically center on the Time Slip printout when the program is run so you don't have to worry about adding extra spaces.
- Select save (Ctrl S) to permanently save your changes.

Figure 3 shows an example time slip with 2 lines of header text and one line of footer text (2'nd footer line left blank).

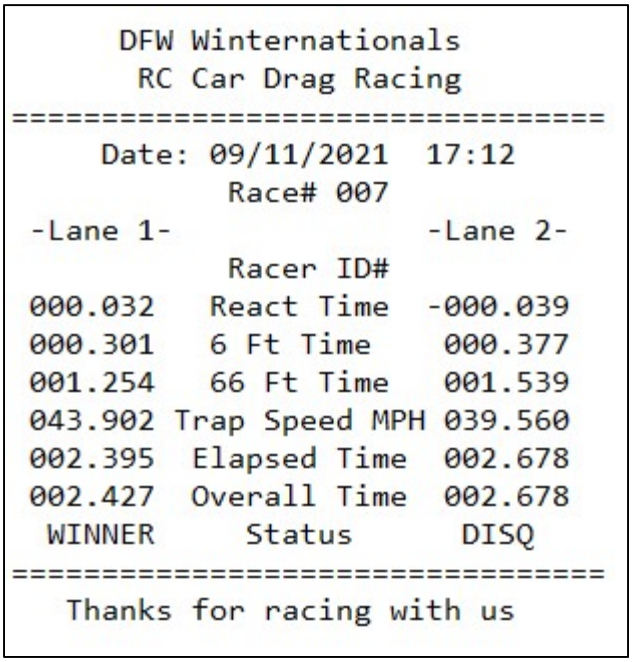


Figure 3 – Sample Time Slip

2.3.3.3 Modifying the Number of Time Slip Copies Automatically Printed

The race management software source file has a variable that defines the number of Time Slip copies to be automatically printed at the completion of each race. The software is delivered with this variable set to 0 (zero). To change the number of copies to be automatically printed, perform the following:

- In the Processing Display Environment scroll down to the "USER DEFINED PARAMETERS" section of the code (See Fig. 2) and find the line starting with *"int Autoprintcopies = 0;…"*
- Change the value from 0 to the desired number of copies. Do not enter a negative number. Typically a value of 2 is used (one copy for each racer).
- Select save (Ctrl S) to permanently save your changes.

NOTE: It is recommended that this setting be kept at zero during initial startup until correct time slip printing has been verified using the "Print Time Slip" button.

2.3.3.4 Modifying the File Folder Directory Path for the Time Slip Text File

NOTE: This step is mandatory as part of the software installation process.

The race management software source file (RC_DRT_RaceManager_Ver3.pde) has a string variable that defines the directory file path in which the Time Slip text file is saved. **Program limitations require that the file be saved in the same folder containing the program code (sketch).** A Windows command line is executed to print the text file to the printer. The file path must be updated to match the folder in which it is saved on your computer. To update the file path, perform the following:

- In the Processing Display Environment scroll down to the "USER DEFINED PARAMETERS" section of the code (See Fig. 2) and find the line starting with: *String File_Path = "C:/Users/Bill/…."*
- Edit the portion of text within the quotes with the correct file path for your PC. Note that the file path text uses forward slashes, not backward slashes.
- Select save (Ctrl S) to permanently save your changes.

2.4 Race Management Software Features

This version of the race management software provides a number of features to enhance the race management experience. They include:

- COM port detection & selection at startup
- Ability to load a previously saved race event file and continue from where it left off
- Ability to view results from prior races
- Ability to enter a racer's ID number
- Manual and automatic Time Slip print capability
- User editable Time Slip headers and footers for race event customization.
- Ability to select between "Standard", "Professional" or "Street Outlaw" Christmas tree operation.
- Ability to select between automatic and manual race start
- Ability to select between single racer or dual racer timer operation
- Ability to initiate the Christmas tree lamp test
- Race winner indication via flashing Green indicator on the Christmas tree
- Remote manual race start and "next race" reset capability via a hand-held pushbutton switch
- Display of elapsed time (in seconds) while the race is in progress

2.4.1 COM Port Detection & Selection

When the race management program is started it will check the PC for all currently active COM ports and respond as follows:

- No COM ports Detected: Displays a warning pop-up message informing the user no COM ports were detected and then exits the program when the user clicks on OK.
- One COM port Detected: Assumes it is the Arduino COM port, automatically selects it and displays a pop-up message informing the user what COM port was selected.
- Two or more COM ports Detected: Displays a pop-up providing a list of available COM ports and allows the user to select which COM port to use. Once selected, a second pop-up message is displayed informing the user what COM port was selected.
- Selected COM Port unavailable: Displays a pop-up informing the user a COM port is not available and may be in use by another program.

2.4.2 Continuation from a Previously Saved Race Event

At program startup and following the COM port selection the user will be prompted if he wishes to continue from a previously saved race event (See Fig. 4). If he answers in the affirmative the user will be presented with a file selection popup from which to select the race event file (See Fig. 5). The filename will have the following format: “Race_Results_YYYYMMDDHHMM.csv”. These files can be found in the same folder containing the program code (Ref. Section 2.3.1). The selected file is then loaded and the results of the last race ran in the loaded file is displayed. The user can then continue the race event with the next available race number. Additionally, the user can also use the up/down arrows to view and print time slips of those races.

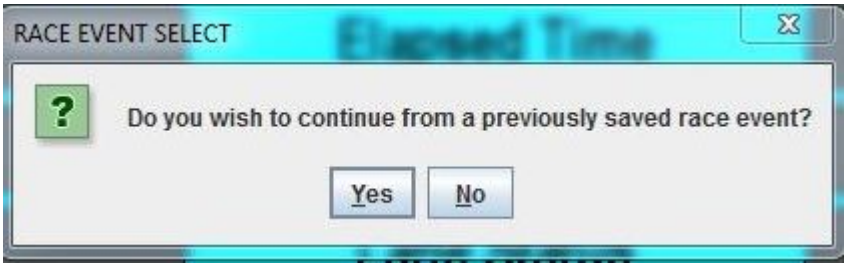


Figure 4 – Race Event Select Pop-up at Program Startup

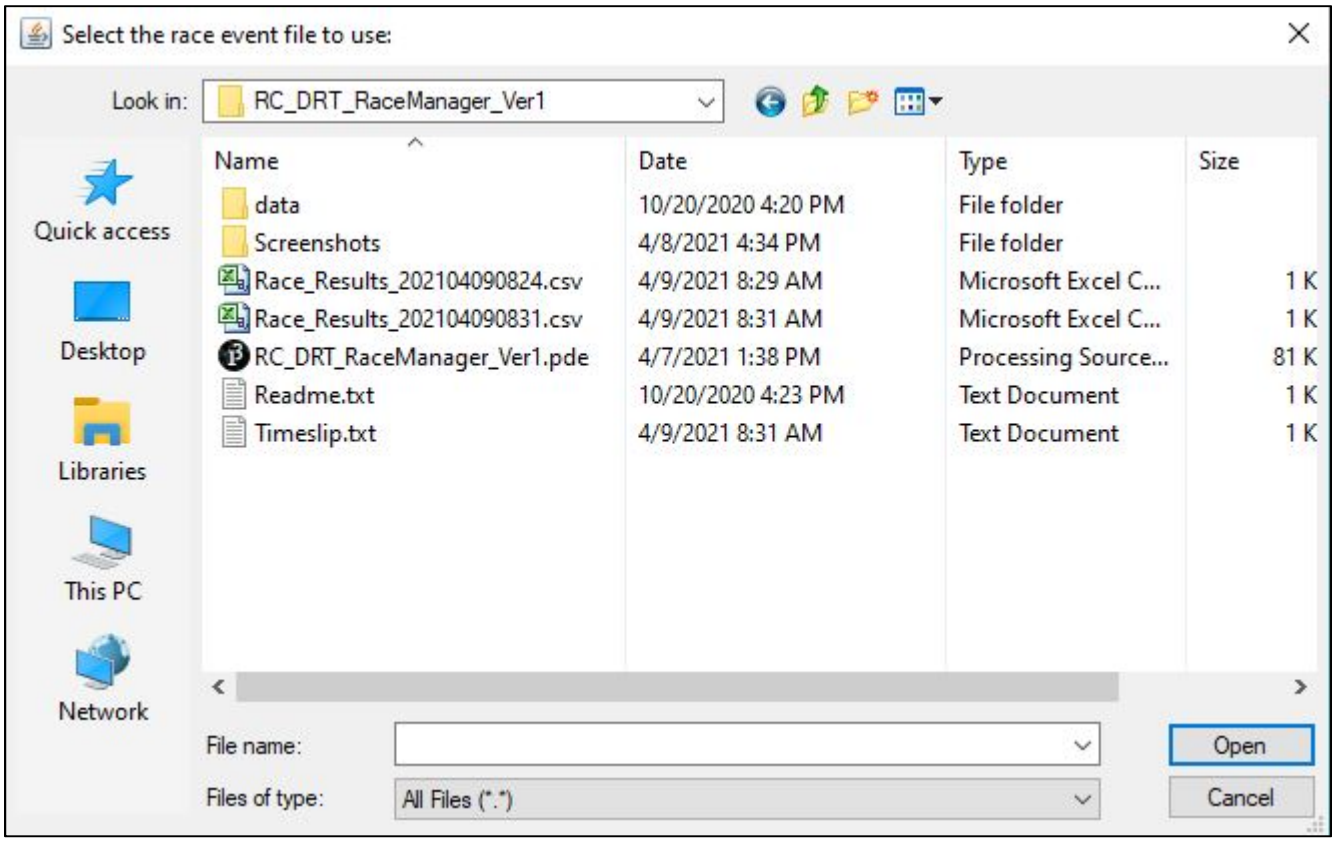


Figure 5 – Race Event File Selection Pop-up Example

2.4.3 View Prior Ran Race Results

Data from each race ran, or loaded from a prior race event as discussed in the Section 2.4.2 above, is stored in a data table and can be easily recalled for viewing and printing of Time Slips. To view a prior ran race click on the up/down arrow buttons in the Race # box. Note that the number cannot be advanced beyond the number of races in the data table. Note that the timer is disabled from starting a race while viewing previously run race results. Click on the up arrow until the new race number is again displayed to enable race start.

2.4.4 Race Management Display

The race management display displays the race results consisting of the reaction time, 6 foot time, 66 foot time, trap speed, elapsed time and total overall time (reaction time + elapsed time). Racer ID numbers and win/loose/draw status is also displayed. Refer to Figures 11a & 11b.

2.4.4.1 Reaction Time

Reaction time is the time from when the race timer starts (green Christmas tree light illuminates) to when the racer trips the guard sensor. If the guard sensor was tripped prior to illumination of the green Christmas tree light (racer left early), the reaction time is displayed as a negative number in red text. Reaction time is measured and displayed to the millisecond.

2.4.4.2 6 Foot Time

The 6 foot time is the time from when the racer leaves the start line (trips the guard sensor) to when the racer trips the 6 foot line sensor. This distance is the 1/10 scale equivalent of the typical 60 feet distance used in a quarter-mile drag strip. Time is measured and displayed to the millisecond. If the racer fails to trip the 6 foot line sensor dashes will be displayed.

2.4.4.3 66 Foot Time

The 66 foot time is the time from when the racer leaves the start line (trips the guard sensor) to when the racer trips the 66 foot line sensor. This distance is the 1/10 scale equivalent of the typical 660 feet (1/8 mile) distance used in a quarter-mile drag strip. Time is measured and displayed to the millisecond. If the racer fails to trip the 6 foot line sensor dashes will be displayed.

2.4.4.4 Trap Speed

The trap speed is calculated from the difference in the trap time and finish time (finish line sensor). This speed calculation is as follows: S = 3600 / (Finish Time – Trap Time) where S is the speed in Miles-Per-Hour (MPH) and the times are in milliseconds. Speed is displayed to 3 places to the right of the decimal point. If the racer fails to trip the trap or finish line sensor dashes will be displayed for the trap speed. Note that the spacing between the trap and the finish line sensors has purposely been set to 5.28 feet in order to simplify the speed equation and floating point calculations done in the software.

2.4.4.5 Elapsed Time

Elapsed time is the time from when the racer leaves the start line (trips the guard sensor) to when the racer trips the finish line sensor. Time is measured and displayed to the millisecond. If the racer fails to trip the finish line sensor dashes will be displayed for the elapsed time.

2.4.4.6 Overall Time

Typically overall time is the time from when the green Christmas tree light illuminates (race timer starts) to when the racer crosses the finish line. In other words, it is the sum of reaction time plus elapsed time. However, if the racer leaves the start line early (before the green Christmas tree light illuminates), overall time is the same as the elapsed time.

2.4.4.7 Lane Status

Lane status displays the status of each racer at the conclusion of each race. Typically the winner is the first vehicle to cross the finish line and therefore the driver with the lowest combined reaction time and elapsed time (i.e. overall time). Status is determined by the racer's overall time and whether or not he was disqualified as a result of leaving the start line early.

- DISQ – Is displayed if the racer disqualified (red-lighted)
- WINNER – is displayed when that racer has the fastest overall time or the other racer disqualified (red-lighted)
- WINNER* - is displayed if the other racer has the fastest overall time but disqualified (red-lighted) making you the winner by default
- **- - -** (dashes) – are displayed if the racer loses or does not cross the finish line.

If both racers leave the line early the first offender will be disqualified (red-lighted).

2.4.4.8 Racer ID Numbers

Text boxes are provided at the top of each lane for the display of the racer's ID number. Racer ID numbers are manually entered by the operator just prior to the start of each race and are saved as part of the race results in the race results data file. See Section 2.4.5.6 for how to enter racer ID numbers.

2.4.4.9 Race-In-Progress Timer Display

When a race is underway, a race-in-progress time is displayed in the Race Status box just to the right of the green "Racing" status indication (See Fig. 6). It displays the number of seconds that have elapsed (not to be confused with the racer's Elapsed time) since the race started. In addition, it also displays the race timeout duration just to the right of the "/" (forward slash) symbol. The example shown in Figure 6 shows the race has been underway for 3 seconds with a timeout duration of 10 seconds.

Figure 6 – Race-In-Progress Timer

2.4.5 Race Management Display Controls

The race management display has the following controls available to the user. Refer to Figures 11a & 11b.

2.4.5.1 Next Race Button

The 'Next Race' button when clicked sends a reset command to the Arduino timer to ready it for the next race. In addition it increments the race count to the next available race number which is then displayed in the Race # box. The 'Next Race' button is deactivated (greyed out) when the timer is in the "Ready", "Staged", "Countdown" or "Racing" state.

2.4.5.2 Start Race Button

The ‘Start Race’ button when clicked sends a start command to the Arduino timer to cause the Xmas tree to start its countdown sequence. The ‘Start Race’ button is deactivated (greyed out) whenever the timer is not in the “Staged” state.

2.4.5.3 Print Time Slip Button

The ‘Print Time Slip’ button when clicked causes a time slip of the currently displayed race results to be created and printed on the thermal receipt printer. Only one copy is printed each time the button is clicked. Used in conjunction with the ‘Race #’ Up/Down arrows, time slips can be printed of prior run races. Note that if the “Auto Print Copies” user setting is set to a value > 0 (See Section 2.3.3.3), one or more time slips will automatically print at the conclusion of each race.

2.4.5.4 Race # Up/Down Arrow Buttons

The Up/Down arrow buttons in the Race # box allow the user to select and view results from prior ran races. Used in conjunction with the ‘Print Time Slip’ button, this feature can be used to print time slips of prior run races. Note that the timer is disabled from starting a race while viewing previously run race results. Click on the up arrow until the new race number is again displayed to enable race start.

2.4.5.5 Timer Reset Button

The Timer Reset button provides a method to issue an independent RESET command to the Arduino timer. This is typically done to clear any lane sensor error messages reported by the timer.

2.4.5.6 Racer ID Entry

Racer ID numbers can be entered by the operator when the timer is in the Ready or Staged state. Entry of a racer’s ID number is optional and not required to run the race. To enter a racer ID number click on the desired Racer ID text box (highlighted in orange). A pop-up window will appear from which you can enter an alpha-numeric racer ID number up to 6 characters in length. Refer to Figure 7 below. Note that the timer’s remote hand-held pushbutton is disabled while the Racer ID pop-up window is active, thus preventing an inadvertent race start.

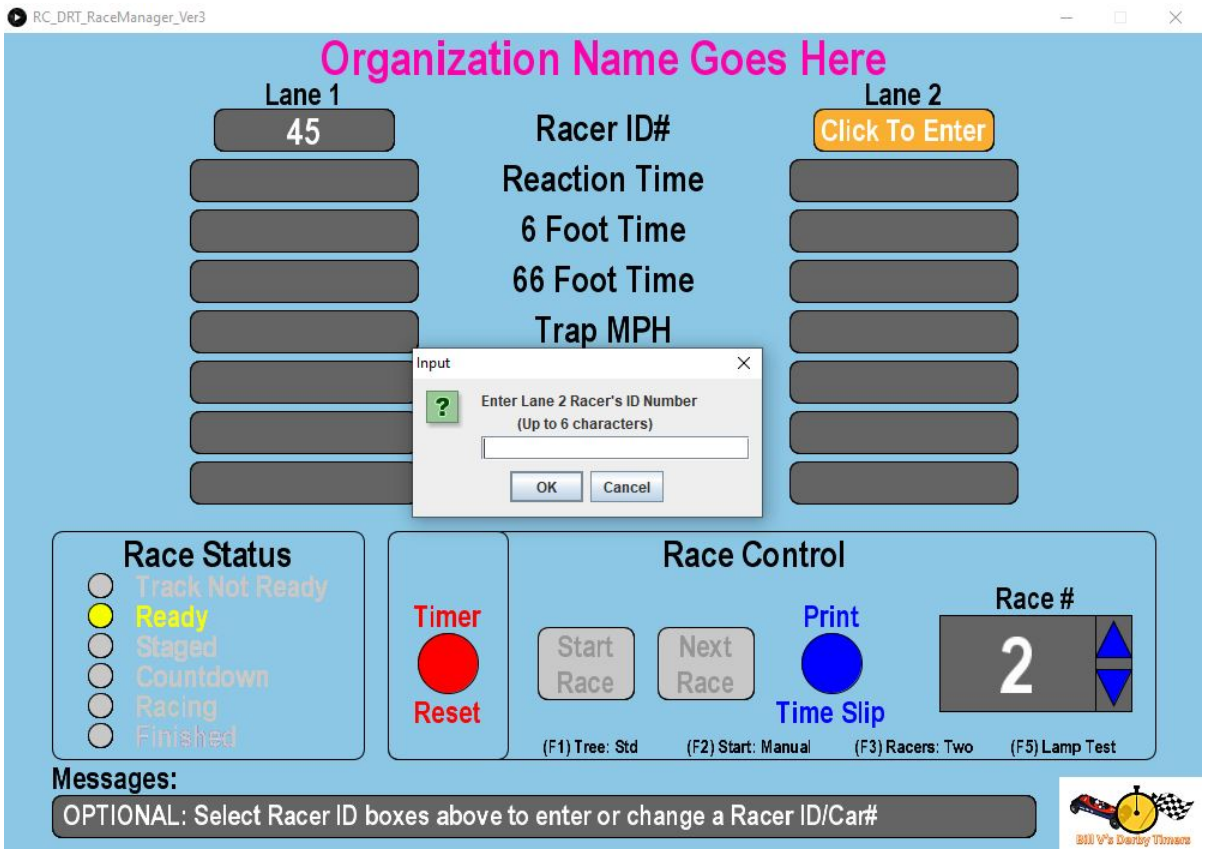


Figure 7 - Racer ID Number Entry

2.4.5.7 Christmas Tree Mode Selection (F1)

The Christmas tree can be set to function either as a “Standard” (Std) tree (AKA “sportsman” or “full” tree), a “Professional” (Pro) tree or as a “Street Outlaw” tree. Light timing for the Std and Pro tree modes is in accordance with the Radio Controlled Drag Racing League (RCDRL) 2021 Rulebook. When set to the “Standard” mode the amber lights will illuminate in sequence from top to bottom, 0.4 seconds apart and followed 0.4 seconds later by the green light. When set to the “Professional” mode the three sets of amber lights flash simultaneously, followed 0.4 seconds later by the green light. When set to the “Street Outlaw” mode the amber lights are not used and the tree will immediately illuminate the green lights upon race start.

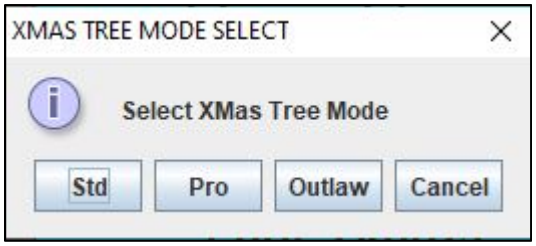


Figure 8 – Xmas Tree Mode select Pop-Up Window

To change the Christmas tree operation momentarily press the F1 key while the timer is either in the Finished or Ready state. This will cause the Xmas Tree Mode Select pop-up window (Fig. 8) to appear from which you can select the “Std”, “Pro” or “Outlaw” mode. The settings line at the bottom of the Race Control box will update to display the current selection. Note that the timer’s remote hand-held pushbutton is disabled while the Racer ID pop-up window is active, thus preventing an inadvertent race start. **Note:** On some Windows PCs

(typically laptops) it may also be necessary to simultaneously press the “Fn” key to bypass the Windows default function key action.

2.4.5.8 Automatic or Manual Timer Start (F2)

The timer can be set to start the race either manually or automatically. The default selection is manual start. In the manual start mode the timer is started either via the hand-held pushbutton or the Race Start button on the PC race management display. When in the auto start mode the timer automatically starts after a short random delay following detection that the racers have staged.

Figure 9 – Manual/Auto Start Mode Select Pop-Up Window

To change between the manual and automatic start modes momentarily press the F2 key while the timer is either in the Finished or Ready state. This will cause the Auto Start Mode Select pop-up window (Fig. 9) to appear from which you can select the Auto Start or Manual Start mode. The settings line at the bottom of the Race Control box will update to display the current selection. Note that the timer’s remote hand-held pushbutton is disabled while the Auto Start Mode Select pop-up window is active, thus preventing an inadvertent race start. **Note:** On some Windows PCs (typically laptops) it may also be necessary to simultaneously press the “Fn” key to bypass the Windows default function key action.

2.4.5.9 Single or Dual Racer Timing (F3)

The timer can be set to operate with just one racer instead of the default two-racers. When set to the two-racer mode (default), both racers must be staged in order for the timer to initiate the start/countdown sequence. When set to the one-racer mode, a single vehicle staged in lane 1 will allow the timer to initiate the start/countdown sequence.

Figure 10 – Single Or Dual Racer Select Pop-Up Window

To change between single or dual racer modes momentarily press the F3 key while the timer is either in the Finished or Ready state. This will cause the Single or Dual Racer Select pop-up window (Fig. 10) to appear from which you can select the Dual Racer or Single Racer mode. The settings line at the bottom of the Race Control box will update to display the current selection. Note that the timer’s remote hand-held pushbutton is disabled while the Single or Dual Racer Select pop-up window is active, thus preventing an inadvertent race start. **Note:** On some Windows PCs (typically laptops) it may also be necessary to simultaneously press the “Fn” key to bypass the Windows default function key action.

2.4.6 Remote Hand-Held Pushbutton

A hand-held pushbutton on a long cable provides a means to remotely control the race timer. This is typically done by the person positioned at the start line assisting in vehicle staging.

The pushbutton has two functions. When the timer is in the “Staged” state (white Xmas tree stage lamps illuminated), pressing and holding the pushbutton for 1/2 second will initiate the countdown sequence. When a race has completed and the timer is in the “Finished” state, pressing the button for about ¼ second will cause the timer to automatically reset for the next race. This eliminates the need for someone to constantly be at the computer to control the race timer. However, if a sensor error is detected during the timer’s reset function, a reset must still be issued from the PC once the problem has been corrected. This is because when an error is detected, the hand-held pushbutton is disabled.

2.4.7 Christmas Tree Lamp Test (F5)

A self-test of the Christmas tree lamps can be initiated using the F5 function key. When pressed the lamp test sequence is executed where each set of lamps will cycle on/off at a 0.5 second rate. The lamp test is disabled when the timer is in the staged or racing state.

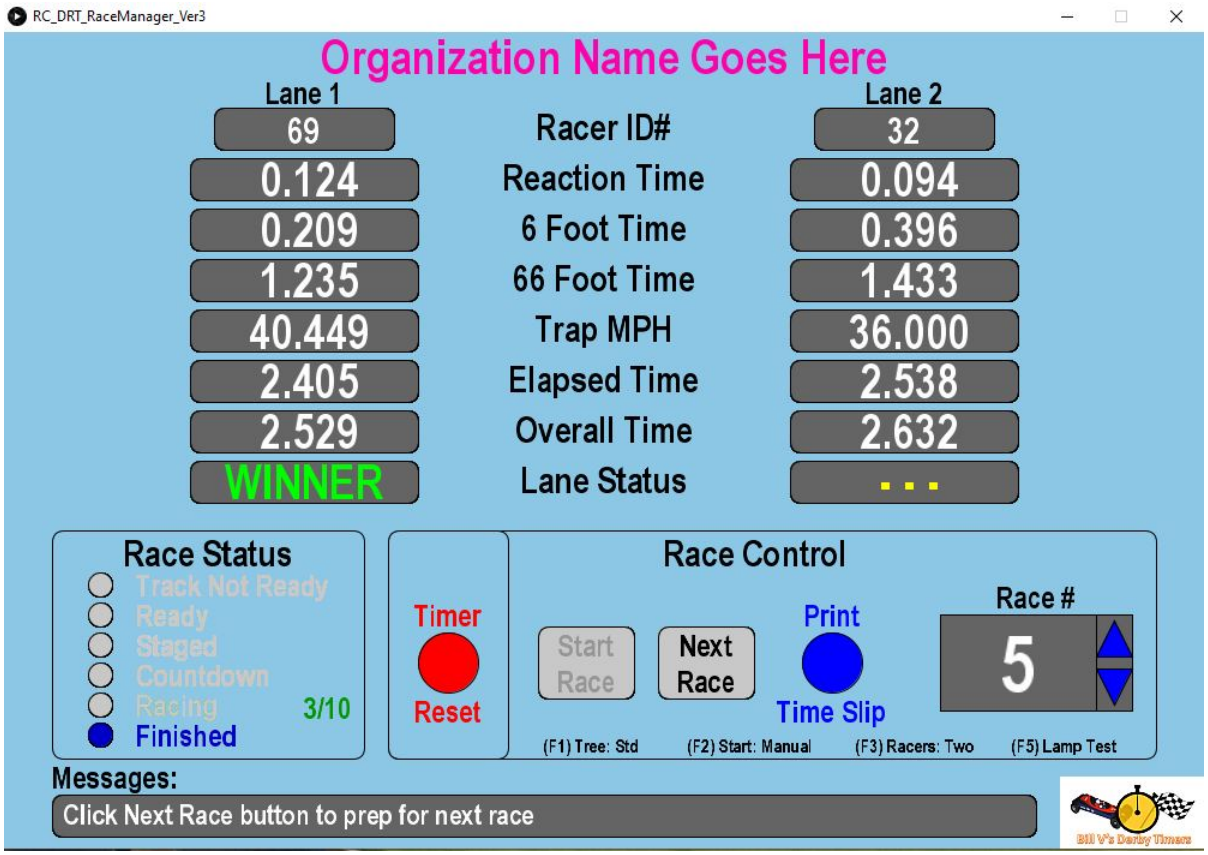


Figure 11a – Sample Screenshot of the Race Management Display

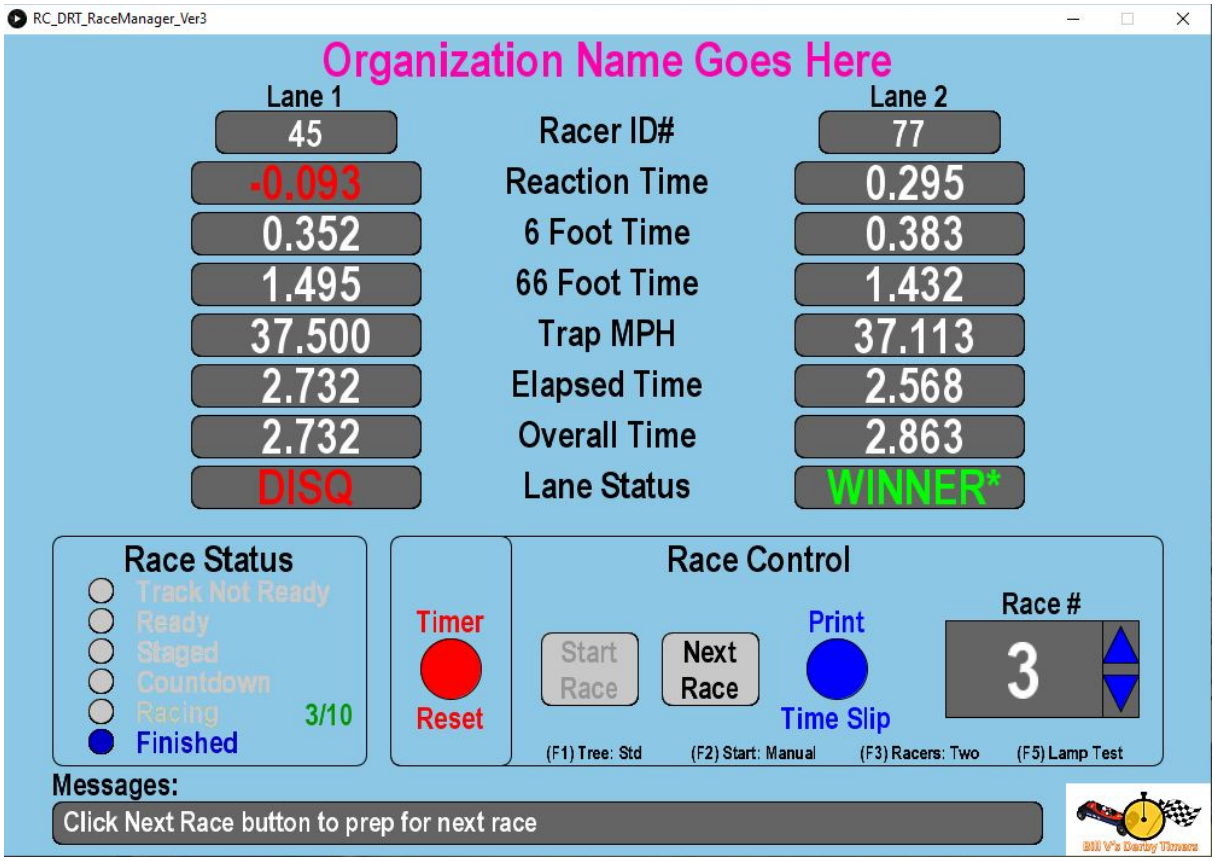


Figure 11b – Sample Screenshot of the Race Management Display

3 RUNNING A RACE

3.1 Setup

It is assumed the user has chosen a location that has a flat surface and is of sufficient length and width to accommodate the drag strip. Per the 2021 Radio Controlled Drag Racing League (RCDRL) rule book "the minimum width of each lane shall be 8 feet with 12 foot maximum. The length of the racing surface shall be exactly 132 feet. The racing surface may be asphalt or concrete or like surface." Note that if the surface has a crown (curved), shims may be required to ensure the sensor beams are at the correct height.

3.1.1 Layout the Track

Tools required: Chalk line, Tape measure

Perform the following (Refer to Figure 1):

- Establish the location for the start line and using the chalk line, snap the start line onto the track surface. Ensure it is perpendicular to the direction of the track.
- Layout the lane 1 and lane 2 left and right boundaries. Provide enough separation between the two lanes for the timer unit and light tree. Lane width should be between 8 and 12 feet.
- Using the tape measure, measure a down-track distance of 6 feet from the start line and using the chalk line, snap a line onto the track surface ensuring it is perpendicular to the direction of the track.
- Using the tape measure, measure a down-track distance of 66 feet from the start line and using the chalk line, snap a line onto the track surface ensuring it is perpendicular to the direction of the track.
- Using the tape measure, measure a down-track distance of exactly 132 feet and using the chalk line, snap the finish line onto the track surface ensuring it is perpendicular to the direction of the track.
- Using the tape measure, measure a distance of 5.28 feet (5' 3 3/8") back from the finish line and using the chalk line, snap the trap line onto the track surface ensuring it is perpendicular to the direction of the track.

3.1.2 Timer Equipment Setup

First Time Only Setup:

- On each IR receiver unit (BJ15M-TDT2) ensure the sensitivity adjustment screw and the D/L adjustment screw is set to the full clockwise position. Refer to the Autonics™ BJ Series datasheet for more information.

Perform the following (Refer to Figure 1):

- Position the timer and Christmas tree unit between the two lanes.
- Position the start line/stage sensor assembly between the two lanes at the start line and connect its cable (W3) to J3 of the timer unit.
- Position the 6 Ft sensor unit between the two lanes at the 6 Ft line and connect its cable (W4) to J4 of the timer unit.
- Position the 66 Ft sensor unit between the two lanes at the 66 Ft line and connect its cable (W5) to J5 of the timer unit.
- Position the trap/finish line sensor assembly at the finish line ensuring the sensors line up with the corresponding chalk lines. Extend the trap/finish line sensor cable between the two lanes and back to the timer unit and connect its cable (W6) to J6 of the timer unit.
- Position the battery powered IR transmitter units outside the lanes at the appropriate start, 6 Ft, 66 Ft, trap and finish line locations. Ensure they are lined up with and point to their corresponding receiver unit on the opposite side of the lane.
- Connect the hand-held pushbutton cable (W2) to J2 of the timer unit.
- Connect The Christmas Tree cable W7 and Christmas tree power cable W8 to J7 and J8 of the timer unit.
- Connect the 12 volt power source to J9 of the timer unit.
- Connect the PC to J1 of the timer unit via a USB cable. Note: For long USB cable runs it is recommended that a high quality extender cable be used.

3.1.3 Timer Equipment Power up

Perform the following:

- Apply power to the timer unit and the Christmas tree power source.
- Apply power to the PC and start the race management software.
- Apply power to the battery powered IR emitter units for both lane 1 and lane 2.Verify that the emitter unit's green power indicator is illuminated. If not, check the batteries.
- Verify the green power/stability indicator and the red operation (beam detect) indicator on the IR receiver units are illuminated. If the green power indicator is illuminated and the red operation (beam detect) indicator is not illuminated check the sensor and/or emitter alignment since this is an indication that the receiver unit is not seeing the beam from the emitter unit.
- At each IR receiver unit obstruct the beam from the emitter unit and verify the red operation (beam detect) indicator extinguishes. Note, it may be required to adjust the receiver sensitivity. Refer to the Autonics™ BJ Series datasheet for more details.
- On the PC's race management screen click on the Next Race or Reset button to issue a reset to the timer. Verify that both green Christmas tree lamps flash twice. If the lane 1 and/or lane 2 red foul lamps flash it means that one or more of the corresponding lanes IR receiver units is not detecting the beam. The message box at the bottom of the race management screen will identify the sensors that are not ready. You must troubleshoot and correct the problem before continuing.
- Install the protective covers, if any, over the IR emitter and receiver units.

3.2 Operation Overview

Operation of the Arduino based timer is straight forward. The timer code cycles through six states. They are:

- Track Not Ready
- Ready
- Staged
- Countdown
- Racing
- Finished

The "Track Not Ready" state is displayed at initial power-up. The "Track Not Ready" state is also displayed when the timer is commanded to ready for the next race and the timer software senses that one or more of the optical lane sensors is obstructed or not properly illuminated/aligned. This condition will cause an error message to be displayed in the race management software message box at the bottom of the screen and will require the operator to issue a Timer Reset once the problem is corrected.

The "Ready" state is displayed when the timer is commanded to ready for the next race and the optical lane sensors are in the correct state to begin the staging process. As each vehicle stages the corresponding white stage lamps illuminate on the Christmas tree.

The "Staged" state is entered when both vehicles are staged signifying the timer is ready to start the race. If the timer is in the auto-start mode the timer automatically enters and starts the countdown sequence after a short random delay. If the timer is in the manual-start mode it will wait for a manual start command before entering the Countdown state to begin the countdown sequence. A manual start is performed by pressing the hand-held remote start pushbutton or by clicking on "Start Race" on the race management screen.

The "Countdown" state is entered and displayed when the timer is either automatically or manually started as described in the previous paragraph. During the countdown state the timer cycles the amber and green Christmas tree lights and monitors the guard sensors. If a guard sensor is tripped before the green light illuminates the corresponding red DQ (Disqualification/foul) light will illuminate instead of the green "Go"

indicator. The DQ status for that lane will be recorded along with the time the sensor was tripped ahead of the green light illuminating. This time is displayed as a “negative” reaction time and gives the racer insight into how early he left the start line.

The “Racing” state is entered and displayed when the green Christmas tree light illuminates. At this point the start time is recorded and all lane sensors are monitored. When a sensor is tripped, the time at which it tripped is recorded. Note that no race results are displayed until the race is complete. However, while the race is underway, a race-in-progress duration counter is displayed showing the number of seconds that have elapsed since race start.

The “Finished” state is displayed when both vehicles have crossed the finish line or when 10 second seconds have elapsed, whichever occurs first. The time-out is for cases where a vehicle fails to cross the finish line or a lane was not used. In those cases, dashes will be displayed in the corresponding time boxes for those sensors that were not tripped. A reset command (Next Race button or press of the hand-held pushbutton) must be issued to the Arduino timer to exit the ‘Finished’ state and ready it for the next race.

3.3 Running the Race

This section describes the steps for running a race. Prior to running your first race ensure all timer components have been installed, powered up and tested per Section 3.1 of this document.

Step	Action	Expected Results / Comments
1	On the PC race management screen, click/select the Next Race button. Optionally, if a race has just been completed, the timer can be advanced to the next race by momentarily pressing/releasing the remote hand-held pushbutton.	• The next race number will be displayed in the RACE # box • Race Status changes to “Ready”. • The Racer ID text boxes turn amber with text “Click To Enter” signifying the operator can enter Racer ID numbers (Optional). • If the Race Status does not change to “Ready” the timer has detected a fault and will display an error message at the bottom of the screen. In most cases the fault will be an obstructed or out of alignment lane sensor. Additionally, if an obstructed or out of alignment lane sensor is detected the red Xmas tree DQ light for the lane having the obstructed sensor will flash twice. The fault must be corrected before you can proceed.
2	(Optional) On the PC race management screen, click on the Race ID# box to enter a Racer ID number. Do for both racers.	A racer ID number up to 6 alpha-numeric characters is entered and displayed.
3a	**DUAL RACER MODE** Stage the racers.	• As each racer is staged the corresponding white stage indicators will illuminate. • When both racers are staged the timer advances to the Staged state and the race can be started. • If a racer advances too far and trips the guard beam the red foul light will illuminate and will be disqualified.
3b	**SINGLE RACER MODE** Stage the racer in Lane 1.	When the racer has staged the timer advances to the Staged state and the race can be started.

Step	Action	Expected Results / Comments
4a	**AUTO START MODE** If the timer is in the Auto Start mode the timer will start automatically after a short random delay from when both vehicles are staged.	• The Christmas tree lights will begin their countdown sequence. If a racer trips the guard sensor before the green light illuminates, the corresponding red foul light will illuminate and remain illuminated until the timer is reset for the next race. • Race Status changes from “Staged” to “Countdown” and then to “Racing” when the green Christmas tree lights illuminate.
4b	**MANUAL START MODE** Start the race. This can be done via the hand-held start button or the Start Race button on the PC. ***Note**: If using the hand-held start button to start the race, it must be pressed and held for a minimum of 0.5 seconds to initiate a start.*	• The Christmas tree lights will begin their countdown sequence. If a racer trips the guard sensor before the green light illuminates, the corresponding red foul light will illuminate and remain illuminated until the timer is reset for the next race. • Race Status changes from “Staged” to “Countdown” and then to “Racing” when the green Christmas tree lights illuminate.
5	Allow the race to complete. This will occur when the racers have crossed the finish line or the 10 seconds has been exceeded, whichever occurs first.	• The green Christmas Tree lights extinguish • Race Status changes from “Racing” to “Finished”. • Race results are displayed on the PC’s race management screen. • The green Xmas tree indicator will flash for the winning lane for 15 seconds. • If the “Auto Print Copies” setting is set to 1 or greater, the selected number of time slips is automatically printed.
6	Repeat Steps 1 through 5 for each race.	

3.4 Post-Race Processing

As mentioned in the Introduction, all race results are saved to a comma-delimited (.csv) data file that can be read by MS Excel or other spreadsheet software for post-race processing. By default the file is saved in the same folder containing the program code (sketch). This can be changed by including the path in the filename variable (See the Processing.org website (https://processing.org) under the "saveTable" command). The filename for the data file saved to disk is created at program startup and includes a date/time value retrieved from the computer's clock. The filename structure is as follows: "Race_Results_YYYYMMDDHHMM.csv", where: YYYY = 4 digit year, MM = 2 digit month, DD = 2 digit day, HH = 2 digit hour and MM = 2 digit minutes. This guarantees a unique file each time the program is started and prevents any previous files from being accidentally overwritten.

Figure 12 shows a formatted example of the data saved to the race results file for each race. "L1" and "L2" stand for Lane 1 and Lane 2 respectively.

Race	L1 Racer	L1 DQflag	L1 React	L1 6 Ft	L1 66 Ft	L1 Trap	L1 Speed	L1 ET	L1 Ovl	L1 Win
1	001	0	0.227	0.199	1.311	2.546	37.5	2.642	2.869	0
2	49	0	0.105	0.325	1.448	2.805	39.56	2.896	3.001	1
3	13	1	-0.07	0.354	1.483	2.872	38.298	2.966	2.966	0

L2 Racer	L2 DQflag	L2 React	L2 6 Ft	L2 66 Ft	L2 Trap	L2 Speed	L2 ET	L2 Ovl	L2 Win	Date	Time
69	0	0.099	0.377	1.36	2.631	40.449	2.72	2.819	1	4/9/2021	15:35
023	0	0.291	0.231	1.583	2.78	37.895	2.875	3.166	0	4/9/2021	15:37
101	0	0.167	0.253	1.421	2.58	37.5	2.676	2.843	1	4/9/2021	15:39

Figure 12 – Example of Race Results File (formatted)

Appendix A
DIAGNOSTIC TEST PROCEDURE

This test procedure was written to assist in testing and troubleshooting the Arduino timer hardware and software. This test requires a minimum of two people. The second person is needed to trip the lane sensors down the track. Cell phones or walkie-talkies may be required for communication.

Setup:

- Connect the PC to the main timer unit via the USB interconnect cable
- Bring up the Arduino Integrated Development Environment (IDE) on your PC
- Select and load the RC_DRT_Timer_Ver3.ino file.
- On the Arduino IDE 'Tools' drop-down menu verify/select the correct COM port.
- Note: You do not need to compile and upload the code onto your Arduino board unless you suspect it has been compromised.
- On the Arduino IDE open the serial monitor by clicking on the little magnifying glass near the upper right corner of the IDE display. Ensure the baud rate is set to 9600.

Perform the following test procedure.

Step	Action	Expected Results
1	Ensure the hand held Race Start Switch is not pressed and the lane sensors are functioning properly.	N/A
2	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The two green Christmas tree lights flash on/off two times in rapid succession. The message "RDY" is displayed on the monitor. If you get the message "TRK <sensor ID>" followed by "NRD" one or more lane sensors as identified by their sensor ID is not ready. Troubleshoot and correct the problem before continuing.
3	Obstruct (block) the light illuminating the Lane 1 pre-stage sensor.	The Lane 1 Christmas tree white pre-stage lights illuminate.
4	While continuing to block the light illuminating the Lane 1 pre-stage sensor, enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light will flash twice indicating a lane 1 sensor is not ready. The message "TRK PStg1" followed by "NRD" is displayed indicating the pre-stage sensor for Lane 1 is not ready.
5	Restore the light illuminating the Lane 1 pre-stage sensor then enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree white pre-stage lights extinguish. The two green Christmas tree lights flash on/off two times. The message "RDY" is displayed on the monitor.

Step	Action	Expected Results
6	Repeat steps 3 through 5 for the Lane 1 stage sensor.	Results are the same as noted above except for Lane 1 Christmas tree white stage lights. The message “TRK Stg1” followed by “NRD” is displayed indicating the stage sensor for Lane 1 is not ready.
7	Repeat steps 3 through 6 for the Lane 2 pre-stage and stage sensors	Results are the same as noted above except for Lane 2 Christmas tree white pre-stage and stage lights. The messages “TRK PStg2” and “TRK Stg2” followed by “NRD” are displayed for their corresponding sensor.
8	Obstruct (block) the light illuminating the Lane 1 guard sensor.	The Lane 1 Christmas tree red foul light illuminates
9	While continuing to block the light illuminating the Lane 1 guard sensor, enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light will flash twice indicating a lane 1 sensor is not ready. The message “TRK Grd1” followed by “NRD” is displayed indicating the guard sensor for Lane 1 is not ready.
10	Restore the light illuminating the Lane 1 guard sensor then enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light extinguishes. The two green Christmas tree lights flash on/off two times. The message “RDY” is displayed on the monitor.
11	Repeat steps 8 through 10 for the Lane 2 guard sensor.	Results are the same as noted above except for Lane 2 Christmas tree red foul light. The messages “TRK Grd2” followed by “NRD” are displayed.
12	Obstruct (block) the light illuminating the Lane 1 6-foot sensor.	N/A
13	While continuing to block the light illuminating the Lane 1 6-foot sensor, enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light will flash twice and then remain extinguished. The message “TRK 6ft-1” followed by “NRD” is displayed indicating the Lane 1 6-foot sensor is not ready.
14	Repeat steps 12 and 13 for the Lane 2 6-foot sensor.	Results are the same as noted above except for Lane 2. The message “TRK 6ft-2” followed by “NRD” is displayed indicating the Lane 2 6-foot sensor is not ready.
15	Obstruct (block) the light illuminating the Lane 1 66-foot sensor.	N/A

Step	Action	Expected Results
16	While continuing to block the light illuminating the Lane 1 66-foot sensor, enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light will flash twice and then remain extinguished. The message “TRK 66ft-1” followed by “NRD” is displayed indicating the Lane 1 66-foot sensor is not ready.
16	Repeat steps 15 and 16 for the Lane 2 66-foot sensor.	Results are the same as noted above except for Lane 2. The message “TRK 66ft-2” followed by “NRD” is displayed indicating the Lane 2 66-foot sensor is not ready.
17	Obstruct (block) the light illuminating the Lane 1 trap sensor.	N/A
18	While continuing to block the light illuminating the Lane 1 trap sensor, enter the letter R in the command line, press ENTER or click on the Send button.	The Lane 1 Christmas tree red foul light will flash twice and then remain extinguished. The message “TRK Trp1” followed by “NRD” is displayed indicating the Lane 1 trap sensor is not ready.
19	Repeat steps 17 and 18 for the Lane 2 trap sensor.	Results are the same as noted above except for Lane 2. The message “TRK Trp2” followed by “NRD” is displayed indicating the trap sensor for Lane 2 is not ready.
20	Repeat steps 17 and 19 for the lane 1 and lane 2 finish line sensors.	Same result as steps 18 and 19 except the reported sensor ID will correspond to the sensor being obstructed. Also, for Lane 2 sensors the Lane 2 Christmas tree red foul light will flash twice. The message “TRK Fin1” or “TRK Fin2” followed by “NRD” is displayed indicating the corresponding finish line sensor is not ready. **NOTE**: If the reported sensor does not correspond to the sensor being obstructed, check the sensor cable connections to ensure they are plugged into the correct receptacle.
21	Remove all sensor obstructions and ensure the hand-held Start Switch is not depressed.	N/A
22	On the serial monitor enter the letter T in the command line, press ENTER or click on the Send button.	The Christmas tree lamp test sequence is executed where each set of lamps will cycle on/off at a 0.5 second rate. The message “@” is displayed on the monitor when the test completes.
23	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed on the monitor. No Christmas tree lamps are illuminated.

Step	Action	Expected Results
24	Obstruct and continue to obstruct the beam of both the Lane 1 and Lane 2 stage sensors.	The white stage lights are illuminated on the Christmas tree. The message “STG” is displayed on the monitor.
25	While continuing to obstruct the Lane 1 and Lane 2 stage sensors momentarily press & hold the hand-held Start Switch for at least 0.5 second.	The message “CNT” is displayed on the monitor. The Christmas tree amber and green lights cycle through their countdown sequence at a 0.4 second rate. When the green lamps illuminate the message “RAC” is displayed on the monitor.
26	Wait about 10 seconds.	After 10 +/-1 seconds the green Xmas tree lights extinguish and the following messages are displayed on the monitor: “Lane1: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” “Lane2: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” Followed by the message “FIN”.
27	Remove the obstruction from the Lane 1 and Lane 2 stage sensors.	N/A
28	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed.
29	On the serial monitor enter the code M1 in the command line, press ENTER or click on the Send button. **Note**: This sets the Xmas Tree to function in the “Pro” mode.	The message “@” is displayed on the monitor.
30	Obstruct and continue to obstruct the beam of both the Lane 1 and Lane 2 stage sensors.	The white stage lights are illuminated on the Christmas tree. The message “STG” is displayed on the monitor.
31	While continuing to obstruct the Lane 1 and Lane 2 stage sensors momentarily press & hold the hand-held Start Switch for at least 0.5 seconds.	All three sets of amber Christmas tree lights illuminate simultaneously followed 0.4 seconds later by the green lights. The message “CNT” is displayed on the monitor. When the green lamps illuminate the message “RAC” is displayed on the monitor.
32	Allow the timer to time out.	After 10 +/-1 seconds the green Xmas tree lights extinguish and the following messages are displayed on the monitor: “Lane1: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” “Lane2: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” Followed by the message “FIN”.

Step	Action	Expected Results
33	Remove the obstruction from the Lane 1 and Lane 2 stage sensors.	The white stage lights on the Christmas tree extinguish.
34	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed.
35	On the serial monitor enter the code M2 in the command line, press ENTER or click on the Send button. **Note**: This sets the Xmas Tree to function in the “Street Outlaw” mode.	The message “@” is displayed on the monitor.
36	Obstruct and continue to obstruct the beam of both the Lane 1 and Lane 2 stage sensors.	The white stage lights are illuminated on the Christmas tree. The message “STG” is displayed on the monitor.
37	While continuing to obstruct the Lane 1 and Lane 2 stage sensors momentarily press & hold the hand-held Start Switch for at least 0.5 seconds.	The green lights illuminate. The message “CNT” is displayed on the monitor immediately followed by the message “RAC” when the green lamps illuminate.
38	Allow the timer to time out.	After 10 +/-1 seconds the green Xmas tree lights extinguish and the following messages are displayed on the monitor: “Lane1: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” “Lane2: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” Followed by the message “FIN”.
39	Remove the obstruction from the Lane 1 and Lane 2 stage sensors.	The white stage lights on the Christmas tree extinguish.
40	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed.
41	On the serial monitor enter the code M0 in the command line, press ENTER or click on the Send button. **Note**: This sets the Xmas Tree to function in the “Standard” mode.	The message “@” is displayed on the monitor.
42	On the serial monitor enter the code A1 in the command line, press ENTER or click on the Send button. **Note**: This sets the timer to function in the auto-start mode.	The message “@” is displayed on the monitor.

Step	Action	Expected Results
43	Obstruct and continue to obstruct the beam of both the Lane 1 and Lane 2 stage sensors.	The white stage lights are illuminated on the Christmas tree. The message “STG” is displayed on the monitor. After a short delay (< 2 seconds) the Christmas tree amber and green lights automatically begin to cycle through their countdown sequence and the message “CNT” followed by “RAC” is displayed on the monitor.
44	Allow the timer to time out.	After 10 +/-1 seconds the green Xmas tree lights extinguish and the following messages are displayed on the monitor: “Lane1: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” “Lane2: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” Followed by the message “FIN”.
45	Remove the obstruction from the Lane 1 and Lane 2 stage sensors.	The white stage lights on the Christmas tree extinguish.
46	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed.
47	On the serial monitor enter the code A0 in the command line, press ENTER or click on the Send button. **Note**: This sets the timer to function in the manual-start mode.	The message “@” is displayed on the monitor.
48	On the serial monitor enter the letter P1 in the command line, press ENTER or click on the Send button. **Note**: This sets the timer to function in the single racer mode.	The message “@” is displayed on the monitor.
49	Obstruct and continue to obstruct the beam of the Lane 1 stage sensor.	The white stage lights for Lane 1 are illuminated on the Christmas tree. The message “STG” is displayed on the monitor.
50	While continuing to obstruct the Lane 1 stage sensor enter the letter S in the command line, press ENTER or click on the Send button.	The message “CNT” is displayed on the monitor. Only the lane 1 amber and green Christmas tree lights cycle through their countdown sequence at a 0.4 second rate. Lane 2 lights remain extinguished. When the lane 1 green lamp illuminates the message “RAC” is displayed on the monitor.

Step	Action	Expected Results
51	Wait about 10 seconds.	After 10 +/-1 seconds the green Xmas tree lights extinguish and the following messages are displayed on the monitor: “Lane1: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” “Lane2: 0 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 9999.999 0” Followed by the message “FIN”.
52	Remove the obstruction from the Lane 1 stage sensor.	N/A
53	On the serial monitor enter the letter K in the command line, press ENTER or click on the Send button. **Note**: This sets the timer to function in the dual racer mode.	The message “@” is displayed on the monitor.
54	On the serial monitor enter the letter R in the command line, press ENTER or click on the Send button.	The message “RDY” is displayed.
--	TEST COMPLETE	

Appendix B
Arduino Timer Serial Communication Details

Communication between the Arduino based timer and the PC is via the USB interface which has been set up as a serial link running at 9600 baud, 8 bits, no parity, and 1 stop bit (9600/8-N-1). ASCII character strings transmitted between the timer and the PC are used to control the timer as described in the table below.

ASCII Command	Direction	Description
R	PC-to-Timer	Reset – Resets the Arduino timer
S	PC-to-Timer	Race Start – Commands the Arduino timer to start the race.
M0	PC-to-Timer	Sets the Xmas Tree to function in the “Standard” mode.
M1	PC-to-Timer	Sets the Xmas Tree to function in the “Pro” mode.
M2	PC-to-Timer	Sets the Xmas Tree to function in the “Street Outlaw” mode.
P1	PC-to-Timer	Command the timer for single racer timing
P2	PC-to-Timer	Command the timer for dual racer timing (default)
H	PC-to-Timer	Hold - Command Arduino timer to disable remote hand switch
C	PC-to-Timer	Continue – Command Arduino timer to enable remote hand switch
A0	PC-to-Timer	Manual Start - Command Arduino timer to enter the manual start mode
A1	PC-to-Timer	Auto Start - Command Arduino timer to enter the auto start mode
T	PC-to-Timer	Command timer to run Xmas tree lamp test
@	Timer-to-PC	Acknowledge character (for testing purposes only)
NRD	Timer-to-PC	Not Ready – Informs the race management software the timer is in the ‘Not Ready’ state.
RDY	Timer-to-PC	Ready – Informs the race management software the timer is in the ‘Ready’ state.
STG	Timer-to-PC	Staged – Informs the race management software the timer is in the ‘Staged’ state.
CNT	Timer-to-PC	Countdown – Informs the race management software the timer is in the ‘Countdown’ state.
RAC	Timer-to-PC	Racing – Informs the race management software the timer is in the ‘Racing’ state.
FIN	Timer-to-PC	Finished – Informs the race management software the timer is in the ‘Finished’ state.
RST	Timer-to-PC	“Next Race” reset request
TRK -or- TRK, x, y, …	Timer-to-PC	Track Status – Informs the race management software that the track is not ready for the next race because one or more optical lane sensors are obstructed or out of alignment. The TRK message will include the sensor code for each effected sensor.

In addition to the above serial command messages the Arduino timer passes the race results to the PC display software via two ASCII strings (one for each lane) having the following format:

Lane1: x aaaa.aaa bbbb.bbb cccc.ccc dddd.ddd eeee.eee ffff.fff y
Lane2: x aaaa.aaa bbbb.bbb cccc.ccc dddd.ddd eeee.eee ffff.fff y
Where:

- x = Lane disqualification (DQ) status (0=OK, 1=Disq.)
- aaaa.aaa = Lane reaction time (padded with 1000 seconds)
- bbbb.bbb = Lane 6 Ft marker time (padded with 1000 seconds)
- cccc.ccc = Lane 66 Ft marker time (padded with 1000 seconds)
- dddd.ddd = Lane trap time (padded with 1000 seconds)
- eeee.eee = Lane Elapsed (Finish) time (padded with 1000 seconds)
- ffff.fff =Lane speed in MPH (padded with 1000)
- y = Lane win status (0=lose, 1=Win)

Note that the Arduino software adds 1000.000 seconds to the actual values when formatting the race results string to ensure floating point time and speed values always have the same character position within the string. The added 1000.000 seconds is subtracted from the received results by the race management software. Additionally, if the disqualification (DQ) status character is a “1” the reaction time value provided is the time from when the guard sensor was tripped to the time the green Christmas Tree light illuminates (race start time) and will be displayed on the race management screen as a negative number to signify the racer left early.

Troubleshooting: Use of the Arduino IDE serial monitor or another serial terminal program can be used to observe these commands. Refer to the diagnostic test procedure in Appendix A to assist in troubleshooting any issues. Feel free to contact the author via email at billv923@outlook.com for additional help.