

BILL V's  
DERBY TIMERS

Arduino Based Drag Race Timer  
Version 14

# USER MANUAL



## 1 INTRODUCTION

The drag race timer discussed herein replicates many of the features of a professional drag race system including the following:

- Easy driver lane assignment (Class, Car# & Dial-in) from user generated roster
- Handicapped racing capability
- A functional Christmas tree (Standard, Pro or Street Outlaw mode selectable).
- Vehicle pre-staging and staging
- Single or dual lane timing
- Selectable Manual or Auto start timing
- Measurement/Display of Reaction Times, Elapsed Times, Speeds, Margin & racer win/loose/draw/foul/breakout status
- Winner indication shown on Light Tree & optional win lights at the finish line
- Generation & printout of Timeslips at conclusion of each race
- Race results saved to data file for post-race processing

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

1. **Pre-Stage Sensors:** Positioned 7 inches aft of the Stage Sensors to provide the pre-stage indication on the Christmas tree.
2. **Stage Sensors:** Positioned at the start line
  - a. Support vehicle staging
  - b. Measure reaction time (Green light to when vehicle leaves start line).
  - c. Determines if a vehicle leaves the start line too early (i.e. red-lighting).
3. **Guard Sensors (Optional):** Positioned 13 3/8 inches down track from stage sensor (per NHRA)
  - a. Measure reaction time (Green light to when vehicle leaves start line).
  - b. Determines if a vehicle leaves the start line too early (i.e. red-lighting).
4. **60 Foot Sensors:** Positioned 60 feet down track from the start line and provides the elapsed time (ET) when the vehicle has traveled 60 feet down track.
5. **1/8 Mile Sensors:** Positioned 660 feet (1/8 Mile) down track from the start line and provides the elapsed time (ET) when the vehicle has traveled 660 feet down track.
6. **1/4 Mile Trap Sensors:** Positioned 66 feet prior to the 1/4 mile finish line. Work in conjunction with the finish line sensors to determine the vehicle speed at the 1/4 mile finish line.
7. **1/4 Mile Finish Line Sensors:** Positioned at the finish line (1320 feet). Measure vehicle race 1/4 mile finish time.

The software provided with this version has been tailored to operate on a quarter-mile track with speed indications in Miles-Per-Hour (MPH) or Km/h. The Christmas tree can be set to function as either a NHRA professional, NHRA sportsman (standard) or street outlaw type tree and the timer can be set to either start the race manually or automatically.

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 (Ref. Fig. 6) provides display of the dial-in time, reaction time, 60 foot ET, 660 foot (1/8 mile) ET, 1320 foot (1/4 mile) ET & speed, margin and racer's status (win, draw,

foul or breakout). 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 timeslip 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 for post-race processing. The results are saved at the end of each race to ensure no data is lost. 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) load a roster of racers, (2) add/delete names to/from the race roster, (3) select the Christmas tree mode, (4) select manual or auto start, (5) enable/disable handicap mode (i.e. use dial-in times), (6) ready the timer for the next race, (7) start the race, (8) manually print timeslips, and (9) 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 key F1 can be used to initiate a self-test of the Christmas tree lamps.

A hand-held pushbutton tethered on a long cable provides the ability to start or reset the timer for the next race from a remote location such as the start line. Also, an optional interface is provided for the addition of win indicator lights positioned at the finish line.

## 2 GETTING STARTED

### 2.1 Timer Components

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

**Table 1. Timer Components**

<b>Component</b>	<b>Description / Function</b>
Lane Sensors (Qty=14)	<p>The lane sensors are photodiode assemblies that sense and report when the infrared beam is interrupted (broken) by an object (i.e. vehicle). They are positioned at designated points along the track as follows (One set for each lane):</p> <ul style="list-style-type: none"><li>• Pre-stage sensors (7 inches behind Stage sensors)</li><li>• Stage sensors (start line)</li><li>• Guard sensors (Fwd of Start line) (Optional)</li><li>• 60' time marker</li><li>• 660' (1/8 Mile) time marker</li><li>• 1320' Trap (66 Ft before the 1320' finish line)</li><li>• 1320' (1/4 mile) finish line</li></ul> <p>The Pre-stage, Stage and Guard sensors are "through-beam" sensors whereas all the down-track sensors are "retroreflective" sensors.</p>
Lane Sensor Junction Boxes (Qty=4)	<p>The lane sensor junction boxes combine the down-track lane sensor signals into one of two cables for transmission to the main timer unit. Each junction box contains the electronics to convert and send the sensor's signal through a differential line driver thereby allowing it to travel down long transmission lines without degradation or interference from electromagnetic noise. Differential line receivers in the main timer unit convert the signals back into digital format for use by the Arduino microcontroller. Outdoor (weatherized) CAT6 Ethernet cables are used to interconnect the junction boxes. Each junction box is powered by a user provided 12-volt battery that powers the junction box electronics and the sensors.</p>
Main Timer Unit	<p>Contains all the electronics including the Arduino microcontroller for (1) monitoring the lane sensors and start switch, (2) driving the Christmas tree, (3) performing the timing and timing calculations, and (4) sending race results to the PC.</p>
Hand-Held Race Start Button	<p>Provides a means to start the race or advance the timer for the next race from a location other than the PC. Typically, this is done by the same person who is staging the vehicles at the start line.</p>
Christmas Tree	<p>Houses the staging, sequencing and disqualification/foul lights.</p>
Win Light Unit (Optional)	<p>Provides the electronics (two opto-isolated relays) to drive the win lights positioned at the finish line.</p>
PC (Laptop)	<p>Computer that runs the race management software.</p>
Timeslip Printer (Optional)	<p>Thermal (receipt) printer that prints the timeslips at the end of each race.</p>
Cable Assemblies	<p>Provide for the electrical connection of the timer components.</p>

## 2.2 Component Setup

It is assumed the end user has already measured and laid out the 2-lane track. Instructions for laying out a track can be found on the PortaTree™ website (<https://portatree.com/track-system-instructions/>). Figure 1 provides the suggested locations of the timer components.

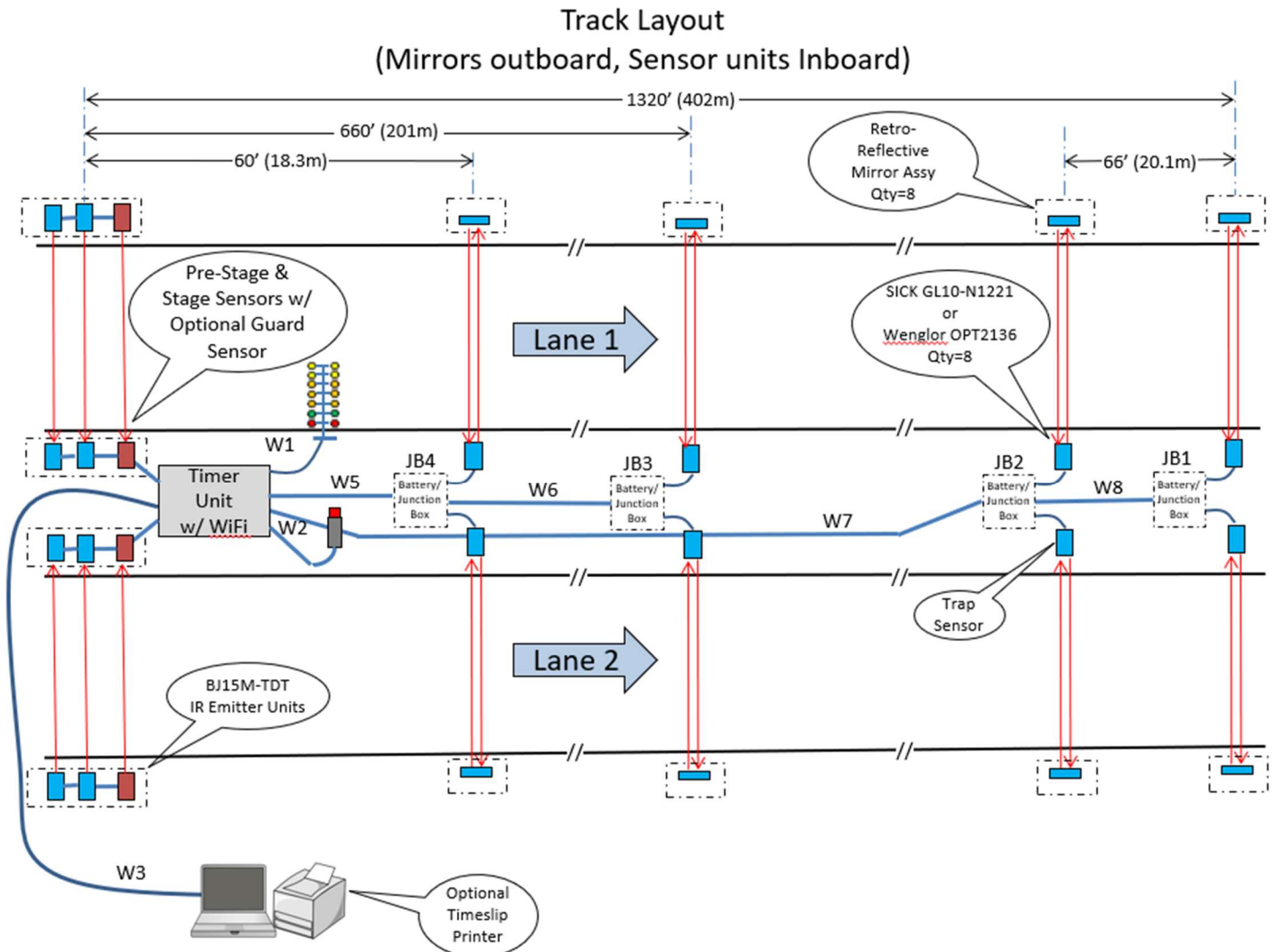


Figure 1 – Timer Component Layout

## 2.3 Timer Software Installation

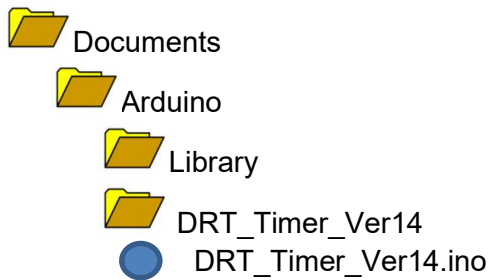
All required software except for the Arduino Integrated Development Environment (IDE) and the Processing Integrated Development Environment (IDE) is provided as part of the design package. It is assumed the end user will select and acquire a suitable thermal receipt printer to be used as the Timeslip printer and install/setup the drivers required for the Timeslip printer. 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 “Processing4” which is downloadable from the WEB at the Processing.org website (<https://processing.org>).

### 2.3.1 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 ‘DRT\_Timer\_Ver14’ 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 ‘DRT\_Timer\_Ver11.ino’ from the source to the ‘DRT\_Timer\_Ver14’ 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.

#### 2.3.1.1 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. <b>-- Note --</b> Track Timer should always be powered up before connecting it to your PC.	N/A
3	Connect the track timer (Arduino board) to your PC USB port via the USB cable.	N/A
4	Double click on the ‘DRT_Timer_Ver14.ino’ file to launch the file and bring up the Arduino integrated development environment.	Arduino integrated development environment window is displayed with the DRT_Timer_Ver14 source code listing.

Step	Action	Comments
5	If the optional finish line win light hardware is installed, the software must be modified as follows to enable the feature: a. Locate the line <code>WinLight_Enable = false;</code> in the Arduino IDE editor. b. Change the term <code>false</code> to <code>true</code> . Do not change any other part of the line. c. Select CTRL S to save the changes.	N/A
6	Select the 'Tools/Board' pull-down menu to select/verify the "Arduino MEGA or MEGA 2560" board is selected.	N/A
7	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.
8	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 race management software and you should be ready to go.

### 2.3.2 Race Management Software Installation & Setup

Download and install the free Processing integrated development environment (IDE) from the Processing.org website. For complete instructions on how to download and install the Processing development environment visit <https://processing.org>. The WEB site also provides tutorials and step-by-step instructions to help you every step of the way. **NOTE:** *At the time of this writing the latest release of the Processing software was at Version 4.3.*

For Windows machines:

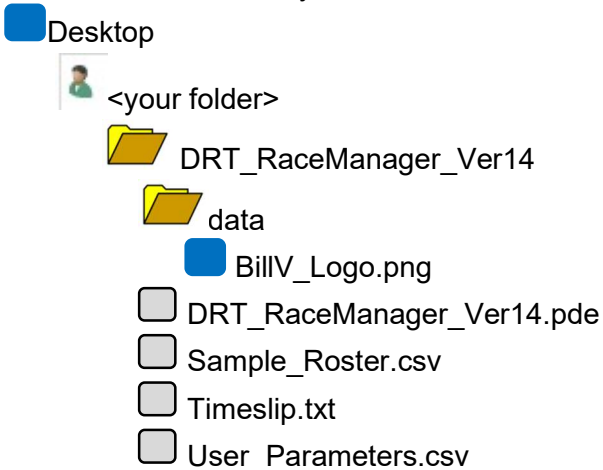
- Use File Explorer to view the contents of the Processing zip file (e.g. processing-4.3-windows-x64.zip) you downloaded from the processing.org website. It should contain a folder called 'processing-x.' (where x is the version#).
- Drag the 'processing-x' folder into your C:\Program Files\ folder.
- 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 'DRT\_RaceManager\_Ver14'.
2. Copy the following files from the source to the 'DRT\_RaceManager\_Ver14' folder just created.
  - a. DRT\_RaceManager\_Ver14.pde
  - b. Sample\_Roster.csv
  - c. Timeslip.txt
  - d. User\_Parameters.csv
3. Now create a subfolder under the 'DRT\_RaceManager\_Ver14' folder called 'data'.

4. Copy the file 'BillV\_Logo.png' from the source into the 'data' folder.
5. Update the Timeslip file path per Section 2.3.2.3 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:



### 2.3.2.1 Timeslip Printer Setup (Optional)

It is assumed the end user will provide the Timeslip printer and install/setup its drivers. During the driver setup the user must set the Timeslip 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 timeslip 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 timeslip is generated.

### 2.3.2.2 User Modifiable Parameters

The race management software has a handful of settings that can be modified by the user at program startup as follows:

- Display Title: Text displayed at the top of the screen
- Timeslip Header Line 1: 1'st line of user modifiable text printed at the top of the Timeslip
- Timeslip Header Line 2: 2'nd line of user modifiable text printed at the top of the Timeslip
- Timeslip Footer Line 1: 1'st line of user modifiable text printed at the bottom of the Timeslip
- Timeslip Footer Line 2: 2'nd line of user modifiable text printed at the bottom of the Timeslip
- Auto Print Copies: Number of Timeslip copies to automatically print at completion of each race
- Timeout: Amount of time the timer will wait for both racers to cross the finish line

A separate file titled “User\_Parameters.csv” has been provided in which these parameters are saved for future events (see Fig. 3). The file resides in the same folder as the race manager software (See Section 2.3.2). Modification of these parameters can be done in two ways. The first and easiest method is at program startup on the User Modifiable Parameters page (See Section 2.4.1). The second method is to use your favorite spreadsheet software to modify the parameter values directly as shown in Column B of Figure 2 below.



	A	B
1	PARAMETER	VALUE
2	Disp_Title:	User Display Title Goes Here
3	TS_Header1:	Time Slip Header Text Line1
4	TS_Header2:	Time Slip Header Text Line2
5	TS_Footer1:	Time Slip Footer Text Line1
6	TS_Footer2:	Time Slip Footer Text Line2
7	Auto print copies:	0
8	Timeout seconds	10

Figure 2 - Screenshot of User Modifiable Parameters

## DEFAULT PARAMETER VALUES

A default set of the user modifiable parameters are stored in the program source code in case the parameters file is missing at program startup. The default set also includes a file path parameter that must be modified in the source code to match your computers file path setup. Figure 3 shows the section of source code that contains the default parameter values.

```

38  /***** DEFAULT USER MODIFIABLE PARAMETERS *****/
39  boolean MetricFlag = false;           //Set to true when speed is in Km/h
40  String Disp_Title = "Organization Name Goes Here"; //Text string to hold display title
41  String TS_Header1 = "DFW Internationals"; //Time Slip header line 1 (33 Char Max)
42  String TS_Header2 = "Championship Drag Racing"; //Time Slip header line 2 (33 Char Max)
43  String TS_Footer1 = "Thanks for racing with us"; //Time Slip footer line 1 (33 Char Max)
44  String TS_Footer2 = "Come back soon"; //Time Slip footer line 2 (33 Char Max)
45  int Autoprintcopies = 0;             //Number of copies to automatically print after race
46  int timeout = 20;                   //Race timeout in seconds (32 Max)
47  //Set the default file path for the Time Slip & Parameters file - MUST BE SAME FILE PATH AS THIS FILE
48  String filePath = "C:/Users/Bill/Timers/Drag Race Timers/DRT_Ver12X_With_Roster/DRT_RaceManager_Ver12X/";
49  /*****

```

Figure 3 - Screenshot of Default User Modifiable Parameters Code

### 2.3.2.3 Modifying the File Folder Directory Path for the Timeslip Text File

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

The race management software source file (DRT\_RaceManager\_Ver14.pde) has a string variable that defines the directory file path in which the Timeslip and User Parameters file are saved. **Program limitations require that these files be saved in the same folder containing the program source code (sketch).** 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 “DEFAULT USER MODIFIABLE PARAMETERS” section of the code (See Fig. 3), find the line starting with: *String filepath = “C:/Users/....”*
- 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.

### 2.3.2.4 Modifying the Speed Display from MPH to Km/h

The race management software source file (DRT\_RaceManager\_Ver14.pde) has a Boolean variable called “MetricFlag” that determines whether speed is displayed in miles-per-hour (MPH) or kilometers-per-hour (Km/h). Its default setting is false. When set to true the display and timeslip printout speed legend will be “Km/h

instead of “MPH”. Note that a similar variable in the Arduino timer code must also be set to alter the default speed calculation for Km/h. To change the “MetricFlag” setting, perform the following:

- In the Processing Display Environment scroll down to the “DEFAULT USER MODIFIABLE PARAMETERS” section of the code (See Fig. 3) and find the line starting with: *boolean MetricFlag = false;*
- Change the word ‘false’ to ‘true’ to set the metric flag. Do not change any other part of the line.
- Select save (Ctrl S) to permanently save your changes.

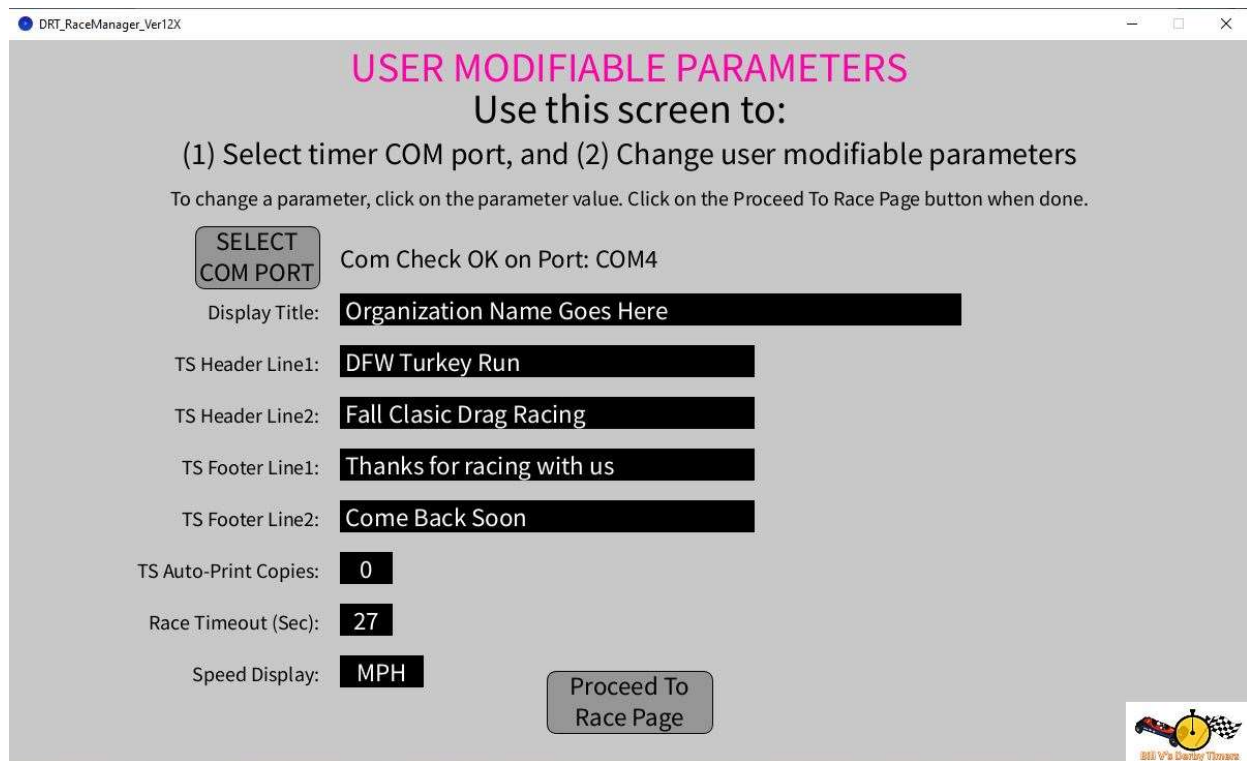
## **2.4 Race Management Software Features**

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

- COM port detection & selection at startup
- User editable Timeslip headers and footers for race event customization.
- Manual and automatic Timeslip print capability
- Ability to set the timer’s timeout duration
- Ability to load a previously saved race event file and continue from where it left off
- Ability to view results from prior races
- Driver lane assignment (Class, car# & dial-in time) from a roster (list) of driver data
- Ability to load a roster, add/delete names & save roster
- Ability to select Christmas tree operation mode
- Ability to select between single or dual lane timer operation
- Ability to select between automatic and manual race start
- Ability to print individual driver timeslips even when two drivers are racing (See Section 2.4.3.6)
- Ability to enable/disable “Double Red” tree operation (See Section 2.4.3.7)
- Ability to enable/disable “Top Bulb Lock” tree operation (See Section 2.4.3.8)
- Ability to initiate the Christmas tree lamp test (Function key F1)
- 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

### **2.4.1 User Modifiable Parameters Page**

When the race manager program is started the User Modifiable Parameters screen is displayed from which you can select the timer COM port and optionally modify the user parameters as shown in Figure 4.



**Figure 4 – User Modifiable Parameters Screen**

#### 2.4.1.1 COM Port Detection & Selection

To select the COM port to which the Arduino timer is connected, mouse click the SELECT COM PORT button and follow the pop-up dialogs.

- 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.

Once a COM port is selected, a COM port check is performed. If successful, a Com check OK message will be displayed to the right of the button. Note that you will not be allowed to proceed to the race page unless the COM port selection is successful.

#### 2.4.1.2 Modifying the Display Title (Optional)

The title shown at the top of the race manager display can be modified as follows:

- On the User Modifiable Parameters screen mouse click anywhere in the Display Title text box. A dialog box will pop up in which you can type a new title.

- Select OK when done.

### 2.4.1.3 Modifying the Timeslip Header and Footer Text (Optional)

The timeslip header and footer text can be modified as follows:

- On the User Modifiable Parameters screen mouse click anywhere in one of the timeslip header or footer text boxes. A dialog box will pop up in which you can type a new header or footer line.
- Select OK when done.

Figure 10 shows an example timeslip with 2 lines of header text and one line of footer text (2'nd footer line left blank).

### 2.4.1.4 Modifying the Number of Timeslip Copies Automatically Printed

The race management software source file has a variable that defines the number of Timeslip 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:

- On the User Modifiable Parameters screen mouse click anywhere in the TS Auto-Print Copies text box. A dialog box will pop up in which you can type a value in the range of 0 to 9. Typically, a value of 2 is selected (one for each racer).
- Select OK when done.

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

### 2.4.1.5 Modifying the Timeout Duration

The timeout duration is the amount of time the timer will wait for both racers to cross the finish line. This allows the race to terminate if a racer's car doesn't cross the finish line in the allotted time. This also allows the user to accommodate different speed classes. Valid values range from 5 to 30 seconds. To change the timeout duration, perform the following:

- On the User Modifiable Parameters screen mouse click anywhere in the Race Timeout text box. A dialog box will pop up in which you can type a value in the range of 5 to 30 seconds. Ensure you enter a value that is slower than the slowest car participating in the event.
- Select OK when done.

### 2.4.1.6 Modifying the Speed Display

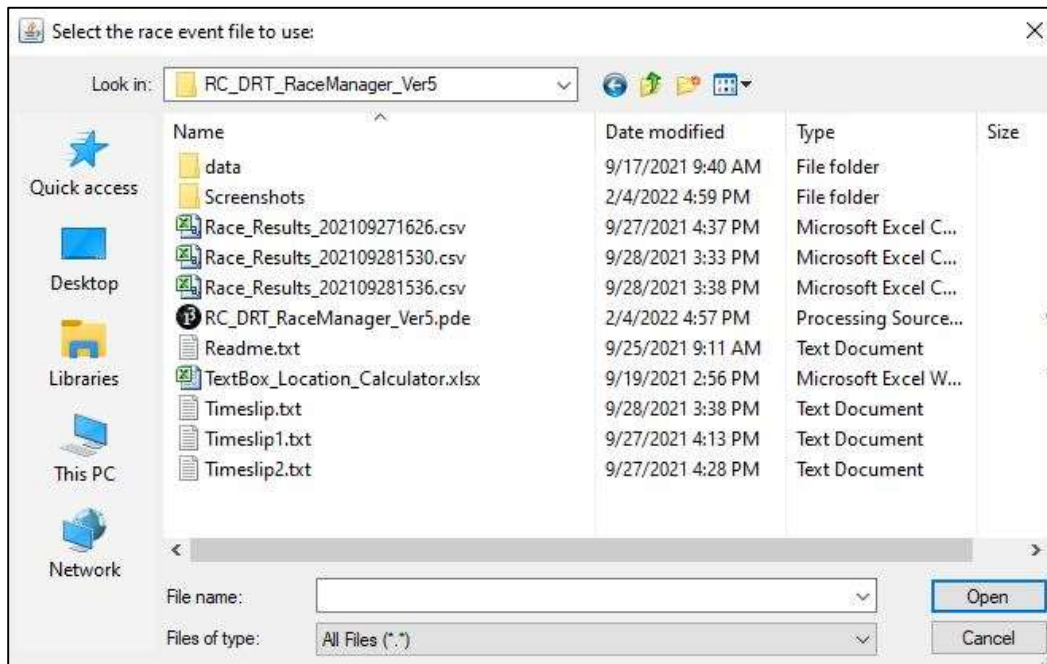
Racer speed can be displayed in Miles-Per-Hour (MPH) or in Kilometers-Per-Hour (Km/h). To change the displayed speed, click anywhere in the Speed Display text box on the User Modifiable Parameters screen. The value will toggle between MPH and Km/h.

### 2.4.1.7 Continuation from a Previously Saved Race Event

When the Proceed To Race Page button on the User Modifiable Parameters page is selected the user will be prompted if he wishes to continue from a previously saved race event (See Fig. 5a). 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. 5b). 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 2.3.2). 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 5a – Race Event Select Pop-up**



**Figure 5b – Race Event File Selection Pop-up Example**

## 2.4.2 Race Management Display - Left Side

The left side of the race management display displays racer information and race results consisting of the reaction time, 60' ET, 660' (1/8 mile) ET, 1/4-mile ET, 1/4-mile speed, Overall Time (RT + ET), Status (Win, DISQ, Breakout), and Margin. The left side also contains the race status display, race control buttons. Refer to Figure 6 below.

### 2.4.2.1 Racer Information - Class, Car# & Dial-in

Text boxes are provided to display the racer's race class, car number and dial-in time (if used). These boxes are populated prior to race start from racer data selected from the roster displayed on the right side of the race management page. Refer to section 2.4.3.1 for assigning racers to a lane.

### 2.4.2.2 Reaction Time

Reaction time (RT) is the time from when the race timer starts (green Christmas tree light illuminates) to when the racer trips the start line stage or guard sensor. If the stage or guard sensor was tripped prior to illumination of the green 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.



Organization Name Goes Here

**Lane 1**      **Class**      **Lane 2**      **TS Select**

**Pro Stock**      **Pro-Stock**

49      Car#      10

0.00      Dial In      0.00

0.317      RT      -0.032

2.360      60' ET      1.984

9.916      1/8 ET      8.720

13.660      1/4 ET      13.407

109.30      1/4 MPH      105.37

13.977      Ov'l Time      13.407

WINNER      Status      DISQ

0.570      Margin      0.000

**Roster**

Click on Driver No. to assign to a lane

No.	Name	Car#	Class	Dial-In
1	Tow Mater	21	Pro Stock	0.00
2	Phlat Tired	77	Funny Car	0.00
3	Mini Cooper	101	Top Fuel	13.57
4	Harley Davidson	33	Pro Stock	12.98
5	Speedy Gonzales	147	Funny Car	12.47
6	Mario Kart	1	Pro Stock	13.21
7	Lightning McQueen	99	Funny Car	11.95
8	Wiley Coyote	7	Street	0.00
9	Rode Runner	49	Outlaw	0.00
10	Slow Poker	10	Outlaw	0.00

**Race Status**

- ☒ Not Ready
- ☐ Ready
- ☐ Staged
- ☐ Countdown
- ☐ Racing
- ☐ Finished

**Timer**

**Race Control**

**Race #** 4

**Race Control Options**

Click on box to change selection

Tree Mode:       Active Lanes:   
 Start Mode:       Double Red:   
 Handicap Enbl:       Top Bulb Lock:   
 Timeslip Print:

Msg:

Figure 6 – Race Management Display

#### 2.4.2.3 60 Foot ET

The 60-foot ET is the time from when the racer leaves the start line (trips the start line stage sensor) to when the racer trips the 60-foot line sensor. Time is measured and displayed to the millisecond. If the racer fails to trip the 60-foot line sensor dashes will be displayed.

#### 2.4.2.4 660 Foot (1/8 Mile) ET

The 660-foot ET is the time from when the racer leaves the start line (trips the start line stage sensor) to when the racer trips the 660-foot line sensor. Time is measured and displayed to the millisecond. If the racer fails to trip the 660-foot line sensor dashes will be displayed.

#### 2.4.2.5 1/4 Mile ET

The 1/4-mile ET is the time from when the racer leaves the start line (trips the start line stage sensor) to when the racer trips the 1/4-mile line sensor. Time is measured and displayed to the millisecond. If the racer fails to trip the 1/4-mile line sensor dashes will be displayed.

#### 2.4.2.6 1/4 Mile Speed

1/4-mile speed is calculated from the difference in time between the tripping of the 1/4-mile trap sensor and the 1/4-mile finish line sensor. The 1/4-mile trap sensor is placed 66 feet before the 1/4-mile finish line sensor. 1/4-mile trap speed is displayed to 2 decimal places in either MPH or Km/h. If the racer fails to trip either of these sensors, dashes will be displayed for the 1/4-mile speed.

#### 2.4.2.7 Overall Time

Overall time is the sum of Reaction Time (RT) and 1/4-mile ET. If RT is negative (racer fouled), Overall Time is the equal to 1/4-mile ET. Overall time is displayed to the millisecond.

#### 2.4.2.8 Margin

Margin is the difference between the winning and losing racer's overall time (RT + ET). Margin is displayed for the winning racer only and can be negative if the losing racer had a faster overall time but lost due to a foul (i.e. red lighting). Margin is displayed to the millisecond. *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.*

#### 2.4.2.9 Lane Status

Lane status displays the status of each racer at the conclusion of the race. Status is determined by applying the win/lose/disqualification rules set forth in the National Hotrod Association (NHRA) 2021 Rulebook to the race results. Typically, the winner is the first vehicle to cross the finish line but that is not necessarily the case if one or both vehicles foul (red-light) or breakout (handicapped race only).

- DISQ – displayed if the racer disqualified (red-lighted).
- BREAKOUT – displayed if the racer lost due to underrunning his dial-in time (handicapped race only)
- WINNER – displayed when that racer has the fastest overall time or the other racer disqualified (red-lighted).
- WINNER\* - displayed if the other racer has the fastest overall time but disqualified (red-lighted) making you the winner by default.
- - - - (dashes) – displayed if the racer loses or does not cross the finish line.

#### 2.4.2.10 Next Race Button

The 'Next Race' button when clicked sends a reset command to the 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.

#### 2.4.2.11 Start Race Button

The 'Start Race' button when clicked sends a start command to the 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.

#### 2.4.2.12 Print Timeslip Button

The 'Print Time Slip' button when clicked causes a timeslip 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, timeslips can be printed of prior run races. Note that if the "Auto Print Copies" user setting is set to a value > 0 (See Section 2.4.1.4), one or more timeslips will automatically print at the conclusion of each race.

#### 2.4.2.13 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 Timeslip' button, this feature can be used to print timeslips 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.

#### 2.4.2.14 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 Arduino timer.

#### 2.4.2.15 Race Status

The Race Status box displays the current state of the race timer consisting of the following:

• Not Ready	Timer Not Ready – Typically occurs when one or more lane sensors are obstructed or out of alignment when timer is reset for the next race.
• Ready	Timer is ready for cars to stage.
• Staged	Cars are staged (Stage sensors tripped).
• Countdown	Race started – Christmas tree lamps cycle through their sequence.
• Racing	Race Underway – Green light.
• Finished	Cars have crossed finish line or race timer timed out.

### 2.4.3 Race Management Display – Right Side

The right side of the race management display (Ref. Fig. 6) displays the roster and a set of mouse clickable buttons for the selection of various race control options.

#### 2.4.3.1 Roster

The roster provides a list of drivers from which selection is made to assign a driver's class, car number and dial-in time to a lane and subsequent printout on the timeslip when the race completes. The roster is generated ahead of time using spreadsheet software to create a comma delimited (.csv) data file (See Fig. 7) or using the Add Driver button. Four mouse clickable buttons are provided for managing the roster as follows:

• Load Roster	Provides a pop-up window from which a roster file can be selected for loading.
• Add Driver	Provides a series of pop-up windows from which a driver's name, car number, race class and dial-in time can be entered.
• Delete Driver	Allows the user to select a driver for deletion from the roster.
• Save Roster	Saves the roster and any changes made thereto.

	A	B	C	D
1	Name	CarNo	Class	Dialin
2	Tow Mater	21	Pro Stock	0
3	Phlat Tired	77	Funny Car	0
4	Mini Cooper	101	Top Fuel	13.57
5	Harley Davidson	33	Pro Stock	12.98
6	Speedy Gonzales	147	Funny Car	12.47
7	Mario Kart	1	Pro Stock	13.21
8	Lightning McQueen	99	Funny Car	11.95
9	Wiley Coyote	7	Street	0
10	Rode Runner	49	Outlaw	0
11	Slow Poker	10	Outlaw	0
12	Daisy Duke	45	Outlaw	0

Figure 7 – Example Roster Data File (Spreadsheet Format)



**Assigning a driver to a lane** – A driver from the roster can be assigned to a lane by clicking on the driver's number located in the left most column. Doing so causes a pop-up window (See Fig.8) from which the lane can be selected.



**Figure 8 – Driver Lane Assignment Pop-Up**

#### **2.4.3.2 Tree Mode Selection**

The Christmas tree can be set to function either as a "Standard" tree (AKA "sportsman" or "full" tree), a "Professional" (Pro) tree or as a "Street Outlaw" tree. Clicking on the Tree Mode select box causes a pop-up window (See Fig. 9) to be displayed from which the tree mode can be selected. Note that the selection can only be changed when the timer is in the Ready or Finished state.



**Figure 9 – Xmas Tree Mode select Pop-Up Window**

When set to the "Standard" mode the amber lights will illuminate in sequence from top to bottom, 0.5 seconds apart and followed 0.5 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 "Outlaw" mode the three sets of amber lights do not flash and only the green lights will illuminate.

#### **2.4.3.3 Timer Start Mode**

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 start switch 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 all racers have staged. Clicking on the Auto/Man Start select button will cause the selection to toggle between Auto Start or Manual Start. Note that the selection can only be changed when the timer is in the Ready or Finished state.

#### **2.4.3.4 Active Lanes Selection**

The timer can be setup to handle two racers or a single racer as would be common for practice runs. Clicking on the Active Lanes select box causes a pop-up window (See Fig. 10) to be displayed from which the lane usage can be selected. When lane usage is set to both lanes (default), both racers must be staged in order for the timer to initiate the start/countdown sequence. When lane usage is set to Lane 1 or Lane 2, a single vehicle staged in the selected lane will allow the timer to initiate the start/countdown sequence. Note that the selection can only be changed when the timer is in the Ready or Finished state.



**Figure 10 – Lane Usage Select Pop-Up**

#### 2.4.3.5 Handicap Enable Option

The Handicap Enable option allows the user to enable or disable running of a handicap race. When enabled, a handicap race will automatically be run if both drivers have a valid dial-in time as listed in the roster. When disabled, any listed dial-in times will be ignored and the race will execute as a non-handicap race.

#### 2.4.3.6 Timeslip Print Option

By default, when two drivers are racing (both lanes used), the resultant timeslip will show both racers as shown in the left timeslip of Figure 11 below. Additionally, if only one driver is racing (one lane used), the resultant timeslip will show only the single racer as shown in right timeslip of Figure 11. The Timeslip Print select button allows the user to select printing of individual timeslips even though both lanes are used (two racers). Clicking on the Timeslip Print select button will cause the selection to toggle between Normal and Individual. Note that the selection can only be changed when the timer is in the Ready or Finished state.

DFW Turkey Run RC Car Drag Racing		
-----		
Date: 11/24/2023 12:19		
Race# 009		
-Lane 1-		-Lane 2-
Pro-Stock	Class	Pro-Stock
77	Car#	609
0.000	Dial-In	0.000
0.054	R/T	-0.104
1.867	60 Ft	1.868
8.443	1/8 ET	8.443
12.443	1/4 ET	12.443
115.681	1/4 MPH	115.979
WINNER	Status	DISQ
0.046	Margin	-----
-----		
Thanks for racing with us Come Back Soon		

**Dual Timeslip**

DFW Turkey Run RC Car Drag Racing	
-----	
Date: 11/24/2023 13:19	
Race# 011	
-Lane 1-	
Class.....	Street
Car#.....	555
Dial-In....	0.000
R/T.....	0.104
60 Ft.....	1.868
1/8 ET.....	8.443
1/4 ET.....	12.443
1/4 MPH....	115.979
Status.....	WINNER
Margin.....	0.048
-----	
Thanks for racing with us Come Back Soon	

**Individual Timeslip**

**Figure 11 – Example Timeslip Printouts**

#### 2.4.3.7 Double Red Option

Normal tree operation utilizes the “first or worst” methodology when it comes to red-lighting (foul) in that only the first driver to foul will get a red light. If the second driver fouls, he will not get a red light and will get the green light. When the Double Red option is turned on, both racers will get a red light if they foul. The second racer to foul will still get the green light as well. Clicking on the Double Red select button will cause the selection to toggle between On and Off. Note that the selection can only be changed when the timer is in the Ready or Finished state.

#### **2.4.3.8 Top Bulb Lock Option**

Also known as “Cross-Talk”, when the Top Bulb Lock feature is turned on, the top amber bulb in each lane comes on at the same time when running a handicapped tree. The second and third amber operate as they normally would. Clicking on the Top Bulb Lock select button will cause the selection to toggle between On and Off. Note that the selection can only be changed when the timer is in the Ready or Finished state.

#### **2.4.4 Christmas Tree Lamp Test (F1)**

A self-test of the Christmas tree lamps can be initiated using the F1 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. **Note:** On many Windows PCs it will also be necessary to simultaneously press the “Fn” key to bypass the Windows default function key action.

#### **2.4.5 Remote Hand-Held Pushbutton**

A hand-held pushbutton switch on a long cable provides a means to remotely control the race timer. This is typically 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 and holding the pushbutton for about 1/4 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 the hand-held pushbutton is disabled when an error is detected.

## 3 RUNNING A RACE

### 3.1 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 software senses that one or more of the optical lane sensors is obstructed or not properly illuminated. 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 “pre-stage” and “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 single racer mode is selected only a vehicle in the selected lane needs to be staged. 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 start line stage and guard sensors. If a stage sensor is tripped before the green light illuminates the corresponding red foul light will illuminate instead of the green “Go” indicator. Foul 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. For handicapped races the countdown sequence for the car having the shortest dial-in will be delayed by the difference between the two dial-in times. Note that if one or both racers do not have a valid dial-in time, the timer automatically defaults to a non-handicapped race.

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 for all racers.

The “Finished” state is displayed when both vehicles have crossed the finish line or when the timeout duration has 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 timer to exit the ‘Finished’ state and ready it for the next race.

### 3.2 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 2 of this document. It is assumed the race coordinator has loaded a race roster, selected between a 1/8-mile or 1/4-mile race and has selected the various race control options provided on the right side of the race management screen.

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.	<ul style="list-style-type: none"> <li>The next race number will be displayed in the RACE # box</li> <li>Race Status changes to "Ready".</li> <li>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.</li> </ul>
2	(Optional) On the PC race management screen, assign drivers to the lanes by clicking on the roster's driver number.	<p>Race class, Car# and Dial-in (if provided) is displayed for the assigned lane.</p> <p><b>Note:</b> Both racers must have a valid dial-in time and the Handicap Enable set to "Enbl" to run a handicapped race. If no or only one dial-in time is entered the race will default to a standard non-handicapped race.</p>
3a	<b>DUAL RACER MODE</b> Stage the racers.	<ul style="list-style-type: none"> <li>As each racer is staged the corresponding white stage indicators will illuminate.</li> <li>When both racers are staged the timer advances to the Staged state and the race can be started.</li> <li>If a racer advances too far and trips the guard beam the red foul light will illuminate and the racer must back up to properly stage.</li> </ul>
3b	<b>SINGLE RACER MODE</b> Stage the racer in the selected lane.  <b>Note:</b> In single racer mode, only the selected lane is active.	When the racer has staged the timer advances to the Staged state and the race can be started.
4a	<b>AUTO START MODE</b> If the timer is in the Auto Start mode the timer will start automatically after a short random delay from when the vehicles are staged.	<ul style="list-style-type: none"> <li>The Christmas tree lights will begin their countdown sequence. If a racer trips the start line 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.</li> <li>Race Status changes from "Staged" to "Countdown" and then to "Racing" when the green Christmas tree lights illuminate.</li> </ul>

Step	Action	Expected Results / Comments
4b	<p><b>MANUAL START MODE</b></p> <p>Start the race. This can be done via the hand-held start button or the Start Race button on the PC.</p> <p><b>Note:</b> <i>If using the hand-held start button to start the race, it must be pressed and held for a minimum of 1/2 second to initiate a start.</i></p>	<ul style="list-style-type: none"> <li>• The Christmas tree lights will begin their countdown sequence. If a racer trips the start line 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.</li> <li>• Race Status changes from “Staged” to “Countdown” and then to “Racing” when the green Christmas tree lights illuminate.</li> </ul>
5	<p>Allow the race to complete. This will occur when all racers have crossed the finish line or the maximum allowed race duration (timeout) has been exceeded, whichever occurs first.</p>	<ul style="list-style-type: none"> <li>• The green Christmas Tree lights extinguish</li> <li>• Race Status changes from “Racing” to “Finished”.</li> <li>• Race results are displayed on the PC’s race management screen.</li> <li>• The green indicator of the winning lane will flash for 15 seconds.</li> <li>• The win light of the winning lane (if installed) will illuminate for 15 seconds.</li> <li>• If the “Auto Print Copies” setting is set to 1 or greater, the selected number of timeslips is automatically printed.</li> </ul>
6	Repeat Steps 1 through 5 for each race.	

### 3.3 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). 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 column "L1" and "L2" stand for Lane 1 and Lane 2 respectively.

Race	L1 Car	L1 Class	L1 Foul	L1 BrkOut flag	L1 Dialin	L1 React	L1 60Ft	L1 660Ft	L1 1320Ft	L1 Speed	L1 Ovl	L1 Margin	L1 WinFlag	L2 Car
1	49	Pro-Stock	0	0	0	0.317	2.360	9.916	13.206	109.3	13.523	0.570	1	10
2	45	Pro-Stock	1	0	0	-0.600	1.567	6.501	9.911	141.35	9.911	0	0	77

L2 Class	L2 Foul	L2 BrkOut flag	L2 Dialin	L2 React	L2 60Ft	L2 660Ft	L2 1320Ft	L2 Speed	L2 Ovl	L2 Margin	L2 WinFlag	Date	Time
Pro-Stock	1	0	0	-0.032	1.984	8.720	13.407	105.37	13.407	0	0	11/9/2023	15:35
Pro-Stock	0	0	0	0.215	1.754	6.499	9.967	145.21	10.182	0.207	1	11/9/2023	15:37

**Figure 12 – Example of Race Results File (formatted)**

Table descriptions are as follows:

- Car: Car number
- Foul: 1 = driver fouled (red-lighted), 0 = No foul
- BrkOut flag: 1 = Driver broke out (Time was faster than dial-in), 0 = OK
- Speed: 1/4-mile speed in MPH
- WinFlag: 1 = Winner, 0 = Loser

## 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:

- Install the Arduino Integrated Development Environment (IDE) per Section 2.5 of this document.
- 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 DRT\_Timer\_Ver14.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 letters RS in the command line and press ENTER.	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 letters RS in the command line and press ENTER.	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.



Step	Action	Expected Results
5	Restore the light illuminating the Lane 1 pre-stage sensor then enter the letters RS in the command line and press ENTER.	<p>The Lane 1 Christmas tree white pre-stage lights extinguish.</p> <p>The two green Christmas tree lights flash on/off two times.</p> <p>The message "RDY" is displayed on the monitor.</p>
6	Repeat steps 3 through 5 for the Lane 1 stage sensor.	<p>Results are the same as noted above except for Lane 1 Christmas tree white stage lights.</p> <p>The message "TRK Stg1" followed by "NRD" is displayed indicating the stage sensor for Lane 1 is not ready.</p>
7	Repeat steps 3 through 5 for the Lane 2 pre-stage and stage sensors	<p>Results are the same as noted above except for Lane 2 Christmas tree white pre-stage and stage lights.</p> <p>The messages "TRK PStg2" and "TRK Stg2" followed by "NRD" are displayed for their corresponding sensor.</p>
8	<p><b>Note:</b> Skip steps 8 – 11 if Guard Sensors are not installed.</p> <p>Obstruct (block) the light illuminating the Lane 1 guard sensor.</p>	N/A
9	While continuing to block the light illuminating the Lane 1 guard sensor, enter the letters RS in the command line and press ENTER.	<p>The Lane 1 Christmas tree red foul light will flash twice indicating a lane 1 sensor is not ready.</p> <p>The message "TRK Grd1" followed by "NRD" is displayed indicating the guard sensor for Lane 1 is not ready.</p>
10	Restore the light illuminating the Lane 1 guard sensor then enter the letters RS in the command line and press ENTER.	<p>The two green Christmas tree lights flash on/off two times.</p> <p>The message "RDY" is displayed on the monitor.</p>
11	Repeat steps 8 through 10 for the Lane 2 guard sensor.	<p>Results are the same as noted above except for Lane 2 Christmas tree red foul light.</p> <p>The messages "TRK Grd2" followed by "NRD" are displayed.</p>
12	Obstruct (block) the light illuminating the Lane 1 60 foot sensor.	N/A

Step	Action	Expected Results
13	While continuing to block the light illuminating the Lane 1 60 foot sensor, enter the letters RS in the command line and press ENTER.	The Lane 1 Christmas tree red foul light will flash twice and then remain extinguished.  The message "TRK 60ft1" followed by "NRD" is displayed indicating the Lane 1 60 foot sensor is not ready.
14	Restore the light illuminating the Lane 1 60 foot sensor and obstruct (block) the light illuminating the Lane 2 60 foot sensor.	N/A
15	While continuing to block the light illuminating the Lane 2 60 foot sensor, enter the letters RS in the command line and press ENTER..	The Lane 2 Christmas tree red foul light will flash twice and then remain extinguished.  The message "TRK 60ft2" followed by "NRD" is displayed indicating the Lane 2 60 foot sensor is not ready.
16	Restore the light illuminating the Lane 2 60 foot sensor and obstruct (block) the light illuminating the Lane 1 660 foot sensor.	N/A
17	Repeat the previous four steps for the remaining sensors.	Results are the same except for the corresponding error messages as follows: <ul style="list-style-type: none"> <li>• TRK 660ft1 &amp; TRK660ft2</li> <li>• TRK 1254ft1 &amp; TRK1254ft2</li> <li>• TRK 1320ft1 &amp; TRK1320ft2</li> </ul>
18	Remove all sensor obstructions and ensure the hand-held Start Switch is not depressed.	N/A
19	On the serial monitor enter the letters LT in the command line and press ENTER.	The Christmas tree lamp test sequence is executed where each set of lamps will cycle on/off at a 0.5 second rate.
20	On the serial monitor enter the letter RS in the command line and press ENTER.	The message "RDY" is displayed on the monitor.  No Christmas tree lamps are illuminated.
21	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 for both lane 1 & 2.  The message "STG" is displayed on the monitor.
22	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 Christmas tree amber and green lights cycle through their countdown sequence at a 0.5 second rate.  The message "CNT" is displayed on the monitor.  When the green lamps illuminate the message "RAC" is displayed on the monitor.

Step	Action	Expected Results
23	Wait about 20 seconds.	After 20 +/-1 seconds the green Xmas tree lights extinguish and the serial data messages as shown in Figure A1 are displayed on the monitor followed by the message "FIN".
24	Remove the obstruction from the Lane 1 and Lane 2 stage sensors.	The white stage lights on the Christmas tree extinguish.
25	On the serial monitor enter the letters RS in the command line and press ENTER.	The message "RDY" is displayed.
--	TEST COMPLETE	

<p>"Lane1: 0 0 9999.999 9999.999 9999.999 9999.999 9999.999 0"</p> <p>"Lane2: 0 0 9999.999 9999.999 9999.999 9999.999 9999.999 0"</p>
---------------------------------------------------------------------------------------------------------------------------------------

**Figure A1 Serial Data Output String**

## 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
RS	PC-to-Timer	Reset – Resets the Arduino timer
ST	PC-to-Timer	Race Start – Commands the Arduino timer to start the race.
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
LT	PC-to-Timer	Lamp Test – Command Arduino timer to initiate the Xmas Tree lamp test
M:0	PC-to-Timer	Sets the Xmas Tree to function in the “Sportsman” (Standard) mode.
M:1	PC-to-Timer	Sets the Xmas Tree to function in the “Pro” mode.
M:2	PC-to-Timer	Sets the Xmas Tree to function in the “Street Outlaw” mode.
AS:0	PC-to-Timer	Auto start off - Sets timer to manual start
AS:1	PC-to-Timer	Auto start on - Sets timer to auto start
LN:1	PC-to-Timer	Sets timer to time Lane 1 only
LN:2	PC-to-Timer	Sets timer to time Lane 2 only
LN:3	PC-to-Timer	Sets timer to time both lanes
DBR:0	PC-to-Timer	Sets Double Red feature to off
DBR:1	PC-to-Timer	Sets Double Red feature to on
TBL:0	PC-to-Timer	Sets Top Bulb Lock feature to off
TBL:1	PC-to-Timer	Sets Top Bulb Lock feature to on
D1:xxxxx	PC-to-Timer	Lane 1 dial-in time in milliseconds. Valid range: 00000 - 32767
D2:xxxxx	PC-to-Timer	Lane 2 dial-in time in milliseconds. Valid range: 00000 - 32767
TO:xxxxx	PC-to-Timer	XO:xxxxx where xxxxx is the timeout value in milliseconds Valid range: 05000 - 30000 milliseconds (5 to 30 seconds)
DBug	PC-to-Timer	Enables/Disables the software debug flag. Used when debugging code.
@	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 y aaaa.aaa bbbb.bbb cccc.ccc dddd.ddd eeee.eee z**

**Lane2: x y aaaa.aaa bbbb.bbb cccc.ccc dddd.ddd eeee.eee z**

Where:

- x = Foul status (0=OK, 1=First to foul, 2=Second to foul)
- y = Breakout status (Handicapped races only) (0=OK, 1=Breakout)
- aaaa.aaa = Reaction time (padded with 1000 seconds)
- bbbb.bbb = 60' marker time (padded with 1000 seconds)
- cccc.ccc = 660' (1/8 mile) marker time (padded with 1000 seconds)
- dddd.ddd = 1320' (1/4 mile) marker time (padded with 1000 seconds)
- eeee.eee = 1320' (1/4 mile) speed (padded with 1000)
- z = Lane win status (0=lose, 1=Win)

Note that the Arduino software pads the values with 1000.000 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 value is subtracted from the received results by the race management software.

Additionally, if the foul status character is a "1" or "2" the reaction time value provided is the time from when the start line sensor was tripped to the time the green Christmas Tree light illuminates (race start time) and will be displayed 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](mailto:billv923@outlook.com) for additional help.