***Fencing Scoring Box Mk1***

***User Manual***



***Introduction***

***This document is written by Robin Terry and is © Robin Terry 2022.***

***No liability is implied by this document; the software and hardware designs detailed in this document are freely available for your use entirely at your own risk.***

***Date of latest edition: June 28, 2022***

The fencing scoring box Mk1 is designed to do the following:

* detect and indicate hits by either or both fencers, using timings given in FIE specifications
* support sparring, with optional self-scoring
* support bouts, both single and team
* support priority selection and timing
* support rest period timing
* support passivity timing
* support all three fencing weapons (foil, epee, sabre)
  + the last selected weapon is stored in non-volatile memory
  + this selection is therefore remembered across power on
* support an IR (infra-red) handset for detailed control of operation
* support a 4-digit 7-segment LED display for status/timing indication
* support various discrete LEDs for status indication
* support audible indication of hits (on-target and off-target)
* detect and indicate short-circuit conditions with either or both weapons
* support an up-down counting stopwatch
* support a display repeater connected through the USB interface
* store a piste number in non-volatile memory given to it by the repeater
  + the box does nothing with it except retain it and inform the repeater of it when the repeater is connected

Throughout this document, fencer A is on the left-hand side of the fencing scoring box, and fencer B is on the right-hand side.

The Mk1 version of the fencing scoring box is designed for low power consumption, using common and easily obtainable USB power sources, and for easy portability.

This document also contains a description of the Android-based version of the repeater application which has been written to accompany the fencing scoring box.

***7-segment LED display indications***

**FOIL** - select foil as a weapon (default)

**EPEE** - select epee as a weapon

**SAbr** - select sabre as a weapon

**SPAr** - select sparring mode

**Bout** - select bout mode

**StOP** - select stopwatch mode

**----** - normal (sparring mode with no scoring)

**H --** - fencer A hit (sparring mode with no scoring)

**-- H** - fencer B hit (sparring mode with no scoring)

**o --** - fencer A off-target hit (foil)

**-- o** - fencer B off-target hit (foil)

**Prio** - priority selection starting

**rESt** - 1-minute rest period starting

**]---** - momentary guard touch from fencer A

**---[** - momentary guard touch from fencer B

**]--[** - momentary simultaneous guard touch

**SC--** - fencer A persistent short-circuit

**--SC** - fencer B persistent short-circuit

* if numbers are visible with the centre colon, then this is a timer display
* if numbers are visible without the centre colon, then this is a score display

***Short-circuit detection***

The fencing scoring box Mk1 is able to detect a short-circuit condition and display a visual indication on both LEDs (if fitted) and on the 7-segment display.

If the short-circuit LEDs are fitted, then the appropriate LED for the fencer will be illuminated as soon as the condition is detected, and it will be extinguished as soon as the condition disappears.

Therefore, if a hit to the guard occurs, there will be a momentary illumination of the short-circuit LED.

In addition, if the timer is not running, then the momentary guard touch indication will also be shown on the 7-segment display.

However, a true short-circuit condition has to be persistent for at least 3 seconds. If this happens, then the 7-segment display will show the persistent short-circuit indication, and this will override all other displays while the condition is active.

***Passivity timer***

The fencing scoring box Mk1 will monitor for passivity (if enabled at build time). The box will monitor the period of time between hits and will signal passivity by flashing the hit LEDs briefly if the time between hits reaches 1 minute. The bout timer will continue, and the bout will not be affected in any other way, so the referee is free to ignore the signal if they so wish.

When the repeater application is connected to the fencing scoring box, there is a 60-second timer displayed on the repeater which shows the time between hits. This counts down to zero and works in conjunction with the fencing scoring box indication.

If the score is not incremented after a hit (in other words, the hit was not valid) then the passivity timer is not reset to zero.

***Passivity cards***

With the repeater connected, it is possible to award passivity cards to fencer(s) using the IR handset, and these are displayed on the repeater. The way that passivity cards are awarded follows the current FIE rules regarding passivity.

The fencing scoring box is not able to display passivity cards itself, so passivity card support is only enabled when the repeater is connected.

***Piste number storage***

With the repeater connected, the fencing scoring box is able to store the piste number. The user can set the piste number through the repeater (see later) and the repeater informs the box which number has been selected through the polling mechanism.

The box will store the piste number in its non-volatile memory but will not make use of it. However, next time when the repeater is connected, the box will inform the repeater which piste has been stored by using the *!GO* command. The repeater will keep a record of this number for the remote indication messages.

Piste numbers from 1 to 30 inclusive are supported.

***IR handset key functions (summary)***

A picture containing electronics, remote

Description automatically generated

SWAP SCORES

WIND TIMER BACK (BOUT)

PASSIVITY CARD/

CLEAR PENALTY CARDS

FENCER A YELLOW/RED PENALTY CARD

FENCER B YELLOW/RED PENALTY CARD

START & STOP TIMER (BOUT)/

CONFIRM HIT (BOUT)/

START & STOP (STOPWATCH)/

CLEAR SCORES (SPAR)

RESET TIMER (BOUT)

WIND TIMER FORWARD (BOUT)

DECREASE SCORE/

SCORE DISPLAY (BOUT)/

DECREASE TIME (STOPWATCH)

SELECT FENCER B/

SCORE DISPLAY (BOUT)/

SELECT SECONDS (STOPWATCH)

INCREASE SCORE/

SCORE DISPLAY (BOUT)/

INCREASE TIME (STOPWATCH)

1-MINUTE REST (BOUT)

PRIORITY (BOUT)/

RESET (STOPWATCH)/

SCORING ON or OFF (SPAR)

CLEAR SCORES

SELECT MODE:

SPAR/BOUT/STOPWATCH

SELECT FENCER A/

SCORE DISPLAY (BOUT)/

SELECT MINUTES (STOPWATCH)

***IR handset key functions (sparring mode)***

A picture containing electronics, remote

Description automatically generated

SWAP SCORES

CLEAR SCORES

CLEAR SCORES

SCORING ON or OFF

INCREASE SCORE FOR

SELECTED FENCER

SELECT FENCER B

DECREASE SCORE FOR

SELECTED FENCER

SELECT FENCER A

SELECT MODE:

SPAR/BOUT/STOPWATCH

CLEAR SCORES (SPAR)

NOTES

* when the *SCORING ON or OFF* function is activated, the scores are cleared
* if scoring is on, the fencer(s) who won the hit is selected, but not automatically incremented
* Therefore, one of the fencers increments the score using the IR handset Up button

***IR handset key functions (bout mode)***

A picture containing electronics, remote

Description automatically generated

SWAP SCORES

WIND TIMER BACK

PASSIVITY CARD/

CLEAR PENALTY CARDS

FENCER B YELLOW/RED PENALTY CARD

FENCER A YELLOW/RED PENALTY CARD

START PRIORITY SELECTION

START & STOP TIMER/

CONFIRM HIT

RESET TIMER

WIND TIMER FORWARD

1-MINUTE REST

DECREASE SCORE FOR

SELECTED FENCER/

SCORE DISPLAY

SELECT FENCER B/

SCORE DISPLAY

INCREASE SCORE FOR SELECTED FENCER/

SCORE DISPLAY

SELECT FENCER A/

SCORE DISPLAY

SELECT MODE:

SPAR/BOUT/STOPWATCH

CLEAR SCORES

NOTES

* the *SCORE DISPLAY* function is only active when the timer is running
* the *START & STOP TIMER* function is active all the time, except when a hit has been detected
* all other functions are only active when the timer is stopped
* the *CONFIRM HIT* function is only active if a hit has been detected
* the *CONFIRM HIT* function also clears the hit LEDs
* once a hit has been confirmed, the OK key will restart the timer to continue the bout
* the *SELECT MODE* function can be used to restart the bout (when the timer is not running) if the bout is not already at the start

***IR handset key functions (stopwatch mode)***

A picture containing electronics, remote

Description automatically generated

SELECT SECONDS

RESET BACK TO START TIME/

RESET TIME TO 00:00

SELECT MINUTES

START & STOP

DECREASE SELECTED TIME

SELECT MODE:

SPAR/BOUT/STOPWATCH

INCREASE SELECTED TIME

NOTES

* If the initial start time is 00:00 the stopwatch will count up
* If the initial start time is not 00:00 the stopwatch will count down
* pausing the stopwatch with the OK key will not change the count direction when restarted, unless the time is changed
* the *RESET TIME TO 00:00* function will be active if the stopwatch is not running and the time has already been set to the initial start time
* the *RESET BACK TO START TIME* is active even when the stopwatch is running
* the *SELECT MODE* function can be used to restart the stopwatch (when it is not running) if the stopwatch is not already at the start

***Description of software operation***

The fencing scoring box Mk1 can support all three fencing weapons – foil, epee and sabre.

The weapon type can be selected by pressing and holding the push button (see later).

The selected operating mode (sparring/bout/stopwatch) is also stored in non-volatile memory. If this setting is not valid, then the default selection is sparring.

The box can also support a number of features in each mode:

* sparring - with no scoring
* sparring - with scoring
* bout – scoring and timing
* bout - priority selection
* bout - yellow and red penalty card indication for either fencer
* bout - 1-minute rest period
* stopwatch – up or down counting with visual and audible indication
* short-circuit detection and display

When the box starts up, it will read the stored weapon type and operating mode from non-volatile memory and set itself up for that.

***Sleep display***

If the fencing scoring box Mk1 has been left in a static state for over 5 minutes, then the 7-segment LED display will show a dimmed animated display to save power. It will do this until either a key is pressed on the IR handset, or (in sparring mode) a hit is detected, after which the display is woken up.

If an IR handset key is pressed while the display is dimmed, the key will not be actioned – it is just used to wake up the display. Press the same key again to action it.

***Weapon select***

The weapon type (foil, epee or sabre) can be selected by pressing and holding the push button.

A short press and release of the push button will display the current weapon type and operating mode.

The selected weapon type is stored in non-volatile memory, so it is remembered across power off. If this setting is not valid (as in, for example, a previously unused box) then the default selection is foil.

***Operating modes***

The fencing scoring box Mk1 supports three different modes – these are ***sparring*** mode, ***bout*** mode, and ***stopwatch*** mode.

The modes are selected using the \* key on the IR handset, and are stored in non-volatile memory.

The modes are described below:

* Sparring mode
  + with no scoring
    - the box will indicate successful hits, but will not keep score
    - the box will indicate off-target hits for foil
    - there is no timing
    - scoring can be enabled by using the # key on the IR handset
  + with scoring
    - the box will indicate successful hits and will automatically select the fencer(s) who won the hit
    - the score is ***not*** automatically incremented
      * however, see the description of the ***SPAR\_INCR\_SCORE*** feature macro later in this document
    - fencers can use the IR handset to increment or decrement the score
    - the box will indicate off-target hits for foil
    - there is no timing
    - the other fencer can also be selected using the IR handset
    - scoring can be disabled by using the # key on the IR handset
    - scores can be swapped using the 4 key on the IR handset
      * this is required if fencers agree to change ends
* Bout mode
  + bout
    - the box will keep score and will time the bout
    - there will be an audible signal when the timer expires
    - the audible signal consists of three short notes from the buzzer
    - when the remaining time is less than 10 seconds, the timer will change to 1/100 second timing
    - the box will automatically stop the timer on a successful hit
    - the box will indicate successful hits
      * the score will increment automatically ***for epee only***
      * see the description of the ***BOUT\_INCR\_SCORE*** feature macro later on in this document on how to disable automatic increment
    - scores can be swapped using the 4 key on the IR handset
      * this is required if fencers agree to change ends
    - the box will indicate off-target hits for foil
    - the box will monitor for passivity and indicate when the passivity timer (1 minute) has expired
    - the referee can control the box using the IR handset, including
      * increment/decrement/reset the score for each fencer
      * extinguish the hit indicator LEDs
      * start/stop/reset the timer
      * wind the timer forward or backward
        + the timer will wind forward or backward in 1/100 second units when less than 10 seconds
      * award a yellow or red penalty card to each fencer
      * restart the bout
      * continue the bout if in a team competition
    - hits will still be indicated when the timer is not running, but with a shorter audible and visual warning
      * this is useful for testing weapon points
  + priority
    - the box will allow a fencer to be selected for priority at random
    - priority selection is started from bout mode by using the # key
    - priority selection is stopped automatically after a random period
    - the box will also set a 1-minute timer for the priority point
    - the buzzer will sound three times when the timer expires
    - the referee can stop/start/reset/wind the priority timer using the IR handset
    - hits will still be indicated when the timer is not running, but with a shorter audible and visual warning
      * this is useful for testing points
    - if the 1-minute timer expires, then the fencing scoring box will indicate which fencer won priority by flashing the appropriate hit LED and the 7-segment display
  + 1-minute rest period
    - the box will allow a 1-minute timed rest period to be started
    - the 1-minute rest timer is started from bout mode by using the 0 key
    - the buzzer will sound three times when the timer expires
    - the referee can stop/start/reset/wind the 1-minute timer using the IR handset
    - hits will still be indicated when the timer is not running, but with a shorter audible and visual warning
      * this is useful for testing weapon points
    - once the timer has expired, the bout can continue
      * press OK to switch back to the bout timer
      * press OK again to restart the timer
* Stopwatch mode
  + count-up
    - the stopwatch will time up to 60 minutes in seconds
    - the stopwatch will wrap around to 00:00 when it reaches 60 minutes
    - the stopwatch can be stopped, restarted or reset using the IR handset
  + count-down
    - the stopwatch can be started from an initial set time
    - when the stopwatch reaches 00:00 it will give an audible signal and stop counting
    - the stopwatch can be stopped, restarted or reset using the IR handset
    - the initial set time can be set using the IR handset

***Notes on the key functionality***

If a key press actually does something, then the fencing scoring box Mk1 will emit an audible click. Absence of a click means either that the key was not detected (in which case, press it again) or the key is inactive in the current mode.

The arrow keys (keys Up, Down, Right, Left) are always used to adjust the score, when scoring is active.

Scoring is always active in bout mode, and optionally active in sparring mode (key # is used to activate or deactivate scoring in sparring mode).

Keys Left and Right are used to select which fencer, and keys Up and Down adjust the score for that fencer.

Key functionality for modifying the timer is all on the first row (keys 1, 2, 3).

The only key on the second row that is active is key 5, for clearing all scores.

Key functionality for handling yellow/red penalty cards and passivity cards is all on the third row (keys 7, 8, 9).

Key functionality for changing mode (ie bout/spar/stopwatch, 1-minute rest, priority) is all on the fourth row (keys \*, 0, #).

The OK key is used for:

* starting/stopping timers when timers are in use
* in bout mode
  + confirming a hit after a hit has been detected
    - the hit LEDs are turned off
* continuing a bout after the 1-minute rest timer has expired
* in stopwatch mode
  + stopping and restarting the stopwatch
* in sparring mode with scoring
  + clearing the score

The Left and Right keys are used for:

* selecting fencer A or fencer B to change their score, if scoring is active
  + scoring is always active in bout mode, but optional in sparring mode
  + when a hit is scored, the fencer who scored the hit is selected automatically
  + if the hit is a double (epee only) then both fencers are selected
  + the selected fencer’s score can be changed using the Down and Up keys
* in bout mode and when the timer is running
  + displaying the score for one second
* in stopwatch mode
  + for selecting either minutes (Left) or seconds (Right) for modification

The Down and Up keys are used for:

* decrementing or incrementing the score of the selected fencer, if scoring is active
  + scoring is always active in bout mode, but optional in sparring mode
  + when a hit is scored, the fencer who scored the hit is selected automatically
  + if the hit is a double (epee only) then both fencers are selected
  + the selected fencer can be changed using the Left and Right keys
* in bout mode and when the timer is running
  + displaying the score for one second
* in stopwatch mode
  + incrementing (Up) or decrementing (Down) minutes or seconds, depending on which one is selected

The \* key is used for:

* selecting either sparring mode, bout mode or stopwatch mode if the timer has stopped

The 0 key is used for:

* in bout or priority mode when the timer has stopped
  + starting a 1-minute rest timer

The # key is used for:

* in sparring mode
  + selecting between scoring and no scoring
  + any previous score will be cleared when selecting scoring
* in bout mode when the timer has stopped
  + starting priority selection
* in stopwatch mode
  + resetting the stopwatch to the initial start time, or
  + clearing the stopwatch to 00:00

The 1 and 3 keys are used for:

* when the timer is active but stopped
  + winding the timer forward (3) or backward (1)

The 2 key is used for:

* in bout mode
  + resetting the timer to the start for bout/priority/1-minute rest

The 5 key is used for:

* resetting scores to all zeros if scores are enabled

The 7 and 9 keys are used for:

* in bout mode
  + awarding a yellow or red penalty card to fencer A (key 7) or fencer B (key 9)
  + the key operates the card LEDs in a rotational manner:
    - yellow, red, yellow+red, all off

The 8 key is used for:

* in bout mode, and with the repeater application connected
  + awarding passivity cards
    - these can only be seen with the repeater application
* in bout mode, and with no repeater application connected
  + clearing all penalty cards for both fencers

The 4 key is used for:

* in bout mode, and in sparring mode with scoring
  + swapping scores if scores are enabled
    - this is required if the fencers agree to swap ends

The 6 key is not currently used.

***Extra features for sabre only***

The fencing scoring box Mk1 also keeps a count of the number of hits per fencer for each separate 3-minute bout. For foil and epee this is of no special use, but for sabre there is a rule that says if 8 hits are scored by one fencer in a single 3-minute bout, then the bout should end.

To support this rule ***for sabre only***, in bout mode the box will indicate (by flashing the score display and also by flashing the hit LED) when this threshold has been reached. The referee is free to ignore this and can cancel it by pressing the OK key to continue the bout.

In 2016, the rule that defines the time period for a sabre hit was changed from 120ms +/- 10 to 170ms +/- 10. The fencing scoring box supports this change.

***Stopwatch operation***

The fencing scoring box Mk1 supports an up-down counting stopwatch. It has two counting modes:

* count-up: this will count up from 00:00 up to 60 minutes in units of a second, and will then wrap around to 00:00 and continue
* count-down: this will count down from a programmable start time in units of a second and will stop at 00:00, emitting an audible signal

The count-down start time is programmed using the Up, Down, Left and Right keys.

The Left and Right keys can be used to select either the minutes value (Left) or the seconds value (Right).

The Up and Down keys can then be used to modify the selected value.

If the initial start time is 00:00, then the stopwatch will be in count-up mode when started. If the stopwatch is then stopped, it will remember that it is in count-up mode and will continue counting upwards when restarted.

However, if at any point the stopwatch time is modified using the Up, Down, Left or Right keys, then the stopwatch will switch to count-down mode.

If the initial start time is not 00:00, then the stopwatch will be in count-down mode when started. When the stopwatch reaches 00:00, there will be an audible signal, the stopwatch will stop, and will switch back to count-up mode.

The audible signal consists of three short notes from the buzzer.

While the stopwatch is running, the LEDs will illuminate in an oscillating pattern - so that those on one side of the fencing scoring box are on for one second, then the next second the other side will be on, and then the first side again, and so on.

The OK key can be used to stop and start the stopwatch.

The # key is used to reset the stopwatch back to its initial start time. In count-up mode this will of course be 00:00, whereas in count-down mode, the stopwatch will reset back to the initial start time as set by the Up, Down, Left and Right keys.

If the stopwatch has already been reset to its initial start time using the # key, then pressing the # key again will clear the stopwatch back to 00:00 and will switch back to count-up mode.

***Fencing Scoring Box Mk1***

***Android repeater application***

******

***Android repeater application display***

NETWORK CONNECTED

INDICATOR

VIBRATION ENABLED

INDICATOR

VOLUME MUTED

INDICATOR

HIT/OFF-TARGET LIGHT (FENCER B)

HIT/OFF-TARGET LIGHT (FENCER A)

TIME

BATTERY

A screenshot of a video game

Description automatically generated with medium confidence

PASSIVITY TIMER

MAIN TIMER

PENALTY CARDS &

SHORT-CIRCUIT  
(FENCER B)

PENALTY CARDS &

SHORT-CIRCUIT  
(FENCER A)

PASSIVITY CARD

(FENCER B)

PASSIVITY CARD

(FENCER A)

PRIORITY INDICATOR

(FENCER B)

PRIORITY INDICATOR

(FENCER A)

SCORE

(FENCER A)

SCORE

(FENCER B)

***Introduction to the Android repeater application***

As part of the fencing scoring box Mk1 project, a repeater application was written to run on Android-based smartphones, tablets or TVs.

The Android repeater application was written in an attempt to overcome the limitation of the 4-digit 7-segment display for longer-distance viewing. It repeats what is being displayed on the fencing scoring box and allows control of the box through a Bluetooth remote control. Using the repeater allows the current state of the fencing scoring box to be seen more easily.

This arrangement also allows the fencing scoring box to be powered from a smartphone or tablet, which is a usefully portable power source.

***Other operating systems***

There is no reason why a repeater application could not be written for other operating systems, for example iOS (for iPhones) or Windows (for laptops) as long as the general principles are followed, and the repeater commands (see later) are all supported.

***Features of the repeater application***

The repeater is able to detect when the fencing scoring box has been disconnected and will continually try to reconnect. However, it will not restore the state of the fencing scoring box at the time of disconnection – the fencing scoring box will be restarted.

As can be seen in the above diagram, the Android repeater application uses the ‘leanback’ display mode to give the maximum amount of screen space. This means that the action bar and the navigation bar are normally hidden, but it is possible to unhide them by touching the screen. Touching the screen again will cause them to be hidden.

Controlling the fencing scoring box using the IR handset or the Bluetooth remote control will also cause the action bar and navigation bar to be automatically hidden on the Android repeater application.

Changing the orientation of the smartphone or tablet will not affect the current state of the fencing scoring box nor the repeater.

The repeater is able support a paired Bluetooth remote control, and keys on the remote control will map to equivalent IR handset keys. Currently, however this functionality is disabled by default, but see the later section on this functionality.

***General functionality***

The repeater will always show the current time and the percentage battery capacity at the top of the screen, in small type and coloured white. If the battery capacity drops to 15% or below, then *the battery capacity display will flash as a warning that the battery is running low*.

If the repeater application is being run on a device where there is no battery (for example an Android TV) then the battery capacity value will be blanked.

***Bluetooth remote control support***

***Note that this support is currently disabled in the repeater unless it is running on an Android TV platform***.

The Android repeater application will support a paired Bluetooth remote control handset. Keys on the Bluetooth handset are mapped to IR handset keys and sent to the fencing scoring box. The Android repeater application does not itself support Bluetooth pairing/unpairing functionality – this must be done using the Android *Settings* application.

Note that key repeat is not supported currently through the Bluetooth remote control.

Here is a table that shows the mapping of Bluetooth remote control handset keys to IR handset keys:

|  |  |
| --- | --- |
| ***Android Bluetooth remote key*** | ***IR handset key*** |
| *Numeric keys (0-9)* | *Numeric keys* |
| *OK* | *OK* |
| *Arrow keys (up, down, left, right)* | *Arrow keys* |
| *\** | *\** |
| *#* | *#* |
| *Play/Pause* | *OK* |
| *Rewind* | *Numeric key zero* |
| *Fast Forward* | *#* |
| *Record* | *Numeric key zero* |
| *Back* | *Stops timer first, then \** |
| *Channel Up* | *\** |
| *Channel Down* | *\* (but modes are selected in reverse order)* |
| *Google Assistant* | *\** |
| *Page Up* | *\** |
| *Page Down* | *#* |
| *Guide* | *Numeric key zero* |
| *Mute* | *Mutes/unmutes the buzzer* |

Note also that the *Home* and *Power* keys on the Bluetooth remote are intercepted and handled by Android, and therefore will have the same function as on any other application.

***Bout mode***

In bout mode, the repeater will show active hits, off-target hits (foil only), red and yellow penalty cards, short-circuit (white), the current clock, the current score, current priority holder (if applicable), passivity timer and passivity cards.

***Passivity timer***

The passivity timer will count down from 60 seconds from the start of the bout. When a hit is scored, the passivity timer is stopped.

If the hit is deemed by the referee to be valid, then when the hit is confirmed (using the OK key on the IR handset) the passivity timer will be blanked. When the bout is resumed (using the OK key again) the passivity timer will again count down from 60 seconds.

When the passivity timer reaches zero, it will simply stop there – it is for the referee to decide whether or not to call passivity and award any passivity cards.

***Passivity and invalid hits***

If the hit is deemed by the referee to be invalid (for example, a floor hit) then the referee would ensure that the score was not changed as a result of the hit. This would entail either decrementing the score (if it is automatically incremented on a hit) or not manually incrementing the score before pressing the OK key on the IR handset to confirm.

In this case, because the score after the hit is the same as the score before the hit, the passivity timer is not reset back to 60 seconds and will continue from where it stopped. This is done because an invalid hit does not affect passivity.

***Passivity cards***

The repeater will also show passivity cards as they are awarded, and these can be awarded by the referee using key 8 on the IR handset. The fencing scoring box cannot show them itself – only the repeater application can do so.

If the repeater is not connected to the fencing scoring box, then passivity cards are not supported by the fencing scoring box, and key 8 reverts to its original function of clearing all penalty cards for both fencers.

When the repeater is connected to the fencing scoring box, then key 8 on the IR handset will award the appropriate passivity card(s) depending on the previous card(s) held by the fencer(s) and the current score. This will only work when in bout mode, when the passivity timer has expired, and when the main timer has been stopped by the referee.

The fencing scoring box decides which passivity card to award and to which fencer(s) using the current FIE rules regarding passivity.

***Passivity card display***

The passivity cards are displayed on the repeater as follows:

|  |  |
| --- | --- |
| ***Passivity card*** | ***Display*** |
| No card | blank |
| P-Yellow | “1” in yellow |
| P-Red #1 | “1” in red |
| P-Red #2 | “2” in red |

***Sparring mode***

In sparring mode, the repeater will show active hits, and the clock display and the passivity timer are blanked. The score display is blanked by default, but if scoring is enabled then it will be redisplayed.

***Stopwatch mode***

In stopwatch mode, the repeater will show the hit lights flashing once per second as part of the timing function. The clock will also show the current stopwatch time in minutes and seconds. If the stopwatch is in count-up mode, then the passivity timer shows the number of hours that have passed. The current score is blanked.

***Buzzer operation***

When the repeater is connected to the fencing scoring box, it takes over the responsibility of sounding the buzzer. The fencing scoring box will mute its internal buzzer. Therefore, you need to turn up the volume of your smartphone or tablet in order to hear the buzzer.

The repeater will also emit a click when a key is pressed on the IR handset or the Bluetooth remote control.

If the repeater notices that the volume is at zero, then it will display a “muted” icon at the top centre of the screen as a reminder that the volume needs to be turned up.

The advantage of using the repeater to output the buzzer tone is that it can be routed through a speaker to give better audibility.

***Priority selection animation***

When the fencing scoring box is put into priority selection mode (using the # key on the IR handset) the repeater will display a progress bar animation until the selection stops. The repeater will then display a red **P** at the bottom left or bottom right of the display, depending on which fencer won priority.

***Options menu***

The options menu you to change the behaviour of the repeater application, and also of the fencing scoring box (if attached) through various associated activities.

When the action bar is displayed, the options menu is accessed from the options icon at the right-hand side:

A picture containing shape

Description automatically generated

When the options icon is selected, the options menu is displayed:

Graphical user interface

Description automatically generated with low confidence

Here is a description of each menu item.

1. ***Vibration on/off***

When in ***remote live indication*** mode, this feature will configure the repeater to briefly vibrate when a hit is scored on the currently displayed piste.

The menu option will be either ***Vibration off*** or ***Vibration on*** depending on whether or not vibration is already enabled or disabled.

See later for a full description of remote live indication mode.

1. ***Weapon select***

The ***Weapon select*** menu option will allow you to set the current weapon type.

When the ***Weapon select*** menu option is selected, this starts up the Weapon Select activity, which displays this screen (note that this screen is only displayed in ***portrait*** mode):

Graphical user interface, application, Teams

Description automatically generated

It is then possible to select which weapon is to be used by touching on the corresponding radio button, and then touching the ***Select*** button at the end. This selection is sent to the fencing scoring box via the USB port, and the box will react to the weapon change as though the push button (see earlier) had been pressed to change the weapon.

1. ***Piste select***

The ***Piste select*** menu option will allow you to set the current piste number. This is used as part of the remote indication feature (see below).

When the ***Piste select*** menu option is selected, this starts up the Piste Select activity, which displays this screen (note that this screen is only displayed in ***portrait*** mode):

Graphical user interface, application

Description automatically generated

The piste number can be selected by spinning the number picker by touch so that the required piste number is highlighted, and then touching the ***Select*** button at the end. This selection is sent to the fencing scoring box via the USB port, and the box will store the piste number in non-volatile memory.

When the box restarts with the repeater connected, the box will send the *!GO* message with the stored piste number to the repeater.

1. ***Demo mode***

The ***Show demo*** menu option will show the demonstration display.

When the repeater is not connected to the fencing scoring box, it has a mode which shows a demonstration display:

A screenshot of a video game

Description automatically generated with medium confidence

While the demonstration display is active, the menu option will change to ***Clear demo***. Select this to close the demonstration display.

Swiping left or right will change the demonstration display to show a demonstration remote live indication display on piste 2. Swiping again will return to the original demonstration display.

When the repeater is connected to the fencing scoring box, demo mode is not available.

***Fencing Scoring Box Mk1***

***Android repeater remote live indication***

***Introduction to the remote live indication feature***

One very important feature of the Android repeater is that it is able to show the current live status of other fencing scoring boxes, when they are all connected to the WIFI local network.

Only repeaters that are ***not directly connected to fencing scoring boxes*** are able to show the live status of repeaters that ***are*** directly connected.

It is possible to see the live status of ***all*** fencing scoring boxes, one at a time, from one repeater. This is done on the repeater user interface by swiping the repeater screen from left to right (or vice versa) with your finger. Swiping top to bottom (or vice versa) also works.

***How does it work?***

Each repeater that is directly connected to a fencing scoring box on a given piste, and is also connected to the WIFI local network, will broadcast a special message once every 250 milliseconds using the IP multicast protocol. This message contains all of the status information for that piste. The other repeaters will receive this message and will convert it for display.

One major problem with IP multicast over WIFI is that it is unreliable and suffers from substantial packet loss. Also, the speed of transmission has to be slow, and there is no way to check that a message has been received. Therefore, a repeater will send its message continually every 250 milliseconds, even if the box live status has not changed, to make sure that the message gets through.

***How to set up the feature***

To get this feature to work correctly:

1. At least one repeater connected to a fencing scoring box must be present
2. All repeaters, whether connected to boxes or not, must also be connected to the same WIFI local network in the venue
3. The WIFI local network must support IP multicast traffic (some disable it)
4. Mobile data connection is not supported
5. Each repeater/box combination must be set to a different piste number

The ***NETWORK CONNECTED*** indicator at the top of the repeater display will be visible if a valid IP multicast connection is available.

***Example display***

Here is an example display of a remote piste:

A screenshot of a video game

Description automatically generated with medium confidence

PISTE INDICATOR

The remote indication display has the same functionality as the normal display, except that the passivity timer has been replaced by a number in white indicating the piste from which this display is coming.

The white piste indicator will change to red if the repeater associated with that piste is offline, and back to white when the repeater is once again online.

***How to display different pistes***

Firstly, as stated before, this feature will only be operative if:

1. There are other repeaters connected to fencing scoring boxes and also to the WIFI local network
2. Your own repeater is not connected to a fencing scoring box, but is connected to the WIFI local network

To display a different piste, you swipe to the left or to the right, or to the top or to the bottom. The display will be updated to either the previous piste or the next piste depending on the direction of swipe.

Note that to swipe, the repeater has to have display focus. Therefore, if the action bar is not displayed, touch the screen to bring the action bar and navigation bar onto the display. Then, swiping will work. Once you have selected the piste you want, you can dismiss the action bar and navigation bar by touching the screen again.

***Timer quantisation***

The messages are broadcast by each repeater/box combination every 250 milliseconds, but the main timer on the remote display will only update every 5 seconds. The reason for this is due to the previously stated unreliability of IP multicast over WIFI. If the timer display was updated every second, the timer would not change every second regularly, and would appear to stutter.

By quantising the timer to a 5-second interval, this lack of regularity is greatly minimised from a visual point of view. Timer quantisation is purely a visual trick to make the viewer think that the timer is updating on time and regularly.

Despite timer quantisation, if there is a hit or other event, the repeater will update its display as soon as possible, so there is little time lag on other aspects of the display.

***Passivity timer and cards***

The display of the passivity timer is not supported in remote live indication mode. Passivity cards, however, are supported.

***Vibration on a hit***

The repeater will briefly vibrate (if supported) if the currently displayed piste indicates a hit; however, intentionally it does not make any sound.

This vibration can be turned off through the options menu (see earlier for a description of this).

***Fencing Scoring Box Mk1***

***Android repeater – miscellaneous***

***Android TV operation***

The repeater application will run on Android TV platforms. It is able to detect this and will amend its behaviour.

The application can be controlled by a Bluetooth paired remote control, and in this case, the following keys will operate:

|  |  |
| --- | --- |
| ***Key*** | ***Operation*** |
| OK | Brings up the options menu |
| Up, Down | Navigates the options menu |
| OK | Selects an item on the options menu |
| Back | Dismisses the options menu |

***Source code***

The entire source code for the Android repeater application (including source code files from other designers – see the license text files contained in the application) is included as part of the fencing scoring box Mk1 project under a GPL version 3 license.

The application can be built using Android Studio version 4.2.1 or later.

The repeater has been written to API level 28 (Android Pie 9).

***Fencing Scoring Box Mk1***

***Technical description***

***Credits for software and hardware designs***

This fencing scoring box Mk1 project is based on previous software and hardware designs by *wnew* and *digitalwestie*. Due credit and thanks are hereby given to both designers.

The software and hardware designs described in this document are by Robin Terry, Skipton, Yorkshire, UK, and are derived from the above designs.

The designs, plus this document, are licensed under GPL version 3. All provisions contained in that license must be complied with regarding the designs and regarding this document.

Arduino libraries *IRRemote*, *IRLib2* and *TM1637Display* are used in the software for this project. Due credit and thanks are hereby given to the authors of these libraries. The licenses for these libraries are listed at the end of this document.

***Description of hardware components***

* Arduino Nano
  + main processing engine for the fencing scoring box
  + software can be found on GitHub
* 74HC595
  + 8-bit shift register
  + used for the penalty card LEDs and the short-circuit LEDs
* TM1637-based 4-digit plus centre colon 7-segment LED display
  + 4 pins – Vcc, GND, CLK, DIO
* IR sensor plus handset
  + manufactured by Keyes
  + raw IR key codes are given in the below table
  + used to control the fencing scoring box
* Active buzzer
  + does not need an oscillating input to sound
  + connecting 5 volts DC to it will cause it to sound
  + used to signal hits, timeouts and IR key presses
* Push button
  + simple press-to-make momentary switch
  + used to change weapon (epee, foil, sabre)
* On-target hit indicator LEDs
  + red for fencer A (left)
  + green for fencer B (right)
  + These are also used to indicate passivity, if enabled
* Yellow/red penalty card LEDs
  + one yellow and one red LED per fencer
  + these are controlled by the referee using IR keypresses
* Off-target hit indicator LEDs (foil only)
  + these are normally white for both fencers
  + these were not fitted to the prototype
* Short-circuit indicator LEDs
  + these are normally orange for both fencers
  + these were not fitted to the prototype

***Power***

For the current design, the +5V DC power for the entire fencing scoring box Mk1 is taken direct from the Arduino Nano and is supplied via the mini-USB female connector mounted on the Arduino Nano circuit board.

The box should be powered from a normal USB charger unit with the appropriate cable to convert to a mini-USB male connector.

The ***Vcc\_out*** pin on the Arduino Nano is the regulated +5V DC output and supplies the power rails for the other components.

In the prototype design, a standard USB Type A male to Type B male cable (as used for USB printers and other peripherals) was used to connect to the box to the USB charger. A short adaptor cable to convert from Type B panel-mount female to mini-USB male was fitted inside the fencing scoring box enclosure and connected to the Arduino Nano.

Part of the reason for only using a small number of LEDs for the Mk1 design, and not including LED matrices for hit display, is so that a relatively low power consumption can be achieved, along with reduced cost of components, a compact form factor and easy portability. Power consumption tests have shown that the fencing scoring box Mk1 can run for several hours from a small USB phone charger battery pack.

***Powering the box from a smartphone or tablet***

If the Android repeater application is used, then this runs on an Android smartphone or tablet. The Android device should be connected to the fencing scoring box using a suitable USB cable, and the device will provide power to the box. No other power source is required.

100u

10u

100n

0V

orange

orange

red

red

yellow

yellow

55

45

35

25

15

155

all 470R

Fencer B hit

Fencer A hit

74HC595

Arduino Nano

13

8

0V

10

5V

D4

GND

5V

0V

IR sensor

Fencer B pin A

Fencer B pin B

Fencer B pin C

Fencer A pin A

Fencer A pin B

Fencer A pin C

1k0

1k0

0V

1k0

1k0

1k0

1k0

5V

A5

A4

A3

A2

A1

A0

10k

220R

220R

push switch

active buzzer

red

green

D10

D9

D5

D6

D3

TM1637 LED module

D7

DIO

CLK

5V

0V

Mini-USB input

Vcc \_out

white

Fencer A off-target

220R

D11

Fencer B off-target

220R

D12

white

0V

D8

D13

D2

Penalty Cards

16

Fencer A yellow

11

Fencer A red

12

14

Fencer B yellow

Fencer B red

***Fencing scoring box Mark 1***

***Schematic***

Fencer A short

Fencer B short

***Feature macros in the Arduino firmware source code***

***ENABLE\_DISPLAY***

***ENABLE\_IR***

If you are only interested in making a simple hit indicator box, without the 7-segment display, nor the IR support, nor the penalty card LEDs, then you can undefine the macros ***ENABLE\_DISPLAY*** and ***ENABLE\_IR*** in the software source. This will disable all of these features, limit the box functionality to hit indication only, and reduce the size of the software executable considerably.

***DEBUG\_L1, DEBUG\_L2, …***

These macros enable various sorts of debug messages on the serial port, which works at 115200 baud.

A warning: do not enable all of these macros simultaneously, as this will increase the size of the memory requirement to nearly maximum. This may result in features not working correctly.

***LOW\_POWER***

This macro enables the low-power support. This attempts to put the CPU to sleep when it is idle, hence saving battery life.

Unfortunately, due to the requirement to keep IR support alive (which requires the CPU to wake up periodically to poll the IR) this does not result in a major power saving but will save some power.

***OFFTARGET\_LEDS***

This macro enables support for discrete off-target LEDs for foil (these are normally white in colour).

The original prototype of the fencing scoring box did not have these LEDs fitted, and indicated off-target hits using the normal hit LEDs in conjunction with the 7-segment LED display. This behaviour is enabled if ***OFFTARGET\_LEDS*** is not defined.

***PRITIMER\_RANDOM***

This macro enables support for an automatically generated random time period for priority selection. Once the time period expires, the fencing scoring box will indicate which fencer has priority - the user does not have to stop priority selection manually. The current firmware sets a time period between 3000ms and 6000ms, but this can be changed in the firmware source code.

If the ***PRITIMER\_RANDOM*** macro is undefined (this can be changed in the firmware source code) then the user has to stop priority selection by pressing the OK key or the # key.

***STOPWATCH***

This macro enables support for the stopwatch. It is only active if either ***ENABLE\_DISPLAY*** or ***ENABLE\_REPEATER*** is defined.

***EEPROM\_STORAGE***

This macro enables support for storing the weapon type and operating mode in non-volatile memory. The memory locations used for this are defined by the macros ***NV\_WEAPON*** and ***NV\_MODE*** respectively.

***SPAR\_INCR\_SCORE***

This macro enables the automatic increment of the score in sparring mode with scoring. This is normally disabled, because in use it was found that fencers would frequently test their points during sparring, so the score would be incremented automatically when they did so.

If this macro is disabled, then the score can still be incremented or decremented manually using the Up and Down buttons on the IR handset.

***BOUT\_INCR\_SCORE***

This macro enables the automatic increment of the score in bout mode. This is normally enabled, as the score will only be incremented when a hit is scored while the bout timer is running and will not be incremented when fencers test their points.

When this macro is enabled, the score is automatically incremented only for epee – for foil and sabre there are other considerations, like right of way, to decide upon before a point is awarded, so the referee has to make the decision to award the point or not to.

If this macro is disabled, then the score can still be incremented or decremented manually using the Up and Down buttons on the IR handset.

***IR\_FRAMETIMEOUT***

If you use a different IR handset to the one used for the prototype (Keyes/Hobby Components) then you may need to modify the source code to make it work.

If the IR protocol of your handset is the same, but it does not work reliably, you might need to amend the ***IR\_FRAMETIMEOUT*** macro in the source code. The value assigned to this macro in the master source code is optimised to make the Keyes/Hobby Components IR handset work at its most reliable in the prototype design.

***PASSIVITY***

This macro enables support for the passivity monitoring feature. If this feature is enabled in the Arduino firmware, then the 8 key on the IR handset is used to award passivity cards.

***PASSIVITY\_SIGNAL***

If passivity monitoring is enabled, then this macro will enable support for signalling the expiry of the passivity timer on the hit LEDs.

Expiry of the passivity timer will still be signalled to the Android repeater application, even if ***PASSIVITY\_SIGNAL*** is not enabled.

***ENABLE\_REPEATER***

This macro enables support for the repeater application. If this is enabled, then various short messages are sent to the repeater via the serial port, and these inform the repeater of the current state of the fencing scoring box.

***REPEATER\_POLLING***

This macro enables support for polling the repeater application to get key presses from it.

***Diagram of Keyes/Hobby Components IR handset plus IR key codes***

|  |  |
| --- | --- |
| Key name | Key code (hexadecimal) |
| 0 | FF9067 |
| 1 | FFA25D |
| 2 | FF629D |
| 3 | FFE21D |
| 4 | FF22DD |
| 5 | FF02FD |
| 6 | FFC23D |
| 7 | FFE01F |
| 8 | FFA857 |
| 9 | FF906F |
| \* | FF6897 |
| # | FFB04F |
| Up | FF18E7 |
| Left | FF10EF |
| Right | FF5AA5 |
| Down | FF4AB5 |
| OK | FF38C7 |

A picture containing electronics, remote

Description automatically generated

***Repeater application control commands and responses***

These are sent by the fencing scoring box Mk1 over the USB port to the repeater application. The default baud rate is 115200 baud.

The repeater will need to support a device driver for the CH340 USB to UART IC, as the fencing scoring box uses this IC to send the commands over the USB connection. The Android repeater application already contains such a driver, so there is no requirement to install a separate driver under Android.

The *!GO* command requires the repeater to return with *OK* within one second. If this is not done, then the fencing scoring box assumes that the repeater is not connected and will send no more commands. The fencing scoring box will then operate standalone.

The */?* (*Poll repeater)* command also requires a response from the repeater (see below).

Otherwise, no other command requires a response from the repeater.

***Repeater key press polling***

During normal operation, the fencing scoring box will also poll the repeater for any key presses from the Bluetooth remote control using the */?* command. The repeater is expected to respond as soon as possible with either a key press (if one is pending) or a “no key press” response.

***Repeater command table***

The following table lists all of the commands that are supported by the repeater application, including the poll and response commands:

|  |  |
| --- | --- |
| ***Repeater control commands***  ***(all fields in decimal)*** | ***Function*** |
| *!GOxx* | Fencing box starting up, with xx being the 2-digit piste number as stored in the fencing scoring box (default “01”)  *(the repeater must respond with “OK” within 1 second, otherwise further control messages will not be sent)* |
| *!SS* | Sparring start |
| *!HS* | Hide score display |
| *!BS* | Bout start |
| *!BR* | Bout resume  *(after a hit or a pause)* |
| *!BC* | Bout continue  *(in a team match)* |
| *!BE* | Bout end |
| *!PC* | Priority choose |
| *!P0* | Fencer A has priority |
| *!P1* | Fencer B has priority |
| *!PE* | Priority end |
| *!RS* | 1-minute rest start |
| *!WS* | Stopwatch start |
| *!WR* | Stopwatch reset |
| *!WW* | Stopwatch wrap round to 00:00 from 59:59 |
| *!RL* | Reset all lights |
| *!TF* | Weapon is foil |
| *!TE* | Weapon is epee |
| *!TS* | Weapon is sabre |
| *!VS* | Passivity timer start |
| *!VC* | Passivity timer clear |
| *!VT* | Passivity timeout |
| *!CR* | Clock restart  *(a repeater clock command will immediately follow)* |
| *!KC* | Key press click |
| ***Repeater passivity card commands*** | ***Function*** |
| *+0x* | Fencer A passivity card  *x = 0 – clear cards*  *x = 1 – P-yellow card*  *x = 2 – P-red card #1*  *x = 3 – P-red card #2* |
| *+1x* | Fencer B passivity card  *x = 0 – clear cards*  *x = 1 – P-yellow card*  *x = 2 – P-red card #1*  *x = 3 – P-red card #2* |
| ***Repeater clock commands*** | ***Function*** |
| *@mmss* | Clock: mm minutes, ss seconds  *(this message is sent every second)* |
| *:sshh* | Clock: ss seconds, hh hundredths  *(this message is sent as quickly as possible, but no more than every hundredth of a second)* |
| ***Repeater score and indicator commands*** | ***Function*** |
| *\*aabb* | Score: fencer A aa, fencer B bb  (*if previously hidden, this redisplays the score*) |
| *$H0* | Clear all hits |
| *$H1* | Hit for fencer A, ignore fencer B |
| *$H2* | Hit for fencer B, ignore fencer A |
| *$H3* | Hit for fencer A, clear fencer B |
| *$H4* | Hit for fencer B, clear fencer A |
| *$S0* | Stopwatch tick 0  *(alternates with tick 1 every second)* |
| *$S1* | Stopwatch tick 1  *(alternates with tick 0 every second)* |
| *?0x* | Fencer A penalty card and short-circuit LED bits:  *Bit 0 – yellow penalty card LED*  *Bit 1 – red penalty card LED*  *Bit 2 – short-circuit LED* |
| *?1x* | Fencer B penalty card and short-circuit LED bits:  *Bit 0 – yellow penalty card LED*  *Bit 1 – red penalty card LED*  *Bit 2 – short-circuit LED* |
| *<0x* | Fencer A short-circuit condition  *x = 0 – off*  *x = 1 - on* |
| *<1x* | Fencer B short-circuit condition  *x = 0 – off*  *x = 1 – on* |
| ***Repeater buzzer commands*** | ***Function*** |
| *!Z0* | Buzzer off |
| *!Z1* | Buzzer on |
| ***Repeater poll message***  ***(to repeater)*** | ***Function*** |
| */?* | Poll repeater for key press or weapon type select |
| ***Repeater key press message***  ***(from repeater in response to poll message)*** | ***Function*** |
| */0--, /1--, /2--, /3--, /4--, /5--, /6--, /7--, /8--, /9--* | Key 0 to Key 9 pressed |
| */U--, /D--, /L--, /R--* | Key Up, Down, Left, Right pressed |
| */B--* | Key Back pressed *(not on IR handset)* |
| */\*--* | Key \* pressed |
| */#--* | Key # pressed |
| */K--* | Key OK pressed |
| */P--* | Key Play/Pause pressed *(not on IR handset)* |
| */W--* | Key Rewind pressed *(not on IR handset)* |
| */F--* | Key Fast Forward pressed *(not on IR handset)* |
| */u--* | Page Up pressed *(not on IR handset)* |
| */d--* | Page Down pressed *(not on IR handset)* |
| */---* | No key pressed |
| ***Repeater weapon type select message***  ***(from repeater in response to poll message)*** |  |
| */f--* | Select foil as the weapon type |
| */e--* | Select epee as the weapon type |
| */s--* | Select sabre as the weapon type |
| */pxx* | Set piste number xx (the box will store this) |

***Software library licenses***

***IRLib2***

Copyright information for IRLib – an Arduino library for

infrared encoding and decoding

IRLib2 is a collection of libraries which we will collectively referred

to as the PACKAGE. The PACKAGE consists of all files in the IRLib2,

IRLibFreq, IRLibRecv, IRLibRecvPCI, and IRLibProtocols folders.

The PACKAGE is Copyright (c) 2014-2017 by Chris Young

This program is free software: you can redistribute it and/or modify

it under the terms of the GNU General Public License as published by

the Free Software Foundation, either version 3 of the License, or

(at your option) any later version.

This program is distributed in the hope that it will be useful,

but WITHOUT ANY WARRANTY; without even the implied warranty of

MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the

GNU General Public License for more details.

These files will be maintained at https://github.com/cyborg5/IRLib2

Documentation and other support info at http://tech.cyborg5.com/irlib

This is an updated version of my original IRLib which is still available at

https://github.com/cyborg5/IRLib which will not be updated after this

PACKAGE has its first stable non-beta release.

Both libraries are derived from the original source code in a library called

IRemote by Ken Shirriff which was covered by GNU LESSER GENERAL PUBLIC

LICENSE version 2.1. This package is covered by the GNU GENERAL PUBLIC

LICENSE 3.0. See LICENSE.txt for a copy of that license or visit

https://www.gnu.org/licenses/

As I understand these licenses it is permissible to upgrade the license

this way. Additionally this license change was made with the approval of

Mr. Shirriff in an email conversation I had with him. In accord with his

wishes and out of respect for his work, his original copyright message is

shown below.

/\*

\* IRremote

\* Version 0.1 July, 2009

\* Copyright 2009 Ken Shirriff

\* For details, see http://www.righto.com/2009/08/multi-protocol-infrared-remote-library.html http://www.righto.com/

\*

\* Interrupt code based on NECIRrcv by Joe Knapp

\* http://www.arduino.cc/cgi-bin/yabb2/YaBB.pl?num=1210243556

\* Also influenced by http://zovirl.com/2008/11/12/building-a-universal-remote-with-an-arduino/

\*/

We also acknowledge and thank the developers of the AnalysIR program. AnalysIR is a Windows-based application which allows you to graphically analyze IR input signals through an Arduino, Raspberry Pi or other microcontrollers systems. The frequency analysis and other PCI based versions of the program are based upon and inspired by their work. We value their input into the development of that portion of the code. You can find more about their software at http://analysir.com

We also knowledge and thank programmer Gabriel Staples contributed bug fixes and an earlier version of the auto resume feature. Although much of his code was rewritten it could not have been possible without his contributions.

Other major contributors will be acknowledged in this file in the future.

***TM1637***

Author: avishorp@gmail.com

This library is free software; you can redistribute it and/or

modify it under the terms of the GNU Lesser General Public

License as published by the Free Software Foundation; either

version 2.1 of the License, or (at your option) any later version.

This library is distributed in the hope that it will be useful,

but WITHOUT ANY WARRANTY; without even the implied warranty of

MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU

Lesser General Public License for more details.

//

You should have received a copy of the GNU Lesser General Public

License along with this library; if not, write to the Free Software

Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA

***IRRemote***

c) Copyright 2009 Ken Shirriff http://www.righto.com

(c) Copyright 2016 Rafi Khan

(c) Copyright 2020 Armin Joachimsmeyer et al.

Licensed under the MIT license:

http://www.opensource.org/licenses/mit-license.php

Permission is hereby granted, free of charge, to any person obtaining a copy

of this software and associated documentation files (the "Software"), to deal

in the Software without restriction, including without limitation the rights

to use, copy, modify, merge, publish, distribute, sublicense, and/or sell

copies of the Software, and to permit persons to whom the Software is

furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in

all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR

IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,

FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE

AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER

LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,

OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN

THE SOFTWARE.