***Fencing Scoring Box Mk1***

***User Manual***

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***Introduction***

***This document is written by Robin Terry, and is © Robin Terry 2021.***

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***Date of latest edition: May 11, 2021***

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 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 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

In the description given below, 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 power sources, and for easy portability.

***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.

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

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START & STOP TIMER (BOUT)/

CLEAR HIT LEDS (BOUT)/

START & STOP (STOPWATCH)/

CLEAR SCORES (SPAR)

CLEAR CARDS

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)

FENCER B YELLOW/RED CARD

CLEAR SCORES

FENCER A YELLOW/RED CARD

WIND TIMER BACK (BOUT)

SELECT MODE:

SPAR/BOUT/STOPWATCH

SELECT FENCER A/

SCORE DISPLAY (BOUT)/

SELECT MINUTES (STOPWATCH)

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

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CLEAR SCORES

SCORING ON or OFF

INCREASE SCORE FOR

SELECTED FENCER

SELECT FENCER B

CLEAR SCORES

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)***

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START PRIORITY SELECTION/

END PRIORITY SELECTION

START & STOP TIMER/

CLEAR HIT LEDS/

END PRIORITY SELECTION

RESET TIMER

WIND TIMER FORWARD

FENCER B YELLOW/RED CARD

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

WIND TIMER BACK

FENCER A YELLOW/RED CARD

CLEAR SCORES

CLEAR CARDS

NOTES

* the *SCORE DISPLAY* function is only active when the timer is running
* the *START & STOP TIMER* function is active all the time
* all other functions are only active when the timer is stopped
* the *CLEAR HIT LEDS* function is only active if a hit has been detected
* the *END PRIORITY SELECTION* function is also performed by the OK key, but not the *START PRIORITY SELECTION* function

RESET

DECREASE SELECTED TIME

START & STOP

SELECT MINUTES

INCREASE SELECTED TIME

SELECT SECONDS

SELECT MODE:

SPAR/BOUT/STOPWATCH

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

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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

***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. 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.

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:

* sparring with no scoring
* sparring with scoring (optional feature)
* bout – scoring and timing
* priority selection
* yellow and red card indication for either fencer
* short-circuit detection and display
* 1-minute rest period
* up-down counting stopwatch

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.

***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.

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 (optional feature, set at compile time)
    - the box will indicate successful hits and will automatically select the fencer(s) who won the hit
    - the score is not automatically incremented
    - 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
* 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
    - the box will automatically stop the timer on a successful hit
    - the box will indicate successful hits, but will not increment the score
    - the box will indicate off-target hits for foil
    - 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
      * award a yellow or red card to each fencer
      * restart the bout
      * continue the bout if in a team competition
  + 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 (once started) by using either the # key or the OK key
    - 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
    - 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
    - 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 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
  + turning off the hit indicator LEDs after a hit has been detected
* continuing a bout after the 1-minute rest timer has expired
* during priority selection
  + stopping the priority selection and showing who has priority
  + this is also performed by the # key
* 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 (if scoring is enabled)
  + any previous score will be cleared when selecting scoring
* in bout mode when the timer has stopped
  + starting priority selection
* during priority selection
  + stopping the priority selection and showing who has priority
  + this is also performed by the OK key
* 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
  + setting a yellow or red card for 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
  + clearing all cards for both fencers

The 4 and 6 keys are 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***

***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 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 indicator LEDs
  + red for fencer A (left)
  + green for fencer B (right)
* Yellow/red card LEDs
  + one yellow and one red LED per fencer
  + these are controlled by the referee using IR keypresses
* Off-target 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.

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 a compact form factor and portability. Power consumption tests have shown that the Mk1 fencing scoring box can run for several hours from a small and easily portable USB phone charger battery pack.

100u

10u

100n

0V

orange

orange

Cards

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

Vcc

D7

DIO

CLK

5V

0V

Mini-USB input

white

Fencer A off-target

220R

D11

Fencer B off-target

220R

D12

white

0V

D8

D13

D2

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 software source***

***DISP\_IR\_CARDS\_BOX***

If you are only interested in making a simple hit indicator box, without the 7-segment display, nor the IR support, nor the card LEDs, then you can undefine the macro ***DISP\_IR\_CARDS\_BOX*** 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 230400 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.

***STOPWATCH***

This macro enables support for the stopwatch. It is only active if ***DISP\_IR\_CARDS\_BOX*** is defined.

***EEPROM\_STORAGE***

This macro enables support for storing the weapon type and operating mode in non-volatile memory. Memory locations 16 and 17 are used for this.

***SPAR\_INCR\_SCORE***

This macro enables the “sparring with scoring” feature. 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 when they did so.

Sparring without scoring is permanently enabled, and is the default behaviour in sparring mode.

***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 |

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***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

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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

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***IRRemote***

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(c) Copyright 2016 Rafi Khan

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