TIM 2015 Speaking Clock

User Manual

TIM 2015 is part-funded by the Telecommunications Heritage Group (THG) and designed by

WORK IN PROGRESS! This document is not yet complete, so please make allowance for this. It should be read in conjunction with the equivalent document that has the word OLD in the file name. Thank you for your understanding.

Document doesn't print properly?

All TIM 2015 documentation is produced in the DIN A4 format (8.27" x 11.69"), which may cause problems when printing on US Letter size (8.5" x 11") paper. With Acrobat Reader for instance under **Size Options**, you will see four options: Fit, Actual size, Shrink oversized pages and Custom Scale. One of these should work; we would suggest **Shrink oversized pages**, which will normally reduce the scale by a few per cent and will not be very noticeable.

And now

Even if you don't normally read instructions, please break the habit of a lifetime and… read *ALL* of this first! The sheer number of clever features built into this product will take a little bit of figuring out, meaning that you may remain unaware of all of its functions unless you read this documentation.

Our thanks to you — and your guarantee

Thank you for investing in this unique product, which we hope will provide years of satisfaction and good service. It is **guaranteed for 12 months**, so long as you treat it lovingly! We'll explain what that means in a moment.

We have total confidence in TIM 2015, so feel free to get in touch if you encounter any problems. We prefer to receive enquiries by e-mail; send your messages to ***andrew_emmerson@btinternet.com*** and they will be answered as soon as humanly possible (but please bear in mind this is a spare-time activity).

For your reassurance, every assembled TIM 2015 has been tested before it leaves the workshop (the date is shown on a label on the underside of the case). To confirm it is working, the only thing you need to connect is the power, using the far-right connector and the mains-to-low voltage converter supplied.

What's this 'treat it lovingly' business then?

Unfortunately it's easy to ruin TIM 2015 — if you overdo things, that is! In order to make TIM 2015 as compact as possible, the loudspeaker used for monitoring the audio output is remarkably small. That's how we manage to squeeze it behind the front panel of the unit. However, loudspeakers as small as this cannot handle high audio volume and are rated at 0.5 watts maximum. On the other hand the amplifier chip inside TIM 2015 is capable of driving much larger loudspeakers, with up to 3 watts of power. Delivering three watts of audio into a half-watt loudspeaker will result in its rapid and painful death.

When you switch on the monitor speaker (right-hand control knob), please advance the control only as far as necessary. **Please resist the temptation to 'turn up the wick' and see how loud you can make the sound**. Yes, you can make it shout but this will rapidly destroy the loudspeaker, causing the internal fuse to blow and protect the rest of the circuitry. Loudspeakers destroyed in this way can be replaced but at the user's expense. Another thing: please avoid straining the connecting cables. Never withdraw a cable by pulling the cable; please use the connectors instead. Thanks for your understanding. We wish you and your TIM 2015 a long and happy life!

Don't panic!

If all else fails... read the manual! In all likelihood the answer lies within these pages. If it doesn't, feel free to ask for help (see previous paragraph). Also check the Updates section of the website at ***www.TIM2015.uk*** once this has been established (creating this user manual delayed production of the website).

How to use this manual

This manual is written in something close to plain English and should be easy to follow (if not, tell us!). Yes, there's a lot of it but you don't have to read it all in one session.

- *Important information* is printed in bold type **like this.**
- *Supplementary information* that it is not essential to read the first time around, but could well be of value at a later stage, is printed in panels (box-outs) with a grey background.

The manual is arranged in numbered sections. The contents page is overleaf.

Finally, if you get stuck, do try reading the manual a second time, perhaps more slowly. Things often become simpler after several readings. For a valuable and independent guide to using TIM 2015 please visit ***http://www.samhallas.co.uk/repository/tim_2015.htm*** .

Clarification

Here are three things that we need to make clear at the outset in order to avoid any confusion.

Accuracy. The claim that we make for TIM 2015 is that it is accurate to within a second but no more. In other words, if you synchronise TIM 2015 to a source of GPS signal or to a

radio time signal transmitter such as MSF, DCF77 or WWVB, it is of 'indicative' but not 'absolute' accuracy, making it adequate for all everyday purposes.

Authenticity. The voice files used in TIM 2015 are all taken from recordings of actual speaking clocks, taken from a variety of sources. In several cases the recordings were taken directly from the speaking clock apparatus with the agreement and kind cooperation of the musuem authorities involved. In other cases they were made from Internet files or tape recordings made in the past, processed for greater clarity as necessary. The method in which the words, phrases and sounds are played out from digital media means the timing of the words may vary very slightly from the timing of the original announcements but only by fractions of seconds and not in a way that users would detect.

Intellectual property. It is our understanding that all recordings used in TIM 2015 are in the public domain. They are provided in good faith for non-commercial use, with no charge made to the end user other than the media on which they are recorded.

TIM 2015 has been designed as a 'pro bono' (not for profit) production, with nobody taking a single penny of payment for the very many hours of time spent bringing it to reality. The design principles and circuit schematic have been put into the public domain and are freely available. The only 'protected' element is the encrypted code used in the microcontroller, for which a design royalty is included in the price of the programmed chip.

Acknowledgments

Thanks to Dave Thorpe for his superb circuit design work, and to Mick Champion, Alan David, Sam Hallas, Howard Harte, John Nice, John Novack, Jayson Smith, Evan Stewart and Dave Whistler for their material assistance and inspiration. Photographs by Dave Thorpe, Sam Hallas, David Henderson, Andrew Emmerson and the manufacturers and suppliers of various parts used. Computer-engraved panels by Architectural & Industrial Engravers, Northampton (***http://www.aiengravers.co.uk/***)

We suggest you print a hard copy of this document and keep it in a binder or display book folder.

The latest version of this manual will be available to download at ***www.TIM2015.uk*** *as soon as the website has been created.*

TIM 2015 IS DESIGNED

AND MADE IN BRITAIN

Index to the sections of this manual

Each section begins on a fresh page.

Section 1 | Basic familiarisation and getting started

Please spend a minute or two before you connect power to your new TIM 2015. This section of the manual will explain the controls, the on-screen messages and how the various connections are made.

Controls and connections

Before you power up TIM 2015 for the first time, take a look at the front and rear panels, also the display screen on the 'lid' of the case (see photos below).

Familiarisation

Looking at the **front panel** we have**,** on the left-hand side, the **multifunctional menu selector** and on the right, the **loudspeaker volume control**. The latter incorporates a switch and you will hear nothing until you have turned the control knob clockwise, overcoming the resistance of the switch, and advance the knob further clockwise until the volume is at a volume convenient for you. Of course you will hear nothing until you have connected power to the device (we'll come to that in a moment) and even then, there is a short delay after switching on before audio is heard, while the little valves are warming up. No, not really, the delay is while the microcontroller gathers its thoughts.

⚠ WARNING!

Please do not turn up loudspeaker volume excessively loud or run it for long periods at high volume. It's only a small speaker (in order to fit the space available) and overloading it might possibly shorten its life.

On the **rear panel** we have four locking connectors (they lock into place to avoid accidental disconnection). Each connector has a different number of pins, to eliminate the opportunity for connecting the power to the monitor output and the phone line into the radio input. From left to right, we see the **telephone line connector** (two pins), the **auxiliary** outputs (five or six pins that can be assigned to a permanent audio output, a 30-second pulse output or anything else you might require), the **radio time signal connector** (three pins) and lastly the 9-12-volt DC **power connector** (four pins, wired in pairs, or alternatively a ROKA connector).

The liquid crystal display **screen** on top of the case looks like this. Normally it is protected against scratching in transit by a thin layer of clear plastic, which you can peel off.

Screen and symbols

When power is connected the screen will illuminate in either white characters on a blue background or yellow on green, according to the stock situation. Other colour combinations are normally procurable, including one with black characters on a near-white background, but these are more expensive and depend on availability in China (on special order only).

A TIM logo appears briefly, after which the main screen is displayed. If anything is amiss with TIM 2015 a diagnostic message will appear instead (see Section 4 of this manual for what these messages mean and how to mitigate them).

This screen shows the time (12-hour clock) and date plus some status icons. Once the clock has been synchronised, a snowflake appears during official Winter Time and a radiant sun during Summer Time (also known as Daylight-Saving Time or DST).

These are the status icons:

Reception of the GPS source is indicated using a satellite dish icon.	
This clock-face icon appears briefly whenever the synchronisation signal is received successfully.	
A telephone handset icon is displayed when a call to the clock is in progress.	
A cross indicates calls are not being accepted owing to a problem with the time (i.e. the time is not valid).	

These are the time source icons:

M **S** **F**	**D** **C** **F**	**W** **W** **V**	**J** **J** **V**	**G** **P** **S**	**N** **E** **T**

The time sync and time source icons are only displayed when a time source has been configured (the actual icons vary according to the type of time source in use).

The four radio time sources (but not the GPS or Internet ones) also display an animated radio transmitter icon with 'radio waves' to indicate data reception activity.

- The GPS source reception is shown using a satellite dish icon.
- A clock icon appears briefly whenever a good sync is received.
- A phone handset icon is shown on the left when TIM 2015 has answered the telephone line that it is connected to and a call is in progress.
- A cross indicates calls will not be accepted due to a problem with the time (the time calculated is not valid).

LED lamp indications

There are four LED lights on the front panel:

- Green LED indicates power is correctly applied to TIM 2015.
- Yellow LED indicates that TIM 2015 is showing the correct time (time has been synchronised within the last 72 hours).
- Red LED indicates that a call is in progress
- Blue LED indicates data activity (time data is being received from the time synchronisation source that you have selected).

There are also two small surface-mount LEDs on the printed circuit board inside the case of TIM 2015:

- A red LED on the Real-Time Clock (RTC) module conforms that power is reaching the RTC module.
- A green LED on Catalex sound module indicates that an audio file is being played.

Getting started

You now know all of the basics and it is time the put TIM 2015 to use. The right-hand knob on the front panel (marked VOLUME) is a combined on/off switch and volume control (with switch). This turns on and adjusts the loudspeaker volume for when you need to check the voice announcements locally. This control does not affect the volume of the announcement heard by callers to the telephone line.

When you first switch on, you will not hear sound from the monitor loudspeaker for up to ten seconds. Do not be concerned: this is because TIM 2015 needs to 'catch its thoughts'. Of course you need to switch on the loudspeaker, which is done by turning the right-hand knob (marked VOLUME) clockwise past the click and advancing it to a reasonable sound level. Avoid having it too loud, as this will protect the loudspeaker from being over-driven. It is also a good idea to turn off the loudspeaker when you have finished checking the audio.

Setting user preferences

You also need to set the current time and various preferences for the operation of TIM 2015. You do this with the left-hand control (marked MENU). This is a dual-function device incorporating a rotary switch (operating both clockwise and anticlockwise) *and* a press-button switch. The technical name for this is a rotary encoder with built-in push-button. We use this to configure the various settings of the clock and to select the information that is shown on the display screen on top of TIM 2015.

Turn the knob one click to view the call statistics.

- The screen shows the number of calls received in the current and previous hour/day/week and month.

Turn the knob another click to view the information screen.

This screen shows the:

- Firmware version.
- Total uptime in days.
- A UTC time-stamp for the last time sync received. UTC, standing for Coordinated Universal Time (*Temps Universel Coordonné* in French), is the primary time

standard by which the world regulates clocks and time. In simple terms it is a more accurate version of Greenwich Mean time.
- The average call length (in seconds) for the last 8 calls.

Note that this data is normally lost when TIM 2015 is disconnected from the power supply, which is why professional users are encouraged to provide battery back-up to the power supply used.

Turn the knob again to return to the time display
The time display also resumes automatically after 3 minutes of inactivity.

While viewing the time, press the button to enter the configuration menu.
In the main menu screen, turn the knob to scroll up/down and left/right through the menu and press the button to select an item to view or adjust.

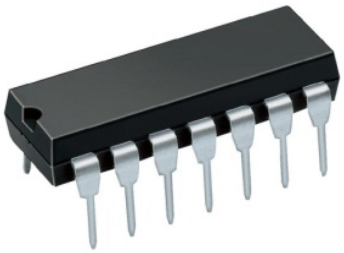
The various options are explained in Section 2 of this Manual.

Cleanliness

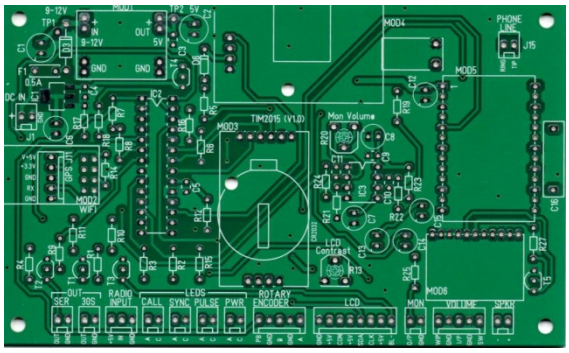
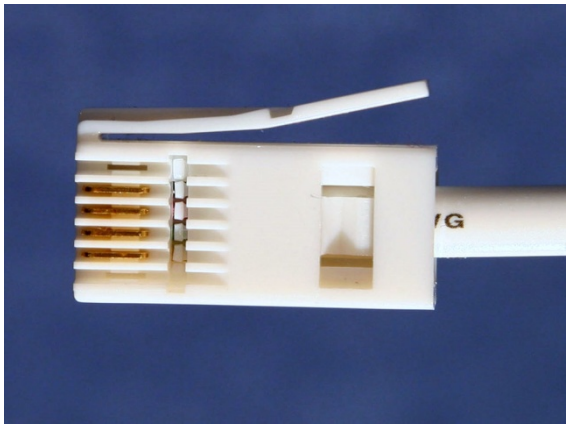
We all know that cleanliness is next to godliness and with that in mind, here are two tips for keeping TIM 2015 looking smart. The high-gloss finish of the Traffolyte overlays (the front and rear panels, also the bezel surrounding the liquid crystal display) tend to pick up fingerprints. A wipe with a soft duster will remove these. The packets of wet wipes sold at pound shops and supermarkets for cleaning spectacles are great for keeping the display smear-free.

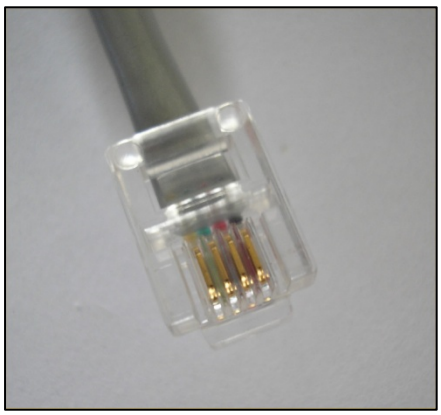
Technical terms used in this manual

BST	British Summer Time, equivalent to GMT+1.
Button cell A long-life 'battery' that looks like a coin — or a button without holes.	
Catalex player This device plays the audio files stored in the microSD card. The digital data on the memory card is turned into the pips and speech that you hear.	
Coin cell	*See **Button cell** above.*

DST	Daylight Saving Time relates to the practice of advancing clocks during summer months so that evening daylight lasts longer, regardless of normal sunrise times. Typically, regions that use daylight saving time adjust clocks forward one hour close to the start of spring and adjust them backward in the autumn to standard time.
GMT	Greenwich Mean Time is the specified at the Royal Observatory in Greenwich, UK. GMT stays the same all year round and is unaffected by any Daylight Saving Time (DST).
GPS	The Global Positioning System (GPS), formerly known as Navstar, is a space-based radionavigation system owned by the United States government and operated by the United States Air Force. It operates globally and provides both geolocation and time information to receiving equipment anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. In practice accurate time can be received wherever one satellite is 'visible', which makes GPS a useful method of synchronising TIM 2015.
IC Integrated circuit, which many people call a computer chip (or a bug). The number of pins (legs) and precise shape may vary. A number of these chips are used in TIM 2015. Second picture courtesy of the admirable Evil Mad Scientist website. Visit *http://www.evilmadscientist.com/2007/one-minute-project-chip-bugs/*	 

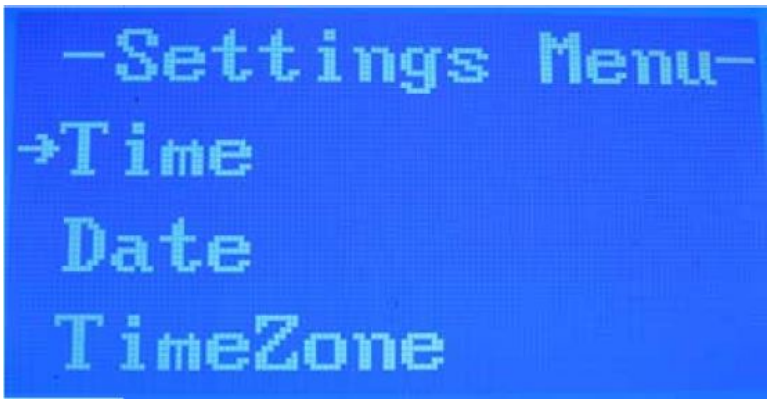
LCD screen An electronic 'liquid crystal display' that is used with TIM 2015 for displaying the time of day and other status information. The LCD used is a physically thin flat panel that uses the light-modulating properties of liquid crystals. These crystals do not emit light directly and are illuminated by back light.	
LED Light-emitting diode, used in TIM 2015 as an indicator lamp. Unlike the traditional incandescent bulb, the LED is an electronic semiconductor device that emits light when activated.	
Locking connector TIM 2015 uses industrial-grade plugs and sockets that are locked in place using an outer ring that you turn to tighten. This prevents any accidental disconnection. Two, three and four-pin connectors are used, making it impossible to mate the connectors wrongly. This particular style of connector is designated the GX 16 series.	
Micro SD card A data memory card, used in TIM 2015 for storing the voice files. SD stands for Secure Data, an agreed technical standard.	
Microcontroller A small computer on a single chip containing a processor core, memory, and programmable input/output peripherals. It manages and controls the operation of all the other chips.	

Printed circuit board (PCB) The PCB is a rigid sheet of resin-bonded glass fibre material onto which the various electronic components are soldered. Holes for the component pins are drilled under computer control and linked by copper tracks plated with tin that form the wiring between the components. The PCB used in TIM 2015 is green, although some photos in this manual show the copper-coloured prototype board.	
Radio time signal transmitters	Around the world a number of radio stations transmit a continuous and highly accurate radio time signal on long wave frequencies. Examples include MSF in England, DCF77 in Germany, WWVB in the USA and JJY in Japan. TIM 2015 can be synchronised using a receiver tuned to one of these radio stations.
RJ-11 phone plug	*See **Western Electric RJ-11 phone plug** below.*
ROKA connectors A design of low-voltage power connectors of German design and now used all over the world. Their name comes from the initials of the Robert Karst electronics company in Berlin, Germany. *Image courtesy of an excellent supplier, http://stores.ebay.co.uk/Useful-Components*	
UK phone plug This is the standard telephone line connector used in the United Kingdom and some other territories. Adapters are widely available for use in other phone sockets. Users living in other territories can fit a lead using the type of plug used in their country or use an adapter. *Image courtesy of Wikimedia Commons.*	
UTC	Coordinated Universal Time (*Temps Universel Coordonné* in French), is the primary time standard by which the world regulates clocks and time. In simple terms it

	is a more accurate version of Greenwich Mean time.
Western Electric RJ-11 phone plug This is the standard telephone line connector used in North America and many other territories worldwide. Adapters are widely available for use in other phone sockets. The RJ in the RJ-11 designations stands for Registered Jack, standardised by the Federal Communications Commission, a government agency of the USA. *Image courtesy of Amicus.*	
Wi-Fi	Wi-Fi is a technology for wireless local area networking with devices based on international standards. Although it is used primarily for enabling personal computers, video-game consoles, smartphones, tablets and other devices to connect to the Internet via a WLAN and a wireless access point, the same means can be used for synchronising the time in TIM 2015. A low-cost adapter that plugs inside TIM 2015 is used for this.

Section 2 Menu settings

The **configuration menu** is accessed by pressing the button from the time display screen. Turn the knob to scroll up/down the menu, press the button to access an item (hold the button pressed for 2 seconds to quit).



Time setting
The vertical arrowheads (^) show the field being adjusted. Each button press moves to the next field. Rotate the knob to adjust the value. After setting AM/PM the button-press shows a **Save**/**Quit** option.

- Selecting **Save** updates the time immediately (seconds are always set to zero).
- Selecting **Quit** exits without making any changes to the time.

If a call is in progress, a warning will be displayed when accessing this menu item (the call can either be terminated to allow setting the time or else you can quit the change operation).

Date setting
You need to configure the date so that DST (daylight saving time, summer time) hour changes can be calculated automatically.
The date is shown in UK format and adjusted in a similar way to the time (see above).
If the day is set to an invalid value for the month (e.g. 30 February) an error message will be shown and the date save will be rejected.

Timezone
Turn the knob to select a positive or negative timezone offset from GMT.
The time will be shown with the specified offset applied.
This setting is intended for applying the local timezone offset to the received time sync obtained from radio, Wi-Fi or GPS time sources.
If a call is in progress, a warning will be displayed when accessing this menu item (the call can either be terminated to allow setting the timezone or else you can quit the operation).

DST region
Turn the knob to enable and select automatic DST (Daylight Savings Time) hour correction for your region. Preset rules are provided for UK, Europe, USA, Australia, New Zealand and Mexico. Use the **Custom** option to manually configure rules for other regions or if your country changes their DST rules.
***Note**: TIM 2015 does not support the small number of locations that do not use Sunday as the DST changeover day.*

Voice
The microSD card contains the files for the default voice (Pat Simmons). If other voice files are added to the microSD card they will be selectable here.
If USA format voice files are found, a message will be displayed to indicate this.
(What we call USA voices are those that use a single toneburst (rather than a number of pips) to indicate the time. Most of these voices include Good Morning, Good Afternoon and Good Evening greetings announcements in addition).
Any one of up to 16 or 64 voices (according to operating system version) can be selected if available. However, storing more than five voices on a microSD card is not recommended, for technical reasons.

Voice Volume
This sets the volume of the announcement sent to the telephone line (usually set to the maximum level 30). It also affects the volume heard on the loudspeaker.
As the knob is turned, the voice will speak the selected volume setting.

Time Source
The time announced by TIM 2015 can be synchronised with external time sources to achieve full accuracy. These sources require the use of optional compatible receiver hardware to be connected to the clock.

The following settings are available:

- **None.** The clock does not sync with any time source (Time and Date must be set manually and timekeeping accuracy depends on the internal temperature-compensated crystal oscillator.
- **MSF**. Synchronised with the 60 kHz radio time signal broadcast from Anthorn radio station in Cumbria, UK (requires external radio receiver module).
- **DCF77**. Synchronised with the 77.5 kHz radio time signal broadcast from Mainflingen radio station in Germany (requires external radio receiver module).
- **JJY**. Synchronised with the 60 kHz or 40 kHz radio time signal broadcasts from Japan (requires external radio receiver module).
- **WWVB**. Synchronised with the 60 kHz radio time signal broadcast from Fort Collins, Colorado, USA (requires external radio receiver module).
- **GPS**. Synchronised using GPS NMEA 0183 $GPRMC timestamps (requires a suitable externally-interfaced GPS module). **Note**: This cannot be used if a Wi-Fi module is already installed).

- **Wi-Fi**. Synchronised to a server via your Wi-Fi network (requires the internal Wi-Fi module to be configured to access your network with the SSID and password).
- Auto. The clock attempts to use any available time sync device found (this may take some time while it detects all potential settings).

Once a time source has been setup, the clock will initially attempt to receive the time signal and sync to it. Synchronisation is indicated by the display icons. The blue LED will flash to indicate data activity and the yellow LED will light when a successful sync has be received.
The radio time sources will be received continually and the time will be updated every minute if the data is validated (no errors detected). A sync will be deferred if a call is in progress to avoid any sudden time announcement changes.
The Wi-Fi or GPS module will subsequently only be powered-up at a random time between midnight and 7am each night until valid time is received or a time-out occurs. (This ensures the module does not waste power and also prevents the Wi-Fi module becoming blacklisted for excessively requesting the time from a server.)
If the clock fails to receive any valid time sync update after 72 hours, the yellow LED will turn off to indicate the time is no-longer synced. (The clock will continue to keep time using its internal oscillator which should be accurate to within about +/- 5 seconds per month).

Timekeeping
This allows very fine-adjustment of the clock's RTC module internal crystal oscillator, which can improve the timekeeping accuracy to better than the manufacturer's specification of +/-5 seconds per month.
If the RTC module has been calibrated to a better accuracy by the maker of TIM2015, a calibration value will be written on the module (enter this value as the timekeeping setting for improved accuracy). The crystal accuracy can drift with age, so you may need to adjust this value slightly each year to maintain the same quality of timekeeping.

Call Duration
This setting terminates a call after the specified number of seconds (default = 70s to allow a caller to listen to a whole minute of announcements). If the caller clears the call (hangs up) before reaching that duration, the clock may be able to detect the call-ended signal and clear the line ready for another call to be received. Some telephone systems do not provide any call-ended signal or use a different protocol. You may therefore need this setting to force the clock to end a call.

Back-light Level
This adjusts the brightness level of the back-light that illuminates the LCD screen.

Masterpulse
The clock provides a pulse output every 30 seconds (available on the **30S** Molex socket at logic level). This pulse can be connected via a suitable external interface to drive some types of electromechanical impulse slave clocks (a separate buffer amplifier must be used). There are options to adjust the pulse width and polarity (low to high or *vice versa*) and facilities to send manual step pulses to advance the time.
If DST has been configured, the masterpulse facility also advances or retards the slave clock hour by sending rapid (1 second) pulses or stopping pulses for one hour at DST changeover.

Voice Audition
This facility allows you to step though and listen to all of the currently selected voice files.

This may be useful for checking that all voices are present and working properly on the microSD card.
Note: A slight error has come to light, which applies only to certain (mainly American) voices. When **Good Morning** appears on the LCD screen, the phrase **Good Afternoon** is played, and vice versa. This applies only to the voice audition feature; there is no error in the announcements made to people calling TIM 2015.

Section 3 | Other settings and housekeeping tasks

Coin-cell battery fitting/replacement

A CR2032 lithium-manganese dioxide 'coin' or 'button' cell is used for timekeeping backup in TIM 2015. You can expect at least ten years' life from a CR2032 cell. If and when it fails please follow the following instructions:

- Replace the battery only with another CR2032 battery. According to Wikipedia, using a BR2032 in place of a CR2032 will not damage equipment, and in most cases will function properly. That may be but CR2032 batteries are more widely available. Use of any other type of battery may present a risk of malfunction, fire or explosion. The old coin cell can be removed from its holder with the aid of a watchmaker's screwdriver or something similar.

- Be sure to observe the correct polarity when installing the battery. Insert the battery so that it clips into place with the lettering and '+' marker visible and uppermost.

- Do not short-circuit the battery or try to recharge it.

- Do not expose the battery to excessive heat.

- Battery may explode if mistreated. Do not recharge, disassemble or dispose of in fire.

- Dispose of used battery promptly and in accordance with local waste disposal policies. Most supermarkets have a container for depositing used cells.

- Keep away from children, who could be attracted to these bright, shiny cells and may swallow or mistreat them.

Note: Coin cells are inserted **with the Plus symbol and lettering side uppermost.**

Performing a reset

Clock configuration and RTC module time/date settings can be reset at power-on by holding down the MENU button until the following message is displayed:
Factory Reset?
Yes >No

Turn the control knob to move the pointer to **Yes** and press the button. The reset is confirmed by **Done** and the clock will restart and prompt for the time to be set.

A factory reset may be required if the clock behaves abnormally or you want to reset the user settings easily back to their default values. **Note**: This reset does not change the network configuration stored in the Wi-Fi module (if fitted).

Serial data output

The clock provides a logic-level serial Time and Date output from the connector on the PCB marked **SER**. This signal could be taken to unused pins on the AUX connector and used for synchronising other devices via a suitable external interface.
The serial data is sent exactly every 10 seconds at 4800 baud as ASCII characters as shown below:

$hhmmss,ddmmyy*checksum
Example (time=12:25:30 date=4 June 2015 (xx=the calculated checksum)
$122530,040615*xx<CR><LF>
(The time is the current local time in 24-hour format)
The checksum is calculated using the bytes after the $ and before the *

Section 4 | Diagnostic messages

TIM 2015 performs various diagnostics at power-on. If a problem is detected one of the following seven messages should be displayed. The parts mentioned that may require your attention are illustrated on the following page.

Please set Time ✕

This indicates no valid time has been set and retained in the RTC module.

Set the time and if it is not retained after power-off, check whether the CR2032 coin-cell has become dislodged or requires replacement.

Please set Date

This indicates no valid date has been set and retained in the RTC module.

Set the date and if it is not retained after power-off, check whether the CR2032 coin-cell has become dislodged or requires replacement.

Error: 01 VoiceHW

The Catalex sound module is not responding.

Try powering off and on again. If the message persists, check the module's connections and try reseating the microcontroller IC in its socket.

Error: 02 SDCARD

The microSD card carrying the voice files is not inserted properly. Alternatively you might see this message if the microSD card becomes corrupted (which is unlikely).

Try powering off and on again. If the message persists, re-seat the microSD card in its socket in the Catalex player. Try using another microSD card or check the card for file corruption, etc. using a PC card reader.

Error: 03 Folders

No file folders have been detected on the microSD card.

Try powering off and on again. If the message persists, check the card for file corruption etc. using a PC card reader (the card must have between 1 and 16 folders containing voice files).

Error: 04 RTCchip

There has been an error communicating with the RTC module chip. This message may also be reported while the clock is running.

Try powering off and on again, or try removing the CR2032 coin-cell for a few minutes. A watchmaker or similar small screwdriver will enable you to prize it out of the holder.

Try re-seating the microcontroller IC in its socket.

Error: 05 RTCdata

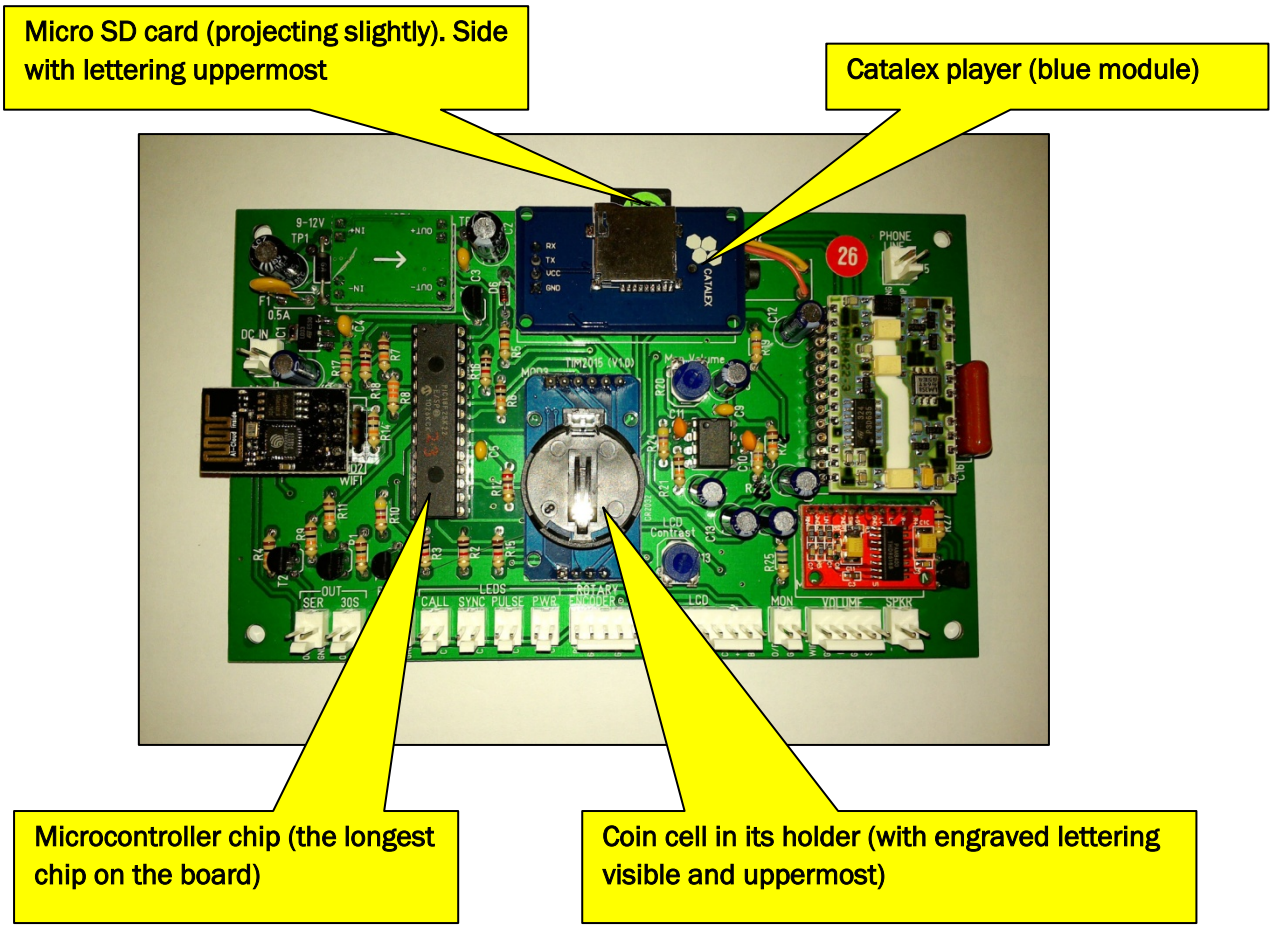
There has been an error with the RTC time or date (this message may also be reported while the clock is running, with all four LEDs flashing).

This fault occurs occasionally when your radio time signal receiver sends non-compliant code (in other words, reports an 'impossible' time of day like 25 o'clock) to TIM 2015 and confuses it entirely. This can occur if local radio interference (such as a noisy thermostat or an unsuppressed passing motorcycle) is stronger than the signal from the distant radio time signal transmitter and corrupts the radio signal received.

The solution is to power down, unscrew the case and remove the CR2032 coin-cell for a couple of minutes. Use a screwdriver to pop it out. This will erase the stored time data and force the realtime clock (RTC) to reset.

If this does not do the trick, you need to force TIM 2015 back to its original state by doing a Factory Reset. Power down the clock, press down the left-hand selector knob and hold it in while reconnecting power until the following message is displayed: **Factory Reset? Yes >No**. Turn the knob to move the pointer to **Yes** and press the button. The reset is confirmed by **Done** and the clock will restart and prompt for the time to be set. A factory reset may be required if the clock behaves abnormally or you want to easily reset the user settings back to defaults. (The reset **does not change** any network configuration stored in the Wi-Fi module, if fitted.)

To gain access to the interior of TIM 2015, turn off the power and then loosen the four screws in the base of the plastic case and remove the upper part of the case.



Section 5 Problem solving

If your TIM 2015 displays an error code on the screen, please go back to **Section 4, Diagnostic Messages**, where these are discussed.

Weak audio

The volume control on the front panel (right-hand knob) adjusts only the loudness of the monitor speaker. There is also a 'master' volume control that you can operate by pressing the left-hand knob and entering the Settings menu. Scroll through until the arrow points to Voice Volume and press the knob again. You can now alter the volume by rotating the knob; this displays the volume from 1 to 30 and also lets you hear what the new volume is. Finally press the knob once more to store the new setting.

No audio at all

The most likely cause is misalignment of the microSD card that carries the sound files. Unpower TIM 2015 temporarily and eject the sound card by pushing it in gently, after which it will pop out. The circular label should be on the *upper* side and the gold-plated contacts on the *lower* side. The end with the gold contacts goes in first. Even if the card was positioned correctly, you may find that ejecting and replacing it cures the problem. This happened with one clock, for no apparent reason, but ejecting and replacing the card put paid to the issue. Then re-apply power to check the result. If this doesn't solve your problem an internal fault may exist. Please contact us for help (see front page of this document).

Failure to synchronise to a radio time signal transmitter (MSF, DCF77, WWVB, etc.)

When using a radio time signal receiver to synchronise TIM 2015 to the exact time please remember that local interference can easily swamp or desensitise the radio receiver, rendering it unable to pick up the transmissions from the time signal transmitter. Sources of interference include computers, electronically-controlled soldering irons and some switchmode ('wall wart') plug-in power supplies. Occasionally radio time signal transmitters are off the air for maintenance purposes but if TIM 2015 refuses to synchronise and the yellow light fails to come on, suspect local interference before other causes.

The interference problem in more detail

The reception of the long wave radio signal is easily disturbed by interference sources, however. These include atmospheric disturbances and electro-mechanical sources near the antenna of the receiver such as motors, computers, monitor screens, power tools, relay racks, switchmode power supplies and so on. The antenna should therefore be positioned with care.

My clock doesn't synchronise at all

Most radio-controlled clocks work great, as evidenced by the hundreds of thousands of units that have been sold throughout the world. However, if your radio clock or receiver isn't working, we suggest:

- The antennas are directional and you might be able to improve the signal strength by turning the antenna.
- Place the receiver box along a wall or near a window that faces the transmitter location. For instance Anthorn (Cumbria) for MSF, Frankfurt am Main, Germany (DCF77), Fort Collins, Colorado (USA) for WWVB. .
- Locate the receiver box at least 1 or 2 metres away from any computer monitors, which can cause interference (some monitors have a scan frequency at or near the WWVB carrier frequency of 60 kHz).
- If nothing else works, power down TIM 2015 (unplug it), then power it up again to force it to look for the signal. If it works outdoors but not indoors, you probably have a local interference problem inside your house or building. If it doesn't work outdoors at night, it's probably best to return it and try a different receiver module.
- The shielding provided by a metal building might prevent the receiver module from working. For example, if you live in a mobile home or a house with steel siding, the clock might not work.

My clock is off by one or more hours

Remember, minutes and seconds are the same in all time zones within the WWVB coverage area; only hours are different. If your TIM 2015 is off (out) by one or more hours, it probably has to do with a time zone setting. Make sure you have properly selected your time zone using the instructions provided in this manual.

If you live in an area that does not observe Daylight Saving Time (Arizona, Hawaii, parts of Indiana), make sure that DST is disabled on your radio-controlled clock. Not all clocks have this feature, so you might have to select another time zone to make your clock display the correct time when DST is in effect.

My clock is off by a few minutes or seconds

If your clock isn't currently receiving the signal, the time will 'drift' and gradually get further and further from the correct time. Remember, if the signal isn't being received, your clock isn't radio-controlled any longer; it's now just a regular RTC clock. Its accuracy will depend on the quality of the quartz crystal. TIM 2015 can keep time to within one or two seconds per day or better, unlike other clocks that will be off by several seconds per day.

The yellow LED on the front panel of TIM 2015 indicates whether the signal is being received properly. If you are not sure if the signal is being received, try powering down the clock (unplug it), then turn it on again to see if it can synchronise. If it doesn't, see the tips above for improving your reception.

Sometimes everything goes haywire

This is a tough problem to resolve but it may be due to power supply instability and/or interference from other equipment installed close by, especially if your clock is fed down a DC power cable more than three feet (one metre) long. You really should avoid this and position the power supply closer to the clock, as the following two paragraphs (adapted from a piece in *Elektor* magazine) explain.

In many circuits, including TIM 2015, we find small capacitors wired between the supply voltage (V_{CC}) and ground (GND). They improve the stability of the circuitry and help prevent radio interference. Whenever electronic circuitry uses a lengthy cable to the power

supply it's not just the resistance of the wires in the cable that comes into play but also the inductivity. A piece of twin-conductor cable 1 m long can have an inductance of around 0.5 μH, according to the gauge (thickness) of the wires and the distance between them. From this arises an inductive resistance of 3 Ω at 1 MHz or 30 Ω at 10 MHz. If your circuit has a varying current load, effectively you have an alternating current in the supply lead and with this some voltage drop. Typical problems with voltage drop of this kind are susceptibility to radio interference and vulnerability to failures in the passive elements of the circuit. The long (from a radio perspective) cable can also act as an antenna. Then you have radio-frequency (RF) signals radiated that potentially may exceed the permitted limits. Conversely pulses of interference may induce brief fluctuations in the supply voltage that might interfere with the correct functioning of a circuit.

Microcontrollers like the one used in TIM 2015 definitely require a capacitor between 12V and ground, as otherwise they would not pass their test for electromagnetic compatibility. In this case they are usually called bypass capacitors, because any radio-frequency currents can be diverted by taking a shortcut through this capacitor most commonly of 100 nF. The older expression 'blocking capacitor' used for these components has fallen out of fashion.

TIM 2015 locks up, showing error code *05 RTCdata*, with the screen flashing rapidly (fibrillation mode).

As mentioned in Section 4, this fault occurs occasionally when your radio time signal receiver sends non-compliant code (in other words, reports an 'impossible' time of day like 25 o'clock) to TIM 2015 and fails to interpret it. The clock then locks up.

This can occur if local radio interference (such as a noisy thermostat or an unsuppressed passing motorcycle) is stronger than the signal from the distant radio time signal transmitter and corrupts the radio signal received. Atmospheric conditions (signal fading) may come into play too.

The solution is to power down TIM 2015, unscrew the case and remove the CR2032 coin-cell for a couple of minutes (at least two minutes). Use a screwdriver to pop it out. This will erase the stored time data and force the realtime clock (RTC) to reset.

If this action does not do the trick, you need to force TIM 2015 back to its original state by doing a Factory Reset. Power down the clock, press down the left-hand selector knob and hold it in while reconnecting power until the following message is displayed: **Factory Reset? Yes >No**. Turn the knob to move the pointer to **Yes** and press the button. The reset is confirmed by **Done** and the clock will restart and prompt for the time to be set. A factory reset may be required if the clock behaves abnormally or you want to easily reset the user settings back to defaults. (The reset **does not change** any network configuration stored in the Wi-Fi module, if fitted.)

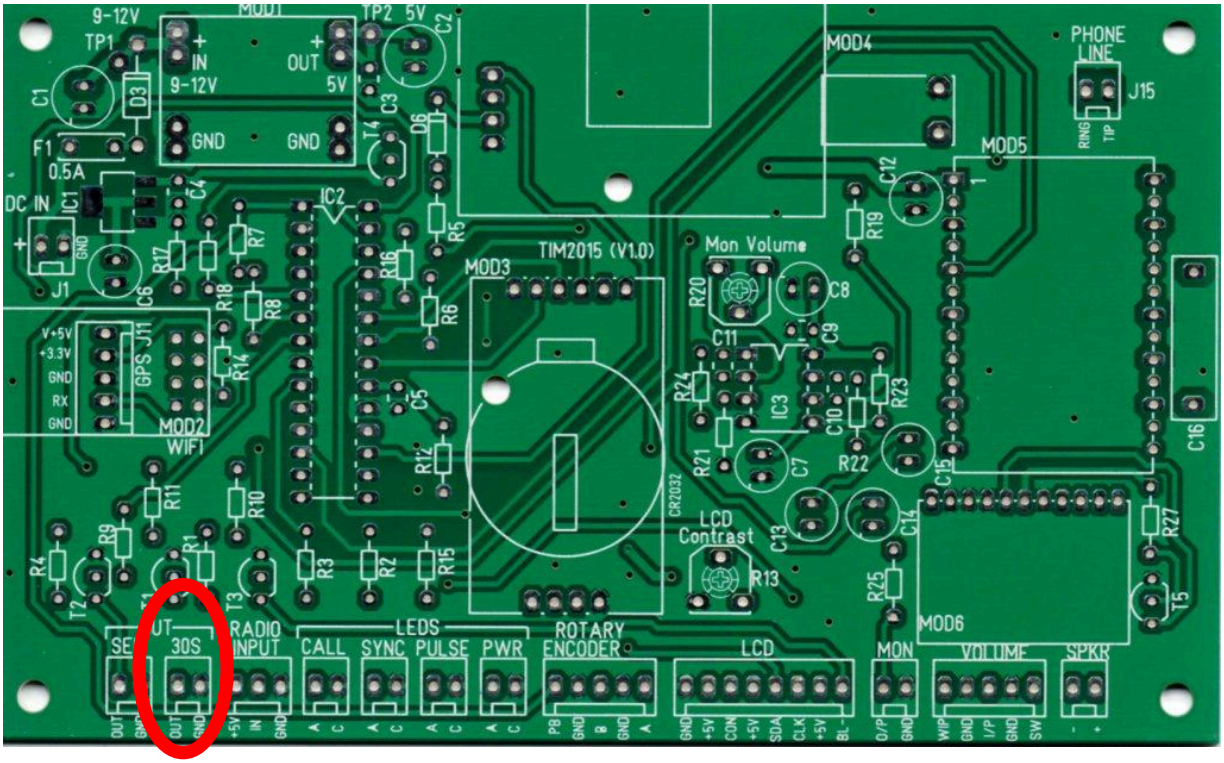
To avoid this problem recurring we suggest that you synchronise TIM 2015 relatively infrequently, say just once a day, week or even month. The real-time clock in TIM 2015 will maintain its accuracy over these periods. The simple solution for people using radio time signal is to unplug the radio receiver and connect it just once a week for an hour or so.

I cannot seem to find the pin-out details for the Aux connector. I am hoping to use the pulse output to drive my slave GPO clock (via an isolated driver interface).

In fact the pins on the AUX (auxiliary) connector are 'user-assignable', so you are free to use them as you please. If you don't have Molex plugs to hand, you will find that Dupont-style female jumper leads will fit firmly on the Molex pin headers. The 20cm-long leads are readily found on eBay under titles such as **Dupont cables jumpers leads female – female**. They look this:

How do I connect slave clock dials to TIM 2015?

A connector providing 30-second pulses is provided on the printed circuit board, as shown below, circled in red.



The user can fix a wire fitted with a Molex or Dupont plug and connect it to two pins of auxiliary (AUX) connector on the back panel of the case. TIM 2015 is not designed to drive slave clocks (dials) direct, so you will need to connect a buffer amplifier between the 30-second output of TIM 2015 and your clock system. We are not clock experts but we believe the circuit shown in **!User_distribution amplifier schematic.docx** (on the data CD provided with your clock) may be suitable.

Settings for the clock pulse output are accessed through the main User Menu (press the left-hand control knob in and rotate clockwise until you see MASTERPULSE).

The clock provides a pulse output every 30 seconds (available at logic level on the '30S' Molex socket).This pulse can be connected via a suitable external interface to drive some types of electromechanical impulse slave clocks. There are options to adjust the pulse width and polarity (low to high or visa-versa) and facilities to send manual step pulses or advance the time. If DST (daylight-saving or summer time) has been configured, the masterpulse facility also advances or retards the slave clock hour by sending rapid (1 second) pulses or stopping it for an hour at DST changeover.

Section 6 The voices of TIM 2015 and how voice files work

TIM 2015 was designed at the outset to demonstrate the authentic voices of personalities who have announced the time of day in the past. We hope to add more options as and when archive recordings are discovered.

Australia

Gordon Gow

was an Australian actor and BBC broadcaster, who spent much of his life in London. He spoke the words and phrases on the British Post Office Mk 2 prototype speaking clock, which in the event was not put into public service in Britain but was in Australia (where it was known affectionately as 'George', see ***https://maas.museum/observations/2012/02/01/george-the-speaking-clock-told-the-time-on-the-telephone/***). Gordon Gow's voice was heard on the Australian speaking clock from 1954 to 1990 and also by visitors to the Science Museum in London where the prototype machine was on display for many years. TIM 2015 provides both versions (prototype and production machine) of this clock.

The clocks were constructed in Britain and the first prototype is in the London Science Museum. Others are preserved in Australia. The only difference between the offerings is that the three pips are lower pitched on the prototype clock. The low-pitched pips were chosen to avoid unpleasant resonance in the Type 1L receivers widely used in Australian telephones at the time. After these had been replaced the higher-pitched pips were used. You will note that the '—nds' on the end of word 'seconds' is inaudible. This is not our error; the word is clipped both on the prototype clock preserved in the Science Museum in London and on the productions clocks in Australia (as can be heard at the end of the You Tube video: ***https://www.youtube.com/watch?v=fp4zlMZVcmM*).** Documents in the BT Archives confirm this was a defect of the clock but nobody seems to have noticed this at the time of making the recordings.

Richard Peach

(1949 – 2008) was an Australian Broadcasting Corporation news anchor. He provided the voice of Australia's second speaking clock, which was in service from 1990 to 2006.

Austria

Renate Fuczik

worked for the Austrian post office. Her voice was used from 1974 – 2009.

Great Britain

Sam Hallas

is a valued collaborator on the TIM 2015 project. He made a test recording using his own voice, which goes to show how anyone can create alternative voices for this device. See the notes headed ***Creating new 'voices' for TIM 2015*** a few pages below.

Pat Simmons

(1920 – 2005) was the voice of the British Post Office speaking clock from 1963 to 1985. More information at ***https://en.wikipedia.org/wiki/Pat_Simmons_(voice_actor)***

In the fullness of time we hope to add the following voices:

Jane Cain (voice used from 1936 – 1963); Brian Cobby (voice used from 1985 – 2007) and Sara Mendes da Costa (voice used from 2007 – 2016).

USA

The five voices most widely used for time-of-day announcements in the USA were Jane Barbe, Joanne Daniels, John Doyle, Pat Fleet and Mary Moore. We have the following voices:

- Jane Barbe (Washington DC)
- Jane Barbe (The Bell Telephone Company brings you the correct time)
- Jane Barbe (The time from your telephone company is)
- Jane Barbe (Las Vegas, Thank you for calling SPRINT)
- Jane Barbe (Ameritech thanks you for calling)
- John Doyle (Baltimore MD)
- Pat Fleet, generic announcement (using Asterisk words and phrases)
- Pat Fleet (Washington DC)

John Doyle

was the voice of the former speaking clock in Baltimore, USA. It was voiced by John Doyle and can be heard at ***https://www.youtube.com/watch?v=oq5-TA8RkI0*** The source recordings were kindly made available by Jayson Smith and extracted from the YouTube film. You will note that the clock includes a period of silence every ten seconds. This is as per the actual clock and was provided to enable a sponsor's announcement to be included if desired.

In the fullness of time we hope to offer additional voices, especially if customers supply recordings.

Detailed information about all of the people mentioned above can be found on Wikipedia.

Adding more voices to your TIM 2015

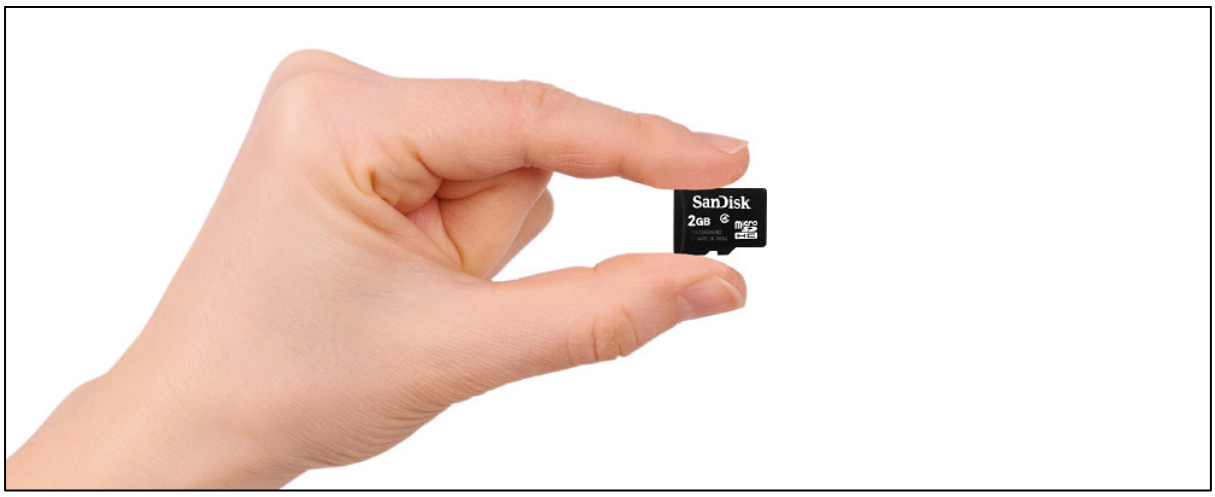
One of the outstanding features and key strengths of TIM2015 is its ability to play a number of different 'voices' contained on a microSD card. Voice files (the words, phrases and pips that are assembled to create the time-of-day announcements) are stored in a memory card known as a microSD card. The same kind of card is used in all manner of digital cameras, smartphones, tablet computers and so on.

From time to time we will offer enhanced or additional voice files so that you can update your speaking clock. You are not obliged to upgrade your clock; it's entirely your choice whether you do this. When updates are ready you will be advised by e-mail. You will then be able to buy a new card for a token charge that covers time, materials and postage. Alternatively, if you are used to programming microSD cards on your computer, we can

send you the files over the Internet. Having saved them to your computer, you can update your memory card by creating new folders and writing the voice files to the card from this folder. Eventually we will have these files available on the TIM 2015 website.

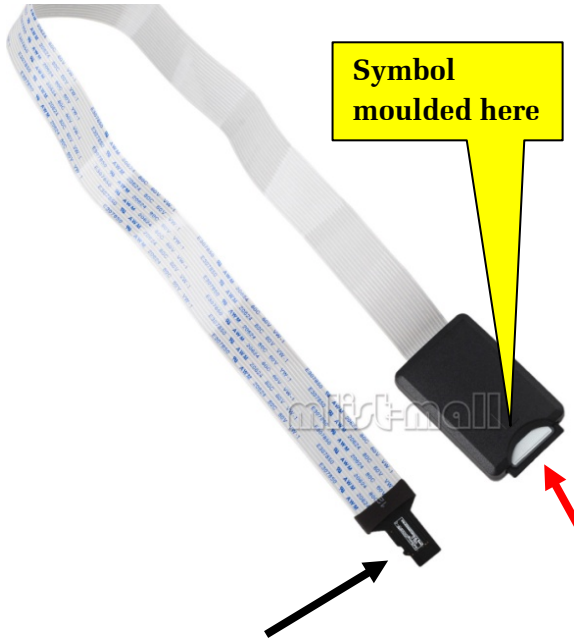
Minutiae of microSD cards

There are many different varieties of microSD card but the type that we use in TIM 2015 is the very basic — and inexpensive — sort with a memory capacity of 1 GB (one gigabyte). This size of memory is more than adequate for our purposes and although 1GB has the capacity to store dozens of different voices, we recommend keeping no more than five voices on any single microSD card. This is because of technical limitations described elsewhere.



A microSD card, showing its physical size (image courtesy of mikroe.com)

If you plan to use more than five of the voices available (listed previously) we recommend that you use an adapter device that allows you to change cards without opening the case of TIM 2015.



This connector plugs into where the microSD card normally fits inside TIM 2015.

To change the microSD card in current use without unscrewing the case, one of these flexible extender cables will come in handy.

A search on eBay for **SD Card Flexible Extension Cable Adapter** should find a choice of these priced at £4 ($6) or less. You can pass the flat ribbon cable out through a narrow gap between the upper and lower halves of the case, with no more unscrewing and re-screwing necessary after that!

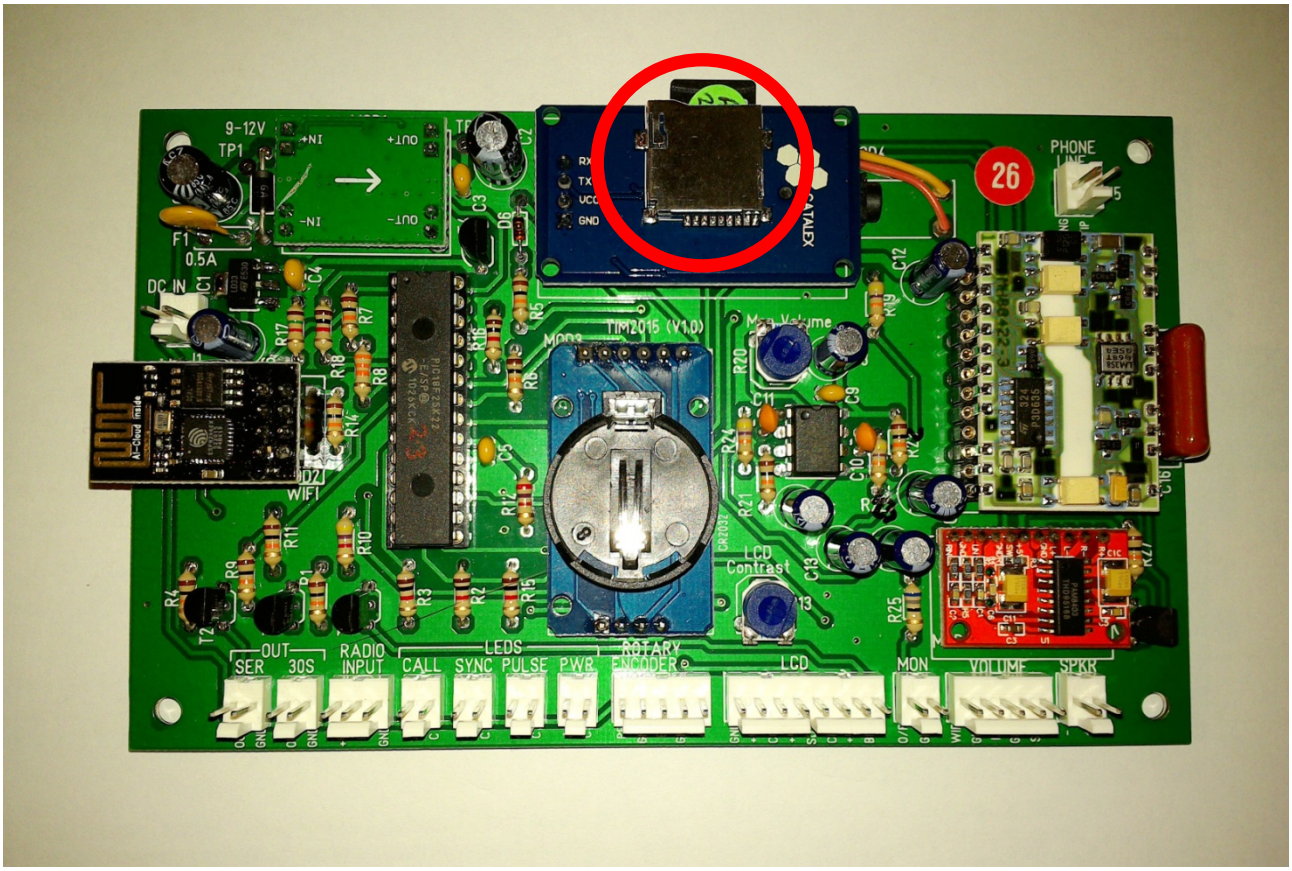
You will also need a **Micro SD Memory Card (TF Card) to SD Card Adapter** (£1 or cheaper).

The adapter, containing your microSD card, slides into this receptacle. The label or writing side of the adapter needs to face upwards, on the same side as the moulded symbol does.

This is what the microSD card adapter (mentioned a moment ago) looks like.

Your selected microSD card (we use 1GB, not 2GB, cards of course) should be pushed into the narrow slot as far as it will go.

You then push the adapter (containing the microSD card) into the receptacle, keeping the writing side uppermost. You will feel a definite click when the adapter is engaged properly.



TIM 2015 interior view. You can see the microSD card projecting out of its silvery socket, ringed in red. Pushing it in, then pulling it out will release the card. If you use the Flexible Extension Cable Adapter, the connector plugs in where you see the microSD card in this photo.

Information about microSD cards

The microSD cards used in TIM 2015 and many other gadgets cram a large amount of memory into a very small space, which is why they are used so widely and enthusiastically. All the same, there is no gain without pain and we must take account of three unavoidable effects that could cause malfunction if ignored. Needless to say, the design of TIM 2015 takes full account of these effects.

Ageing: There is an upper limit to the number of times that each block of memory on the card can be written to. This limit usually falls within 100,000 writes of the memory blocks and causes the cards to fail when the limit is reached. In normal circumstances you will never get close to 100,000 write or delete attempts. Manufacturers cover themselves by stating that the use of any one memory card should not exceed two years to help prevent accidental loss of data or card failure from formatting damage and normal memory wear.

File fragmentation: Where there is not sufficient space for a file to be recorded in a contiguous region (i.e. every byte following on directly after the previous byte), it is split into non-contiguous fragments. This does not cause rotational or head-movement delays as with electromechanical hard drives, but it may nevertheless increase the time taken to read files; for instance, by requiring additional reads and computation to determine where on the card the file's next fragment is stored. (based on material in ***https://en.wikipedia.org/wiki/Secure_Digital***).

Latency: This term refers to the delay time between the moment when the microcontroller in TIM 2015 issues an instruction to access a particular file in memory (the microSD card) and when the file is actually available for use in the Catalex player. By their nature, microSD cards are slow, both in terms of throughput and (critically) latency. Regardless of the impressive-sounding numbers on the package, they are nowhere near as fast as RAM or SSD or even hard drives! They are even slower writing than reading, although this is not a problem when we play out time of day announcements. Files that are buried deep inside a microSD card will take longer to access than others that are 'near the top of the pile'.

Taking all of these factors into account we recommend storing **no more than five voice files** on a microSD card.

More information about microSD cards

If you intend to 'burn' microSD cards with your computer we recommend using a card reader that plugs into your computer via a USB connector. There are loads of them on eBay ***but*** there are a lot of out-of-date adapters being dumped cheaply that do not have a slot for microSD cards. So **do make sure** that the one you buy says it can handle *microSD* cards.

General information: The microSD cards used in TIM 2015 are entirely PC-compatible. This means you can plug them into a card reader, insert the card reader's USB plug into a USB socket on your computer and viola! (as they say in horticultural circles). The microSD card now appears as an external disk drive and can be written to and read from.

A typical card reader. You don't need anything expensive or sophisticated. Even a card reader bought at a Pound Shop will do. But do make sure it handles microSD cards; older ones don't!

Videos of using a card reader at:

https://www.youtube.com/watch?v=ENRqnXiRtUo

https://www.youtube.com/watch?v=2uh2en3JRCw

Creating new 'voices' for TIM 2015

General

Users may well wish to devise additional 'voices' for enhancing the range playable with TIM 2015, perhaps to reproduce other speaking clocks past or current or in other languages. Many hours have been spent capturing and editing the audio files available already and we thank the museums who made available their clocks for recording without charge to us. We hope other developers will show the same generosity and make their creations available to all users.

Making new recordings from scratch

If you intend making an entirely new recording, the process will be greatly simplified if you conform as closely as possible to the same format and timing of phrases as the standard British speaking clock. You can use the speaking clock as a cue and check the time of each of your recordings to be as close to those of the speaking clock as possible.

You will need separate recordings for

- *At the third stroke it will be One* through to *At the third stroke it will be Twelve*
- *O'Clock*
- *One* through to *Fifty-Nine*
- *Precisely*
- *And Ten Seconds* through to *And Fifty Seconds*

As far as possible all recordings should be in the same tone of voice and audio level, sounding as natural as possible. At least two takes should be made of each word or phrase. And make sure you make several backups of your precious recording.

Some basic rules when making voice recordings:

1. Don't record with the microphone touching your lips. It's too close, the voice will sound bassy when using a directional microphone, and you may get pops and sibilants with 'p', 't' and 's', etc.
2. Don't record with the microphone too far away. It will pick up too much of the room sound, and it will sound boxy and roomy.
3. Try different rooms, if you have more than one. Your hallway might sound better than your bedroom, etc.
4. Yes, get a pop-shield and a mic stand. You cannot hold the microphone while speaking, as the noises from the hand movements will be recorded. To get rid of that you need mics made for live use, and noise gates and things.
5. Once you get as good a sound as possible directly out of the microphone, you may care to apply compression, EQ and reverb/delay to make it sound even better. Here you generally need to experiment, as what sounds good depends on both the microphone and the
6. Good equipment helps, but always take the time to get the best out of the equipment you have. If you don't, getting the good equipment will not help much. You learn a lot from using cheap equipment, not least which is why expensive equipment is expensive.

[Adapted from ***http://sound.stackexchange.com/questions/24923/how-to-make-recorded-voice-sound-good*** with full acknowledgement]

You will find further good advice from Sam Hallas at the end this page on Sam's website:

http://www.samhallas.co.uk/repository/tim_2015.htm

Contributing historical recordings that you made from the telephone

You can supply a single tape/Mini Disc/CD or digital WAV file of the entire session (leave the editing into segments to us). As this is a spare time activity, it may well take some time to edit and format the recordings for TIM 2015.

Doing the whole job yourself

All audio files are created and stored in .WAV format, using the freeware Audacity program (***http://audacityteam.org/***) for editing them. Although these files are named 001, 002 and so on, the Catalex module seemingly translates the file number into a 16-bit file number that it allocates internally (like playing a number of tracks on a CD).

Voice file variables

The voice files used for TIM 2015 fall into two basic types, **British** and **USA**. They are not the cleverest names we could have chosen but never mind.

- So-called British files are the default type, in which the exact time is indicated on the third of three pips. It follows from this that the first pip is sounded two seconds *before* the exact time, at the start of each minute and on the 8th, 18th, 28th, 38th and 48th seconds thereafter. This British format is also used in Australia.
- So-called USA files are those in which the exact time is indicated by a single toneburst sounded at the start of each minute and on the 10th, 20th, 30th, 40th, and 50th seconds thereafter. This USA format is valid in most countries. Many (but not all) USA-format voice files include a preamble such as 'Good Morning', 'Good Afternoon' or 'Good Evening' and when the microcontroller detects these additional greetings, it sounds the toneburst at the correct time. When the time-of-day announcement does not include these Good Morning-type preambles, we insert dummy (zero-length) preambles in the voice file to ensure that it is treated as a USA type file.

The voice files are also categorised as announcing in either 12-hour clock or 24-hour clock format. The 12-hour clock is the default but if the microcontroller detects times for hours between 13 and 24, it takes account of this and displays an on-screen message to this effect. The display itself is in 12-hour format with a separate indication of AM or PM. Early versions of the TIM 2015 operating system did not handle 24-hour format time and clocks fitted with the older operating system will announce 24-hour voice files in the 12-hour format.

Working with the Catalex audio file player

First things first. Although the Catalex device is described as a Serial MP3 Player, it is equally capable of handling WAV files, which deliver better audio quality. In this application as a speaking clock, the procedure is as follows:

- Our application software exploits the fact that after every audio file is played, the Catalex player sends one or two confirmation command strings [**3D**]. It appears to be a matter of chance whether it repeats the string or not.
- We send a Play File command for the first audio file and wait for a valid **3D** reply and then send the next one (and so on)…

The time-of-day announcements audio files are delivered every ten seconds and last 10 seconds (including periods of silence). The announcements are assembled from a number of separate words and phrases stored as .WAV files. Playout is arranged like this:

- Playout of each 10-second sequence begins with the time indicator. With so-called British voices this is a set of three pips that begin at 08, 18, 28, 38, 48 and 58 seconds. In this way the last of these three pips will occur at exactly the correct time. In so-called USA voices, where only a single pip or toneburst is given, this is sounded at 00, 10, 20, 30, 40 and 50 seconds (filename is **080.WAV**);
- [*If used, needed only for certain overseas speaking clocks*] As a preamble we send one of the following three greetings: 'Good Morning' (filename is **082.WAV**), 'Good Afternoon' (filename is **083.WAV**) or 'Good Evening' (filename is **084.WAV**). Note that we send empty (zero-length) preambles when no greeting is announced;
- Next we send 'At the third stroke it will be' or an equivalent phrase, followed by the current hour, e.g. 'seven' (filenames are named **001.WAV** to **012.WAV**);
- Then the minute e.g. 'forty-five' (**145.WAV**) (filenames are **100.WAV** to **159.WAV**);
- Lastly we send the seconds, e.g. 'and ten seconds' (**210.WAV**) or the word 'precisely' (**200.WAV**) (filenames are **200**, **210**, **220**, **230**, **240**, **250.WAV**).

Most of these files include periods of silence before and after the actual speech, to ensure that when you assemble and play a string of files, they will sound like natural speech.

The **maximum permissible length of assembled segments** in any single time announcement is around 9.5 seconds (*maximum 9.8*), the remaining 0.5 (*0.2*) seconds unused (for technical reasons related to latency issues). It is also important to note that the Catalex player becomes very confused if ever a new sound file is sent to it before it has finished playing another file that it has already started. For this reason a consistent delay is provided between the end of the 'Precisely' or 'And xx seconds' recording and the start of the three pips or toneburst.

Special cases

There are two special cases, one in which the time of day message includes a preamble greeting such as 'Good Morning', 'Good Afternoon' or 'Good Evening' and the other when the time is given in 24-hour clock format.

When a **preamble** is used, we include additional files. For the John Doyle voice, they are 082. WAV (Good Morning), 083.WAV (Good Afternoon) and 084.WAV (Good Evening). The software makes a check to see whether these files are present and if so, an on-screen message indicates that a 'USA voice' has been selected.

Times in the **24-hour format** include 'hours' files named 013.WAV to 024.WAV. Note that 024.WAV is used for zero hours (midnight) because the file 000.WAV is not supported by the Catalex player. In other respects the format of the other phrases will be the same as the existing British or North American types (such as 'At the third stroke it will be 18.45 and 30 seconds'). For technical reasons the LCD display still shows the time in 12-hour mode even though the voice is in 24-hour mode. As with preambles, the software makes a check

to see whether these additional 013 to 024 files are present and if so, an on-screen message indicates that a 24 Hour Voice has been selected.

Using this file structure

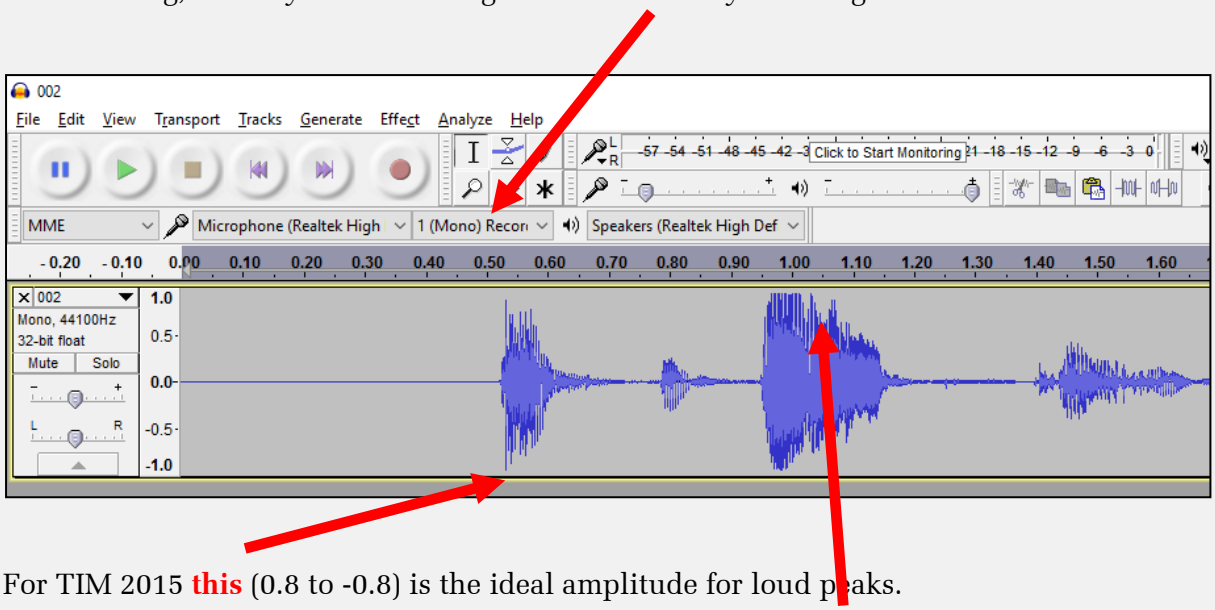
If you are creating your own audio files, you must use the standard TIM 2015 file structure, file names and file lengths. If you examine the files on-screen in Audacity, you will observe that the audio in any particular .WAV file runs for a shorter length of time than the timeslot allocated to it and is seldom placed in the file with equal lengths of silence before and after. This is deliberate, to ensure that the voice files sound natural when played out sequentially, you must leave a short silence, at least 1/10th of a second, before the audio starts and ends. Otherwise the Catalex chip may not play the files correctly.

Whenever you save files with Audacity, ensure that you clear all the 'media attributes' that it may automatically try to fill-in during the **Save** dialogue. If the files include extra metadata of this kind (such as 'genre') the resultant files may play erratically.

Unless you are very brave or skilled, we advise you not to make any alterations to this scheme of things, otherwise commands from the microcontroller (PIC chip) will probably fail to work. The files that you create need to be stored in a numbered folder: **01**, **02**, **03, 04** or **05** (we advise placing no more than five voices on a microSD card).

The memory size occupied by the audio files for a single voice is around 60MB.

Note that in Audacity the voice files should have the following characteristics: mono (*not stereo*), 44,100Hz, 32-bit float, maximum amplitude between -1.0 and +1.0. We suggest sticking to mono to minimise the size of the files created. In fact it does not matter if you used stereo files, but there is no advantage and the MONO files are obviously smaller. The default track created in Audacity when you press the record button is a stereo track displayed in **Waveform** view with a linear vertical scale running from -1.0 (negative values) to +1.0 (positive values), centred on zero *(provided you have not changed Audacity's default for the display)*. Everything in this default setting is fine, but for the stereo setting, which you must change to mono here by selecting Mono in the menu:

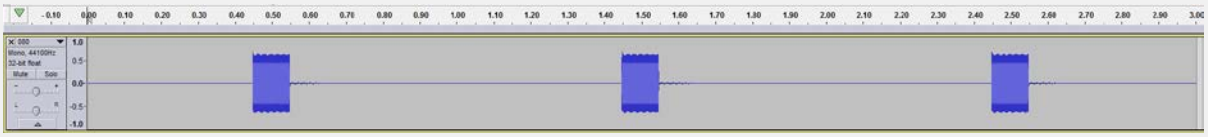


For TIM 2015 **this** (0.8 to -0.8) is the ideal amplitude for loud peaks.

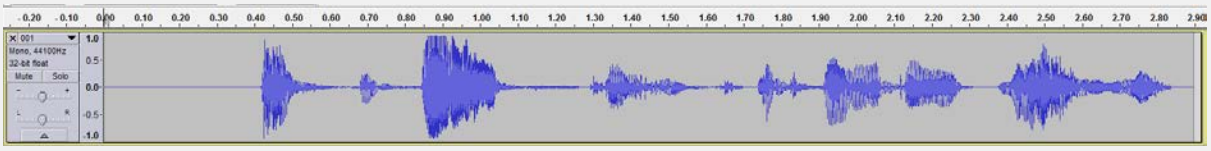
You can expand or reduce the amplitude in Audacity. **This signal here** is slightly too loud (note the flat-topping) and needs to be reduced. Use the **Amplify** effect and 'amplify' by -1.

The length of each audio file and where you place the audio within the file is critical to getting things right too. The following details are correct for the Pat Simmons (British) voice. Other voices will use slightly different timings but the general principles remain the same.

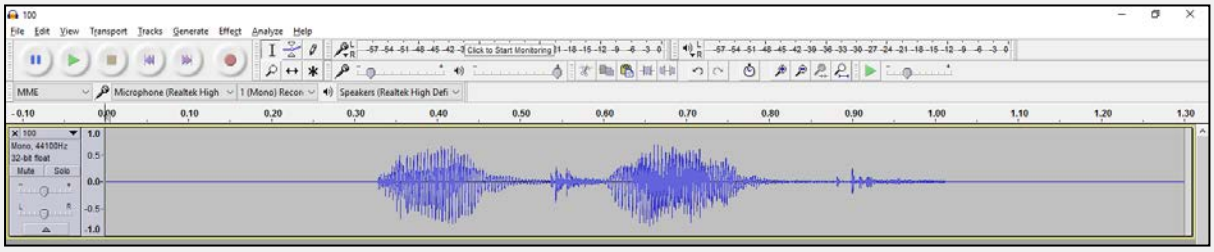
- File **080.WAV** contains the three pips. It lasts 3 seconds, with the audio beginning at 0.45 seconds.



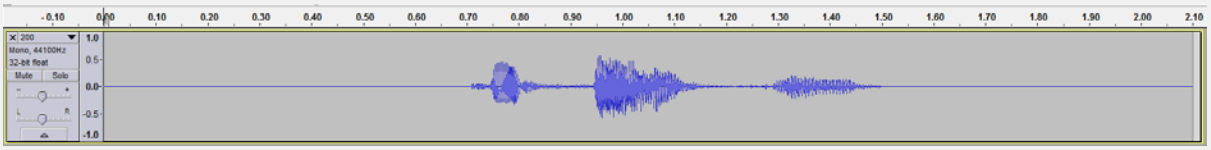
- File **001.WAV** contains the three pips and the words 'At the third stroke <pause> it will be one' [the pause mimics the delay in the original recording when it changed tracks]. This carries on up to **012.WAV** ('At the third stroke it will be twelve'). These files run for 3.1 seconds with the audio beginning at around 0.40 seconds.



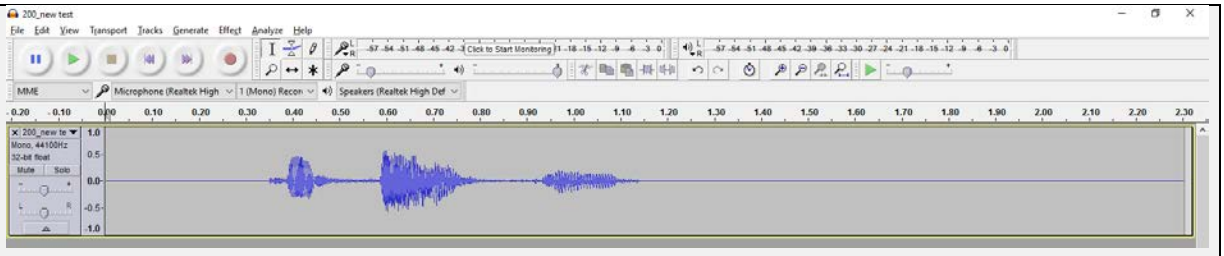
- File **100.WAV** contains the phrase 'O' clock'. It lasts 1.3 seconds, with the audio beginning at 0.32 seconds.



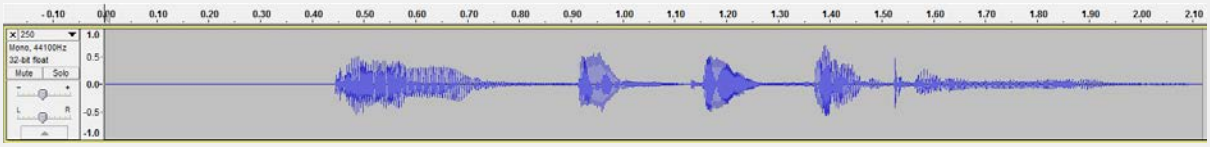
- Files **101.WAV** to **159.WAV** contain the minutes from 1 to 59. These also run for 1.3 seconds, with the audio starting at 0.30 seconds.



- File **200.WAV** contains the word 'Precisely'. It lasts 2.1 seconds, with the audio beginning at 0.70 seconds. It must not start any earlier; otherwise you end up with an unnaturally long silence between the end of 'Precisely' and the next sequence of three pips.



- Files **210.WAV** to **250.WAV** contain the 'And ten/twenty/thirty/forty/fifty seconds' announcements. These also run for 2.3 seconds, with the audio shifted towards the end of the time-slot.



Here is a summary of the timings for the complete cycle:

080 3.0 seconds

00x 3.1 seconds

1xx 1.3 seconds

2xx 2.0 seconds

TOTAL 9.4 seconds (not 10.00 seconds, because we need to take account of the latency or delays that occur while the Catalex chip loads new files).

Note: TIM 2015 has a handy facility for auditioning each of the files that make up any particular 'voice'. Go to the Settings Menu, use the **Select Voice** option to select the voice of interest and then use **Voice Audition** to listen to each of the files in turn.

More Catalex considerations

The following relates to issues not mentioned in the Catalex data sheet (this document is included separately in your information pack). They are important for making TIM 2015 behave in the way we wish it to.

1. The Catalex player is an ingenious and low-cost device. It is not very sophisticated, however, and it cannot play more than one file at a time. If instructed to, say, sound the three pips before a previous file has finished playing, this will cause it to malfunction. Early versions of the data sheet for the Catalex player mentioned a 'Serial Play' command but when designer of TIM 2015 contacted the Catalex team, they admitted that it did not work — and removed all reference from the data sheet.
2. Did we mention, the Catalex player is not a sophisticated device? It does not know or calculate the total length of the files to be played in a time announcement. The microcontroller simply puts all of the files in a queue and the Catalex device plays the next file as soon as it has an indication that a file has finished playing.
   At the start of the next time slot (sequence), at x8 seconds (British voices) or x0

seconds (USA voices), the microcontroller must start a new file queue regardless of whether the Catalex player is still busy or not in order that the pips or toneburst will begin on time.
So the sequence needs to finish within about 9.8 seconds to ensure the module is not still busy when the next pips file command is sent.

3. The 9600 baud communication link between the Catalex player and the PIC takes about 10.4ms to process each command string, so the End of File message from the module plus the Play File command from the PIC should take only about 21ms. For some unknown reason the Catalex module sometimes repeats the End of File message. If that happens, the PIC just ignores it but it appears that the Catalex module then delays playout of the next file.
4. The most significant delay that you need to consider relates to the amount of time required by the Catalex module to access each file stored on the microSD card. To confuse things further, this delay varies according to the card speed, the formatting option chosen and the degree of fragmentation. The delay could in theory be reduced a little by changing the SD card format settings (increasing the allocation unit size) — but not enough to make this ploy worthwhile.
5. Another thing that can delay playback slightly is the microSD card formatting cluster size. The designer of this project experimented with increasing the cluster size from the default and it did reduce the time taken to load a file from the SD card (but this was a matter of milliseconds, so it should not really make much difference unless the sequence timing is very close to being too long).
6. The Catalex module begins to fade-up at around 60ms after the start of each file. If your audio files begin immediately (with no preliminary silence), this leads to some loss of sound. *Consequently you need to include at least 60ms of silence at the beginning of your audio file*. This simple to arrange in Audacity.
7. As a result of all these factors the program starts the command for the pips file 98ms earlier than second x8 (or second x0 for USA-format voices) to allow the pips to start playing promptly at second x8 (or x0).
8. Fragmentation of the data on the microSD card caused by files being added and removed can cause the Catalex module to fail to play files (delete all files on the card and re-copy all files in one fell swoop to avoid this problem). The other delays (the time taken to execute serial commands and latency in accessing data on the microSD card) may also contribute to the sequence over-running into the next pips and the Catalex player becoming confused and truncating announcements. We suspect that the Catalex file processing system is very basic and does not handle fragmented files very well.
9. The Catalex device will definitely truncate (cut off) the end of a file being played if it receives the next Play File command too early (for example it always sends the Play File command for the three pips at the start of second 8 regardless of any existing file still playing). For this reason the 'and *nn* seconds' audio file may need to be shortened (by removing some silence following the speech) to give the microcontroller more time to ensure the Catalex module has finished before sending the command to play the three pips. *Careful editing of voice files (and not putting more than five voices in a microSD card will avoid these unwanted effects.*
10. MP3 files do not work well with TIM 2015. While using some MP3 files, the designer encountered trouble with files not playing properly. But they worked fine after converting them to .WAV format and also removing any data from the file headers (created when saving them in Audacity).
11. There is also a trade-off when using MP3 files. They need more processing than

.WAV files but occupy less space on the microSD card, meaning that MP3 files may take a shorter time to load initially. In theory the smaller files ought to mean to shorter access time and loading time but our trials indicated this was not the case.

12. The designer tried using lower bit rates for the .WAV files and found that these gave very scratchy results. It is far better to aim for higher quality.
13. If sound files fail to play, they may be too long. If you shorten them by removing any excess silence, you may find they will work then. You may need to remove excess silence from other files.
14. *In any 10-second voice file the actual speech, tone and pauses should not exceed 9.8 seconds. Give the Catalex player adequate breathing space!*

If you get into difficulties, do send an e-mail (***andrew_emmerson@btinternet.com***).

Testing your newly created voice files

Testing is a straightforward business. Having saved you voice files into separate folders (numbered 01 onwards) on your computer, take a 1GB microSD card and format it (if not already formatted) using the FAT16 or FAT32 method.

Create five directories numbered 01, 02, 03, 04 and 05 on the microSD card. Remember, saving more than five voice files onto a card is not a good idea.

Copy your newly created voice file onto the microSD card and when the data has 'settled', eject the card.

Now insert it in the Catalex player inside TIM 2015, or if you have taken our advice, in the external **SD Card Flexible Extension Cable Adapter** that we mentioned under the heading **Adding more voices to your TIM 2015**. This low-cost gadget makes changing microSD cards so much easier. Select the voice wanted and see how it runs.

Perfectly if you are lucky and if so, leave it running for 24 hours and come back to it now and again. In some cases errors occur only at certain times of day, usually when the 'and 45 seconds' is cut short in its prime and replaced by the next toneburst or pips. This indicates that the sum total of elements in a 10-second sequence has exceeded the 9.8 seconds limit, meaning that you must trim a second or two off one of the elements making up that sequence.

If the new voice fails to run properly, you may have bigger problems. Recording a minute of the audio output from TIM 2015 on your computer and displaying a 10-second sequence as a screenshot may help you identify the problem. More simply you can make a table of the elements of this sequence, based on Pat Simmons:

080 (pips)	3.0 seconds
012 (at the third stroke it will be 12)	3.1 seconds
117 (seventeen)	1.3 seconds
240 (and 40 seconds)	2.0 seconds
TOTAL	9.4 seconds

No problem here, though: 9.4 seconds is well within the 9.8 seconds limit.

Section 7 Time synchronisation

The built-in real-time clock (RTC) of TIM 2015 is set to current time when the device is constructed. Thanks to the high level of accuracy of this RTC, it loses only a few seconds a year. To ensure that the time indicated is always accurate, you need to *synchronise* your TIM 2015 to Universal Coordinated Time (UTC).

There are three methods of doing this, using:

1. A **radio receiver** connected to TIM 2015 that receives data from a time signal transmitter in Britain, Germany, the USA or elsewhere, depending on your location in the world;

2. A **Wi-Fi module** fitted inside TIM 2015 that updates a very accurate time server over the Internet;

3. **A GPS receiver** connected to TIM 2015 that receives data from a constellation of satellites in the sky. This will not work indoors in most situations.

It is highly debatable which of these is the simplest, most reliable or lowest cost method, as opinions vary wildly!

The methods used, parts needed and connections to be made are set out in Sections 12, 13 and 14 of this User Manual.

Section 8 Technical description

You can use TIM 2015 very happily without reading anything in this section of the manual! The information in this section is provided for people who like to look 'under the bonnet' (British English) or 'under the hood' (US English) of TIM 2015.

How TIM 2015 works

The clock is controlled by a Microchip PIC18F25K22 microcontroller running encrypted assembler code at a clock speed of 32MHz from its internal oscillator.

Timekeeping is provided by a Maxim DS3231 RTC (Real Time Clock) chip (fitted to module **MOD3**.) This chip has an integrated temperature-compensated crystal oscillator (TCXO) and 32768 kHz crystal for timekeeping accuracy of ±2ppm (or better) from 0°C to +40°C. A long-life CR2032 lithium 3V coin cell maintains timekeeping during power failure.

The DS3231 communicates with the microcontroller using a serial I^2C Interface and also provides a 1-second pulse to synchronise the voice and time display updates (module **MOD3** also contains a separate memory chip, which is not used).

The **time-of-day speech announcements** are handled by the Catalex player module (**MOD4**). This contains a dedicated YX5300 stereo audio processor chip usually used for MP3 players. It also plays the WAV files used for the voice announcements in TIM 2015. The device supports audio sampling frequencies of 8, 11.025, 12, 16, 22.05, 24, 32, 44.1 and 48 kHz.

Only one audio channel is being used for the mono recordings employed in TIM 2015. The microcontroller controls the Catalex player using command strings sent at 9600 baud.

Voice files are stored as .WAV files (or .MP3 files) in folders on a microSD card. For each time-of-day announcement the microcontroller compiles a list of required files and commands the Catalex module to play each file in sequence. The module reports when each file has been played, ready for the microcontroller to request the next one.

The **audio output** from the Catalex player is filtered by an op-amp, IC3B (MC33072), to reduce frequencies higher than 3,300Hz, as they lie above the range of frequencies used for telephony.

The audio is then passed to module **MOD5** (Mitel 88422-3), which connects it to a telephone line (in the same way as a telephone answering machine answers a call). This module a **specialised telephone line interface** to handle the transmission of audio, call ringing detection and line seize/release. It isolates the phone line voltage and provides logic-level control lines for the microcontroller to detect incoming calls (ringing) and answer/release them.

The audio announcements are also sent via a **volume control** (R26) to an audio power amplifier module (**MOD6**). This contains a PAM8403 stereo 3-watt Class D amplifier IC that lets you hear the announcements on a loudspeaker for quality monitoring and testing. This PAM8403 chip uses digital audio processing to achieve an efficiency of up to 90%, resulting in much reduced power consumption. Only one audio channel of the amplifier is used because the sound in TIM 2015 is mono (not stereo).

The volume control also incorporates a **switch output**, which is inverted by transistor T5 to place the PAM8403 chip into very low power shutdown mode (consuming less than 1

µA) when the (switched) volume control is turned off. A separate part (IC3A) of the MC33072 op-amp provides an audio output for headphones, monitoring, etc. and has its own volume preset (R20).

A 128x64-pixel, ST7920-type LCD module (QC12864B) is used for the **graphic display screen**. It uses a 3-wire serial SPI interface to communicate with the microcontroller. Display brightness is controlled using a PWM output from the microcontroller to driver transistor T3.

The **user interface** is provided by a mechanical rotary encoder (with switch). When it is turned between each detent it sends a series of logic level pulses via the two wires (A and B). By analysing the phase of these pulse edges the microcontroller determines the turn direction.

Power for the whole clock is provided by the 3-amp regulator module **MOD1**. This module contains an MP1584 switching regulator chip running at around 1MHz for about 85% power efficiency with a 12V input. The high switching frequency should also reduce any EMI interference that might otherwise degrade reception of radio time signal signals.

Transistor T4 periodically provides power to a small **3.3V regulator** (IC1) under the control of the microcontroller. This 3.3V supply is needed for the Wi-Fi module (MOD2) or can alternatively be used by an externally connected GPS module.

The **Wi-Fi module** (**MOD2**) contains an ESP8266 processor that runs a program for handling the initial Wi-Fi configuration and then periodically requesting the time from network servers. This Wi-Fi module uses a significant amount of power when active (about 200mA) and although there is a low-power Sleep option, the module does not have the necessary Sleep pin connected to the header. This is resolved by using transistor T4 to completely cut the 3.3V power when the module is not being used.

Communication is handled by a serial 3.3V logic link to the microcontroller. The module is not 5V-tolerant, requiring resistors R17 and R18 to lower the microcontroller output 5V logic levels to prevent damage to the Wi-Fi chip. Optional 30-second and serial time data outputs are provided. These are buffered by general-purpose transistors T1 and T2. A separate external interface and power supply will be needed if you want to use these outputs for your own projects such as driving mechanical slave clocks or synchronising other devices.

Obsolescence warning — and reassurance

A crucial component used in TIM 2015 is the **MH 88422-3 integrated circuit** manufactured first by Mitel and subsequently by Zarlink. This handles the interface between an analogue telephone line and the electronics that play out the voice messages.

It was last made in the 1990s and supplies are now hard to find, particularly in one-off quantities. However, there is no equivalent product nor anything even vaguely comparable produced currently, which is why we were forced to employ it again in TIM 2015. We have secured supplies to make at least 70 speaking clocks but must warn do-it-yourself constructors to **ensure that you have one of these devices before starting work**. Supplies will not last forever.

Recycling

At the end of its serviceable life, **this product should not be treated as household or general waste**. It should instead be handed over to the applicable collection point for the recycling of electrical and electronic equipment, or returned to the supplier for disposal.

RoHS regulations conformity

Although the *Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2008* ('the RoHS Regulations') precludes the use of lead-based solder in newly made electrical products, Annexe C to the official RoHS Guidance Notes nevertheless permits "the use of lead-based solders to be used in IT and telecommunications network infrastructure equipment. This exemption does not cover end-terminating products such as PCs or telephones." TIM 2015 is intended for use as a network infrastructure element and users are hereby informed that small quantities of tin-lead solder are used in the product. For this reason it is recommended that TIM 2015 is not used where people unaware of the hazards of lead poisoning might gain access to it.

CE status

Several of the more specialist components used in TIM 2015 are Chinese Exports.

Operating code PIC chip — firmware versions

- **2.0 (August 2015)**. First 'ready for prime time' version.
- **2.1 (January 2016).** Firmware modified to allow up to 16 different voices.
- **2.2 (January 2016).** Method of saving call statistics improved.
- **2.3 (April 2016).** Revised to take account of difficulty in decoding the radio time signal transmitted by MSF. The MSF transmissions currently include data in the DUT1 field to indicate a small offset in the broadcast time in mS between UTC and UT1. One of TIM 2015's data error-checking routines incorrectly flagged the field as an error condition and rejected the data in that field when it was present (which is why the clock failed only intermittently). This particular error-correction routine has been removed, as it was causing problems (there is still plenty of other error-checking carried out).
- **2.4 (October 2016).** Option added to cope with time announcements given in 24-hour format. Most users will not require facility this immediately.
- **2.5 (April 2017).** Voice menu no longer mention Pat Simmons by name. This is to simplify reorganisation of the files in future. Most users will not require this upgrade immediately.

If you wish to upgrade the PIC microcontroller chip in TIM 2015 to the latest version, you can do this for a nominal charge. Please send it (wrapped in aluminium kitchen foil) to

David Thorpe (UE)

10 Redwood Avenue

DUDLEY

DY1 3TT

...together with a cheque for £5 made out to Unusual Electronics and a return label giving your name and address. Alternatively you can buy a fresh PIC programmed with the latest software for £20.

Section 9 Background information

About TIM 2015

Project history

TIM 2015 was conceived as an enhanced replacement for the original TIM 2000 speaking clock and the subsequent TIM 2004 device. Instigator and project manager was **Andrew Emmerson** of the Telecommunications Heritage Group (THG), with all design and prototyping work being carried out by **Dave Thorpe** of Unusual Electronics. **Paul Seward** of the THG played an important role in making and 'cleaning up' recordings for the project, whilst **Jayson Smith** and **Evan Stewart** kindly shared their recordings of U.S. time-of-day announcements with us. **Sam Hallas**, **Mick Champion**, **John Cossins**, **Mike Fletcher**, **John Novack** and **Dave Whistler** have each provided valuable technical feedback (apologies if I have left out anyone).

Design work began in November 2014 on a part-time basis and a working prototype was completed in early June 2015. It was then put on a continuous 'soak test' for several months, during which time no problems occurred. The opportunity was taken to 'fine-tune' some of the audio files. [*Soak Testing* is a type of performance test that verifies a system's stability and performance characteristics over an extended period of time.] *Quantity production* began in April 2016.

Project philosophy

TIM 2015 has been designed as a shareware or 'pro bono' production, with nobody taking a single penny of payment for the very many hours of time spent bringing it to reality. The design principles and circuit schematic have been put into the public domain and are freely available. The only 'protected' element is the encrypted code used in the microcontroller, for which a design royalty is included in the price of the programmed chip.

Timekeeping accuracy

The claim we make for TIM 2015 is that it is accurate to within a second but no more. In other words if you synchronise TIM 2015 to a source of GPS signal or to a radio time signal transmitter such as MSF, DCF77 or WWVB, it is of 'indicative' but not 'absolute' accuracy, making it adequate for all everyday purposes.

Users attest to the accuracy of TIM 2015. One customer says: "The new clock seems to agree very well with the GPS time received on my mobile phone, which makes me think it's accurate." Our own experience confirms this. The prototype was checked against satellite time nine months after it was first set up, during which time it had still not been resynchronised at all. It was two seconds behind the correct time of day. This accuracy says a lot about the stability of the RTC module used in TIM 2015. Two months later the prototype was compared against the BT speaking clock on a landline telephone; it was still spot-on.

Dave Thorpe, the designer of TIM 2015's circuitry, comments: "The RTC can be very accurate, it has temperature compensation and the 'ageing' setting can be used to fine-tune the accuracy and compensate for the crystal ageing."

Another person writes: "The time is indeed correct to the moment, too. I happened to call as the minute was changing and "the third stroke" happened at the same moment that the minute changed on my IP phone, which is synced to my internal NTP server."

About Unusual Electronics

This is the firm that carried out the design of TIM 2015. You can see other products offered by this ingenious and responsive company, at ***http://unusualelectronics.co.uk/*** . In particular 'techies' may well have a use for the Chronvertor; see *http://unusualelectronics.co.uk/products/chronvertor/* .

The Gallery (***http://unusualelectronics.co.uk/gallery/***) displays some of their customers' most ingenious constructions, including a nixie tube clock built inside an old Avo meter case.

Web links

- ***UK MSF Time service*** –The website for MSF time broadcast transmitter serving the British Isles.
- ***German DCF77 Time service*** – The website for the German time broadcast transmitter DCF77 that covers most of Europe.
- ***US NIST Radio Station*** – Explanation of the protocol used by the North American WWVB time broadcast.
- ***Telecommunications Heritage Group*** – The organisation that supported and kick-started the funding of the TIM 2015 project.
- ***Unusual Electronics Ltd*** – Responsible for the technical design of the TIM 2015 project.

Section 10 FAQ file

These are some of the questions that customers have asked — and the answers.

I am still unclear how TIM 2015 interfaces with a telephone line.

TIM 2015 has two methods of connecting to a telephone line. Firstly in can be plugged into a standard telephone line (or switchboard extension), using the telephone line cord supplied. This cord is fitted with a standard UK phone plug (we can provide a Western Electric RJ-11 type if desired). In this mode it works in exactly the same way as a normal telephone answering machine; it answers an incoming call, tripping the ringing, and then plays out the current time for 90 seconds. Then it disconnects and releases the line (clears down).

The other interface is a continuous output that appears on the AUX connector on the back of the unit. This can be fed through a 600-ohm transformer (not supplied by me) to a spare numbering level of a UAX or other telephone exchange. This might be useful for a museum exchange on which several callers might ring the speaking clock at the same time. The wiring would vary according to the user's special needs and the audio level might need to be boosted with an amplifier. Most users will use the first of these two modes though.

Would an RJ-11 jack be an option?

Yes, that will work fine if you don't wish to use the GX-16 2-pin chassis connector on the back of the case. It's a simple two-wire connection, not polarity-sensitive so you can connect the two wires either way round.

When you set the time and date, is what you are setting your local time or UTC?

Local time. You need to apply offsets **only if** you synchronise TIM 2015 to the Internet or GPS or WWVB **and** your local time zone differs from the time received from WWVB, GPS or the Internet.

Also just curious, what time is stored in the RTC module, local time or UTC?

It stores the local time that you set.

Can you have any number of time sources (radio, GPS, Wi-Fi) attached at once or just one?

Only one, since otherwise they would argue with one another.

Which method of time synchronisation (radio, GPS, Wi-Fi) do you recommend?

Each of them! They all have their advantages and disadvantages. Radio works well in most locations although in some countries there is no radio coverage at all (Australia for example). GPS tends not to work inside buildings but if you put your GPS module near a window, you may have no problems. One customer says GPS works reliably in his basement but it takes up to ten minutes to synchronise. W-Fi is pretty straightforward but delays in the Internet may mean the time received may be up to half a second late (but who is arguing over half a second?). Of course you can set up the time 'by ear' listening to the time signal pips at the top of the hour from an FM radio station and using the manual time setting option in TIM 2015.

I read in one of the manuals that the RTC module was originally set up to keep time through a power failure using a supercapacitor. Why is this not being used?

Because supercapacitors are seriously expensive and would increase the price of the device. Coin cells are a lot cheaper and last for five years or more. There is a holder on board for the coin cell.

I bought the Wi-Fi module, which is sitting in my toolbox, awaiting employment. I see it is not compatible with the GPS method – is it possible to use Wi-Fi and GPS together?

No. The Wi-Fi shares the same serial port with the GPS so they can't both be used together (the layout of the printed circuit board deliberately places the Wi-Fi module so that it physically covers the GPS socket. to prevent anyone trying to connect both.)

You can connect Wi-Fi and MSF and use the Menu function to select either one to use from the menu or else select **Auto**. In Auto mode TIM 2015 first tries using Wi-Fi; if this it doesn't work (no response or errors), it tries the next option (GPS) then MSF, DCF77, etc.

With both Wi-Fi and MSF connected, as it tries Wi-Fi first, it would use that if it gets a good connection. Subsequently, if it fails to get a sync, it would try the next time source option and possibly get an MSF sync.

I prefer to select the required time source in the menu, as the auto mode is not foolproof. It tries to identify a potential time signal signature by measuring pulses and checking data. If it gets too many errors, it then tries the next time-source and so on. [*Dave Thorpe*]

Does time synchronisation have to be constant or activated once a day?

Neither really but once a day is fine. Synchronising all the time would be overkill. The Real Time Clock (RTC) incorporated in TIM 2015 is very accurate and will maintain accuracy for a month or more without synchronisation. If you connect a radio time signal receiver to your TIM 2015, this will keep your clock synchronised several times an hour.

Section 11 Making connections

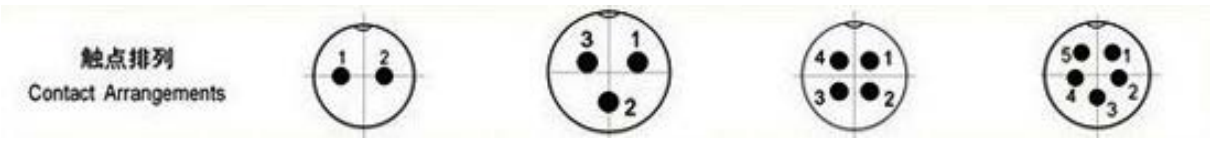
TIM 2015 is provided with cables for connecting the power supply and telephone line. Radio time signal receivers supplied by us also have the appropriate cable and connector attached. If you plan to make your own cables to connect to TIM 2015 the following notes should be of help.

The connectors used are the **GX16 series**, a type used widely in the aviation industry and on amateur and CB radio equipment. These connectors are not expensive, extremely robust and the locking ring eliminates any possibility of accidental disconnection. They are readily available from electronics suppliers such as Maplin and on eBay. **Be careful not to order the GX12 series**, which look very similar but have a smaller format and cannot be mated with GX16 connectors.

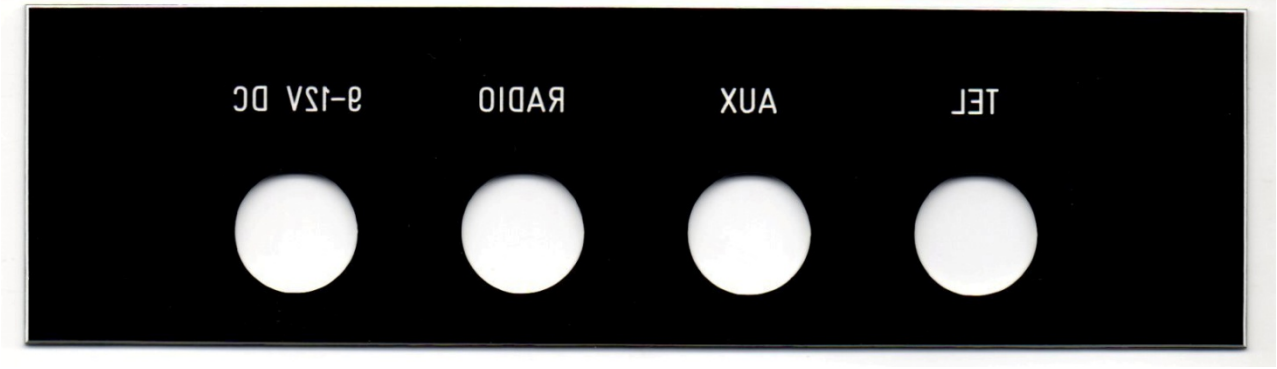
A selection of GX16 connectors. Illustration courtesy of tech999 on eBay.

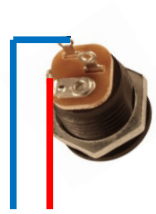
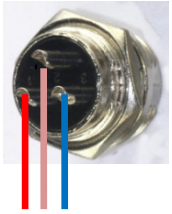
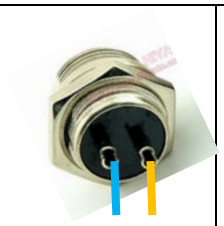
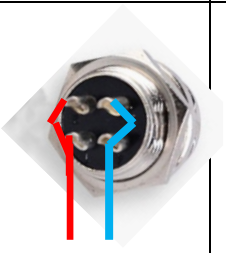
For maximum reliability on TIM 2015 we use locking connectors: GX16-2 for the telephone line, the GX16-3 for the radio time signal or GPS receiver, the GX16-4 for the 9 to 12V DC power supply (on some models) and the GX16-5 or GX16-6 as an auxiliary connector for optional audio and/or serial or pulse outputs.

The pin-out connections are shown below; these are rear views of each connector, looking at the solder pins. Note that the chassis connector is technically a plug (male) and the free or wire-ended connector is a socket (female).



The following chart shows the connectors on the rear panel of TIM 2015, as seen when looking from inside the case. Note that two patterns of power connector can be used, GX16-4 or ROKA.



					
	RED 9 to 12V in. BLUE Ground. No connection to the small pin.	RED +5V (pin 1). PINK Ground (pin 2). BLUE Signal (pin 3).	You can use this connector for any purpose, in any way and using any colours that you wish.	L1 and L2 (or La and Lb) telephone wires. It does not matter which wire goes to which terminal, nor the colours used.	
					
	RED 9 to 12V in (looped to pins 1 and 2). BLUE Ground (looped to pins 3 and 4).				

For the female cable connectors that connect into the male chassis connectors on the rear panel it is a very good idea to use rubber sleeves to grip the cable firmly (to avoid pulling the cable out and breaking the soldered joints) and to avoid chafing the cable where it enters the shell of the connector. For our ready-built units we use Helsyn rubber sleeves (search eBay for **Hellerman sleeve**): types **H30x25 (**narrow) and **H50x25** (wide). The latter size in black is also useful for preventing (or disguising!) any fraying of fabric line and handset cords on older telephones.

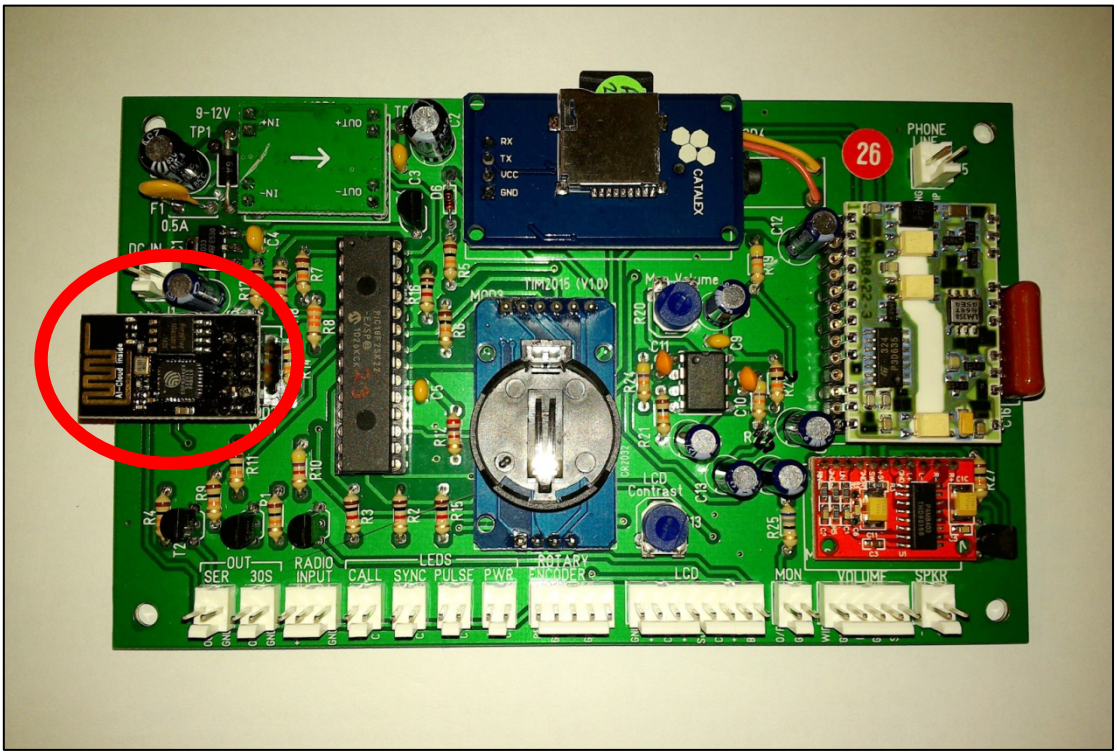
The yellow Helsyn sleeve prevents chafing and slippage of the thin cable here.

Section 12	Using Wi-Fi to synchronise TIM 2015

This document is in several parts. If you definitely plan to use a ready-programmed module (the easy way) please read the first two pages and then go to Sub-section 7. Otherwise read the entire Section 12 and then decide how you wish to proceed.

Installing the Wi-Fi module

To do this you must remove the lid of the case of TIM2015. Use the photograph below to locate where the module plugs in (turn off the power to TIM 2015 first!).



TIM2015 printed circuit board with the Wi-Fi module circled in red.

The Wi-Fi module plugs into an 8-pin socket. Note that the module is fitted with the eight pins to the right and the printed serpentine (wiggly) antenna to the left. Make sure the module is pushed firmly home.

After that, screw the lid of the case back in place.

The Wi-Fi module is a plug-in option for the TIM2015 Speaking Clock that enables the clock to obtain the time and date from a Google server.

- Assuming that Google keeps its servers properly synchronised, the time can be set to within about +/- 1 second. You may well enjoy even greater accuracy. Customers John Novack reports: "Once I had configured the Wi-Fi module for my LAN, it synced the clock in TIM 2015 within 2 to 3 seconds. Quicker than the GPS receiver but I feel both are going to be accurate for normal needs. My unit matches my 'atomic watch' to the second, which syncs to the WWVB atomic clock every night."
- Nearby Google servers can be accessed via DNS, making it easier to get a reliable response without the need to specify server names or IP addresses.

This module can either be purchased pre-programmed for £10 plus postage from ***http://unusualelectronics.co.uk/contact/*** or you can buy a module elsewhere and follow the instructions below to program your own module.

>>> Go straight to the setup instructions (Sub-section 7) now if you have purchased a pre-programmed module.

Part 1, written by Dave Thorpe, designer of TIM 2015

Sub-section 1. The Wi-Fi module

The module used in TIM2015 is an ESP8266-01 made by Espressif Systems.

This **ESP-01** is the first and most popular version of the board. It has a printed antenna and an 8-pin header block to allow it to easily be plugged-in to the main board. The module is readily and cheaply available from many Chinese eBay vendors and various websites. It should work fine in the USA as well as in Europe. It is not FCC certified/approved, however.

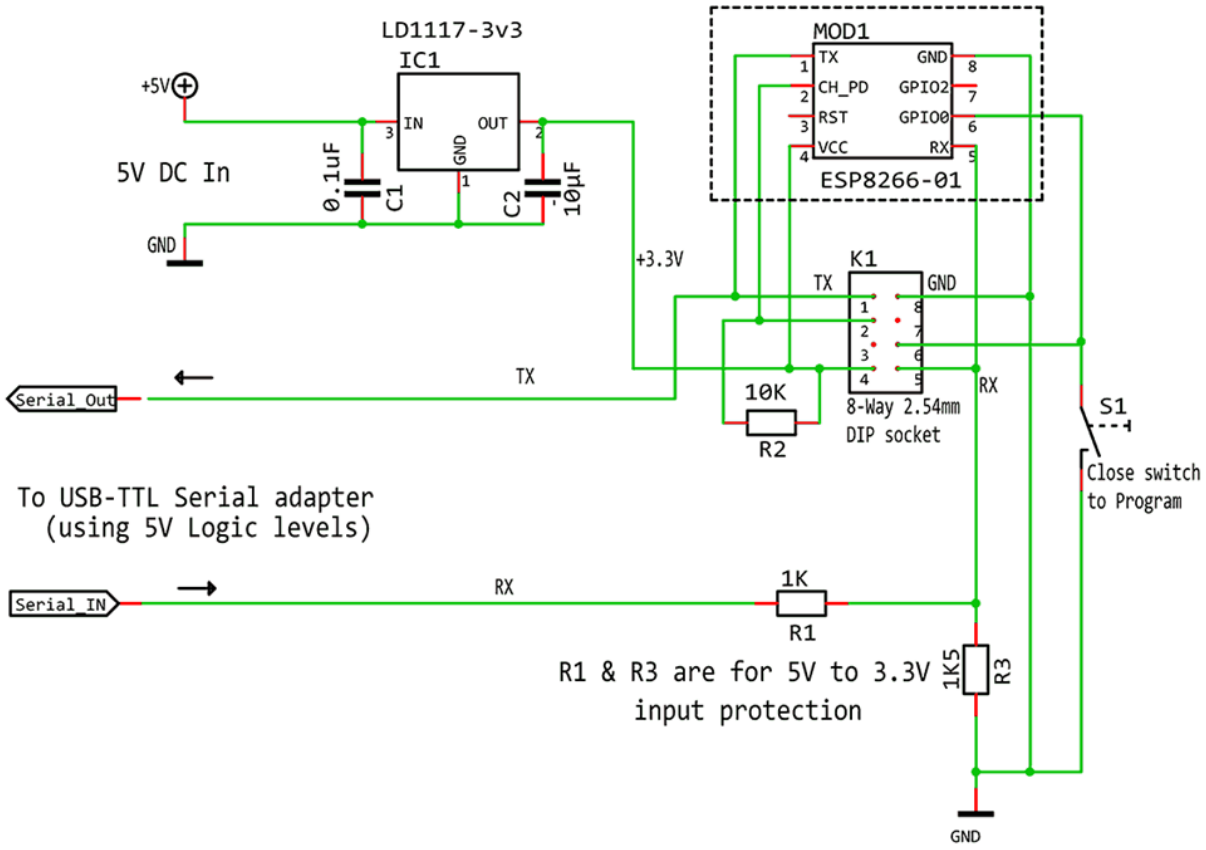
The factory-supplied firmware uses a serial AT command set for basic functions. We need to use different firmware to enable time sync functionality using the **NodeLUA** programming language.

The factory firmware can be replaced and the required program scripts loaded by following the instructions below.

Sub-section 2. Connecting a serial interface and power.

The module requires a 3.3 volt power regulator and a USB to serial interface for PC connectivity.

It is NOT 5 volt-tolerant and will be damaged if 5V power or logic is applied directly.



- IC1 provides the required 3.3V supply.
- The module plugs into an 8-way (2x4 pin) header socket.
- Ensure that it is inserted the correct way round, otherwise the module will be damaged.
- Resistors R1 and R3 reduce the logic input voltage from a USB-to-5V logic serial adapter to prevent damage to the module. (These resistors could be omitted if a USB-to-3.3V logic adapter is being used).
- Switch S1 is closed to enable the module to accept firmware updates.

The required USB to TTL logic serial adapter may look something like the photo below.

There are many types available from eBay and elsewhere. This one has an option to switch between 5V and 3.3V logic. Another common type looks like this:

This one uses 3.3V logic voltages. Check your serial adapter TXD voltages with a meter to be certain before connecting it to the circuit.

Sub-section 3. Download the required files.

The complete set of files including the firmware and time scripts can be downloaded from:
http://unusualelectronics.co.uk/sp91wqmbc78a/WiFimodule.zip

Alternatively the latest firmware is available from:
https://github.com/nodemcu/nodemcu-firmware/releases

(Select the **Integer** .BIN file e.g. **nodemcu_integer_0.9.6-dev_20150704.bin**)

The tool to flash the NodeMCU firmware is the **nodemcu-flasher**. It's an open source program from github. Go to the nodemcu-flasher page and choose the Win32 or Win64 release (depending on your Windows type). Click on **ESP8266Flasher.exe** and then right click and select **Save Link As...** to download it to your PC.

Or use these direct links below:

https://github.com/nodemcu/nodemcu-flasher/blob/master/Win32/Release/ESP8266Flasher.exe?raw=true

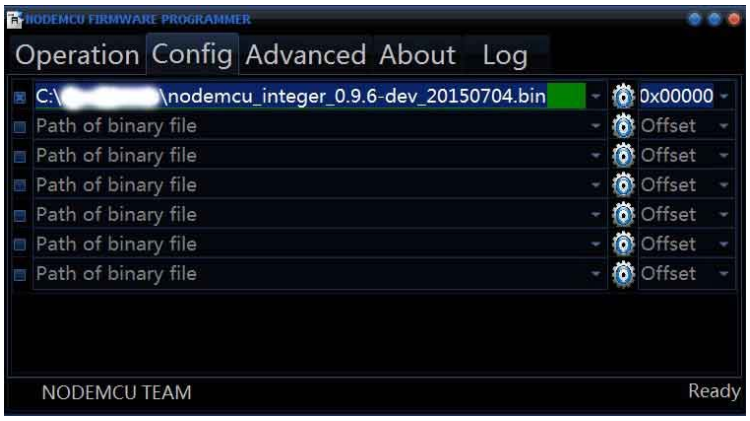
https://github.com/nodemcu/nodemcu-flasher/blob/master/Win64/Release/ESP8266Flasher.exe?raw=true

Sub-section 4. Flash the firmware.

- Plug in your USB to serial adapter (most serial adapters are automatically recognised by Windows 7 onwards (otherwise install the driver for your adapter).
- Connect it to your ESP8266 adapter board.
- Close switch **S1** (firmware program enable) and then turn on the power (the Wi-Fi module's red power LED should light). If the switch is closed *after* power-on the module doesn't re-read it. Note that same versions of this Wi-Fi module are not fitted with the red Power On LED.
- Run **ESP8266flasher.exe**

- If there is only one com port available, it will be selected automatically. Otherwise choose the **com** port for your USB serial adapter.

- Now click the **Config** tab.



- Click the gear wheel icon to the right of the first (internal) file path and select the path to your **nodemcu firmware .bin** file (similar to that shown in the photo).

- Click the **Operation** tab to return to the first screen, then click the **Flash (F)** button. The AP and STA MAC address should then appear together with a progress bar and QR code icon. Also, the blue LED on the Wi-Fi module should flash to indicate data transfer.

- When finished, a green 'tick' will be shown and the status will show **Ready!!br0ken!!**

- Close the program and power-off the module.

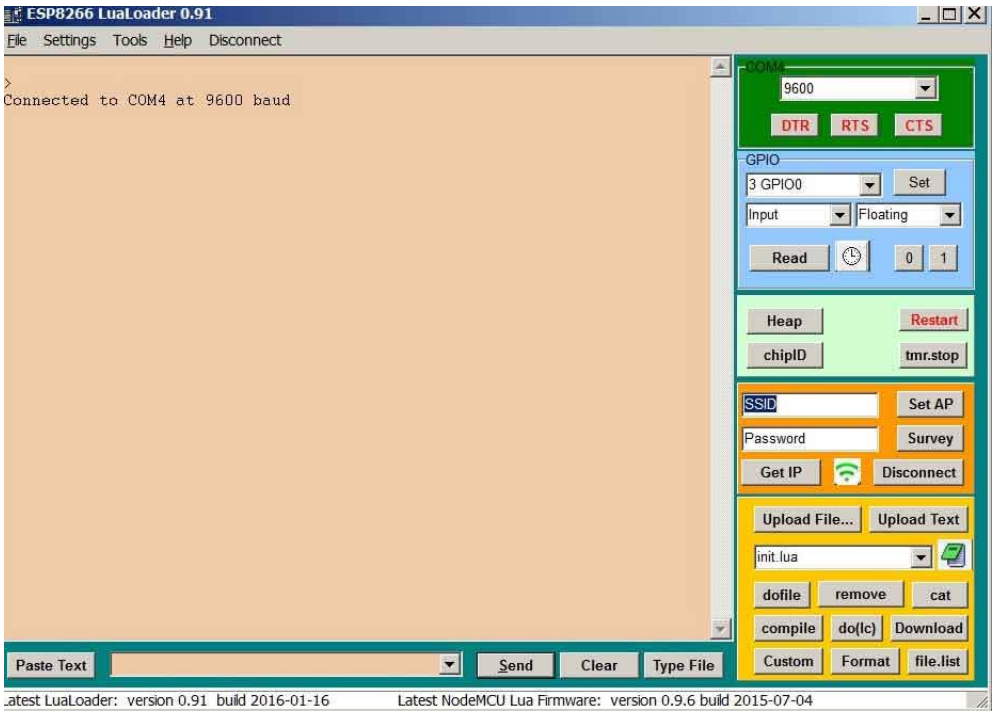
Sub-section 5. Load the LUA scripts.

The LUA scripts can be uploaded to the module using a utility called **LuaLoader.exe**
This file is included in the pack or you can download it direct from the author's website:
http://benlo.com/esp8266/index.html#LuaLoader

- Open switch **S1** (normal mode).

- Then turn on the power to the module. Note that **S1** is not read by the module except at power-on.

- Run the file **LuaLoader.exe**



- If it doesn't connect, click on **Settings**, choose your **com** port and click **Connec**t.

- Click **Upload File** and select the file: **Init.lua**
- A series of **>** arrows will indicate progress (ignore any error messages during the upload)

- Repeat for file: **Task.lua**
- Repeat for file: **configServerInit.lua**
- Repeat for file: **configServer.lua**

- Now click the **file.list** button, which should list all the four files uploaded.

- If everything was loaded correctly then click the **Restart** button to restart the module.

Sub-section 6. Initial power-on after loading the scripts.

At power-on or restart the module initially sends a line of random characters. Then it will change its baud rate and show the current firmware version e.g.:

NodeMCU 0.9.6 build 20150704 powered by Lua 5.1.4

Finally it should show the current status while it acts as a web server for the initial network configuration:

$Stat,0,Idle,* (repeated for up to 45 seconds while the module attempts to connect)

$Stat,6,Starting an AP..,* (this indicates it is starting an Access Point)

$Stat,7,TimeSync-08:a6,* (this is the Access Point name being advertised on the network) (the last five characters are the last two bytes your module's MAC address).

At this stage you can use a smartphone, tablet or PC to browse the list of Wi-Fi networks and you should see the above Access Point name listed.

If all is OK you can plug the module into the clock, select Wi-Fi time source and follow the instructions below.

Other possible status messages include:

$Stat,1,Connecting,* (Connecting to the local network)
$Stat,2,Wrong password,* (The stored network password is incorrect)
$Stat,3,No AP found,* (Can't find the specified Access Point (wrong SSID))
$Stat,4,Connect fail,* (Failed to connect to the local network)
$Stat,5,Got IP,* (Successfully connected and obtained an IP address)
$Stat,8,GET received,* (The config web server received a page get request)
$Stat,9,GET favicon request,* (Config web server received a request to send a favicon)
$Stat,A,POST received,* (Config web server POST data received (from user config))
$Stat,B,SSID: xxxxxx,* (Echoes the SSID entered by the user during setup)
$Stat,C,Password: xxxxxxx,* (Echoes the password entered by the user during setup)
$Stat,D,Rebooting,* (Rebooting after completing the SSID/password config setup)

After a successful time sync, the module sends the following string to the clock:

$Time,hms,dmy,* (hour minute second, day month year)

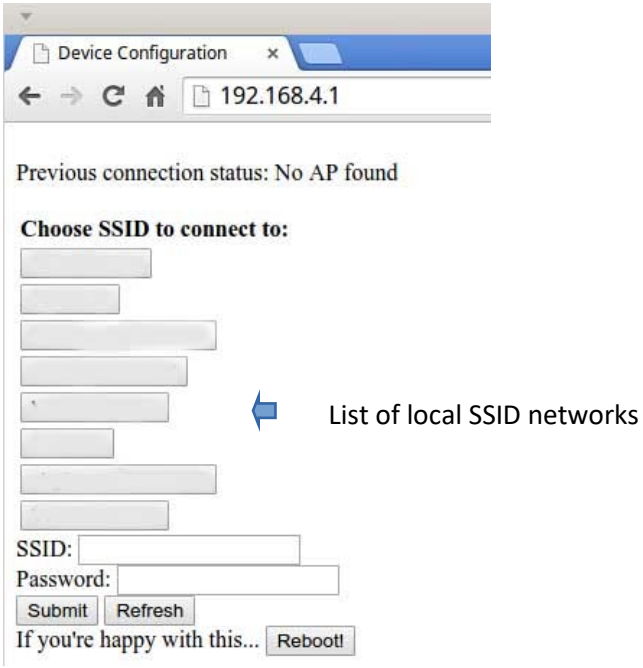
The time is always sent as UTC (GMT)

Sub-section 7. Wi-Fi module setup (SSID name and password)

- Enable (i.e. activate) the Wi-Fi module by selecting it in the **Time Source** menu. The LCD screen on top of the case will invite you to **_Set Time Source_**. Turn the left-hand control knob clockwise until you reach the setting **WiFi Network**. Press the knob in to save this setting.
- The clock will immediately attempt to get the network time from a server.
- If the module has not been configured previously or is unable to connect to your network for any reason, after a time-out the following screen will be displayed:

```
* No Wi-Fi Connection*
Use a mobile device,
Connect to network:
TimeSync-xx:yy
Use a web browser and address:
192.168.4.1
Then enter your SSID
and Network password.
```

- In this display you can see that the module identifies itself as **TimeSync-xx:yy.** In reality the screen shows the last five bytes of the Wi-Fi module's MAC address rather than xx:yy. This feature is provided just in case you have more than one of these speaking clock Wi-Fi modules, because each as to have its own unique name on the local network. You need to know the name of the Wi-Fi module you are trying to configure. Mostly you will not need to worry about this if you have only one speaking clock.
- Use a laptop, tablet or smartphone. Browse the list of available Wi-Fi access points.
- Connect to the access point **TimeSync-xx:yy** (where xx:yy are the last five bytes of the Wi-Fi module MAC address.



- When connected, open a web browser and enter the address **http://192.168.4.1**
- A configuration web page should now be seen on your web browser:
- The clock should also show a screen saying:

```
Web browser connected
Select your network
And type the password
```

- Choose your Wi-Fi network from the list shown (or enter the name in the SSID box).
- Enter your network password (case sensitive) then click on **SUBMIT**, followed by **REBOOT**.
- The module will then reboot, attempt to connect to your network and get the time (after rebooting the module will no-longer provide an access point or web page and you should re-connect your mobile device back to its usual network).
- The blue data LED should flash briefly whilst requesting the network time and the yellow LED should light when successfully synced.

- The Wi-Fi module will then power-off and wait until a random time between midnight and 7am to get the next time sync.

- The module will store your network SSID and password internally. If you change your password or network name you will need to repeat the above configuration process to store the new details.

Part 2, written by Mick Champion, who offers this alternative commentary

Deciding whether to use Wi-Fi to synchronise TIM2015

At the time of writing, using a Wi-Fi module is marginally the **least** accurate method available to sync your TIM2015 but don't let this put you off! Please read on. The Wi-Fi module is activated only once a day, and whilst the time might be accurate when the remote web server sends its data, there will inevitably be a trifling delay before the data is received. In my own unscientific tests from here in London, the delay has been **no more than a third of a second**, but the developer states +/- 1 second. The best way to sync is to use a radio receiver (MSF, DCF77, WWVB, etc.). In a good reception area you will receive an update every minute. Unfortunately not everybody lives in a good reception area. GPS is the next best. Just like Wi-Fi, GPS synchronisation only takes place once a day, but the time received is accurate (mostly).

So you still want or need Wi-Fi synchronisation?

For everyone else Wi-Fi is the most viable choice. The easiest way of using Wi-Fi is to purchase a pre-programmed module directly from the developer. The price stated at the end of December 2016 was £10 excluding postage. To order a pre-programmed Wi-Fi module for TIM2015, contact: ***http://unusualelectronics.co.uk/contact*** and ask for a price quote. Make sure you state you require a Wi-Fi module programmed specifically for TIM2015.

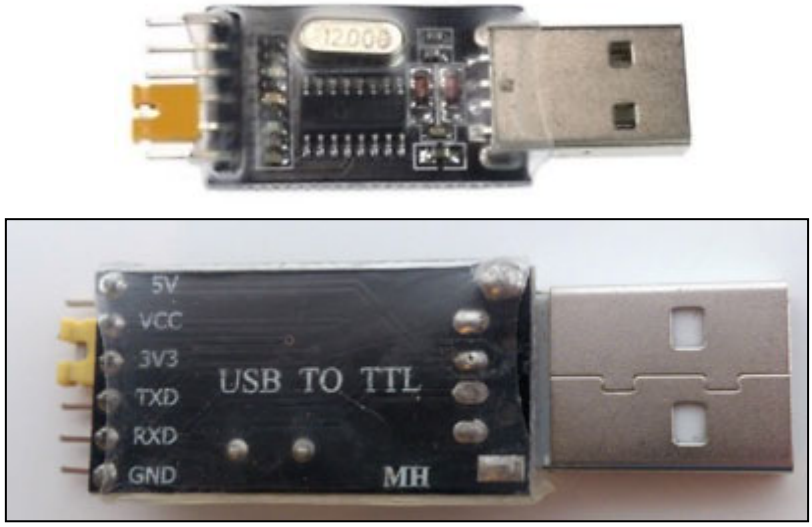
Important: An ESP 8266-01 purchased from other suppliers will not work out of the box. The module needs to be flashed with 'Lua' firmware and four custom files added.

Can I program the device myself?

Yes, if you have the required skill level (bodge level in my case), as the developer has kindly agreed to provide the required custom files to those that have already purchased a TIM2015. You will need extra parts, though, as the device will need to be flashed. Without these parts, it may be cheaper to purchase a pre-programmed module.

What do I need to program the Wi-Fi module myself?

The first thing you will need is a PC and a 3.3 volt TTL serial adaptor. The Wi-Fi module will likely sustain damage at higher voltages than 3.3V, so forget trying the RS-232 serial port, as it uses a much higher voltage range. Plus its Rx /Tx signals oppose that of TTL serial in any case. RS-232 to serial TTL adapters are available, but I purchased a cheap 'USB to TTL Adapter CH340G' from eBay at the huge expense of £1.99.



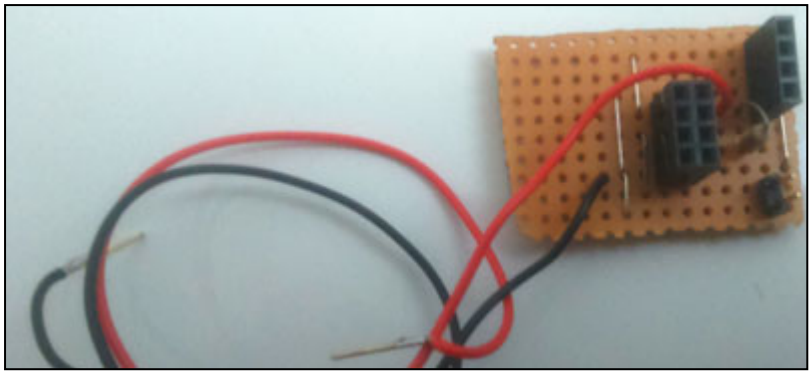
The above came shipped with V_{cc} linked to 3.3V, which is just right. If yours is set with V_{cc} connected to 5V, change it or you'll be 'frying tonight!' The TTL adapter didn't come with any drivers, and Doze 7 couldn't find any either. You could be lucky and your PC may well find and automatically install the drivers , but in my case after searching, I found:

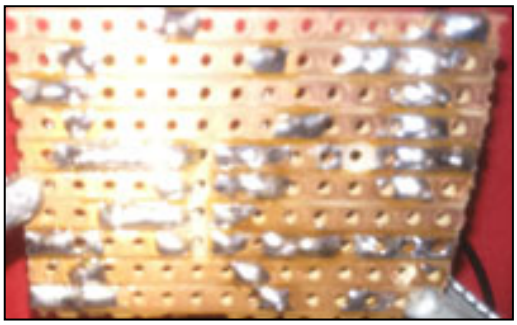
http://www.arduined.eu/ch340g-converter-windows-7-driver-download/

The zip file is for a CH341, but it installed without complaint and worked. I'm a bit allergic to .EXE files so I ignored **install.exe**. All I did was decompress the Zip file, go to the PC device manager, and attempt (successfully) to manually install the drivers by browsing to the CH341 Decompressed folder. It was obvious which devices needed the driver as they only popped up with yellow exclamation marks after plugging in the TTL adapter.

The second thing you'll need to do is create a means to connect the TTL adapter to the ESP8266-01 module and to provide the module with 3.3V. I constructed a temporary bridge but you may have an easier method in mind. Just for reference, here's a rough guide:

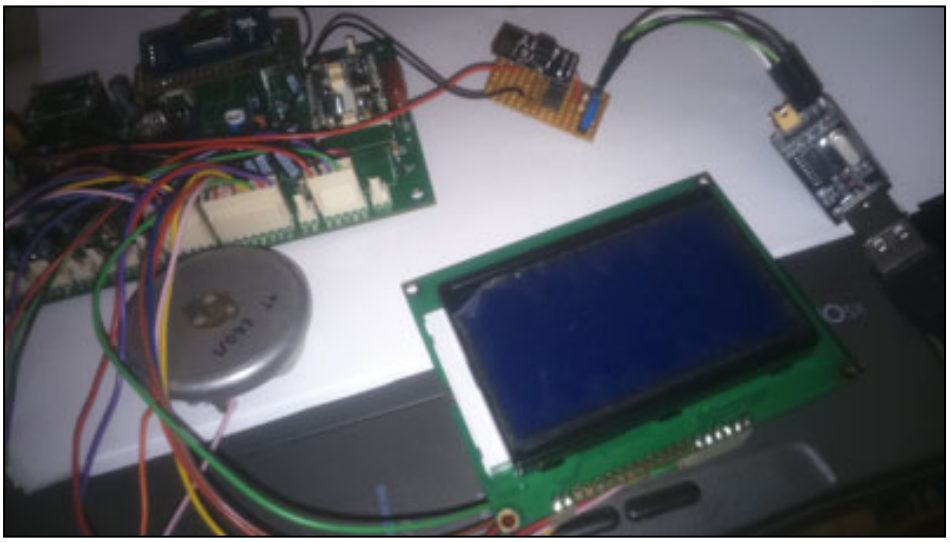
- I used a bit of left over strip board and mounted an 8-way socket (same type as the module plugs into inside the TIM2015). Due to the socket pins being 4 by 4 left to right and up to down, I had to cut away four of the copper tracks where these pins needed to be. So I soldered the four that had copper tracks into place, then bent the 4 remaining pins with no copper tracks onto its neighbouring track and bodge-soldered them.
- Due to having a few single 'pin-to-socket' leads in my drawer and a spare 4-way SIL socket, I also mounted a 4-way SIL connector and linked the connexions to Rx, Tx and ground on the 8-way module socket (Pins 5, 1 and 8).
- Soldered a 10k resistor between pins 4 and 2 of the module socket.
- Added two pin ended fly-leads to power the module (Pin4 V_{cc}, Pin 8 ground).
- Added a two way pin SIL link between pin 6 of the module socket and ground (link for programming mode, remove link for service mode and to add the four custom files).





Note that just like in TIM 2015, the module socket in the photo is upside down. Pin 1 is bottom right and number increases sequentially in an anti-clockwise way until we reach Pin 8 on the bottom left hand corner. The red wire in the photo above goes to Pin 4.

- Then I used three pin-to-socket leads to connect to the pins on the TTL adapter to the 4-way socket on my bodge board. GND to GND, Tx to Rx and Rx to Tx and inserted the Wi-Fi module.



All that remains is to connect up the ESP8266-01 to a 3.3V power supply, plug the USB TTL serial adaptor and get programming!

This guide is not intended as a step-by-step 'how to' instructional, but you should get enough from this to decide whether you have the tools to give it a try.

Part 3, Deeply technical stuff

The Network Time Protocol project

This link may be of help or interest to some users: ***http://ntp.org***
Further information at ***https://www.eecis.udel.edu/~mills/ntp.html***

Credits and revision notes for this section

Version 1.5, with John Nice's amendment regarding pressing the SUBMIT button and additional material by Mick Champion. Added link to Network Time Protocol project. New corrections submitted by John Novack.MAC address explained in greater clarity.

Section 13	Using radio time signals to synchronise TIM 2015

When using a radio time signal receiver to synchronise TIM 2015 to the exact time please remember that local interference can easily swamp or desensitise the radio receiver, rendering it unable to pick up the transmissions from the time signal transmitter. Sources of interference include computers, electronically-controlled soldering irons and some switchmode ('wall wart') plug-in power supplies. Occasionally radio time signal transmitters are off the air for maintenance purposes but if TIM 2015 refuses to synchronise and the yellow light fails to come on, suspect local interference before other causes.

How radio time signal receivers work

Courtesy of the ***WWVB website*** . Much of this information is applicable also to other radio time signal transmitters, such as DCF77 and MSF.

Some manufacturers refer to their radio-controlled clocks as 'atomic clocks', which isn't really true. An atomic clock has an atomic oscillator inside (such as a caesium or rubidium oscillator). A radio-controlled clock has a radio inside, which receives a signal that comes from a place where an atomic clock is located.

In the United States, the signals received by radio-controlled clocks originate from ***NIST Radio Station WWVB***, which is located near Fort Collins, Colorado. WWVB broadcasts on a frequency of 60 kHz. Your radio-controlled clock actually has a miniature radio receiver inside, which is permanently tuned to receive the 60 kHz signal.

The 60 kHz signal is located in a part of the radio spectrum called LF, which stands for low frequency. This is an appropriate name, because the FM radio and TV broadcasts that we are accustomed to listening to use frequencies thousands of times higher.

At 60 kHz, there isn't enough room on the signal (bandwidth) to carry a voice or any type of audio information. Instead, all that is sent is a code, which consists of a series of binary digits, or bits, which have only two possible values (0 or 1). These bits are generated at WWVB by raising and lowering the power of the signal. They are sent at a very slow rate of 1 bit per second, and it takes a full minute to send a complete time signal, or a message that tells the clock the current date and time. When you turn a radio-controlled clock on, it will probably miss the first time signal, so it usually takes more than one minute to set itself (sometimes 5 minutes or longer) depending on the signal quality and the receiver design.

Once your radio-controlled clock has decoded the signal from WWVB, it will synchronize its own clock to the message received by radio. Before it does so, it applies a time zone correction, based on the time zone setting that you supplied. The time broadcast by WWVB is Coordinated Universal Time (UTC), or the time kept at the Prime Meridian that passes through Greenwich, England. Whilst a few users like their clocks to display UTC (ham radio operators, for example), most prefer to display local time. This means that the time in your area is corrected by the number of hours. *You can apply corrections with TIM*

2015. See elsewhere in this manual.

Once your radio-controlled clock has synchronized, it won't decode the signal from WWVB again for a while. Most clocks only decode the signal once per day, but some do it more often (for example, every 6 hours). Those that decode the signal just once per day usually do it at midnight or in the very early hours of the morning, because the signal is easiest to receive when it is dark at both WWVB and at the site where the clock is located. In between synchronizations, the clocks keep time using their quartz crystal oscillators. Therefore, you shouldn't notice any error when you look at your clock display, since it will appear to be on the right second, even though it has probably gained or lost a fraction of a second since the last synchronization.

The interference problem

The reception of the long wave radio signal is easily disturbed by interference sources, however. These include atmospheric disturbances and electro-mechanical sources near the antenna of the receiver such as motors, computers, monitor screens, power tools, relay racks, switchmode power supplies and so on. The antenna should therefore be positioned with care.

If your clock shows the wrong time

Here are a few general tips about what to do if your radio-controlled clock isn't displaying the correct time.

My clock doesn't synchronize at all

Most WWVB radio-controlled clocks work great, as evidenced by the hundreds of thousands of units that have been sold throughout the United States. However, if your radio clock or receiver isn't working, we suggest:

- The antennas are directional and you might be able to improve the signal strength by turning the antenna and/or making sure that the ferrite rod is vertical, not horizontal.
- Place the clock along a wall or near a window that faces Fort Collins, Colorado.
- Locate the clock at least 1 or 2 metres away from any computer monitors, which can cause interference (some monitors have a scan frequency at or near the WWVB carrier frequency of 60 kHz).
- If nothing else works, power it down (unplug it), then power it up again to force it to look for the WWVB signal. If it works outdoors but not indoors, you probably have a local interference problem inside your house or building. If it doesn't work outdoors at night, it's probably best to return it and try a different model.
- The shielding provided by a metal building might prevent the clock from working. For example, if you live in a mobile home or a house with steel siding, the clock might not work.
- If you think your clock is defective, ask the manufacturer or dealer about obtaining a replacement.

My clock is off by one or more hours

Remember, minutes and seconds are the same in all time zones within the WWVB coverage area; only hours are different. If your TIM 2015 is off (out) by one or more hours, it probably has to do with a time zone setting. Make sure you have properly selected your time zone using the instructions provided in this manual.

If you live in an area that does not observe Daylight Saving Time (Arizona, Hawaii, parts of Indiana), make sure that DST is disabled on your radio-controlled clock. Not all clocks have this feature, so you might have to select another time zone to make your clock display the correct time when DST is in effect.

My clock is off by a few minutes or seconds

This can be due to a number of different problems as listed below:

Reception problem If your clock isn't currently receiving the signal, the time will 'drift' and gradually get further and further from the correct time. Remember, if the signal isn't being received, your clock isn't radio-controlled any longer, it's just a regular RTC clock. Its accuracy will depend on the quality of the quartz crystal. TIM 2015 can keep time to within one or two seconds per day or better, unlike other clocks that will be off by several seconds per day.

The yellow LED on the front panel of TIM 2015 indicates whether the signal is being received properly. If you are not sure if the signal is being received, try powering down the clock (unplug it), then turn it on again to see if it can synchronize. If it doesn't, see the tips above for improving your reception.

Checking your clock There is no need to check a properly working radio-controlled clock; it should always display the correct time. However, you might want to check it if you suspect you have a problem. If you use WWVB to synchronise your TIM 2015, you can check your clock by using the **NIST web clock**, or by listening to **NIST Radio Station WWV** using a shortwave radio or telephone (dial 303-499-7111 in the USA).

If the radio time signal receiver appears not to work...

...please read these notes. The problem is easily resolved in most cases. We provide notes for the three most widely used transmitters but many of the general points in each subsection apply equally to the other transmitters.

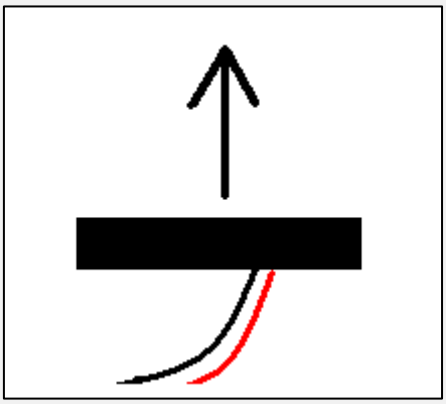
Improving reception

The following suggestions, in order of increasing difficulty, may help to improve reception of the radio time signal:

- It can take up to five minutes for the clock to 'acquire' (pick up) the radio signal, so be patient.
- Try rotating the plastic box containing the radio receiver module. Most radio-controlled clocks have an internal antenna that picks up the signal most effectively when it is facing directly towards or away from the transmitter. Some clocks (not TIM 2015) have a signal strength indication that helps in finding the best reception.
- If this does not change anything, try moving your clock to a different location a few feet away horizontally or vertically. This is why TIM 2015 radio modules come with a long connecting cable. Objects such as televisions, electric motors and fluorescent lights can interfere with the signal. A steel-framed or reinforced concrete building, or large metal objects such as metallic window frames, will reduce the signal inside. Externally, pylons, scaffolding or overhead power cables

can also screen the signal.

- Don't point the long axis of the ferrite rod (bar) antenna at the transmitter — a ferrite bar antenna has a null (no reception) along the long axis, so you should get very poor reception that way.
- If you suspect you are suffering interference from other sources, pointing the null (long axis) directly at the source of interference may give the best reception, because the reduction in noise improves the signal-to-noise ratio. That may still work even though the strength of the wanted signal is also (somewhat) reduced as well. Sometimes achieving a large reduction in noise is more important than a small reduction in the signal.



The plastic box containing the receiver module and ferrite rod antenna should always be positioned broadside on towards the transmitter. For example, if the transmitter is due north of you, the antenna should align east-west. Put another way, the longer side of the box should be at right angles (90 degrees) to the direction of the transmitter.

MSF (note that the transmitter was moved from Rugby to Anthorn in 2007)

The official MSF website (***http://www.npl.co.uk/science-technology/time-frequency/products-and-services/time/common-clock-problems***) states (among other things):

- The MSF signal transmitted from Anthorn (in Cumbria) provides a signal strength in excess of 100 microvolts per metre at a distance of 1,000 km. This level should be sufficient to allow the time and date code to be received without difficulty, and in all areas of the UK radio-controlled clocks have been found to synchronise correctly to the signal.
- Difficulties receiving the MSF signal are generally due to a combination of factors. These include **attenuation of the signal** due to location of the antenna inside a building or close to power lines or other large metal structures, **and background interference**, which may be from a local source such as an electric motor, fluorescent tube, or CRT monitor or TV, or more pervasive in the environment.
- If you have reception problems, first check whether the signal has been turned off for maintenance at the ***MSF Outages*** page or by calling the NPL MSF recorded message (020 8943 6493).

Some interesting 'inside information' about MSF can be found at ***http://www.creative-science.org.uk/MSF1.html*** *. More ideas, including highly directional antennas and a preamplifier for MSF that you can build, at* ***http://www.creative-science.org.uk/MSF.html***

DCF77

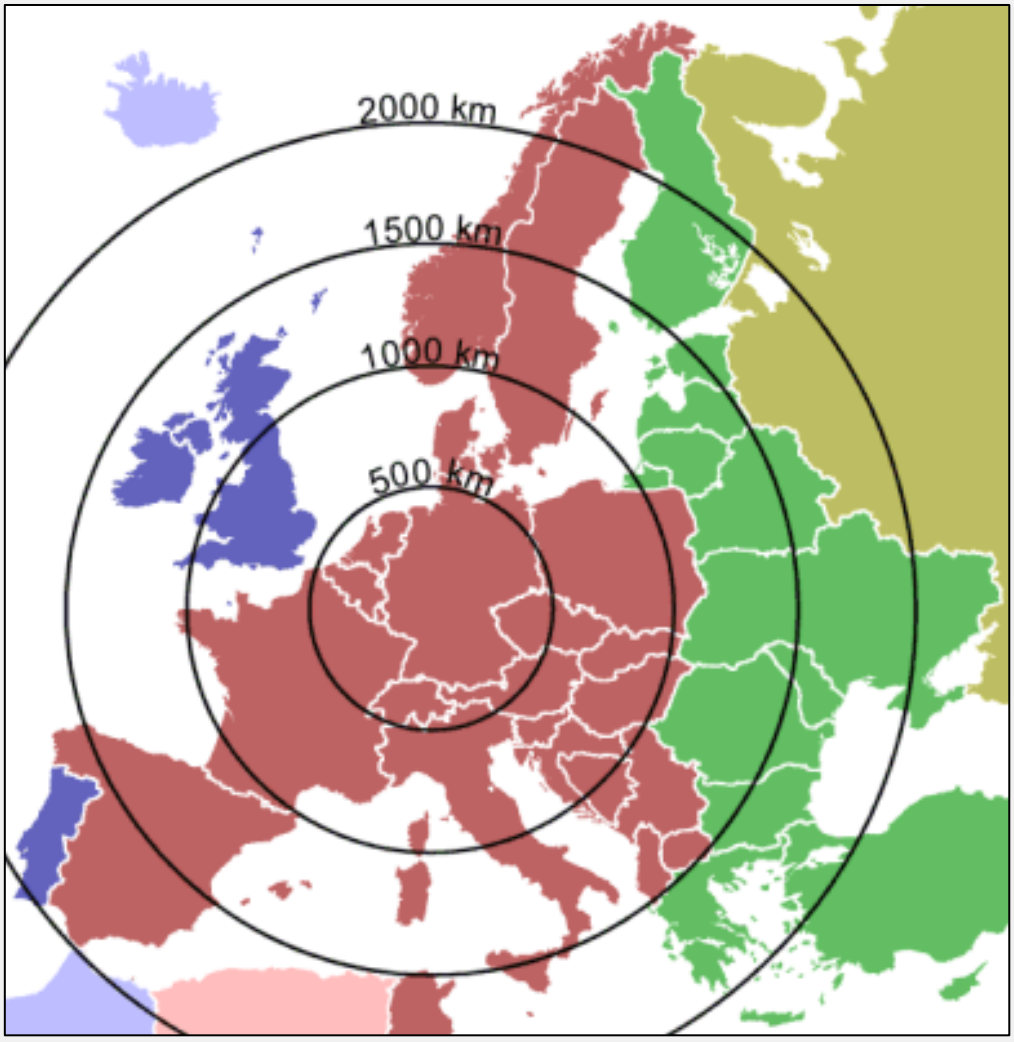
The DCF77 signal transmits the time in local time, which means UTC+1 hour (UTC+2 hours when Daylight Saving Time is in effect; since 1996, Daylight Saving Time is harmonized in Europe). The coloured bands in the map at the right indicate the various time zones in Europe. Great Britain is at UTC-time, Germany and central Europe are at UTC +1 hour (ignoring Daylight Saving Time).

The ***Meinberg radio clocks*** web page states:

The signal from ***DCF77*** can be received in Germany and wide parts of Europe. The most distant locations where Meinberg DCF receivers are operating are southern Spain and Lillehammer (Norway). Often the distance to the transmitter is not the main problem. Metal structures or other electronic parts are often the source of reception problems, even if the antenna location is not so far away from the DCF77 transmitter.

A good example is Rome, where customers told us that the DCF77 signal can be received, but in the inner city there is a lot of interference, making it nearly impossible to receive a sufficient signal.

[*This information, written for Meinberg customers, applies equally to TIM 2015*]



This map indicates the range of the DCF77 transmitter in Germany and time zones. The colours are Blue (UTC-time), Brick Red (UTC +1 hour) and Green (UTC +2 hours).

WWVB

General notes on accuracy (from *Wikipedia*)

Normal low cost consumer grade [radio time signal] receivers solely rely on the amplitude-modulated time signals and use narrow band receivers (with 10Hz bandwidth) with small ferrite ***loopstick antennas*** and circuits with non-optimal digital signal processing delay and can therefore only be expected to determine the beginning of a second with a practical accuracy uncertainty of ± 0.1 second. This is sufficient for radio-controlled low cost consumer grade clocks and watches using standard-quality ***quartz clocks*** for timekeeping between daily synchronization attempts, as they will be most accurate immediately after a successful synchronization and will become less accurate from that point forward until the next synchronization.

Coverage of DCF77

(courtesy of https://www.ptb.de/cms/en/ptb/fachabteilungen/abt4/fb-44/ag-442/dissemination-of-legal-time/dcf77/reach-of-dcf77.html)

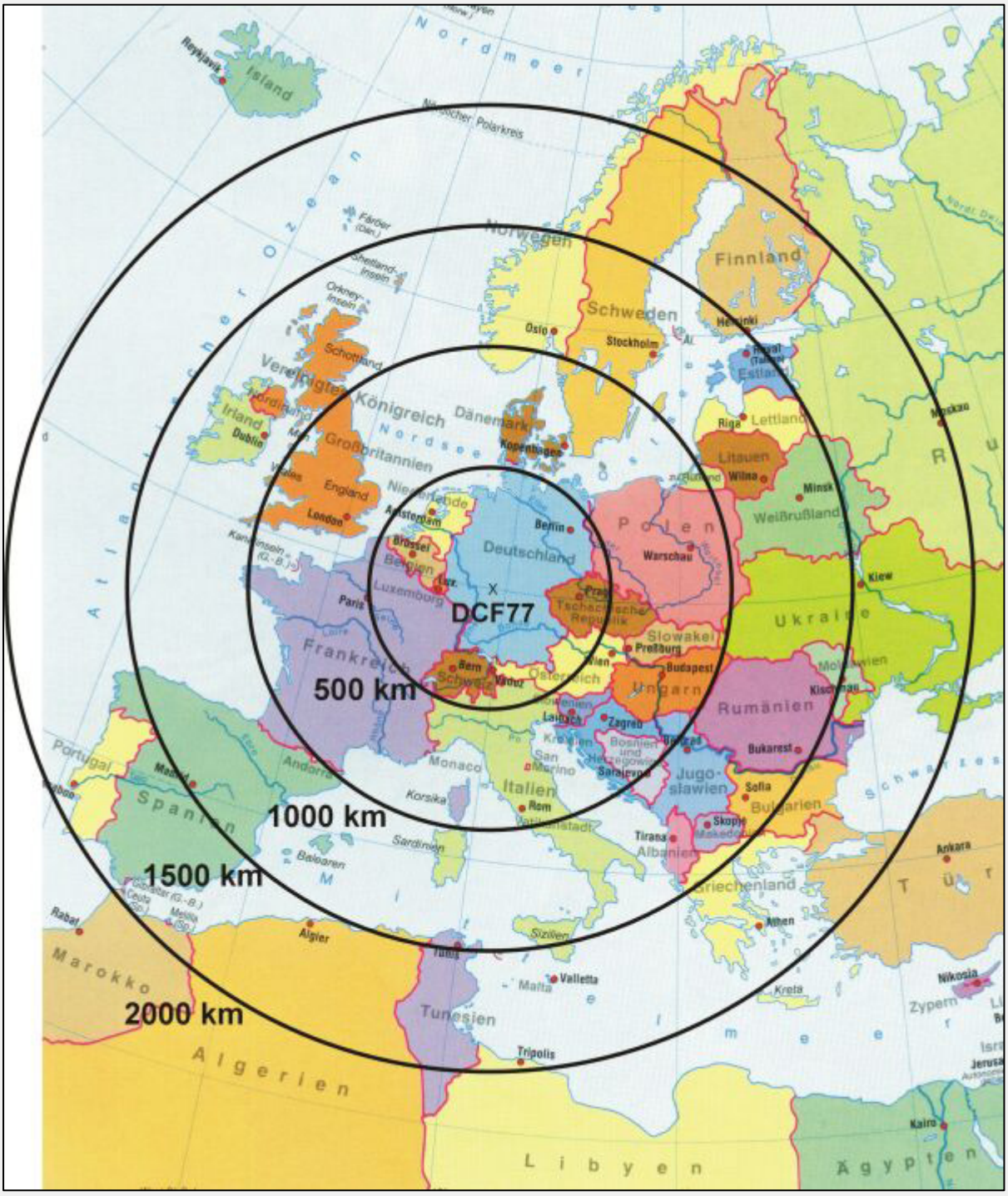
The DCF77 signal radiated by the transmitting antenna reaches the receiver place in two ways: On the one hand, it propagates as ground wave along the Earth's surface; on the other hand it reaches the receiver location as a sky wave after reflection on the ionospheric D-layer. In the case of straight propagation and one hop at the lower side of the ionosphere, maximum reach of the DCF77 sky wave is obtained when it leaves the transmitting place tangentially to the Earth's surface and also incidents tangentially at the receiver place. Under these assumptions, the reach is approx. 1900 km during a day and approximately 2100 km at night. Receivers located at larger distances are reached by the DCF77 signal only after multiple reflections (e.g. two reflections at the D-layer, one reflection at the Earth's surface) which are, however, associated with a strong decrease in the field strength. The map of Europe shown above illustrates the 2000 km circle around Mainflingen. Outside this circle, reliable reception has been proved only in individual cases.

In summary, the following properties result for ground wave and sky wave:

1. The very stable ground wave has a large reach. Up to distances of a few hundred kilometres, its reception field strength is clearly larger than that of the sky wave. At distances below 500 km from the transmitter, field strengths of the ground wave above 1 mV/m can be expected.

2. In the distance range between approx. 600 and 1100 km, ground and sky wave may occasionally be of equal size which may lead to mutual fading when both signals are out of phase. On the other hand, equal phase may also lead to a strong temporary increase in the field strength. Both phenomena are also observed in Braunschweig ($d = 273$ km). In this context it is important to know that this "beat" between ground and sky wave is a slow process (it takes a quarter of an hour and longer) and that there is thus sufficient time for a radio-controlled clock to take up the DCF77 time information.

3. At distances of more than 1100 km, the ground wave fraction constantly decreases, and the sky wave, whose propagation at large distances is fairly constant especially during the day, prevails. At distances between 1100 and 2000 km, field strengths of the sky wave between a few hundred and approx. 100 μV/m are to be expected.



Coverage of DCF77 signals in Europe: The field strength of the DCF77 signal normally achievable in 2000 km is sufficient for commercial DCF77 receivers.

Final thoughts on reception

Reception of the signal from DCF77 is inevitably dependent on the quality of the receiver module used and the antenna. The module in the deluxe receiver supplied by TIM 2015 is made by Symtrik, a variant of which is also used in the wall clocks sold periodically at Lidl stores, endorsed by Jochen Lueg at ***http://www.roevalley.com/newsbrowser/v-projects/dcf77_clock/v-dcf77.htm*** . He states: "The output is rock steady. It can also easily be converted to an MSF receiver by swapping the crystal and using a 60 kHz antenna. Not bad for a fiver!"

Here are four more tips.

The last resort — (1) using batteries (this is for DCF77 and MSF)

As Jochen Lueg (above) says, "If you have bad reception and you run your receiver via a mains power supply, try using batteries. This can make a huge difference."

The last resort — (2) using a preamplifier (this is for MSF)

As Dr Jonathan Hare G1EXG states at

http://www.creative-science.org.uk/MSF_crystal_filter.html, in electrically 'noisy' locations there is a lot of noise (interference) at very low frequencies (VLF around 10–100 kHz) caused by computers, plasma TVs, switchmode power supplies and so on. Noise can be picked up at all angles and over a wide range of frequencies. As a result directional antennas, such as ferrite rods and loops, cannot always improve the signal-to-noise ratio. At his location he has particularly strong interference at 63 kHz that is so strong that he cannot receive the MSF signal on 60 kHz at all. Accordingly he designed a very sharp (narrowband) crystal filter preamp to solve this problem (click on the link shown above).

The last resort — (3) using a larger antenna (this is for DCF77)

Michail Papadimitriou has an interesting article demonstrating how using a larger antenna can deliver significantly better results: ***http://www.electronics-lab.com/testing-cma-77-100-antenna-with-sym-rft-77-dcf77-receiver-module/*** .

Data sheet at ***www.c-max-time.com/downloads/getFile.php?id=506***

The **CMA-77-100** antenna is difficult (impossible?) to obtain retail but a near-identical product is the **FTD02041R** from HKW (***http://www.hkw-shop.de/Empfangstechnik-AM/Antenne-77-5kHz-10x100mm.html***). Data sheet at

http://www.hkw-shop.de/out/media/FTD02041R_AFET77.5_DD.pdf

The very last resort — (4) using a frame antenna (this is for DCF77 and MSF)

http://eliaselectronics.com/blog/hamr/2016/06/14/LF-Frame-Antenna.html

http://www.i1wqrlinkradio.com/antype/ch9/chiave167.htm

Section 14 | Using GPS to synchronise TIM 2015

This section has not been written yet. Until it is ready you can find inspiration by reading the **GPS Module section** on Sam Hallas's excellent TIM 2015 feature at ***http://www.samhallas.co.uk/repository/tim_2015.htm*** .

There is plenty of other material of interest to read there too!

To follow

Section 15 Revisions to this manual

V1.0 Original version.

V2.0 This current version.

For further information please re-read this document.

Section 16 Upgrades

TIM 2015 has been designed with upgradeability in mind. The two components that you may wish to upgrade are the **microcontroller** or PIC chip that contains the operating system of TIM 2015 and the **microSD cards** containing the voice files (voices).

The latest revision of the microcontroller is shown at the end of Section 8 of this manual. As it explains there, if you wish to upgrade this to the latest version, you can do this for a nominal charge. Please send it (wrapped in aluminium kitchen foil) to

David Thorpe (UE)
10 Redwood Avenue
DUDLEY
DY1 3TT

...together with a cheque for £5 made out to Unusual Electronics and a return label giving your name and address. Alternatively you can buy a fresh PIC programmed with the latest version of the software for £20.

If you wish to buy additional microSD cards containing the latest voice files, these are available at cost (£2 including inland postage) at the time of writing. Five voices are supplied per microSD card. Please e-mail ***andrew_emmerson@btinternet.com*** for an order form.

In the fullness of time, voice files will also be available to download (to put on your own microSD cards) from the TIM 2015 website, ***www.TIM2015.uk*** . Customers will be notified by e-mail when updates are available.

Copyright notice

TIM 2015 has been designed as a 'pro bono' (not for profit) production, with nobody taking a single penny of payment for the very many hours of time spent bringing it to reality. The design principles and circuit schematic have been put into the public domain and are freely available. The only 'protected' element is the encrypted code used in the microcontroller, for which a design royalty is included in the price of the programmed chip.

- **Please note. The TIM 2015 team supports recycling and sustainability, so we re-use packing material as far as possible. This helps keep the price that *you* pay as low as possible too!**

LONDON LAUGHS: The Golden Voice

"....and in future, when you want to know the time, ask ME. Understand!"

Courtesy of BT Archives