

# TECHNICAL MANUAL



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



**WORK IN PROGRESS!** A document of this kind is never entirely complete, so once the website is complete ([www.TIM2015.uk](http://www.TIM2015.uk)) please check for a newer version. Thank you for your understanding.

**PLEASE NOTE:** This is the *Technical Manual*. For setting up the clock after completion and information on the various methods of synchronising the correct time please see the separate *User Manual* document. The *Assembly Manual* explains how to construct TIM 2015.

## 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 onto 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.

## 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. The text is as comprehensive as possible, simply because not every constructor will be familiar with some of the tasks.

- *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 Chapters. The contents page follows.

And yes, there are a lot of words to read, simply because we tried to make the assembly process impossible to get wrong. Take it in stages if you prefer.

Finally, if you get stuck, do try reading the manual a second time, perhaps more slowly. Things often become simpler to understand after several readings. For a valuable and independent guide to using TIM 2015 please visit [http://www.samhallas.co.uk/repository/tim\\_2015.htm](http://www.samhallas.co.uk/repository/tim_2015.htm). Sam Hallas describes there how he built his own TIM 2015. It's well worth reading!

## User feedback

We welcome this! So if you have spotted a mistake in this manual, something you disagree with or else something you think could be clarified, please get in touch. The same applies for anything you feel has been left out. Maybe you wish to comment on the product itself or perhaps would like to suggest an improvement. Get in touch by an e-mail to [andrew\\_emmerson@btinternet.com](mailto:andrew_emmerson@btinternet.com). We'll respond as soon as humanly possible (but please bear in mind this is a spare-time activity).

## Clarification

Here are three things that we need to stress 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 some cases the recordings were taken directly from the speaking clock apparatus with the agreement and kind cooperation of the museum 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.

## Acknowledgments

Thanks to Dave Thorpe for his superb circuit design work, also to Mick Champion, Alan David, Mike Fletcher, 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. The computer-engraved panels are produced for us 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 ring binder or one of those plastic display book folders that you can buy at pound shops and in many supermarkets.*

*The latest version of this manual will be available to download at [www.TIM2015.uk](http://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

1. Technical description of TIM 2015
2. Diagnostic messages
3. Troubleshooting (problem solving)
4. Background information
5. Upgrades
6. The Catalex serial MP3 player
7. Creating new 'voices' for TIM 2015
8. Revisions to this manual
9. Safety notice and legal disclaimer

Each section begins on a fresh page.

**Please note that this is the *Technical Manual*. There is also a separate *User Manual* and also an *Assembly Manual*.**

People can use TIM 2015 very happily without reading anything in this 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  $\pm 2$ ppm (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<sup>2</sup>C 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 $\mu$ A) 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.

## Specifications

### Power supply requirements:

9 - 12 Volts DC @ 1Amp rating (Switching type adapter preferred)

3 Volts lithium coin cell (CR2032) for the RTC timekeeping battery backup.

### Power consumption:

- Approx 0.55W (Amplifier=off, Wi-Fi=off, Display brightness setting=34 (half-power)).
- Approx 0.7W (Amplifier=off, Wi-Fi=off, Display brightness setting=maximum brightness).
- Approx 1.14W (Amplifier=off, Wi-Fi=active, Display brightness setting=maximum brightness).
- Approx 2.35W (Amplifier=full volume (8Ω speaker), Wi-Fi=active, Display brightness setting=maximum brightness).

### Backup timekeeping battery power consumption:

0.85μA (Estimated run-time >10 years (or the shelf life of the CR2032 battery)).

### Dimensions:

PCB alone 140mm x 85mm x 1.6mm

### Timekeeping accuracy:

Unadjusted RTC accuracy ±2ppm from 0°C to +40°C (about ± 5.4 seconds per month).

Timekeeping may be improved by timekeeping fine adjustment menu setting.

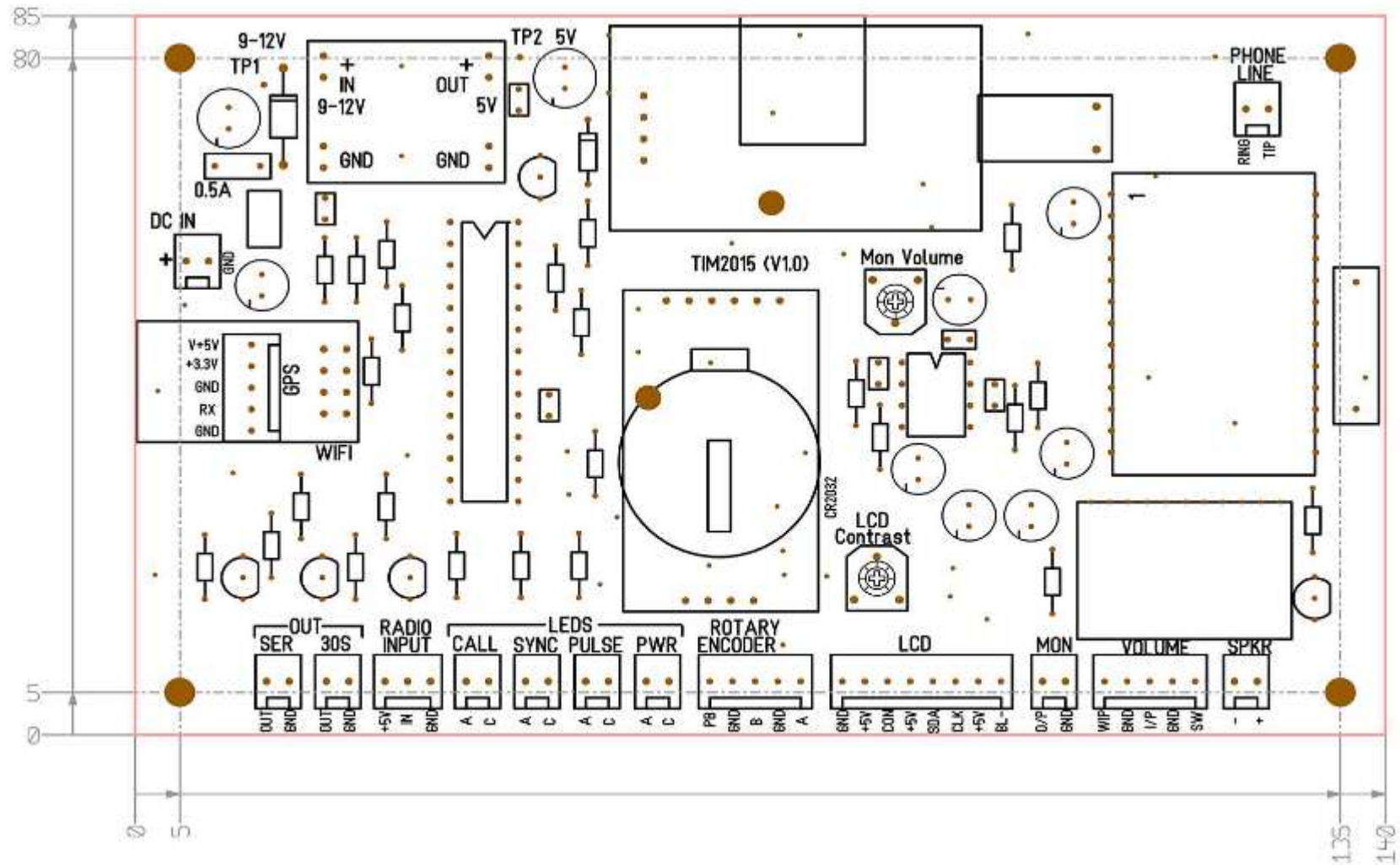
### Crystal ageing:

First year: ±1ppm

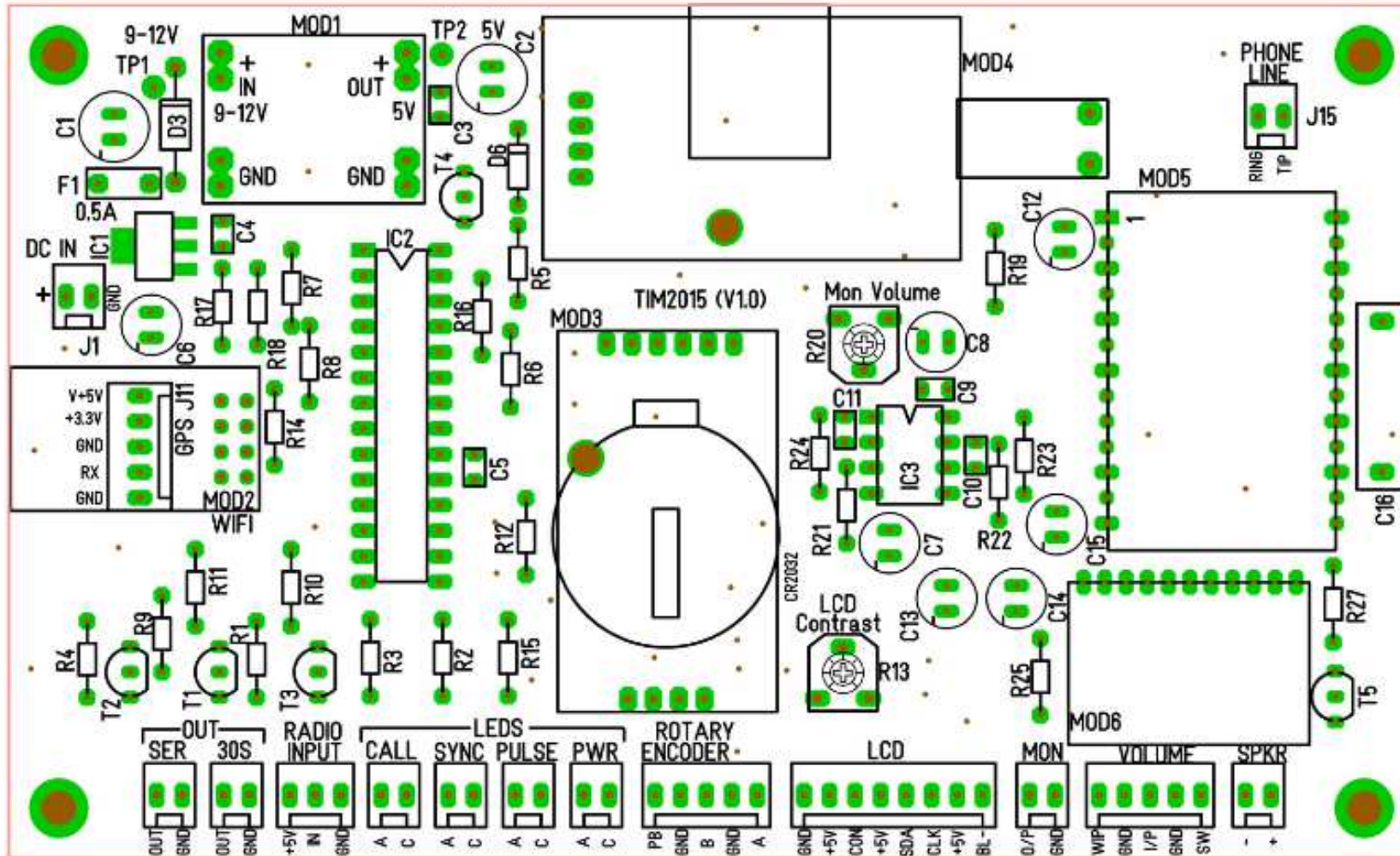
1-10 Years: ±5ppm (RTC manufacturer's estimate).



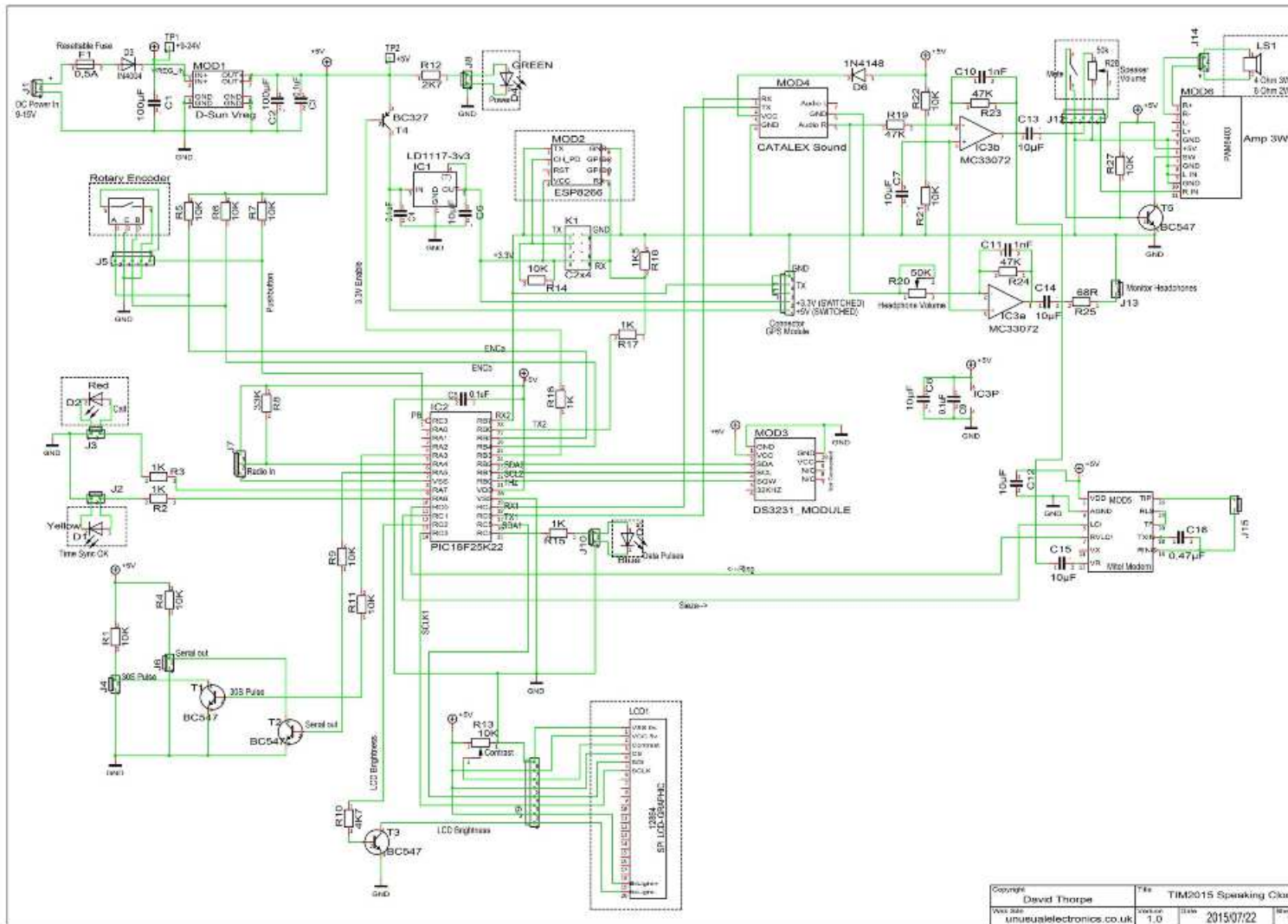
Board dimensions (140 x 85mm)



## Board layout



# Circuit diagram



## 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.

## Chapter 2 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.

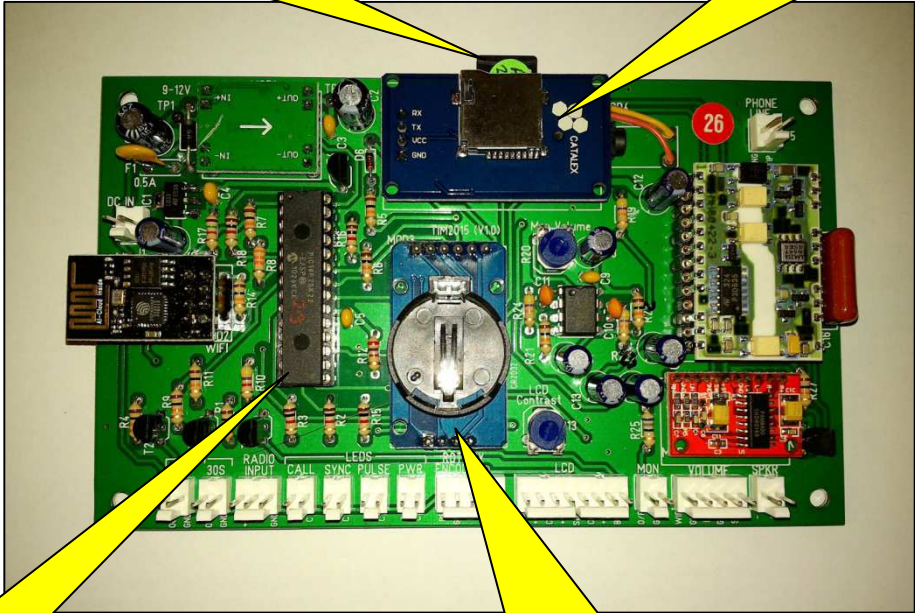
The solution is to power down, unscrew the case and remove the CR2032 coin-cell for a couple of minutes. Use a screwdriver to pop it out. This will erase the stored time data and force the realtime clock (RTC) to reset.

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.

Micro SD card (projecting slightly). Side with lettering uppermost

Catalex player (blue module)



Microcontroller chip (the longest chip on the board)

Coin cell in its holder (with engraved lettering visible and uppermost)

## Chapter 3 Troubleshooting

This chapter is in two halves. The first Chapter lists faults that may occur during construction and prevent you from getting TIM 2015 to work at all, whilst the second section covers things that may come to light once you start using the completed clock.



The companion User Manual lists other problems that may crop up during use of TIM 2015.

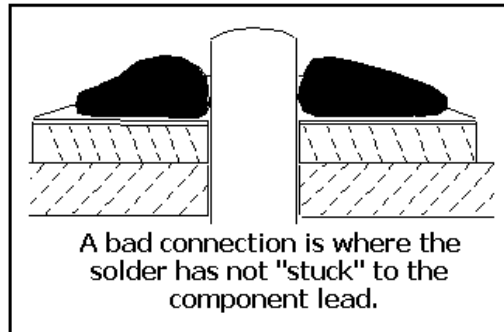
**Note that problems are frequently caused by unsoldered or badly soldered joints** on the track side (underside) of the PCB. Visual examination with a magnifying glass in bright light is the way to go. These words on good soldering are adapted from Wikipedia has these wise words.

The most common defect when hand-soldering results from applying the solder before the parts being joined are heated enough. If their temperature is not higher than the solder's melting point, the result will be a **cold solder joint**. This is usually the result of the soldering iron being used to heat the solder directly, rather than the parts themselves. Properly done, the iron heats the parts to be connected, which in turn melt the solder, guaranteeing adequate heat in the joined parts for thorough wetting by the flux embedded in the solder.

Therefore, heating the solder first may cause the flux to evaporate before it cleans the surfaces being soldered. A cold-soldered joint may not conduct at all, have high resistance or may conduct only intermittently or noisily. Cold-soldered joints are a common cause of equipment which passes testing, but malfunctions after sometimes years of operation.

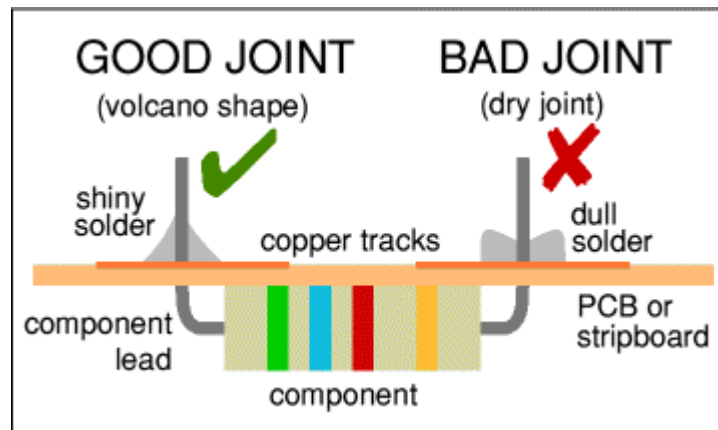
A **dry joint** occurs when the cooling solder is moved, and often occurs because the joint moves when the soldering iron is removed from the joint. Moving the part being soldered before the solder has cooled will cause a highly unreliable cracked joint. A dry joint has a characteristically dull or grainy appearance immediately after the joint is made, rather than being smooth, bright and shiny. This appearance is caused by crystallization of the liquid solder. A dry joint is weak mechanically and a poor conductor electrically.



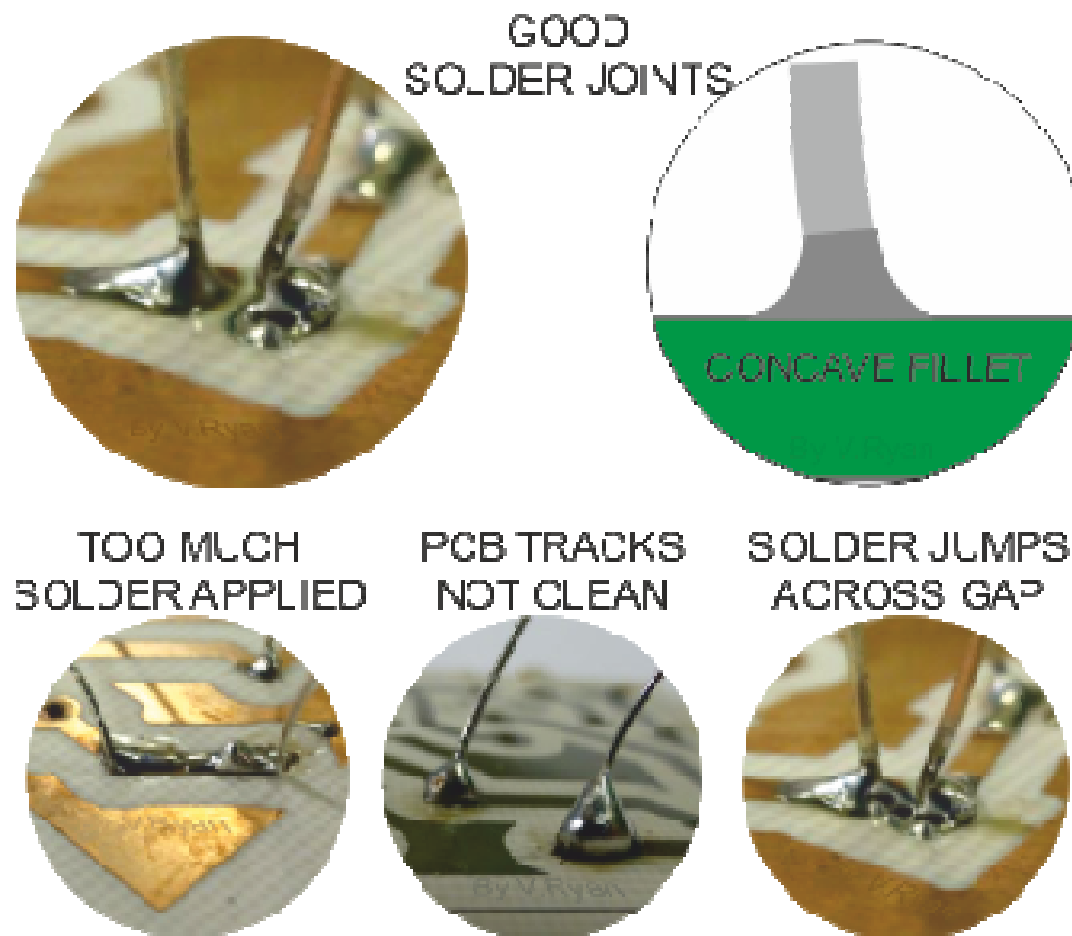


Graphic courtesy of Quora.com

In general a **good-looking soldered joint** is a good joint. As mentioned, it should be smooth, bright, and shiny. If the joint has lumps or balls of otherwise shiny solder the metal has not 'wetted' properly. Not being bright and shiny suggests a weak, dry joint.



Graphic courtesy of Instructables.com



*Graphics courtesy of Technologystudent.com*

**For all of these reasons it is essential to correct any cold or dry solder joints.** If you find one, the solder on the joint should be removed with solder-wick braid or a solder sucker and care taken to ensure that a good joint is made when re-soldering it.

# Assembly errors

## 1. Faulty connections in Molex connectors

Excellent as these Molex connectors are, they can fail. The female contact feeler is retained in the connector shell by a tiny ‘tang’ engaging in a slot. If the tang has not engaged properly, the wire can work up in the shell and lose contact with the spike or post out of the male header part of the connector. If pulling on the wire allows you to withdraw it from the shell, that’s where your problem lies. Resolve the problem by bending out the tang and checking that the wire is now properly restrained.

## 2. Missing lights

TIM 2015 performs a test of all four LEDs at switch-on and then illuminates them individually as appropriate. If any of them fails to illuminate consider, first check whether the LED wired the wrong way round (negative light from a reverse-connected LED is invisible to the human eye). Is the LED faulty? Try substituting another LED. Is plug not making proper contact on the matching connector on the PCB? If this is not the problem check (and reflow if necessary) the appropriate soldered joints on the PCB.

## 3. Pressing the left-hand control knob has no effect; in other words it does not take you into the Settings menu.

*Solution 1:* The pink wire from the encoder switch is not connected to the *Encoder* Molex connector. This may be due to a poor solder joint on the encoder switch itself or a loose contact on the Molex connector. See Problem no. 1 above.

*Solution 2:* The wire connections to the encoder switch are incorrect. On the left-hand side the blue wire should be uppermost, with the pink wire below. The right-hand side should have the brown wire on top, the mauve wire on the central solder tag and the yellow wire at the bottom.

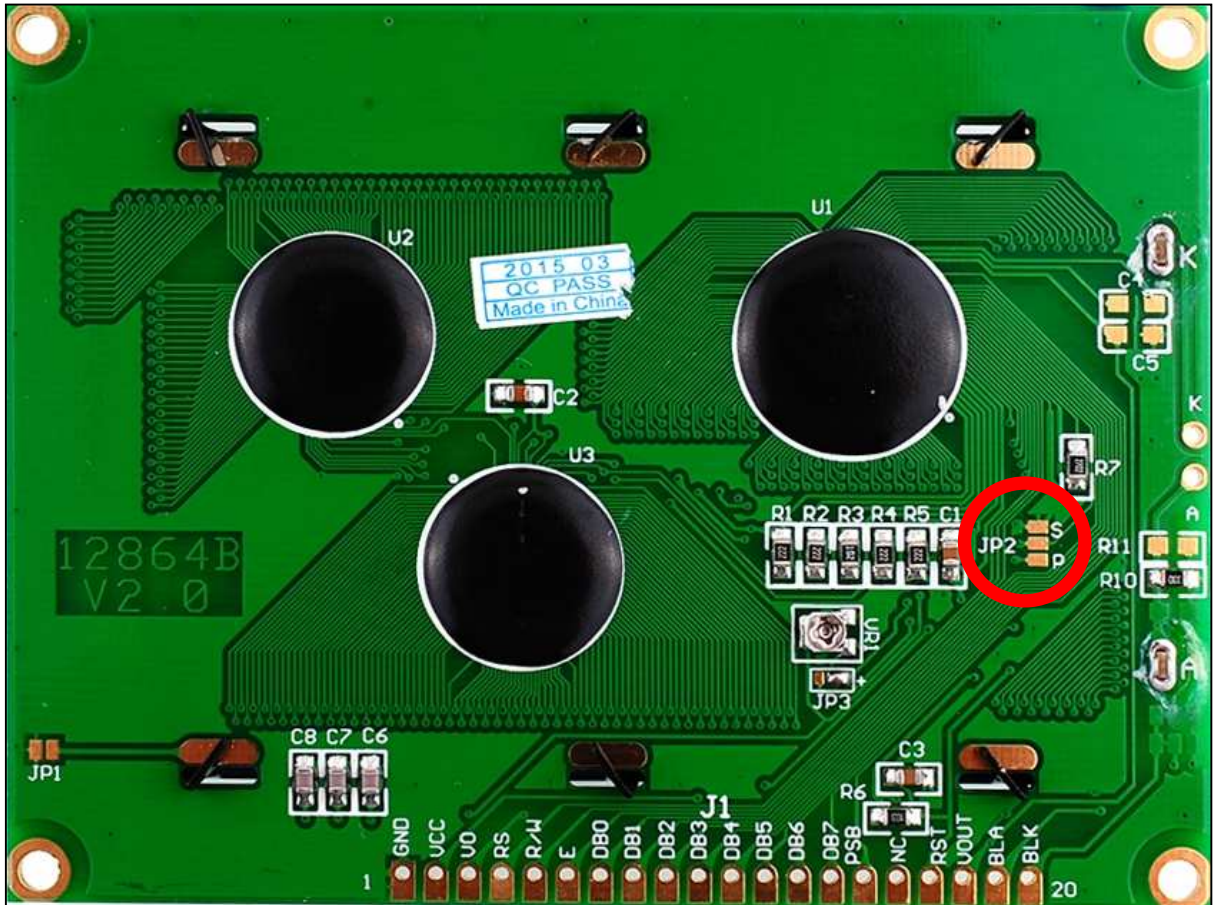
## 4. There is a discernible delay before audio is heard when switching on TIM 2015.

This is intentional. There is no audio output until the pips or toneburst is sounded for the first time. As you may switch on TIM 2015 at any random moment a delay of up to eight seconds may occur until the next pips or toneburst moment.

## 5. The liquid crystal display does not illuminate.

This could be for one of six different reasons.

- (1) The connectors at either ends of the connecting cable (flylead) between the PCB and the display are displaced or offset to the left or right (yes it's easily done). Check visually.
- (2) Accidental solder splash bridging two or more pins of the plug at the display end of the cable.
- (3) Wires of the flylead have been transposed (connected in the wrong order). See sketch in **Chapter 4, Wiring**.
- (4) Loss of continuity in the flylead (probably a loose Molex connector; see first problem in this section). Check with your multimeter using the Resistance mode or even better the Resistance-with-audio-tone made if available.
- (5) The plug at the display end of the cable has been pushed onto the pin header of the display the wrong way round. See sketch in Chapter 4, Wiring. The body of the plug lies back over (covering) the PCB; it does not project over the edge (outside) of the board.
- (6) The serial connection has not been made on the underside of the PCB. Most displays have three gold-plated lands that enable the display to operate in either parallel or serial mode. In the photo that follows these are labelled JP2, circled in red. Our display needs to operate in serial mode, so we need to connect the central land to the land above it, marked S. Make sure the central and upper lands are scrupulously clean, using the Garryflex pad mentioned early in this instructional. Then heat each land with a hot soldering iron and touch it with fine solder to 'tin' the gold pad. Then bridge both pads with the tip of the soldering iron and add a tiny amount of solder so that the two pads are linked. Make sure the link you make does not touch the P pad.



*Typical LCD with the parallel/serial jumper circled in red.*

**6. The liquid crystal display does illuminate but it shows gibberish that changes constantly.**

This is usually a loose wire connection in the flylead or else JP2 is connected wrongly or not at all (see Problem 5 above).

### **7. One of the LEDs lights up brighter/dimmer than the others.**

This is annoying but the truth is that the relative brightness of LEDs differs widely from colour to colour, type to type and manufacturer to manufacturer. The resistor values were chosen for the LEDs that our designer used but you may like to SOT (select on test) the resistors you use. For instance if the blue (DATA) LED appears too bright, you could change the value of R15 to around 5.6k. There is a good article on choosing resistor values for LEDs at <http://www.instructables.com/id/Choosing-The-Resistor-To-Use-With-LEDs/>.

## **Electrical problems**

If your TIM 2015 displays an error code on the screen, please go back to **Chapter 7, Diagnostic Messages**, where these are discussed.

### **1. 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.

### **2. No audio at all**

The most likely cause is misalignment of the microSD card that carries the sound files. Power down 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).

## Chapter 4 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.



## Chapter 5 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 Chapter 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](mailto: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](http://www.TIM2015.uk). Customers will be notified by e-mail when updates are available.

### 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 provide for time announcements given in 24-hour format.
- **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. Number of voice files on microSD card that can be handled increased from 16 to 64.

## Chapter 6 The Catalex serial MP3 player

### 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. Payout is arranged like this:

- Payout 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). Even if the announcement that you create ends at, say, 9.0 seconds, the Catalex module will remain silent until the start of the next three pips or long toneburst.

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. File names must be numerical and in the format 001 to 255.WAV or 001 to 255.MP3 (this is a constraint of the Catalex module). According to the Catalex data sheet you should be able to add text to filenames for user reference purposes, such as 001ABC.WAV and 024xyz.WAV. In theory the Catalex sees only the numeric component of the file name. We have not tested this, however.

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.

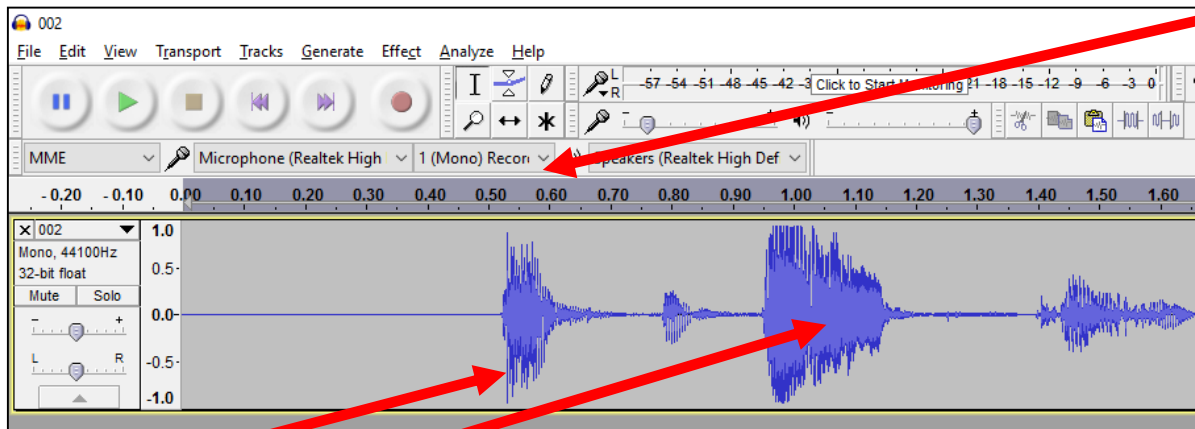
Unless you are very brave or skilled, we advise you not to make any alterations to this scheme of things, otherwise commands from the microcontroller (PIC chip) will probably fail to work. The files that you create need to be stored in a numbered folder: **01, 02, 03, 04** or **05** (we advise placing 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*).

*Continues on next page.*

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:

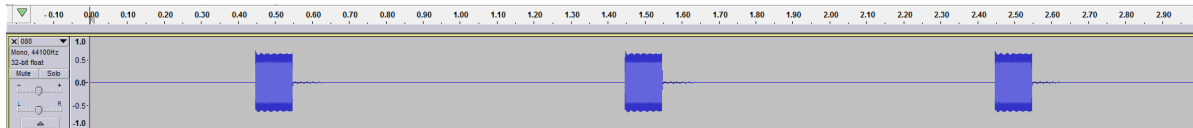


For TIM 2015 **this** (0.8 to 0.8) is the ideal amplitude for loud peaks. You can expand or reduce the amplitude in Audacity.

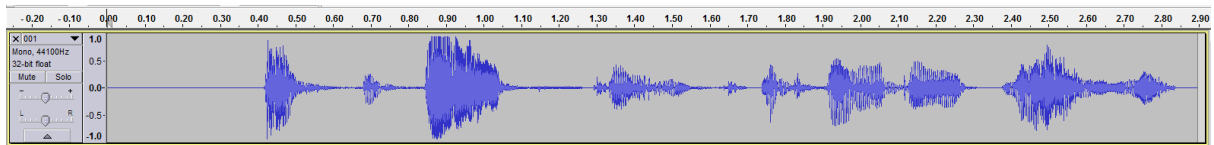
**This signal here** is slightly too loud (note the flat-topping) and needs to be reduced. Use the **Amplify** effect and 'amplify' by -1.

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.

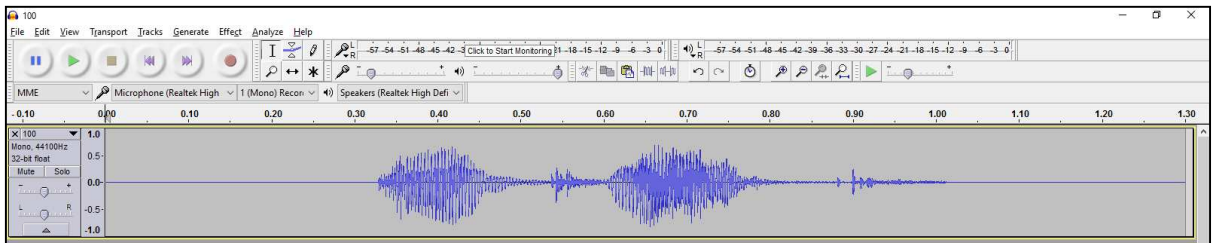
- File **080.WAV** contains the three pips. It lasts 3 seconds, with the audio beginning at 0.45 seconds.



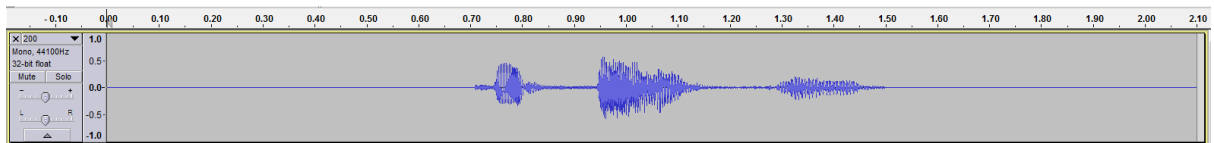
- File **001.WAV** contains the three pips and the words 'At the third stroke <pause> it will be one' [the pause mimics the delay in the original recording when it changed tracks]. This carries on up to **012.WAV** ('At the third stroke it will be twelve'). These files run for 3.1 seconds with the audio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



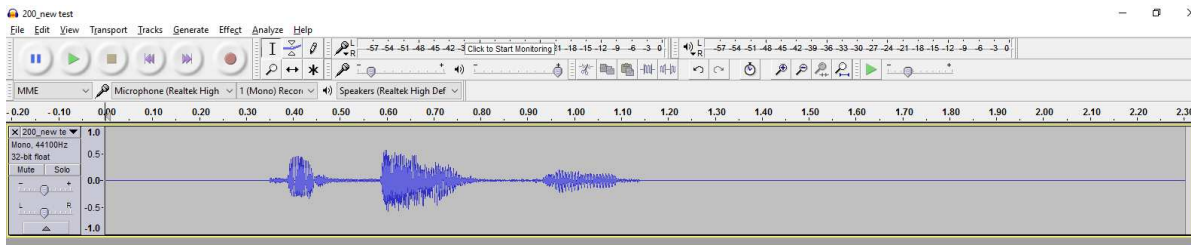
- File **100.WAV** contains the phrase 'O' clock'. It lasts 1.3 seconds, with the audio beginning at 0.32 seconds.



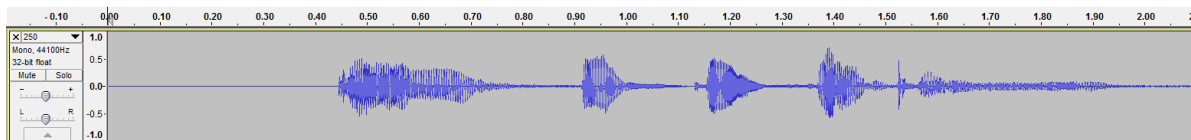
- Files **101.WAV** to **159.WAV** contain the minutes from 1 to 59. These also run for 1.3 seconds, with the audio starting at 0.30 seconds.



- 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.



Here are some questions and answers:

**British and Australian voices begin with three pips, starting at x8 seconds, so that the third pip occurs 'on the button' at the 00/10/20/30/40/50 seconds timing. This is great and works well. However, this does not apply to all speaking clocks. In fact just about every other speaking clock makes do with a single pip or toneburst and this needs to start on the dot of the 00/10/20/30/40/50 seconds timing. What is the best way of doing this?**

*The USA voices start with the single tone on the dot. If you create dummy blank 082, 083 and 084 files (morning, afternoon, evening), the Catalex player should treat the sequence as USA type and sound a single tone at x0 seconds.*

**The next segment following the toneburst beep is usually some words along the lines of 'At the tone the time will be...' and to make this sound natural, there needs to be a period of silence between the toneburst and the start of 'At the tone...' . But frequently it just does not work like that. I have tried inserting silence before the announcement but either it is ignored or worse, it makes the total length of all the segments together too long, meaning that the final 'And ten seconds' segment is truncated. If, alternatively, I add a period of silence after the toneburst in 080, then the beep is sounded too early. What am I doing wrong?**

*When I was writing the program I found the Catalex module has some delays:*

- 1: A serial command to the sound module takes 8ms*
- 2: There is about 60ms silence at the start of a file while it fades-up the volume (maybe intended to make songs playback sound better?)*
- 3: And about 30ms to access the microSD card file.*

*Because of all this the program starts the command for the pips file 98ms earlier than second 8 (or second 0 for US) to allow the pips to start playing promptly at second 8 (or 0). The 60ms fade-up delay may be what is causing them to not sound right (If there is no brief period of silence at the start of a file it may miss a bit of it while the Catalex fades-up).*

*The other delays (in the microSD card and the serial commands) may be contributing to the sequence over-running into the next pips and the Catalex then gets confused and truncates announcements.*

*Also fragmentation of the microSD card files due to files being added/removed can cause the Catalex module to fail to play files (re-format the microSD card and copy all files at once to avoid this).*

**In the general nature of things, the length of the various segments varies. For instance the toneburst/pips (080) and the final announcement (200-250**

**'Precisely' or 'And xx seconds'** are quite short. Whereas the **0xx** announcements (**'At the signal it will be xx hours'**) are significantly longer. The precise length of these differing segments varies according to the particular voice being played out but always totals slightly under 10 seconds. I understand this entirely. Am I right in thinking that **TIM 2015** does not expect these segments to conform to any predetermined length, so long as the sum total does not exceed, say, 9.8 seconds?

*Yes, it doesn't know how long the files are, it just puts all the files for a time announcement in a queue and plays the next file as soon as the Catalex indicates the last file has finished playing. At the next time sequence at second x8 (or x0 for USA) it must start a new file queue regardless of whether the Catalex is still busy or not in order to have the pips begin on time. So it needs to finish within about 9.8 seconds to ensure the module is not still busy when the next pips file command is sent.*

**Does the Catalex player load up all of the segments needed to play a (nominally) 10-second announcement in one step? Or does it load each segment separately as it needs it? I suspect it's the latter but please confirm!**

*It is the latter, because the Catalex unit cannot play more than one file at a time. (I contacted Catalex about their 'Serial Play' command back in 2015 and they said it did not work and removed it from their datasheet).*

**Does it matter that some segments are of variable length? It's evident that 'Fifty-nine' takes longer to say than 'One', and that "And fifty seconds" takes longer than 'Precisely'.**

*Not at all. The program just waits until the sound module sends a 'File finished playing' status string and then it plays the next file.*

**In case where the lengths of a particular segment do vary, do we need to pad them out with silence so that they all last the same (long) time?**

*There's no need to do that. The only thing that you may need to check is that the silence length between "and xx seconds" and the start of the pips is acceptable and there are no combinations where the total length of the announcement overlaps the next pips (the software will always send the pips at the start of x8 seconds and if the last file hasn't finished by then it would have unpredictable results (the sound may be corrupted or it may just not play the file) The best thing to do is make sure the announcements finish at perhaps around x7 seconds and the software will automatically have about a second of silence before it has to send the pips.*

**Can I add silence before or after words to make the end result sound more natural?**

*You can add silences anywhere to the files to make them sound right. But never allow an announcement to exceed 9.8 seconds in length, as there is always a small delay (waiting for the 'File finished' status notification to be received from the sound chip) after each file.*

**The WAV file segments in a particular voice take up around 61MB of memory. Is this acceptable or do we need to convert them to MP3 in order to save memory?**

*It is perfectly acceptable and to the user, WAV files sound slightly better than MP3 files. It is perfectly acceptable to use a mixture of MP3 and WAV files without any problem (just make sure the files are mono and the bitrate matches the rates allowed in the Catalex data sheet).*

*TIM 2015 is supplied with a 1GB (gigabyte) microSD card and its large capacity means there is no need to worry about file sizes. Of course TIM 2015 will also work fine with 2GB cards. According to the Catalex specifications the player can take up to 32GB SDHC cards but we haven't tried any sizes above 2GB yet.*

## **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 device and priced attractively. 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 payout 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 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](mailto:andrew_emmerson@btinternet.com)).

## Catalex serial MP3 player limitations

*Mick Champion reports:*

A voice timing bug has come to light due the increased number of voices now available to TIM 2015. It didn't take long to spot that the Catalex MP3 player is at the root of the problem but unfortunately little can be done about it. The table below shows the time it takes to complete playing the same one track 'At the third stroke, it will be Three'. All folders contain Pat Simmons for the purpose of this experiment.

## Timing report for Catalex : Single Track

		1st run	2nd run		Extra time
Folder 1	Track 3 :	3.168473959	1st Play	3.157424927	
Folder 1	Track 3 :	3.157727003	2nd Play	3.157483816	0
Folder 2	Track 3 :	3.187798023	1st Play	3.209244013	
Folder 2	Track 3 :	3.178072929	2nd Play	3.167721987	0.010238171
Folder 3	Track 3 :	3.23844099	1st Play	3.228770018	
Folder 3	Track 3 :	3.198143005	2nd Play	3.208297968	0.050814152
Folder 4	Track 3 :	3.25948	1st Play	3.238322973	
Folder 4	Track 3 :	3.228674889	2nd Play	3.228118896	0.07063508
Folder 5	Track 3 :	3.279507875	1st Play	3.284944057	
Folder 5	Track 3 :	3.258905888	2nd Play	3.258529902	0.101046085
Folder 6	Track 3 :	3.309886932	1st Play	3.30043602	
Folder 6	Track 3 :	3.278951883	2nd Play	3.279416084	0.121932268
Folder 7	Track 3 :	3.339715958	1st Play	3.339516163	
Folder 7	Track 3 :	3.299515963	2nd Play	3.309262037	0.151778221
Folder 8	Track 3 :	3.363430023	1st Play	3.359964848	
Folder 8	Track 3 :	3.33957386	2nd Play	3.32967186	0.172188044
<del>Folder 9</del>	<del>Track 3 :</del>	<del>0.546814293</del>	<del>1st Play</del>	<del>0.556980133</del>	
<del>Folder 9</del>	<del>Track 3 :</del>	<del>0.556988955</del>	<del>2nd Play</del>	<del>0.546674967</del>	<del>-2.61080885</del>
Folder 10	Track 3 :	3.339570045	1st Play	3.339548111	
Folder 10	Track 3 :	3.335175991	2nd Play	3.329371214	0.171887398
Folder 11	Track 3 :	3.371709108	1st Play	3.389994144	
Folder 11	Track 3 :	3.360105038	2nd Play	3.35649991	0.199016094
Folder 12	Track 3 :	3.410365105	1st Play	3.390434027	
Folder 12	Track 3 :	3.390483141	2nd Play	3.370570898	0.213087082
Folder 13	Track 3 :	3.435935974	1st Play	3.44069314	
Folder 13	Track 3 :	3.410736799	2nd Play	3.410443068	0.252959251
Folder 14	Track 3 :	3.471349001	1st Play	3.460849047	
Folder 14	Track 3 :	3.440948009	2nd Play	3.440625906	0.28314209
Folder 15	Track 3 :	3.481137037	1st Play	3.476700068	
Folder 15	Track 3 :	3.461152792	2nd Play	3.461077929	0.303594112

Folder 16	Track 3 :	3.511431932	1st Play	3.514756918	
Folder 16	Track 3 :	3.481031179	2nd Play	3.491523981	0.334040165
Folder 17	Track 3 :	3.542538166	1st Play	3.535902023	
Folder 17	Track :	3.511014938	2nd Play	3.511684895	0.354201078
Folder 20	Track 3 :	3.572339058	1st Play	3.563921928	
Folder 20	Track 3 :	3.531587839	2nd Play	3.541535854	0.384052038

Ignore Folder 9 as it returned an error.

Ignore First play as it takes longer to play a track if it is your first visit to a directory.

Extra time shows second run, second play differential based on folder 01.

As you can see in the table above, it takes over 1/3 of a second longer for the track in folder 20 to complete compared to playing it in folder 01. This doesn't mean if you rename folder 20 to folder 01 it will be any different; it seems to be down to where the item is in the FAT table. Renaming won't change that.

**Timing report Catalex: Full Sequence on FAT16 (A). Drive was empty but not especially formatted.**

		1st run	Sequence	2nd run	Sequence	Extra time	Extra time
Folder 1	Track 80 :	3.06596899		3.056231022			
Folder 1	Track 80 :	3.056220055		3.056475878			
Folder 1	Track 9 :	3.157927036		3.157480001			
Folder 1	Track 128 :	1.367619991		1.366471052			

Folder 1	Track 250 :	2.064786911	9.64655399	2.084784985	9.665211916	0	0
Folder 5	Track 80 :	3.248657942		3.251117945			
Folder 5	Track 80 :	3.147192001		3.157522917			
Folder 5	Track 9 :	3.359699011		3.363786936			
Folder 5	Track 128 :	1.467803955		1.46765399			
Folder 5	Track 250 :	2.178403854	10.1530988	2.175333023	10.16429687	0.506545	0.499085
Folder 10	Track 80 :	3.298041105		3.308758974			
Folder 10	Track 80 :	3.228356123		3.237987995			
Folder 10	Track 9 :	3.512026072		3.51099205			
Folder 10	Track 128 :	1.548631191		1.54822588			
Folder 10	Track 250 :	2.256424904	10.5454383	2.250149012	10.54735494	0.898884	0.882143
Folder 15	Track 80 :	3.481557846		3.470875025			
Folder 15	Track 80 :	3.370018959		3.369731188			
Folder 15	Track 9 :	3.764777899		3.764256001			
Folder 15	Track 128 :	1.680520058		1.669682026			
Folder 15	Track 250 :	2.388429165	11.2037461	2.389487028	11.19315624	1.557192	1.527944
Folder 20	Track 80 :	3.49217701		3.511645079			
Folder 20	Track 80 :	3.440698147		3.450252056			
Folder 20	Track 9 :	3.92645216		3.926408052			
Folder 20	Track 128 :	1.751247168		1.75099802			
Folder 20	Track 250 :	2.459429026	11.5778265	2.458956003	11.58661413	1.931273	1.921402

In the next table you will see one full sequence for Folder 1, 5, 10, 15 and 20. Because of the delay I mentioned earlier when changing to a folder, the pips (080.wav) are played twice and the timing calculation starts from the



second. This time I played 11:28 and 50 seconds.

So there you have it. It took 1.93 seconds longer to play a full sequence in folder 20 on one of the passes. When we're only talking 10 seconds here, that is a heck of a long time.

This experiment was conducted using Debian8, and a PERL script I cobbled together with help from t'Internet, a CH341 serial USB -TTL device, a bridge board (that I knocked up to provide power and connexion points) and finally the Catalex.

The timing calculation was made by saving the current time immediately after the command to play the track was sent, then subtracting that time from current time the moment the first byte was received back from the Catalex. To prevent the processor from spiralling out of control in an endless loop, I put a delay of 10,000 micro seconds in between each check of the input buffer so this could be subtracted.

**Timing report Catalex : Full Sequence freshly formatted to FAT16 (B)**

		1st run	Sequence	2nd run	Sequence	Extra time	Extra time
Folder 1	Track 80 :	3.066857815		3.060096025			
Folder 1	Track 80 :	3.049524069		3.048336983			
Folder 1	Track 9 :	3.150367022		3.149287939			
Folder 1	Track 128 :	1.3671		1.357398987			
Folder 1	Track 250 :	2.065809965	9.63280106	2.065979958	9.621003866	0	0
Folder 5	Track 80 :	3.242493153		3.250827789			
Folder 5	Track 80 :	3.149612188		3.159179926			
Folder 5	Track 9 :	3.341564178		3.361958027			
Folder 5	Track 128 :	1.448503971		1.458629847			
Folder 5	Track 250 :	2.177393913	10.1170743	2.177531958	10.15729976	0.47052	0.492088
Folder 10	Track 80 :	3.291043997		3.30148077			
Folder 10	Track 80 :	3.230140924		3.240552902			
Folder 10	Track 9 :	3.504113913		3.503427029			
Folder 10	Track 128 :	1.539644957		1.529073			
Folder 10	Track 250 :	2.237846136	10.5117459	2.249000072	10.522053	0.865192	0.856841
Folder 15	Track 80 :	3.473417997		3.473144054			
Folder 15	Track 80 :	3.351972103		3.362617016			

Folder 15	Track 9 :	3.766855955		3.76569891			
Folder 15	Track 128 :	1.661230087		1.672559977			
Folder 15	Track 250 :	2.359658957	11.1397171	2.371753931	11.17262983	1.493163	1.507418
Folder 20	Track 80 :	3.491577864		3.497166157			
Folder 20	Track 80 :	3.436648846		3.432595015			
Folder 20	Track 9 :	3.919348955		3.919244766			
Folder 20	Track 128 :	1.733397961		1.731719971			
Folder 20	Track 250 :	2.461392879	11.5507886	2.450766087	11.53432584	1.904235	1.869114

**Timing report Catalex : Full Sequence Freshly formatted to FAT32**

		1st run	Sequence	2nd run	Sequence	Extra time	Extra time
Folder 1	Track 80 :	3.057796001		3.057779789			
Folder 1	Track 80 :	3.058138132		3.047650814			
Folder 1	Track 9 :	3.158977985		3.149448872			
Folder 1	Track 128 :	1.36714983		1.346889019			
Folder 1	Track 250 :	2.065678835	9.64994478	2.075988054	9.619976759	0	0
Folder 5	Track 80 :	3.229890823		3.250292063			
Folder 5	Track 80 :	3.148864985		3.139023066			
Folder 5	Track 9 :	3.352252007		3.352571964			
Folder 5	Track 128 :	1.468384027		1.458656073			
Folder 5	Track 250 :	2.177117109	10.1466181	2.177175999	10.1274271	0.500064	0.462215
Folder 10	Track 80 :	3.290970802		3.292360067			
Folder 10	Track 80 :	3.21993804		3.237958908			
Folder 10	Track 9 :	3.504219055		3.504500866			
Folder 10	Track 128 :	1.530152798		1.539201021			
Folder 10	Track 250 :	2.253262997	10.5075729	2.248157024	10.52981782	0.861019	0.864606
Folder 15	Track 80 :	3.476930141		3.47276783			
Folder 15	Track 80 :	3.361520052		3.361459017			
Folder 15	Track 9 :	3.759212017		3.756291151			
Folder 15	Track 128 :	1.670948029		1.67087698			

Folder 15	Track 250 :	2.3795681	11.1712482	2.379256964	11.16788411	1.524694	1.502672
Folder 20	Track 80 :	3.503583908		3.503309965			
Folder 20	Track 80 :	3.432532072		3.432507992			
Folder 20	Track 9 :	3.908316851		3.908960819			
Folder 20	Track 128 :	1.741719007		1.741852045			
Folder 20	Track 250 :	2.44029808	11.522866	2.450479984	11.53380084	1.876312	1.868589

### Full Sequence side by side

	First Run			Second Run		
	FAT16 (A)	FAT16 (B)	FAT32	FAT16 (A)	FAT16 (B)	FAT32
Folder 1	9.646554	9.632801	9.649945	9.665212	9.621004	9.619977
Folder 5	10.1531	10.11707	10.14662	10.1643	10.1573	10.12743
Folder 10	10.54544	10.51175	10.50757	10.54735	10.52205	10.52982
Folder 15	11.20375	11.13972	11.17125	11.19316	11.17263	11.16788
Folder 20	11.57783	11.55079	11.52287	11.58661	11.53433	11.5338

## Chapter 7 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](http://www.samhallas.co.uk/repository/tim_2015.htm)

## Contributing historical recordings that you made from the telephone

You can provide us with 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.

## Testing your newly created voice files

Testing is a straightforward business. Having saved your 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
<b>TOTAL</b>	<b>9.4 seconds</b>

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

## Chapter 8 Revisions to this manual

V1.0 Original version.

**For further information** please re-read this document.

## Chapter 9 Safety notice and legal disclaimer

There are no hazardous voltages inside the case of the TIM 2015 speaking clock, which operates using the low voltage of 9 to 12V DC.

The information and advice provided in the User, Assembly and Technical Manuals and any advertisements and leaflets are purely advisory and given in good faith, without any legal engagement or responsibility.

Errors and omissions excluded.

Making repairs and assembling TIM 2015 from piece parts will involve the use of knives, saws and soldering irons. It is assumed that people are aware of the risks involved and are capable of assessing their own competence. Neither the Telecommunications Heritage Group nor Unusual Electronics will take responsibility for user misadventure.