ASSEMBLY 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) please check for a newer version. Thank you for your understanding.

PLEASE NOTE: This is the *Assembly 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. Technical information is shown in the *Technical Manual*.

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.

And now

Even if you don't normally read instructions, please break the habit of a lifetime and… read *ALL* of this first! You don't have to read the manual from start to finish in one session. Reading this manual will give you a good understanding before you start construction.

A labour of love

Constructing your speaking clock will be a labour of love, just as the task of designing and supporting the product is. 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 on an Open Source basis. 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. We hope users will share their experience of building and using TIM 2015 with the design team and possibly collaborate in future upgrades.

Our thanks to you — and your guarantee of satisfaction

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 with reasonable care! 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).

Please handle with care!

Unfortunately it's possible to damage TIM 2015 — but only if you overdo things, thank goodness! 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 could well 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. Don't swap components when the unit is powered — turn it off first. 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. 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.

Make sure you read the User Feedback section in Chapter 8, where you can benefit from what other users have discovered and see how they constructed their clocks.

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. Sam Hallas describes there how he built his own TIM 2015. It's well worth reading!

Your comments matter

We welcome your opinions! 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 . 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, Ross Herbert, 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 as soon as the website has been created.

TIM 2015 IS A COLLABORATIVE, INTERNATIONAL AND NOT-FOR-PROFIT PROJECT

THE PRODUCT ITSELF IS DESIGNED

AND MADE IN BRITAIN

Index to the Chapters of this manual

Each Chapter begins on a fresh page.

Information on —

- **Menu settings**
- **Other settings and housekeeping tasks**
- **Problem solving**
- **The voices of TIM 2015 and how voice files work**
- **Time synchronisation**
- **FAQ file**
- **Using Wi-Fi to synchronise TIM 2015**
- **Using radio time signals to synchronise TIM 2015**
- **Using GPS to synchronise TIM 2015**

— will be found in the companion TIM 2015 **User Manual**.

Technical issues and background material are discussed in the companion TIM 2015 **Technical Manual**.

- ***Text continues on next page.***

Chapter 1 Basic familiarisation

Please spend a minute or two reading this document before starting to construct your new TIM 2015 speaking clock.

This section of the manual describes the end result of your efforts. It also explains the controls, the on-screen messages and how the various connections are made.

1.1 Controls and connections

This assumes that you are using the recommended design of plastic case, the overlays for the front and rear panels and the bezel that surrounds display screen on the 'lid' of the case (see photos below). The first two photos show an early prototype that was built before we thought of the bezel (which conceals any rough work when you pierce the opening in the top of the case).

- ***Text continues on next page.***

1.2 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).

Not sure what a ROKA connector is? Not a problem; we have illustrated all the special parts used in TIM2015 later in this chapter.

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.

- ***Text continues on next page.***

1.3 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 dependent on their availability in China (we supply them to 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 Chapter 4 of this manual for what these messages mean and how to mitigate them).

This screen (on a yellow display) shows the time (12-hour clock) and date plus some status icons, as you can see in the following photo. 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 four **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 six **time source icons**:

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

MSF, **DCF**, **WWV** and **JJV** are the callsigns of radio transmitters (located in the UK, the USA and Japan respectively) that broadcast a continuous time signal in the low frequency waveband.

GPS refers to synchronising signals received from navigation satellites that circle the Earth at an altitude of about 20,000 km (12,427 miles).

NET signifies that synchronisation is taken from time servers connected to the Internet, using Wi-Fi on your premises to connect to the Internet.

The time sync and time source icons are displayed only 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).

1.4 LED lamp indications

We use four LED (light-emitting diode) lights on the front panel:

- The **green** LED indicates power is correctly applied to TIM 2015.
- The **yellow** LED indicates that TIM 2015 is showing the correct time (time has been synchronised within the last 72 hours).
- The **red** LED indicates that a call is in progress
- The **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 attached to modules fixed to the printed circuit board inside the case of TIM 2015:

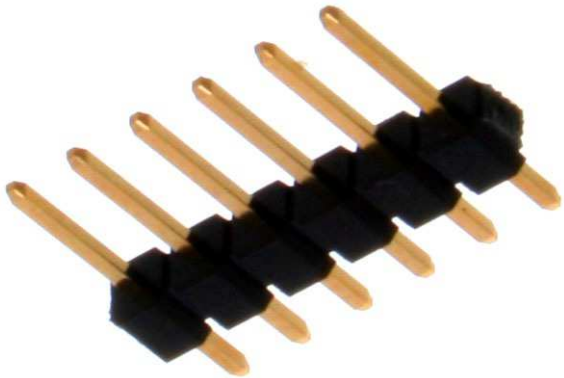
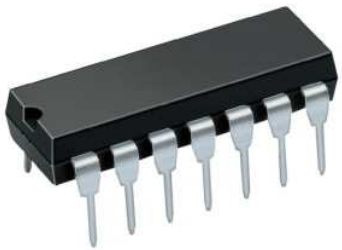
- A **red** LED on the Real-Time Clock (RTC) module conforms that power is reaching the RTC module.
- A **green** LED on the Catalex sound module indicates that an audio file is being played.

1.5 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.

1.6 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.	
Bug	*See **IC** below.*
Chip	*See **IC** below.*
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.

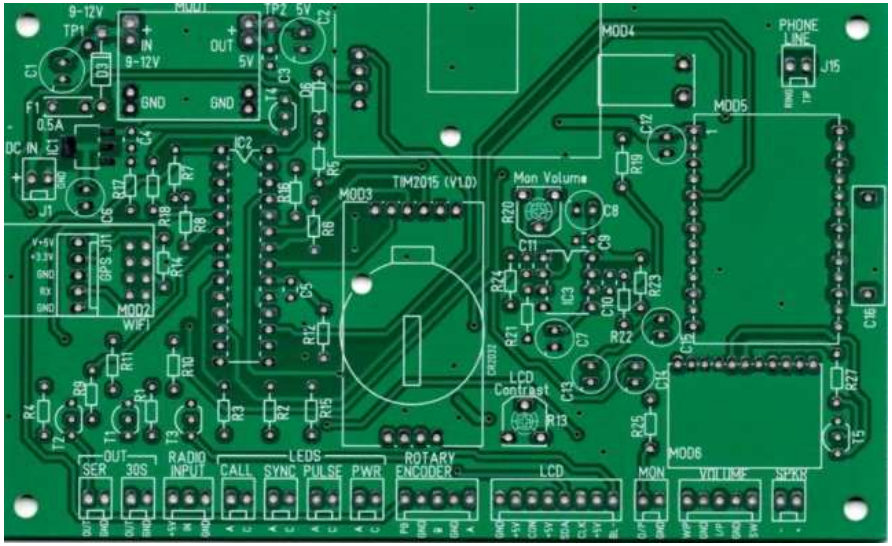
GMT	Greenwich Mean Time is the specified at the Royal Observatory in Greenwich, UK. GMT stays the same all year round and is unaffected by any Daylight Saving Time (DST).
GPS	The Global Positioning System (GPS), formerly known as Navstar, is a space-based radionavigation system owned by the United States 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.
Header strip or Pin header Pin headers, also known as Berg connectors, are often associated with ribbon cable connectors. The most common pitch (distance or spacing between pins, as used in TIM 2015, is 2.54 millimetres (0.1 inch). Pin headers can be either *straight* or *angled*. The latter form is often used to connect two boards together. Headers are often sold as long strips that can be broken off easily to give the right number of pins.	
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.	

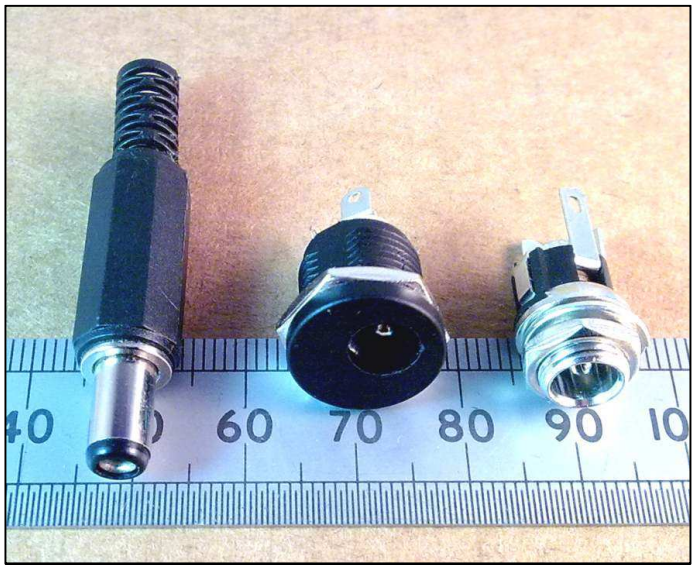
Second picture courtesy of the admirable Evil Mad Scientist website. Visit http://www.evilmadscientist.com/2007/one-minute-project-chip-bugs/	
LCD screen An electronic 'liquid crystal display' that is used with TIM 2015 for displaying the time of day and other status information. The LCD used is a physically 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. LEDs fitted to control panels always look tidier if they are enclosed in a **bezel** like this one is.	

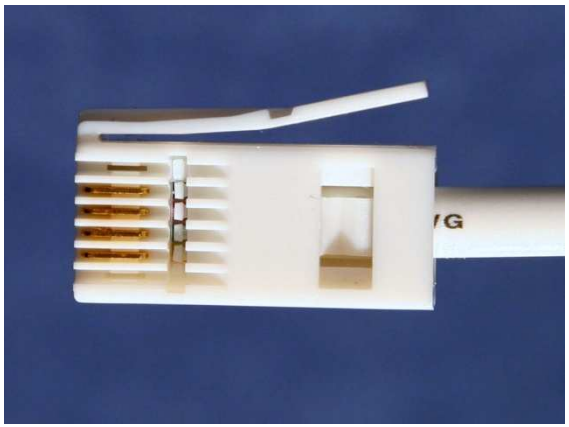
Locking connector TIM 2015 uses industrial-grade plugs and sockets that are locked in place using an outer ring that you turn to tighten. This prevents any accidental disconnection. Two, three and four-pin connectors are used, making it impossible to mate the connectors wrongly. This particular style of connector is designated the GX 16 series.	
Loudspeaker volume control	*See **Switched potentiometer** below.*
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. Micro SD cards come in a variety of 'Class' ratings, shown as a number inside a letter **C**. The greater the rating, the faster you can write data to the card (and the higher the price!). However in TIM 2015 we have little interest in write speeds, so you can safely buy the cheapest cards available (generally Class 2). So save your money! Why so? Because any rating of card will be fast enough for use in TIM 2015. The uncompressed CD audio (16/44.1 WAV) files that we use have a bit rate of 176.4 kilobytes per second, which is probably at	

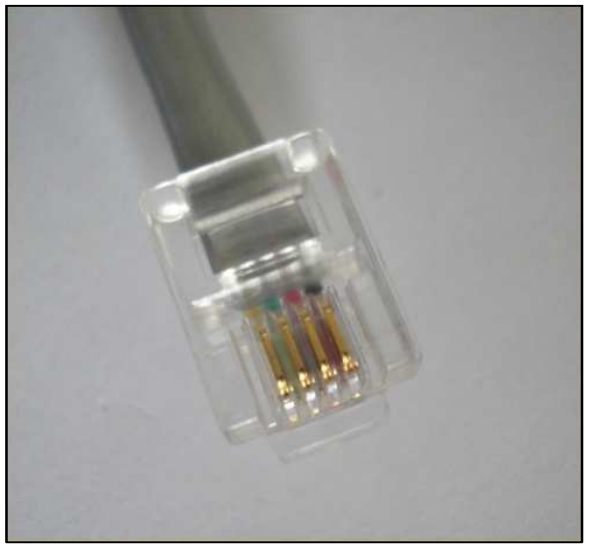
least 10 times below what the slowest SD card can provide. More at https://www.howtogeek.com/189897/how-to-buy-an-sd-card-speed-classes-sizes-and-capacities-explained/	
Microcontroller A small computer on a single chip containing a processor core, memory, and programmable input/output peripherals. It manages and controls the operation of all the other chips.	
Multifunctional menu selector	*See **Rotary Encoder** below.*

Molex connector (male) TIM 2015 makes extensive use of **Molex KK series** 'wire to board' connections to link flying lead wires to the main board, the male connector being an unshrouded multi-pin header device as shown in the photo. A protruding flange interlocks with a feature in the plastic shell of the female connector to prevent the two parts being disconnected accidentally.	
Molex connector (female) This is the corresponding female connector that mates with the header pins. Each channel or 'hole' accommodates a single wire to which is crimped a folded metal contact that is held by spring pressure against the corresponding pin of the header connector. There are a number of differing KK series connectors, not all of which are entirely interchangeable. TIM 2015 uses the KK 6373 series of connectors.	
Pin header	*See **Header strip** above.*

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*	
Rotary encoder This is a rotary switch that produces an electrical impulse each time it is turned either clockwise or anti-clockwise. The microcontroller to which it is connected counts (detects the number of) pulses produced, also the direction the switch was turned. The switch also incorporates a press button that provides extra functions. *Image courtesy of our supplier,* *http://stores.ebay.co.uk/AI-Smart-Chips*	

Switched potentiometer A potentiometer used as a volume control (upper three solder tags). It also incorporates an on/off switch, making it ideal for use at the volume control of the miniature loudspeaker used for checking the audio produced by TIM 2015. Other designs are available but check that they will fit the space available.	
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 technique can be used for synchronising the time in TIM 2015. A low-cost adapter that plugs inside TIM 2015 is used for this.

Chapter 2 | Preparing the plastic case

This chapter assumes that you use the recommended case, measuring 175 x 130 x 58mm. This is the ideal size for the printed circuit board and for which we provide computer-engraved overlay parts.

It was sold by Maplin Electronics (https://www.maplin.co.uk) as their **ABS plastic instrument case, Black**, order code KC61R. However, as the company is now in administration, this source is no longer an option. An alternative supplier is Terrington Components (http://stores.ebay.co.uk/Terrington-Components). They appear to have bought all of Maplin's remaining stocks. The company can also supply direct (avoiding eBay) *but only in quantities greater than 50* (http://www.terrington-components.co.uk). Their description is **ABS Instrument Case Project Box with End Panels and Vents 175mm x 130mm x 59mm** and they supply it in either black or pale grey (grey is sometimes marked 'out of stock').

See end of the document for another suitable case, the Hammond 515-0940, available from numerous suppliers in Britain, North America and Australia.

2.1 Piercing the openings

This section of the Assembly Manual will show you how to turn a blank case into a completed TIM 2015. But take your time over this task; if you mess it up you will need to buy another case, which would be a waste of time and money! So more haste and less speed.

You might be surprised how easy it is to ruin a brand-new plastic case — until you try to do it yourself. There is no easy or quick way, but if you follow the instructions in this chapter you stand a good chance of getting it right. Maybe you know a better way and if so, please tell us, to save others from struggling.

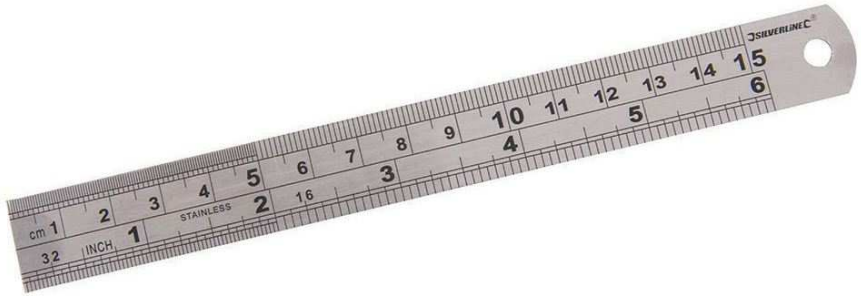
We need to do three things:

1. Drill holes in the case lid and open up a rectangular opening for the liquid crystal display (LCD);
2. Drill holes in the bottom of the case for the screws that fasten the printed circuit board (PCB);
3. Make circular openings in the front and rear panels for the connectors, controls, LEDs and loudspeaker.

Let's go through the processes involved and remember, take your time! There is nothing to be gained by rushing this project. If you do, you'll probably miss something. So relax and take it easy. If you like, complete just two or three steps an evening. Whilst there's nothing complex in the construction, each step requires your concentration. It may not be a good idea to start this when you are tense after a hard day's work…

2.2 Tools required

To do any job properly you need to use the right tools for the job. Truly. Virtually off of these can be found on eBay if you cannot find them in local tool stores or hobby shops.

Scriber with a hardened steel point. Various styles are available.	
Six-inch steel rule (longer ones are fine).	

Sprue cutter, very handy for cutting off excess component leads as well for cutting plastic. It is designed for cutting soft materials and very thin wire. Do not use it for cutting steel wire (piano wire, music wire), as this action is guaranteed to ruin the blades permanently.	
Plastic hobby cutter/scriber. Look for this in hobby shops and on eBay.	

End cutters.	
Rechargeable battery screwdriver, with a hex chuck. A low-cost one is fine. Price on eBay around £15 or $20.	

Set of 3 step cone drills: 4-12mm 4-20mm 4-32mm Price on eBay around £12 or $15.	
Set of titanium-coated High Speed Steel drill bits with hex shanks (1.5-6.5mm). Price on eBay around £5 or $7.	

Countersink bit with ¼" hex shank (often sold in sets of three).	
Pin chuck (often mis-named as a pin vice, which is something entirely different!)	

2.3 Piercing the lid

This is the trickiest part. You need to drill the case with extreme precision (a) for the four screws that fasten the LCD screen and (b) to mark where the rectangular opening needs to be extended to. After that you need to chop out the grille moulded in the lid and widen the opening to make room for the LCD. We made a jig for getting this right, so we will drill pilot holes so that you can carry on in the right places.

But before this you need to **inspect and prepare the case**. The first thing to do is to examine the base and lid of the case. You should see a base (with four holes for the fastening screws) and a lid (with no holes). However, the clowns who pack these cases are dab hands at providing you with a set of either two lids or two bases, which is no help at all. I bought a carton of 12 of these cases and only two were correctly packed! On my next batch four out to the ten were unmatched pairs. Fortunately I was able to make proper cases out of the mismatched parts on each occasion. You might not be as fortunate.

If all's well, open the shrink wrap and to avoid losing the bag of fastening screws, use a piece of masking tape to fix this bag inside one of the two halves of the case. The upper and lower parts of the case are not identical (as mentioned above) and they are both 'handed' (one of the short sides has a tongue, the other side a groove).

Handedness is important!

Before we start any marking or drilling we need to put temporary labels on the top and bottom parts of the case so that the top and bottom match correctly. The top and bottom of the case **are not identical**; both have ventilation grilles but only the *base* has holes for the fixing screws.

- Taking the *top*, turn it over and note how one end has a ridge and the other end has a groove. Turn it upright again and stick a label saying **L/H END** (left-hand end) above the ridge.
- Taking the *bottom*, turn it over and note the ridge and groove. Turn it upright again and stick a label saying **L/H END** (left-hand end) above the groove.

Illustration follows on next page.

Marking the top and bottom of the case with temporary labels. The (grey) top has ***no holes****, whereas the (black) bottom has* ***four fixing holes at the outer edges****. In this photo four additional holes have been drilled to fix the printed circuit board (PCB) but you will do that later.*

Time to start drilling

Start with the lid of the case (it has no screw holes at the outer corners). We have drilled a total of eight 1mm pilot holes for you in the lid of the case. The outer four 1mm pilot holes are for the screws that fasten the LCD. Using the cordless screwdriver and a 2.5mm hex shank drill, enlarge these outer holes, first to 2.5mm diameter and then to 4mm.

By good fortune the ventilation grille in the lid is almost the right size for the 78 x 51mm bezel of the LCD (these dimensions are identical in more than 20 displays examined but do check that your bezel measures 78 x 51mm). Using the scriber and a 6-inch steel rule, scribe straight lines between the four holes of the **inner (smaller) rectangle**. Do this extremely carefully, gripping the steel rule so that it cannot slip. Scribe carefully and **avoid extending the lines beyond the pricked-out dots**; you do not want to deface or mark the visible area of the top of the case. **Do not** 'join the dots' with the scriber for the larger rectangle, as these witness marks for four screw holes, not a rectangular opening.

Get hold of the cordless screwdriver again, go back to the inner four 1mm pilot holes and open them out using a 2.5mm drill. The enlarged holes will prevent you from cutting too far when you use the plastic cutter to score these lines deeper in the next stage. While you are about it, drill a 4mm hole at the dead centre of the grille. This will make it easier to remove the waste material.

Now you create the opening for the display bezel. This is the most tedious task, on which you need to proceed very slowly and carefully.

You will recall that we have drilled holes for the inner rectangle and scribed straight lines between these holes. The scribed lines mark the left- and right-hand vertical edges of the opening made for accommodating the liquid crystal display. The upper and lower edges of this opening are created by removing the vent grilles that were moulded in the top of the plastic case — and then extended outwards towards the scribed lines.

Step one is to remove the bars of the grille carefully, using a Hobbycraft or Italeri sprue cutter (same product, different branding; find it on eBay) to snip through them. See below for photo.

Illustration follows on next page.

You can use small pliers to bend up the bars to make them easier to remove. The result will look crude but do not worry, because the escutcheon plate applied later on will hide the rough edges.

Now get hold of a plastic cutter, as used by model aircraft and model railway enthusiasts. Some model shops keep them and they are plentiful on eBay (search for **Plastic Hobby Cutter Scriber**). These clever gadgets cost about £7 or $10 and a real boon. They have a curved hook that is extremely sharp (warning!) and slices a groove through plastic. Using a steel rule as a guide, draw the blade three times along each of the scribed lines on the case top. Three or four 'scrapes' are sufficient; *do not try to cut all of the way through*. **Do not** scribe beyond the holes you have drilled and do make sure you keep the blade hard against the steel rule (**do not** let it skid away and mark other areas of the case top).

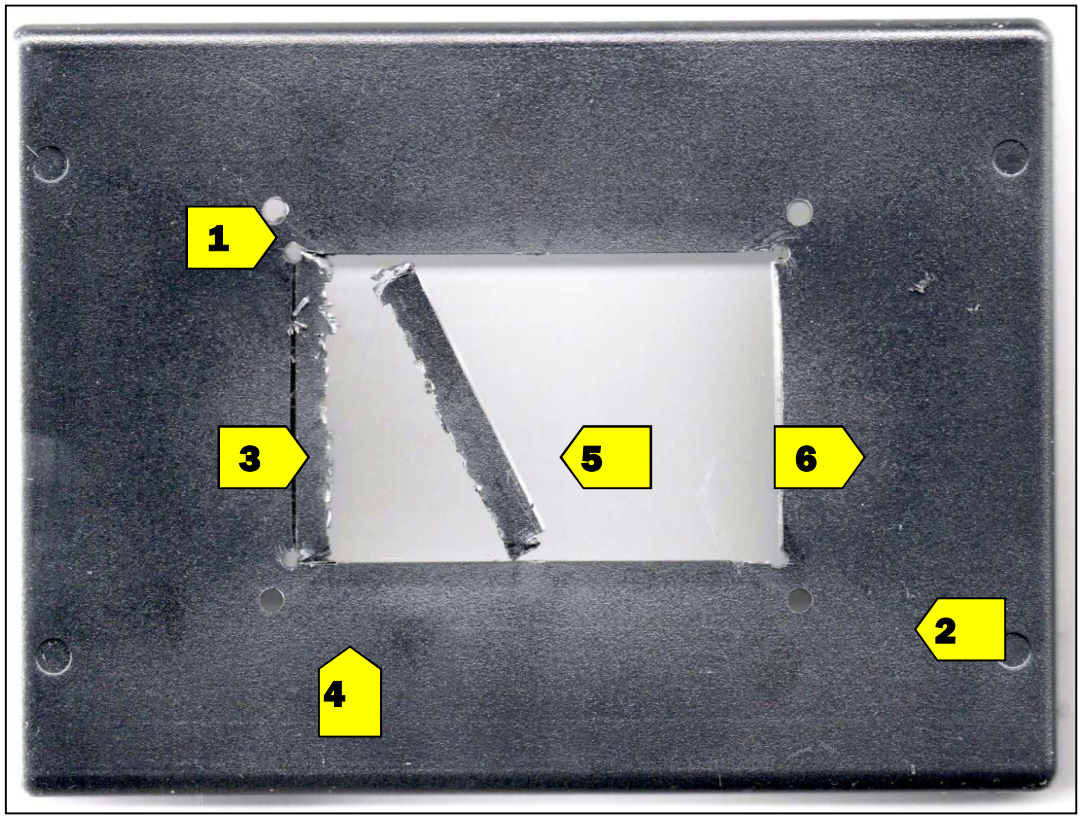
You will also need a set of small **end cutters**, about £3 ($5) from model shops or eBay. Here's what the two tools look like.

Plastic hobby cutter/scriber.

End cutters.

Use the end cutters to grip the waste material and 'wiggle' each piece up and down until it falls off. You will be surprised how easy it is to remove material, simply because the groove cut with the cutter/scriber weakens the plastic very effectively. While you have the cutters in your hand, use them also to remove the two bosses moulded on the underside of the case that foul the area where the display will be fitted.

- There are other methods of cutting the rectangular opening. Some people report good results using a small circular saw disc fitted to a Dremel tool, whilst others have tried keyhole saw or razor saw blades with an X-Acto tool handle. Do feel free to try these if you feel confident!



Not a pretty sight but fortunately the rough handiwork seen here will be hidden later by the bezel frame shown in the next photograph. So what we have here? This is the top of the case after four holes have been drilled, all ribs of the ventilation grille have been 'pruned' away using a sprue cutter and one of the two unwanted slabs of plastic have been removed.

1. *One of the four outer holes, drilled first 2.5mm and then enlarged to 4mm.These are used for the bolts securing the LCD screen.*
2. *One of the four inner holes, drilled 2.5mm. These are used to simplify piercing the opening for the LCD screen.*
3. *Deep groove or score mark in the plastic made by the special Plastic Hobby Cutter Scriber, ready for breaking off using an end cutter tool.*
4. *Short score mark made in the same way, to ease removal of the slab of unwanted plastic.*
5. *Corresponding piece of plastic removed from the right-hand end of the 'window'.*
6. *The pale edge revealing where one slab of unwanted plastic has been removed.*

The opening you have now created may look a little rough but a coarse file will remove any irregular edges. If you have made the opening too large, do not worry. The special bezel frame or escutcheon plate (see photo on the right) will hide any untidiness.

2.4 Drilling the base

We now work on the base of the case (it has screw holes at the outer corners). With the base in front of you, hold it so that the end marked **LEFT** is indeed on the left. It will look rather like this but of course will have no parts fitted yet.

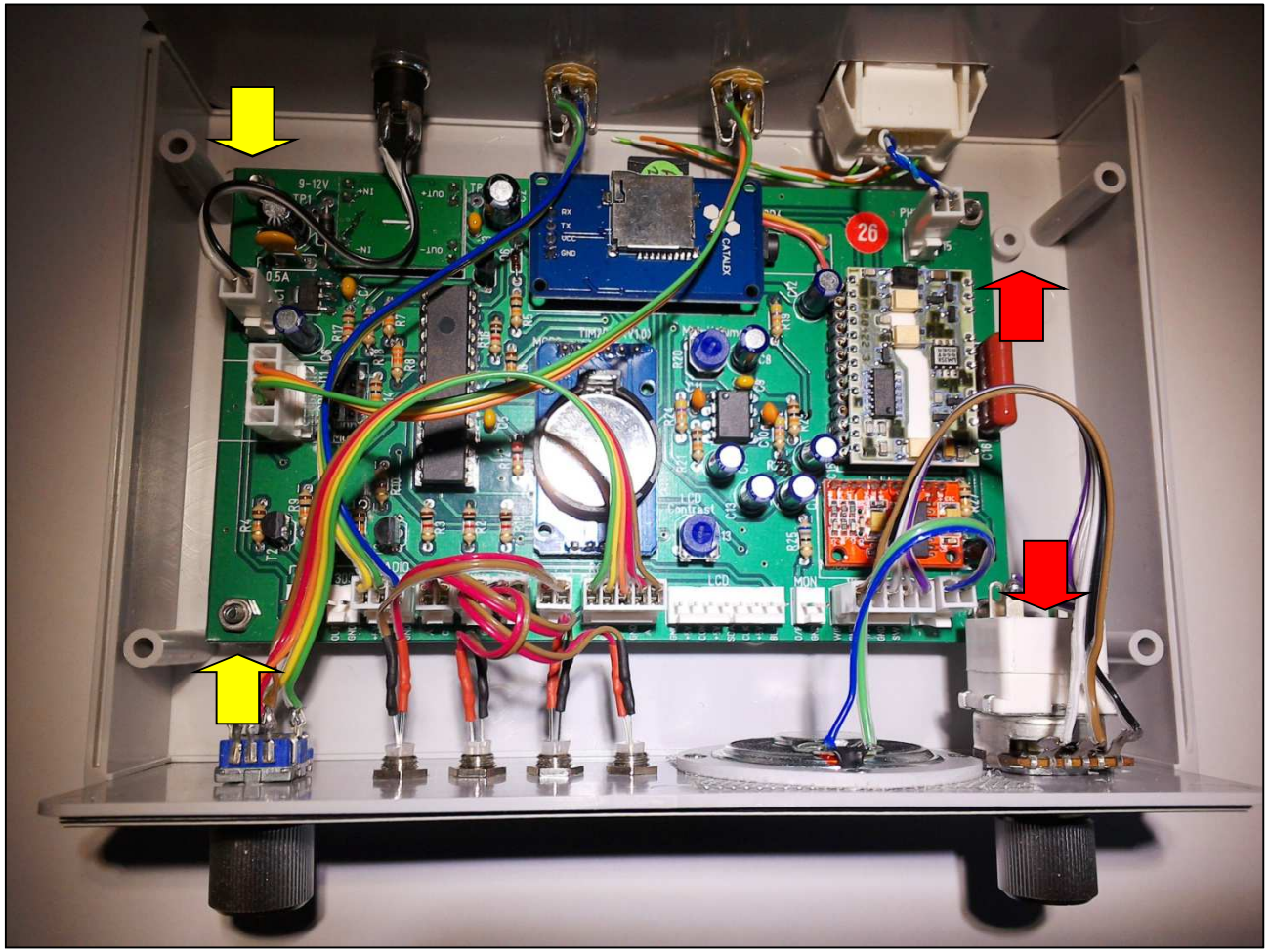
Now turn it over and observe the three pairs of raised bosses. We shall use the pair at far left, marked with yellow arrows. We shall not be using the pair at far right, marked with red arrows. As for the pair closer to the centre of the case, remove these two with end cutters or the sprue cutter.

Next we drill through the two raised bosses on the left (yellow arrows) with a 3mm drill. Now turn the base of the case over again. Take your printed circuit board (PCB) and lay it directly on top of the case, with two holes at one end (it doesn't matter which) directly above the two holes you have just drilled. Take two of the long self-tapping screws provided for fastening the upper and lower halves of the case together and use them to (temporarily) fix the PCB firmly in place on the outside of the case. You will find the screws a fairly tight fit in the boss, so screw them down as far as they will go, so as to clamp the PCB firmly. How tight? Tightly enough to clamp the PCB firmly, so that the PCB cannot slip when you make pop marks/witness marks in the case through the holes of the PCB at its other end, as explained next.

These two holes at the other end of the PCB will serve as a locator for where we need to drill two 3mm holes in the base of the case. Using the steel scriber make two marks accurately in the centre of the holes in the PCB. Press firmly to make distinct pop marks for the drill bit.

After this, unscrew the PCB, put the self-tapping screws aside and drill the two 3mm holes.

Finally use a countersink bit (gently) to make a slight countersink entry to the four holes drilled so that the 12mm-long countersunk-head 3mm screws you will insert here will sit tidily. If you can find four sticky felt feet at a hardware store (there are plenty on eBay too), put one of these under each corner to protect the table or desk surface where the finished TIM 2015 will be placed.

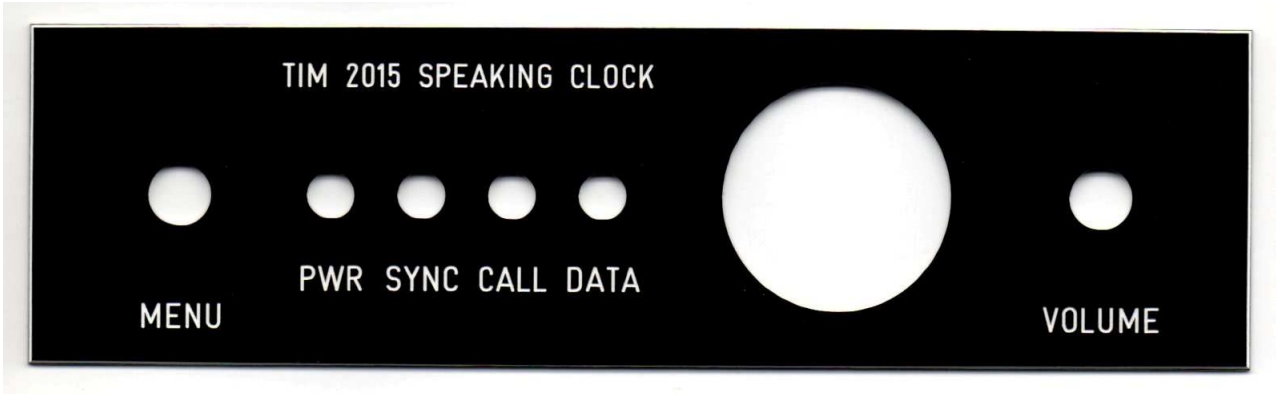


The photo above, taken by Dave Whistler, shows off (among other things) the incredibly neat way he builds projects! He has used his own choice of (different) input and output connectors, together with an alternative method of securing the loudspeaker that uses a plastic 'washer' rather than cool-melt glue.

Shopping list

- You will need four M3 x 12mm screws (eBay http://www.ebay.co.uk/itm/Phillips-Machine-Countersunk-Screws-DIN-965-Stainless-Steel-A2-M3-3mm/112034977761) and six M3 nuts (http://www.ebay.co.uk/itm/112033705391). Why six nuts? Because you will need two more to raise the right-hand end of the PCB and make it stand roughly the same height as the left-hand end, which rests on bosses! You are bound to drop some nuts and bolts, so buy at least a dozen of each.

2.5 Piercing the front panel



The front panel has pilot holes drilled for two controls, four LEDs in holders and the sound outlet from the loudspeaker. Start by opening out each of the pilot holes to 2mm. Enlarge the LED holes to 5mm. Enlarge the other three holes to 4mm With this done you can insert the thinnest part of the step cone drill and then use this tool to open out the mounting holes for the two controls to 7mm and 30mm for the loudspeaker. The opening that you make for the loudspeaker needs to be slightly larger than the hole in the front panel to ensure a tidy look.

Please note: when you drill really large holes (25mm diameter upwards) with the step cone drill bit, you need to do it very gently and carefully. Drilling (relatively) large holes in thin materials is never an easy task and it's also a tough challenge for some electric drills. Be assured that the plastic panel will do its very best not to stay still; instead it will try to whip round on the tip of the drill. To avoid a nasty accident make sure the plastic panel is clamped and secured really well.

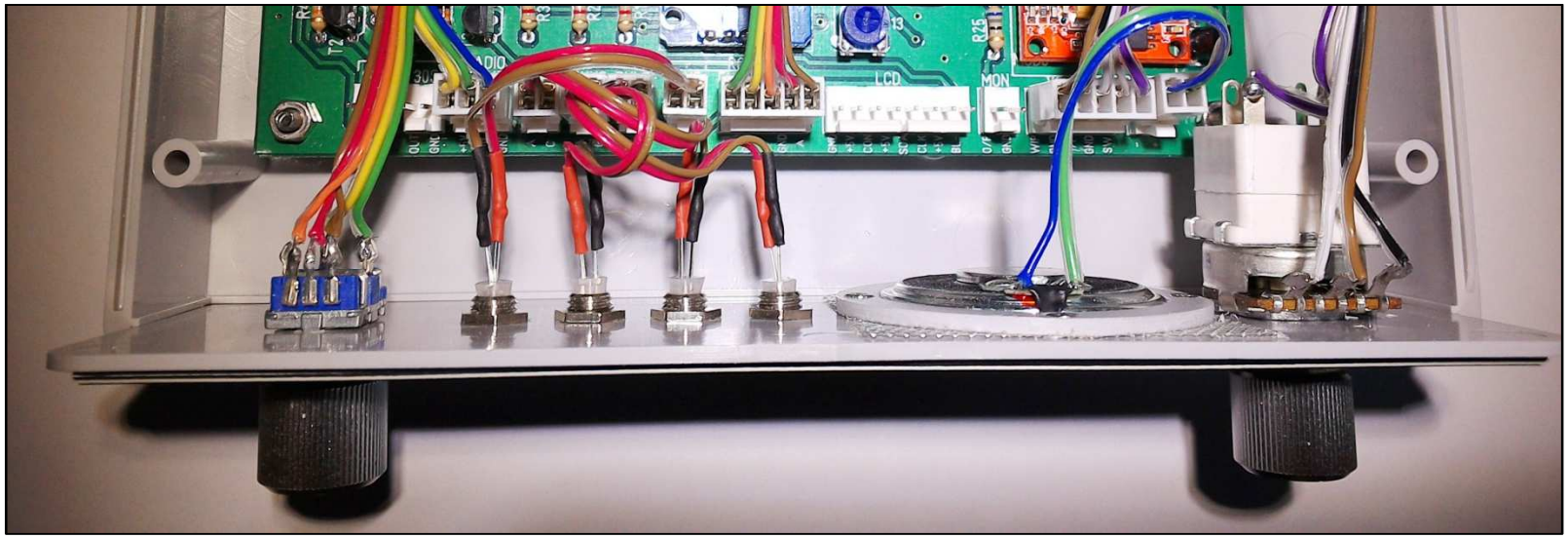
If you have a well equipped workshop you will know that a better way of cutting large holes in thin material is to use a Q-Max sheet metal punch (https://www.cromwell.co.uk/shop/hand-tools/punches-wad-and-hole/q-max-sheet-metal-cutter-hole-punch-1-1-8inch-diameter-

round/p/QMX0451022N) or else a ‘tank cutter’ tool (https://www.cromwell.co.uk/shop/hand-tools/hole-cutters/20-76mm-adjustable-hole-cutter/p/KEN5974520K). But this would be an additional expense that many constructors might prefer to avoid.

With all the holes in the front panel drilled, you can now slip the engraved overlay, centred over the front panel in order to check the holes you have just drilled match up with the openings in the overlay. They certainly should do but if not, you can enlarge the holes in the rear panel (not the overlay) so that the four LEDs and two control shafts fit comfortably through the holes and openings. Finally you can fix the overlay to the panel. Cut some sections of double-sided clear tape (available on eBay), offer it up to the panel and when you are certain that the overlay is properly centred, press the overlay firmly in place. The reason for this centring is because the panels (with their overlays) slide into grooves in the case, which clamp the panels in place. You need an equal margin of clear space to the right and left of, and above and below the overlay for the panels to fit properly.

The LEDs and user controls can now be fitted as shown in the photos on the next page.


TIM 2015 SPEAKING CLOCK
MENU
PWR SYNC CALL DATA
VOLUME



2.6 Fixing the encoder switch

This fits in the left-hand opening, above the legend MENU. See photo on previous page.

2.7 Fixing the volume control

This fits in the right-hand opening, above the legend VOLUME. See photo on previous page.

2.8 Fixing the LEDs

The green LED is fitted in the far left-hand opening, followed by yellow, red and blue. See photo on previous page.

2.9 Fixing the LCD display screen

This task is carried out later and described in Chapter 4, section 4.9.

2.10 Fixing the loudspeaker

We protect the delicate cone of the loudspeaker using a grille made out of aluminium mesh (expanded metal). The mesh sold by Isopon and Davids, available from Halfords and other car parts shops, is ideal for this purpose and is easy to cut neatly with kitchen scissors, taking care not to distort the flat mesh. You can also buy this material on eBay (search for Isopon mesh). The cost is £4 ($6) or less.

Measure the dimensions of the circular opening in the front panel and add margins on either side of at least ¼ inch (6mm). We will fix the mesh in place (on the inner or rear side of the panel of course!) using UHU glue or 'cool melt' glue from a glue gun (e.g. http://www.hobbycraft.co.uk/docrafts-cool-melt-glue-gun/603754-1000 or http://www.amazon.co.uk/Trigger-Stand-Sticks-Mains-Corded/dp/B00DFM6HLQ/ref=sr_1_2?ie=UTF8&qid=1446407562&sr=8-2&keywords=cool+glue+gun or search for **cool melt glue gun** on eBay).

When you are ready to start, put four small dobs of UHU glue (or cool-melt glue from a glue gun) just outside the big hole on the rear side of the front panel. Using a small screwdriver to hold the mesh in place while the glue is hardening, push the grille hard onto the glue so that the glue is worked into the mesh, having first checked that the mesh is straight horizontally and vertically, not crooked. Once the glue is fully cured and rigid, you can place the miniature loudspeaker correctly behind the circular opening and fix this too with glue. Spread the glue so that it overlaps the flange of the speaker and the surrounding mesh.

Cool melt glue is good for this task (because it sets so rapidly). It is quite soft and can be lifted and 'peeled off' if you make a mistake.

Read this note before starting this stage

A customer writes:

> On my first TIM 2015 clock I just glued the speaker grille mesh on the back of the plastic front, with the speaker glued on top of that. The second time, as I was assembling the engraved plate to the plastic front, I slid the mesh in-between, which meant I didn't have to glue it in place. It looks better from the front to me.

2.11 Piercing the rear panel

The rear panel has pilot holes drilled for four connectors, at least two of which are essential for using TIM 2015. As you cannot predict your future requirements we recommend fitting all four connector at the outset. Retrofitting them to an already assembled clock at a later stage could be tricky. Start by opening out each of the pilot holes to 2mm, then to 4mm. With this done you can insert the thinnest part of the step cone drill and then open out the mounting holes for these connectors to 14mm or 16mm as indicated in the table below.

Telephone line connector. We recommend using a 2-pin GX 16-2 'aviation connector', available on eBay. You need to open the mounting hole on the panel to 16mm diameter. *Photo courtesy of YBMY.*	
Auxiliary connector. This fitting is optional and the pinout is not defined. You may wish to use this for a line-level audio output, 30-second pulses for driving slave clock dials or other purposes. If you intend using this, we recommend using a 5-pin GX 16-5 'aviation connector', available on eBay. You need to open the mounting hole on the panel to 16mm diameter.	
Radio timecode connector. This is where you plug in the cable from the radio receiver module, if used. We recommend using a 3-pin GX 16-3 'aviation connector', available on eBay. You need to open the mounting hole on the panel to 16mm diameter.	
Input jack for the 9-12V DC power supply. It is compatible with the ROKA connector that is used on just about every 'wall wart' power supply connector. You need to open the mounting hole on the panel to 14mm (**not 16mm**) diameter. These connectors are available on eBay. Search for *DC Power Socket 2.1mm Chassis Panel Mount Female Jack Connector*. Some versions of assembled TIM 2015 clocks used a different (4-pin) connector (GX16-4), requiring a 16mm hole, but these ROKA connectors are probably a better choice unless you feel a need for the greater security of the locking GX-type connector.	

With this done, you can now slip the engraved overlay, centred over the rear panel in order to check the holes you have just drilled match up with the openings in the overlay. They certainly should do but if not, you can enlarge the holes in the rear panel (not the overlay) so that the connectors fit comfortably through the holes and openings. Finally you can fix the overlay to the panel. Cut some sections of double-sided clear tape (available on eBay), offer it up to the panel and when you are certain that the overlay is properly centred, press the overlay firmly in place. The reason for this centring is because the panels (with their overlays) slide into grooves in the case, which clamp the panels in place. You need an equal margin of clear space to the right and left of, and above and below the overlay for the panels to fit properly.

- ***Text continues on next page.***

2.12 Fixing the rear connectors

At this stage you should fix the four connectors in place. Wiring them is discussed later, in Chapter 5. The photo shows which connector goes into each opening. You may well decide to use a ROKA connector rather than a GX16-4 for the power supply input.

Do your best to align all four connectors in a straight horizontal line. Make sure that each connector has its keyway ridge at the lowest point in the circle (exactly half past the hour). After tightening the retaining nuts on the inner side you may decide to deter the nuts from loosening with a drop or two of superglue.

Chapter 3 Soldering the main board

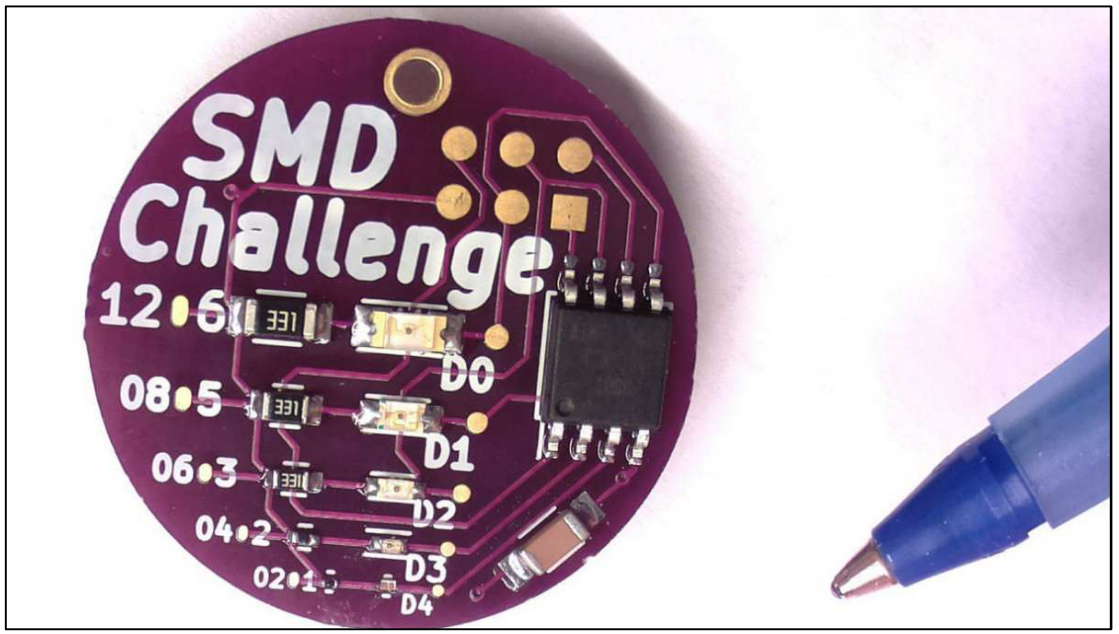
3.1 Some good news first

Look at the photo on the right. Does this look like child's play or does it fill you with horror?

If the latter, don't panic! Only one surface-mount component is used in the TIM 2015 project and it's quite large as surface-mount devices (SMDs) go. Even better, it has only three little legs, which makes it easy enough to solder so long as you have a fine tip on one of your soldering irons.

In case you are interested, the SMD Challenge is a kit for seriously advanced builders! More at

https://hackaday.io/project/25265-an-unfortunate-smd-project/ .



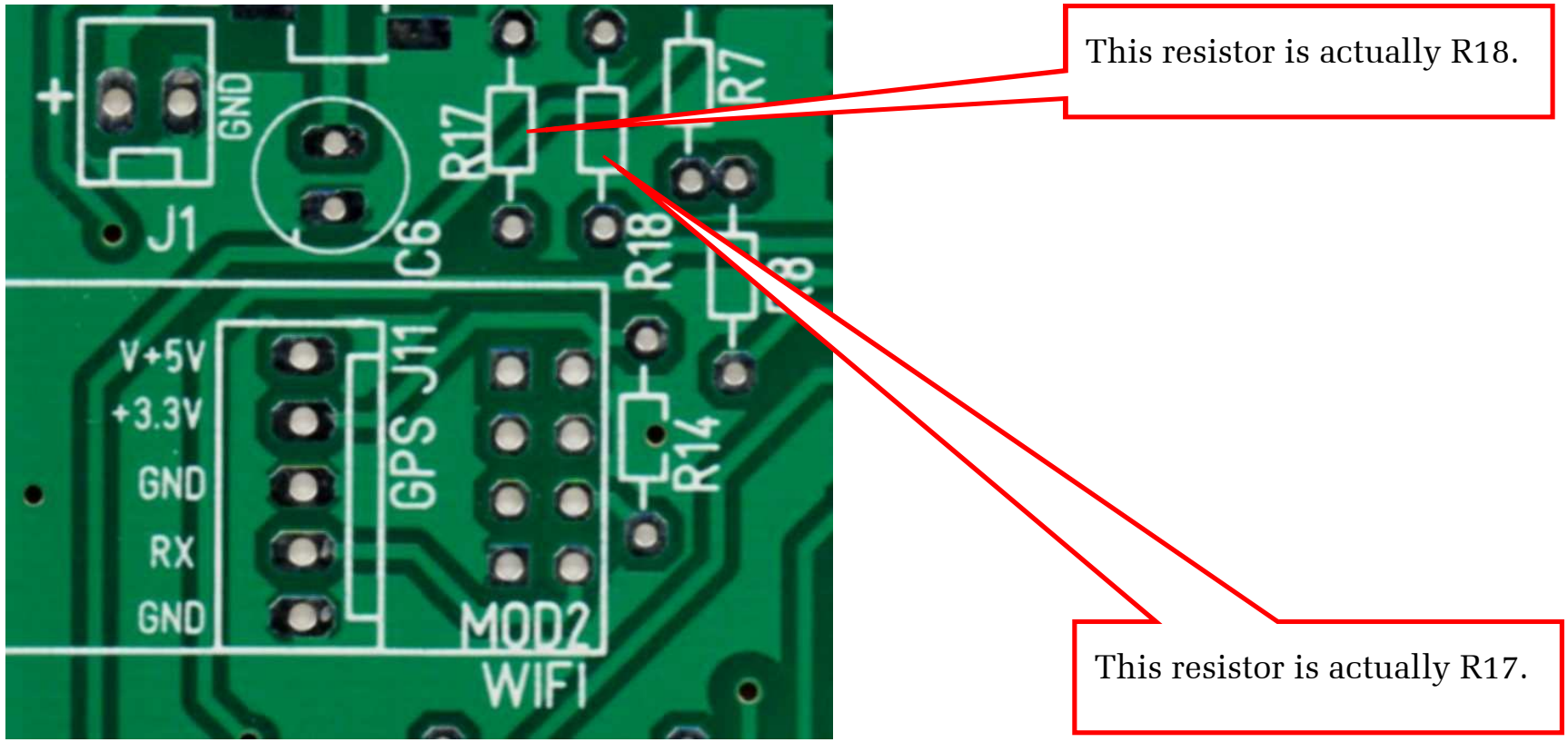
3.2 Cleanliness is next to godliness

The first task is to prepare the PCB and the wire-ended components that you intend to use. You will find that solder takes to the tracks and leads of resistors and capacitors a lot better if you do this. To clean the PCB tracks all you need is a quick rub with a Garryflex block (buy the 240 grit size, as the coarser types will likely damage the printed tracks). Garryflex is made for removing light rust or tarnish and restoring a bright metal finish particularly to cast iron and steel. Garryflex is a block approximately 80mm x 50mm x 20mm made of a flexible rubber-like compound impregnated with silicon carbide abrasive particles. Peco 'track rubbers' or 'rail cleaners' made for cleaning model railway track are equally good and you can find both of these on eBay.

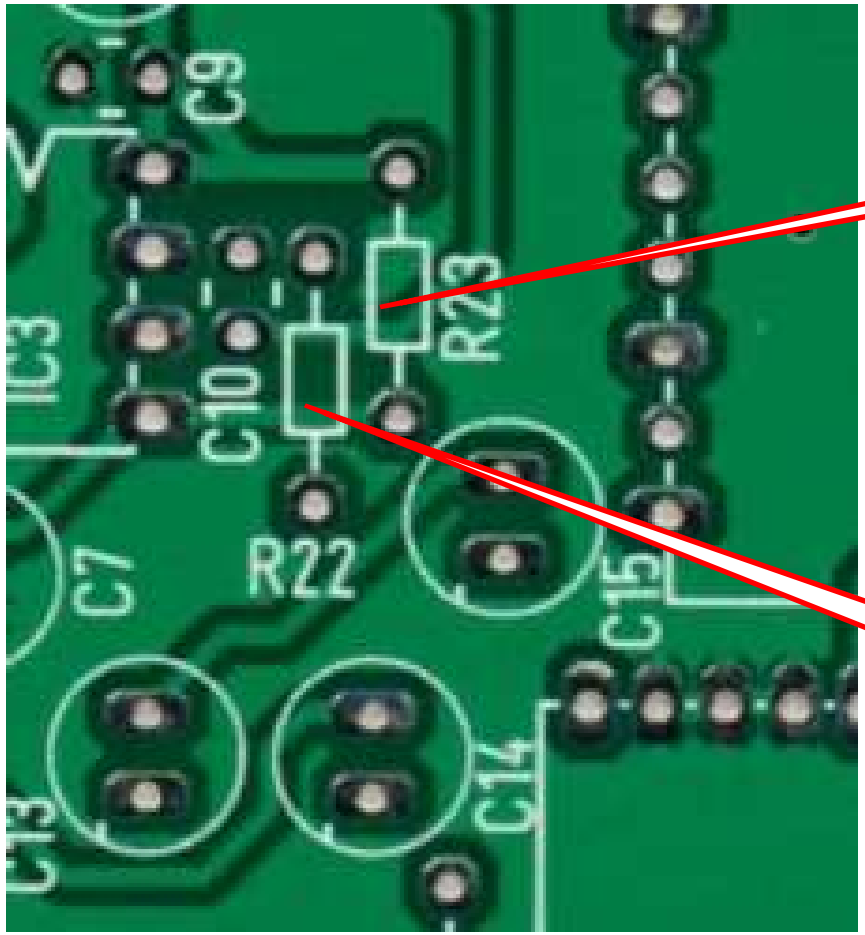
The leads of resistors and capacitors tend to get greasy and they can be cleaned simply by drawing the leads through a pair of lightly clenched pliers.

3.3 Clearing up our mess-ups

Yes, we do make mistakes and we even admit them! On the PCB there are two locations where the screen-printed white overlay that identifies each component is in error. Normally we mark up the boards with a spirit marker but just in case we failed to do this, please take a close look at your board.



R17 and R18 have been transposed. In fact the values (1k0 and 1k5) are very similar and the error will not affect operation — and relate only to the Wi-Fi module, which not everybody uses. But it's best to get everything right.



This resistor is actually R22.

This resistor is actually R23.

The labelling of resistors R22 and R23 is also transposed. The confusion does not stop TIM 2015 from working but it changes the bias of the two halves of operational amplifier IC3 and reduces the gain slightly on the main audio path.

So please take a moment to check that the markings on your PCB have been amended.

3.4 Components used

Component	Value	Package
C1	100µF	25V working electrolytic (pitch 2.5mm)
C2	100µF	25V working Electrolytic (pitch 2.5mm)
C3	0.1µF	50V working ceramic (pitch 2.54mm)
C4	0.1µF	50V working ceramic (pitch 2.54mm)
C5	0.1µF	50V working ceramic (pitch 2.54mm)
C6	10µF	25V working Electrolytic (pitch 2.5mm)
C7	10µF	25V working Electrolytic (pitch 2.5mm)
C8	10µF	25V working Electrolytic (pitch 2.5mm)
C9	0.1µF	50V working ceramic (pitch 2.54mm)
C10	1nF	1000pF 50v ceramic (pitch 2.5mm)
C11	1nF	1000pF 50v ceramic (pitch 2.5mm)
C12	10µF	25V working Electrolytic (pitch 2.5mm)
C13	10µF	25V working Electrolytic (pitch 2.5mm)
C14	10µF	25V working Electrolytic (pitch 2.5mm)
C15	10µF	25V working Electrolytic (pitch 2.5mm)
C16	0.47µF	250V (pitch 15mm) Panasonic ECQE2474JF
D1	Yellow LED	3mm LED (high brightness)
D2	Red LED	3mm LED (high brightness)
D3	IN4004	1N4004 1Amp rectifier diode
D4	Green LED	3mm LED (high brightness)
D5	Blue LED	3mm LED (high brightness)
D6	1N4148	Diode 75v 150ma general purpose
F1	0.5A	PolySwitch fuse 0.5A hold
IC1	LD1117-3v3	Low drop-out 3.3V 800mA regulator (SOT-223)
IC2	PIC18F25K22	Programmed microcontroller
IC3	MC33072PG	Op Amp (DIL8)
J1	DC_IN	MOLEX 22-23-2021 2-pin header
J2	SYNC_OK	MOLEX 22-23-2021 2-pin header
J3	CALL_LED	MOLEX 22-23-2021 2-pin header
J4	30S_OUT	MOLEX 22-23-2021 2-pin header
J5	ENCODER	MOLEX 22-23-2051 5-pin header

J6	SERIAL_OUT	MOLEX 22-23-2021 2-pin header
J7	RADIO_IN	MOLEX 22-23-2031 3-pin header
J8	POWER_LED	MOLEX 22-23-2021 2-pin header
J9	LCD	MOLEX 22-23-2081 8-pin header
J10	PULSES	MOLEX 22-23-2021 2-pin header
J11	Molex_5	MOLEX 22-23-2051 5-pin header
J12	Molex_5	MOLEX 22-23-2051 5-pin header
J13	HEADPHONES	MOLEX 22-23-2021 2-pin header
J14	SPEAKER	MOLEX 22-23-2021 2-pin header
J15	PHONE_LINE	MOLEX 22-23-2021 2-pin header
K1	C2x4	2.54mm 2x4way socket for Wi-Fi module
LS1	8Ω 2watt	34x34mm or similar speaker
MOD1	D-Sun Vreg	D-SUN 3A DC-DC converter module
MOD2	ESP8266	ESP8266 Wi-Fi module (type ESP-01) *This can be purchased ready-programmed from Unusual Electronics, see chapter on Wi-Fi in the User Manual.*
MOD3	DS3231_Module	RTC (Real Time Clock) module
MOD4	Catalex Sound	CATALEX MP3 player module
MOD5	MITEL modem	MITEL modem module
MOD6	Amp 3W	3W PAM8403 Amplifier module
R1	10K	Sub-Miniature resistor (0.25W)
R2	1K	Sub-Miniature resistor (0.25W)
R3	1K	Sub-Miniature resistor (0.25W)
R4	10K	Sub-Miniature resistor (0.25W)
R5	10K	Sub-Miniature resistor (0.25W)
R6	10K	Sub-Miniature resistor (0.25W)
R7	10K	Sub-Miniature resistor (0.25W)
R8	33K	Sub-Miniature resistor (0.25W)
R9	10K	Sub-Miniature resistor (0.25W)
R10	4K7	Sub-Miniature resistor (0.25W)
R11	10K	Sub-Miniature resistor (0.25W)
R12	2K7	Sub-Miniature resistor (0.25W)
R13	10K	6mm Pre-set resistor (LCD contrast)

R14	10K	Sub-Miniature resistor (0.25W)
R15	1K	Sub-Miniature resistor (0.25W)
R16	1K	Sub-Miniature resistor (0.25W)
R17	1K	Sub-Miniature resistor (0.25W)
R18	1K5	Sub-Miniature resistor (0.25W)
R19	47K	Sub-Miniature resistor (0.25W)
R20	50K	Pre-set resistor (monitor headphones volume)
R21	10K	Sub-Miniature resistor (0.25W)
R22	10K	Sub-Miniature resistor (0.25W)
R23	47K	Sub-Miniature resistor (0.25W)
R24	47K	Sub-Miniature resistor (0.25W)
R25	68R	Sub-Miniature resistor (0.25W)
R26	47K	Potentiometer (LOG) with switch
R27	10K	Sub-Miniature resistor (0.25W)
T1	BC547B	General purpose NPN Transistor TO92B
T2	BC547B	General purpose NPN Transistor TO92B
T3	BC547B	General purpose NPN Transistor TO92B
T4	BC327.25	General purpose PNP 800mA TO92B
T5	BC547B	General purpose NPN Transistor TO92B

Enc1	Rotary Encoder	20-step 12mm mechanical with push-button
LCD1	128x64 LCD	12864 128x64 Graphic LCD, blue or yellow back-light, ST7290 protocol (read section on displays in this manual)
IC socket	28 pin	0.3” DIP IC socket for microcontroller
socket	26 pin	Single Row Female 2.54mm Strip Header
		MOLEX 10-11-2023 2way Receptacle
		MOLEX 10-11-2033 3way Receptacle
		MOLEX 10-11-2053 5way Receptacle
		MOLEX 10-11-2083 8way Receptacle
		MOLEX 46999-0101 CONTACT crimps

Two knobs(6mm shaft) for controls
Power jack panel socket
Headphone panel socket (optional)
3.5mm stereo jack plug for sound module
Speaker grille material (see text in this manual)
LED bezels, panel-mount style (3mm)
Right-angle 2.54mm header socket for LCD
2.54mm header pins for LCD module
Micro SDcard (1GB)
CR2032 3V coin-cell
10 x M3 (3mm) nuts and bolts for PCB (we can supply black plastic M3 (3mm) bolts that match the bezel of the LCD)
Suitable case (see text in this manual)
12V or 9V DC power supply (switching type)

3.5 The parts list

Sam Hallas has very kindly made a parts list for the components used in this project. It is shown on the next page and you may well want to print a hard copy of this to keep on your work bench while you assemble the PCB.

It would be a good idea to tick each component when you have soldered it in place, as this will ensure that nothing has been forgotten!

- ***Text continues on next page.***

TIM 2015 components by type (*courtesy of Sam Hallas*)

Resistors

Designation	Value & Colours (3col/ 4 col)
R1, R4, R5, R6, R7, R9, R11, R14, R21, R22†, R27	10k Bn Bk Or/ Bn Bk Bk Red
R2, R3, R15, R16, R17†	1k Bn Bk Red / Bn Bk Bk Bn
R8	33k Or Or Or/ Or Or Bk Red
R10	4k7 Yel Vi Red / Yel Vi Bk Bn
R12	2k7 Red Vi Red / Red Vi Bk Bn
R13	10k (103) preset (LCD contrast)
R18†	1k5 Bn Gn Red / Bn Gn Bk Bn
R19, R23†, R24	47k Yel Vi Or/ Yel Vi Bk Red
R20	50k (503) preset (Headphone vol)
R25	68R Blu Gy Bk/ Blu Gy Bk Gld
R26	47k Log pot & switch (Volume)

† (NB R17 & 18 and R22 & 23 are transposed on the silk screening)

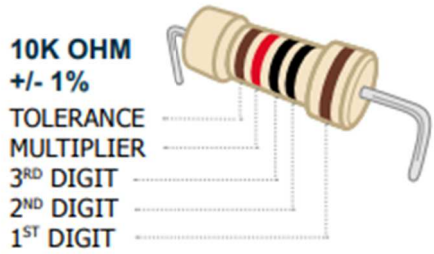
Capacitors

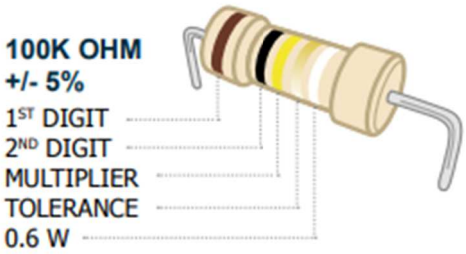
C1, C2	100µF 25V
C3, C4, C5, C9,	0.1µF (104) 50V
C6, C7, C8, C12, C13, C14, C15	10µF 25V
C10, C11	1nF (1000pF, 102) 50V
C16	0.47µF (474, Yel Vi Yel) 250V

Semiconductors

D1, D2, D4, D5	3mm LED Yell (Sync), Red (Call), Gn (Power), Blu (pulse)
D3	1N4004 1A 400V
D6	1N4148 150mA 75V Gen purpose
T1, T2, T3, T5	BC547B NPN
T4	BC327.25 PNP
IC1	LD1117-3.3 3.3V 800mA regulator
IC2	PIC18F25K22 microcontroller
IC3	MC33072PG Operational Amp

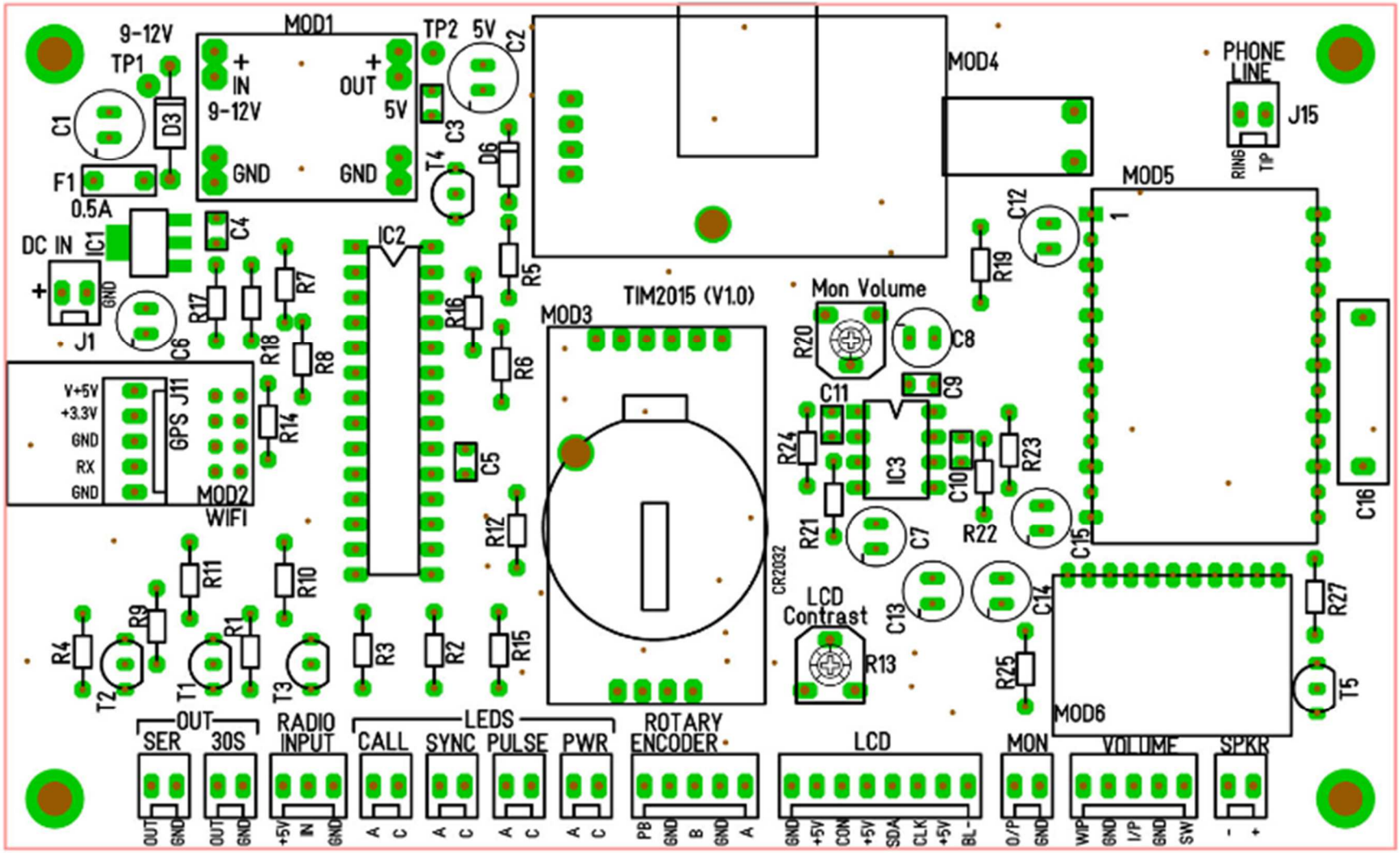
RESISTOR
COLOR CODE



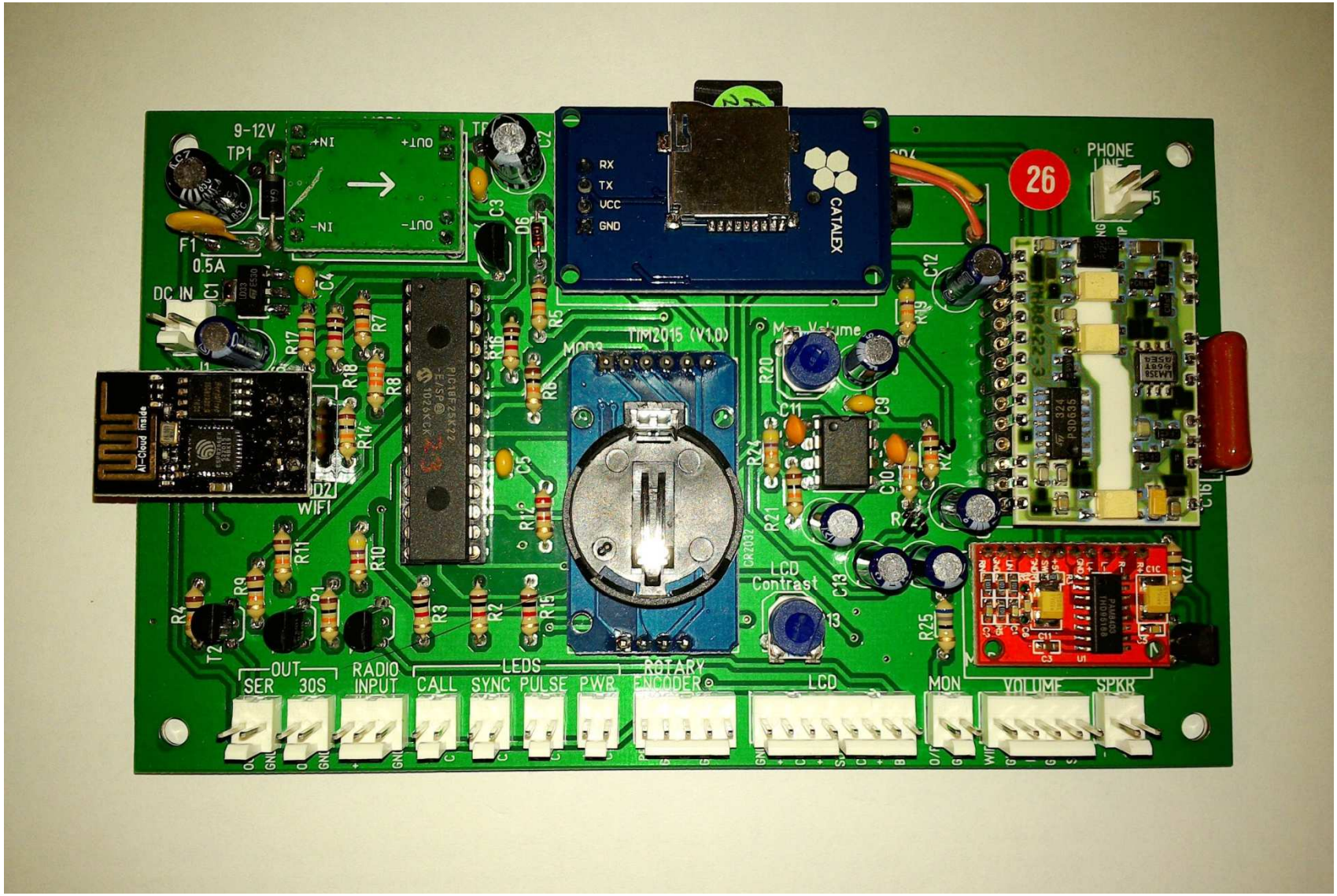


	1ST DIGIT	2ND DIGIT	3RD DIGIT	MULTIPLIER STRIPE	TOLERANCE 4TH STRIPE
Black	0	0	0	x 1	
Brown	1	1	1	x 10	1%
Red	2	2	2	x 100	
Orange	3	3	3	x 1 000	
Yellow	4	4	4	x 10 000	
Green	5	5	5	x 100 000	
Blue	6	6	6	x 1 000 000	
Purple	7	7	7	-	
Grey	8	8	8	-	
White	9	9	9	-	
Gold	-	-	-	x 0.1	5%
Silver	-	-	-	x 0.01	10%

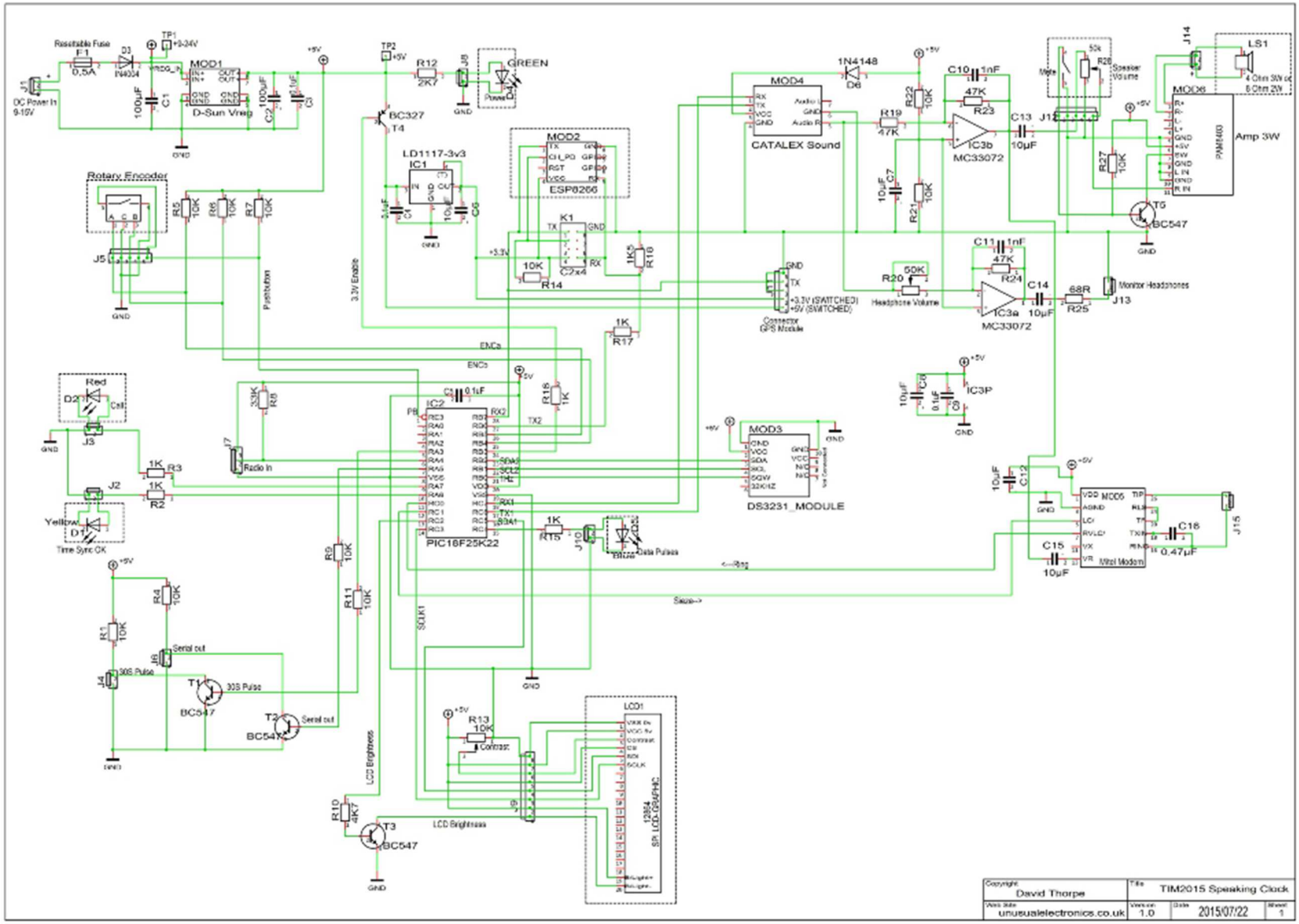
Chart reproduced with acknowledgment to Velleman, makers of excellent hobby electronic kits.



Location of components



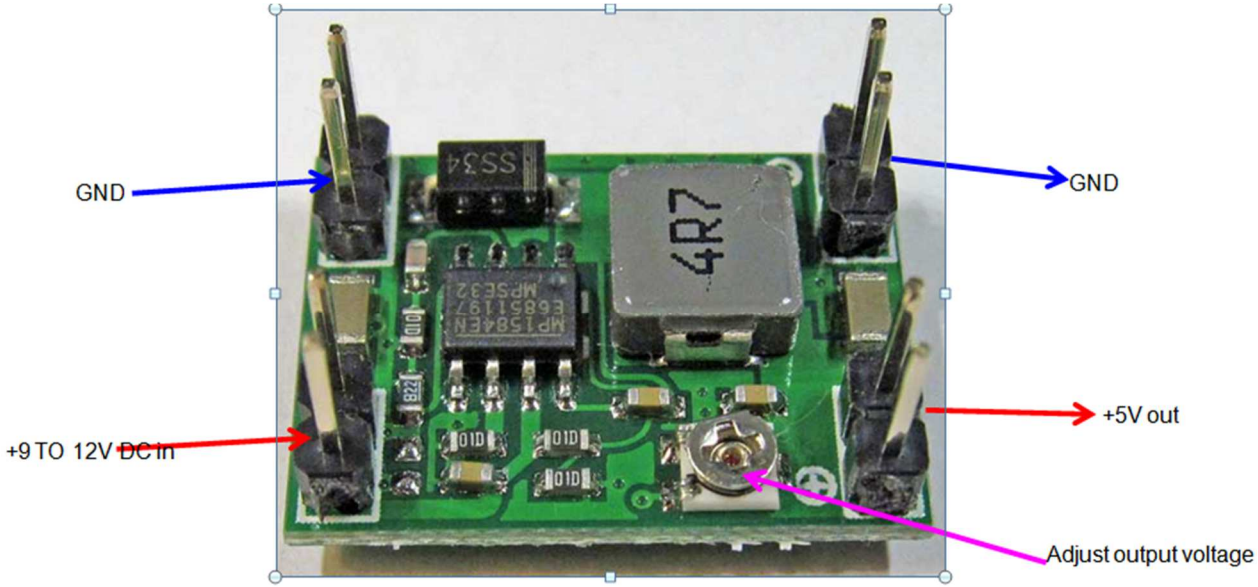
PCB with all components in place. Image by Dave Whistler.


Resettable Fuse
F1
0.5A
D3
IN4004
TP1
+9-24V
J3
DC Power In
9-15V
MOD1
D-Sun Vreg
100µF
C1
100µF
C2
0.1µF
C3
+5V
GND
TP2
R12
2K7
J9
GREEN
Power
BC327
T4
LD1117-3v3
IC1
0.1µF
C4
10µF
C5
MOD2
ESP8266
K1
2x4
1K5
R16
10K
R14
3.3V Enable
Rotary Encoder
J5
R5
10K
R6
10K
R7
10K
Pushbutton
MOD4
CATALEX Sound
1N4148
D6
R19
47K
R22
10K
C10
1nF
47K
R23
IC3b
MC33072
C13
10µF
J12
10µF
C7
R21
10K
50k
Mute
R26
Speaker Volume
J14
LS1
4 Ohm 3W or
8 Ohm 2W
MOD6
PAM8403
Amp 3W
R27
10K
T5
BC547
J11
Connector
GPS Module
R20
50K
Headphone Volume
C11
1nF
47K
R24
IC3a
MC33072
C14
10µF
68R
R25
J13
Monitor Headphones
1K
R17
ENCa
ENCb
Red
D2
Cath
J3
1K
R3
J2
1K
R2
Yellow
D1
Time Sync OK
30K
R8
J7
Radio In
PIC16F25K22
0.1µF
C2
R16
1K
TX2
RX2
SDA1
SCL1
RX1
TX1
SDA1
MOD3
DS3231_MODULE
IC3P
10µF
C8
0.1µF
C9
10µF
C12
MOD5
Mini Modem
C16
0.47µF
C15
10µF
J15
1K
R15
J10
Data Pulses
R9
10K
R11
10K
SCLK1
R4
10K
R1
10K
Serial out
J8
J4
30S Pulse
T1
BC547
30S Pulse
T2
BC547
Serial out
R13
10K
Contrast
LCD1
12864
SPI LCD G64HHC
LCD Brightness
R10
4K7
T3
BC547
LCD Brightness
Copyright
David Thorpe
Title
TIM2015 Speaking Clock
Web Site
unusualelectronics.co.uk
Version
1.0
Date
2015/07/22
Sheet
1

3.6 Module preparation

You are almost ready to start construction! However, before starting to populate (insert components into) the PCB, you need to prepare three modules and the liquid crystal display (LCD) screen. Here's what to do.

D-Sun Switching Voltage regulator module (MOD1)

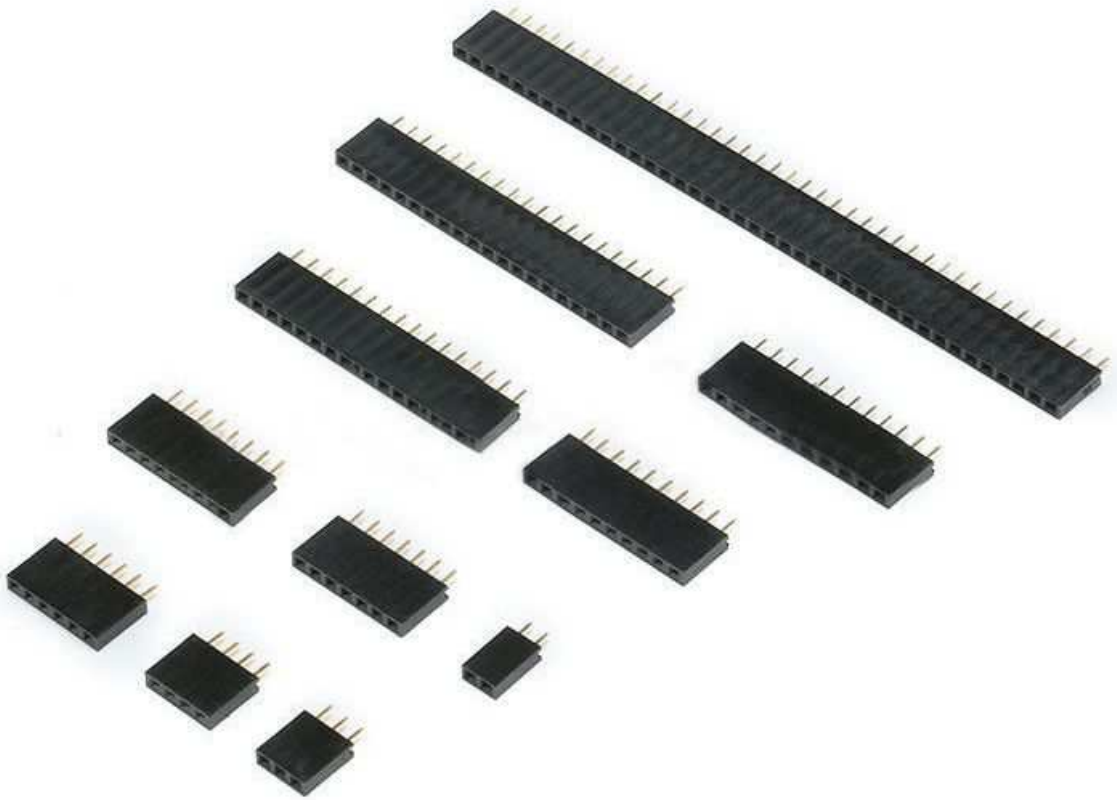


As supplied, this module is not set to any particular output voltage. It must be calibrated to produce 5 volts ***before*** *fitting to the PCB.*

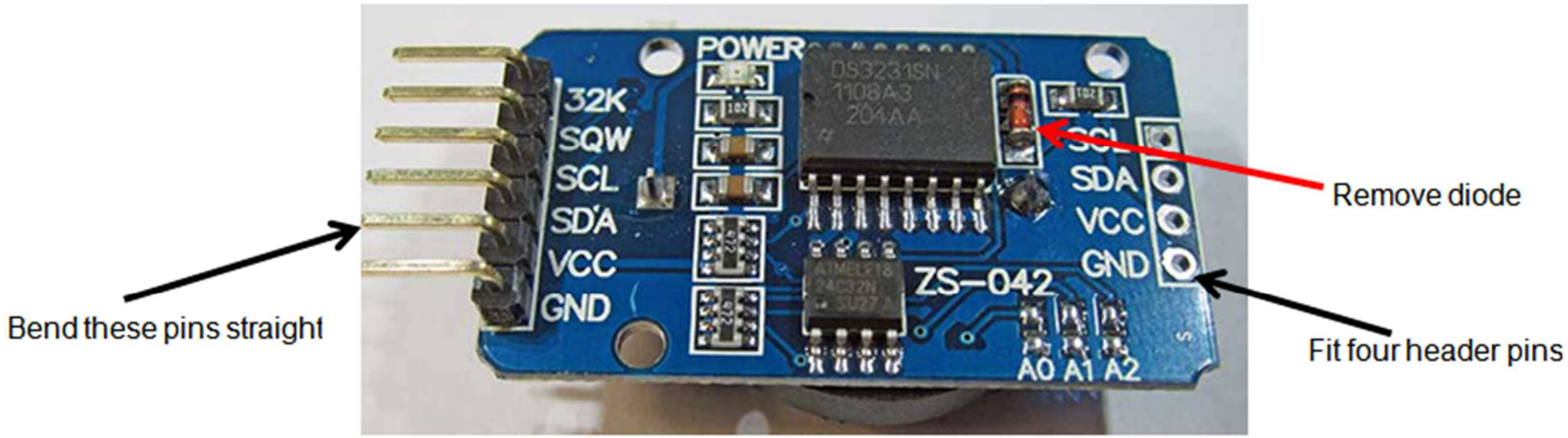
- Fit header pins (cut from a longer strip of them) to the board of this module as shown. Subsequently the board will be fitted 'upside down' on the main PCB and you will no longer have access to the components when they are facing down).
- Connect a 9V or 12V supply to the pins on the left of the photo.
- Now hook up your multimeter, select Voltage and adjust the trimmer potentiometer ('trimpot') to exactly 5 volts. If you can't get it to exactly 5V, slightly below (say, 4.98V) is fine but **do not set the voltage higher than 5V!**

Note: If you solder this module to the PCB it will be very difficult to remove again for adjustment. For that reason we earnestly recommend

using female header sockets, into which the module can be plugged. You can buy these on eBay, searching for **female headers** or **female header sockets**. You will need four 2-way sockets for the D-Sun regulator.



DS3231 RTC (Real Time Clock) module (MOD3)



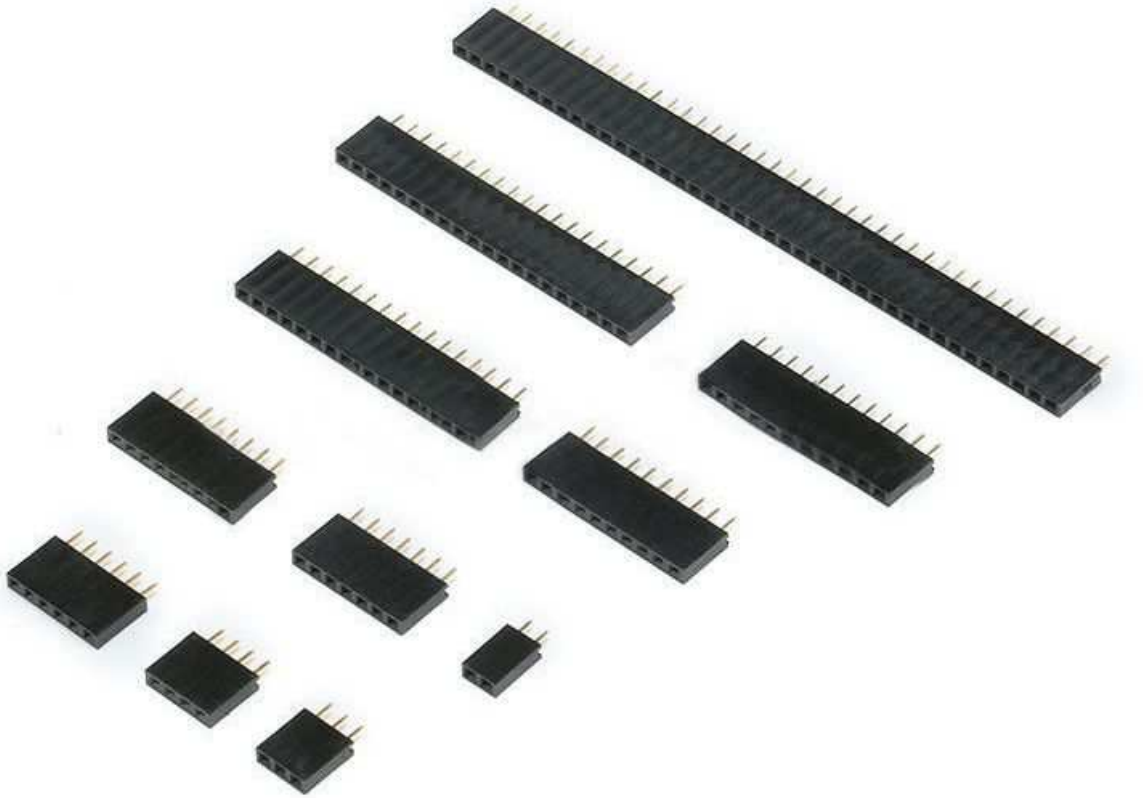
The glass diode (shown to the left of the red arrow) **must be removed**, as the module manufacturer originally provided this module to charge a super-capacitor instead of the lithium coin-cell that we are using.

Failure to remove the diode could cause the coin cell to burst eventually, which might damage TIM 2015 or cause other problems.

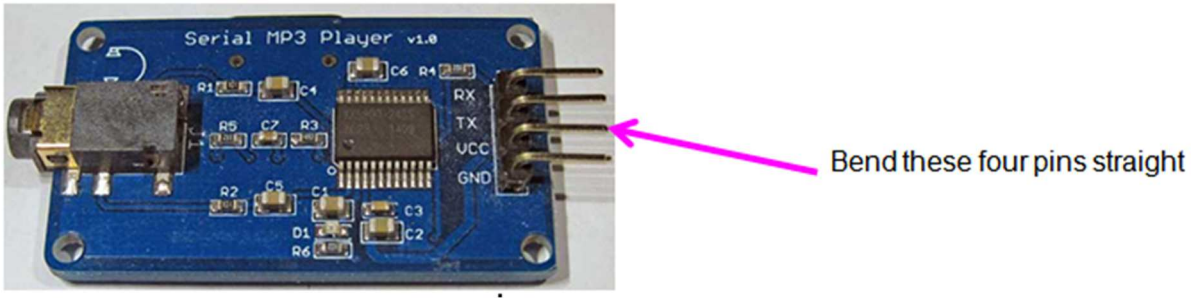
- To remove the diode, wear protective glasses and either break it off using pliers or snip its wires using miniature end-cutters or else unsolder it.
- Straighten the six existing header pins so they stand vertically at right angles to the board of this module. This will enabled the module to be soldered to the main board.
- Fit four header pins to the unused holes as indicated (these will help to secure the module to the main board).
- Do *not* insert the coin-cell battery yet, as it will waste power and may upset testing later on (leave this task until the main board is finished).

Note: If you solder this module to the PCB it will be very difficult to remove again for adjustment. For that reason we earnestly

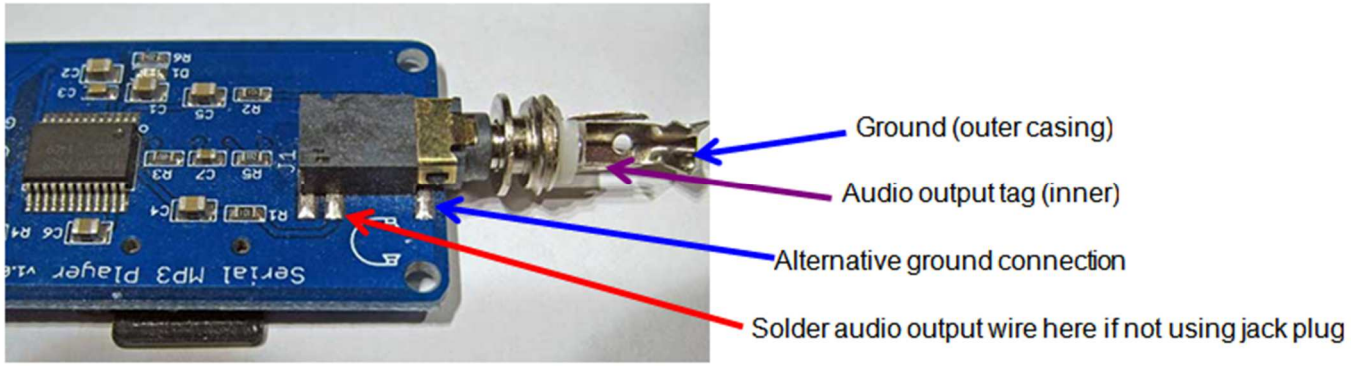
recommend using female header sockets, into which the module can be plugged. You can buy these on eBay, searching for **female headers** or **female header sockets**. You will need one 4-way socket and one 6-way socket for the DS3231 RTC module.



Catalex audio player module (MOD4)



- Straighten the four header pins so they stand vertically (at right angles to the board of this module). This will enabled the module to be soldered to holes in the main board.



- You now have a choice. Choice 1 is to plug a 3.5mm stereo jack plug (without the outer plastic cover) into the module. The output can later be wired via the centre tag of the mini-jack plug.
- Alternatively, choice 2 is to omit the mini-jack plug and simply solder the output wire soldered to the PCB pad as shown. This is the way we do it on ready-assembled versions.
- It is not essential to connect the jack ground tag or pad (as the module already has a ground header pin connection) but making a more direct connection may help to improve sound quality.

Graphic LCD module (12864 type)

There are many variants of this module, mostly with the number sequence 12864 in their designation. Visually they all look very similar and nearly all of them are suitable for use in TIM 2015. Nevertheless, if you are buying one on eBay, AliExpress or Amazon, do *check the description carefully*. The type to buy will have the phrase **ST7920** in the heading title or else among the technical data. If it uses the **KS0107** or **KS0108** driver do not buy it, as *it will not work with TIM 2015.*

The screens are commonly available in blue, yellow-green and white. A higher price is charged for white displays, which are not so widely available.

It's important to note that this type of display has the facility to use either a Parallel or Serial data interface. They are either supplied by the manufacturer pre-jumpered to the wrong, Parallel mode (using a tiny surface mount zero ohm resistor) or else they come 'agnostic' (leaving you to set them into Serial mode). Fortunately your task is simple either way.

- ***Text continues on next page.***

If the rear of your display looks something like this…

… your display is set to Parallel.

Note the zero-ohm resistor marked R9 (circled in red).

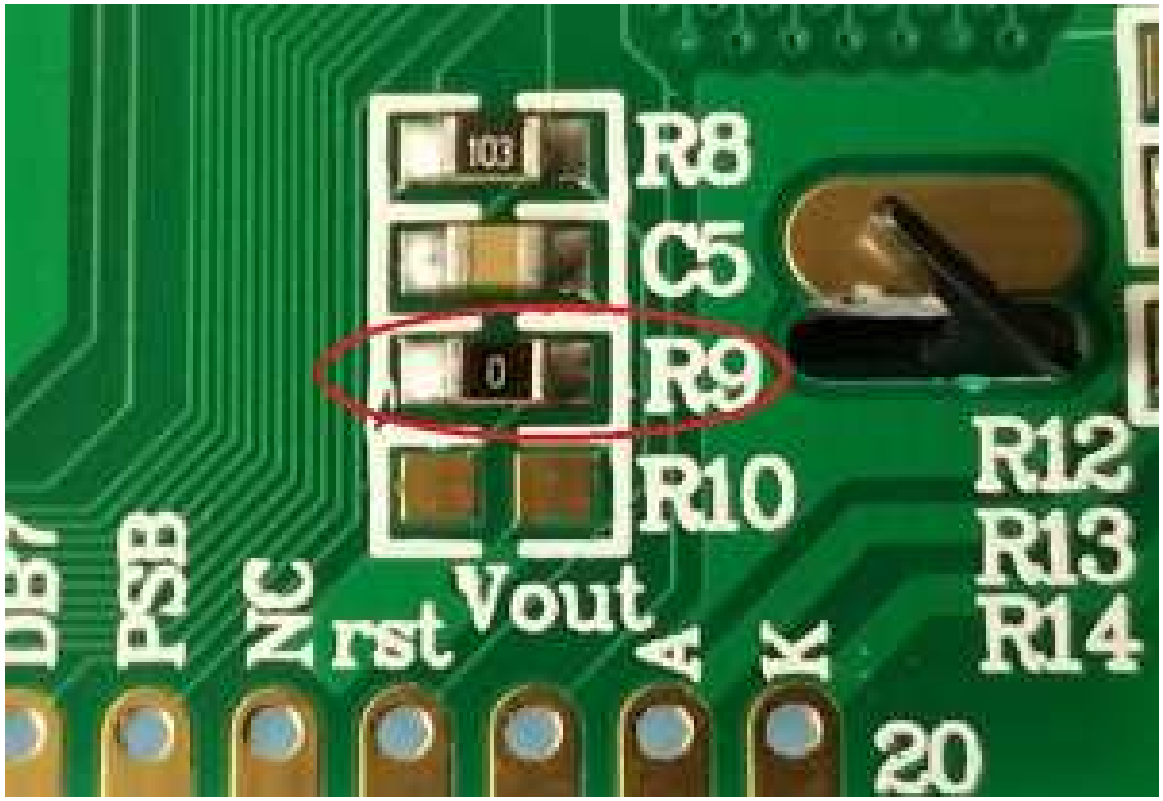
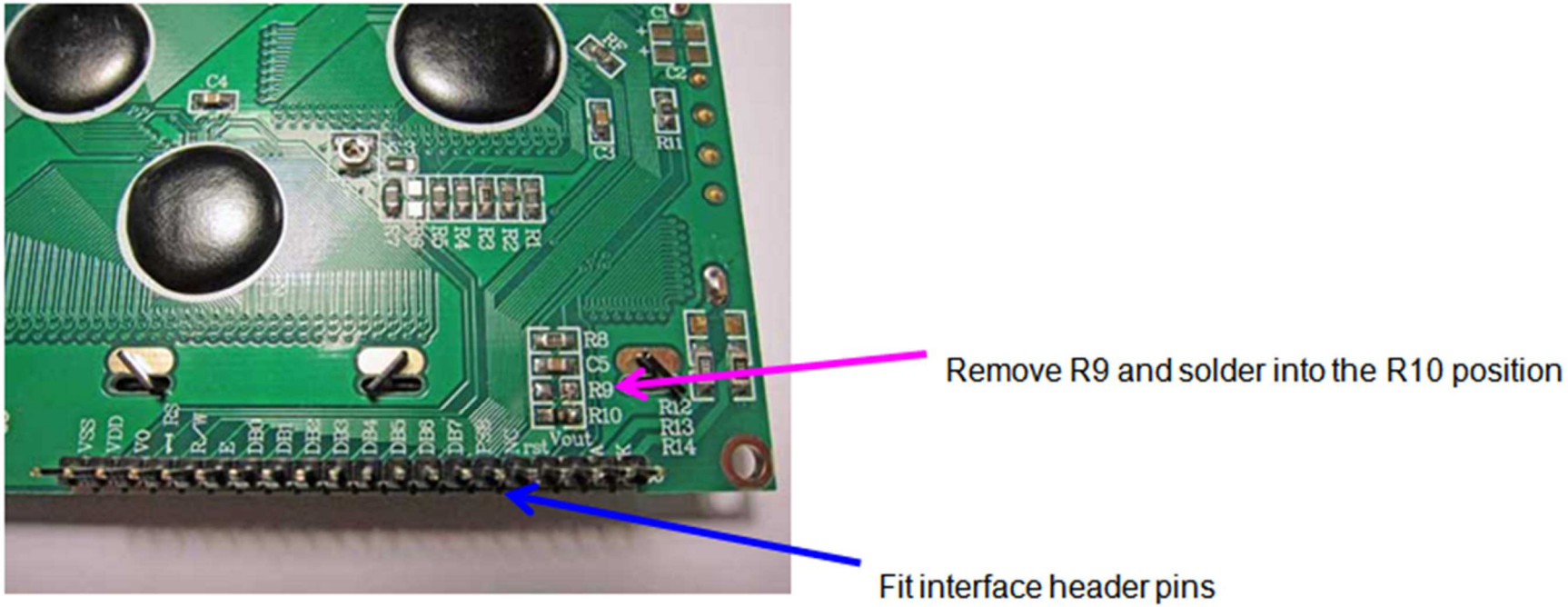


Image courtesy of HobbyComponents.com

This 0Ω resistor (R9) must be unsoldered and moved to the serial interface position below (marked R10).

- You will need to use a magnifying glass, a fine-tipped soldering iron and tweezers to move the resistor. You will also need a steady hand and a degree of skill and patience! If you damage the chip resistor or are unable to place it in the R10 position, just use a blob of solder to bridge the two solder pads for R10 instead.

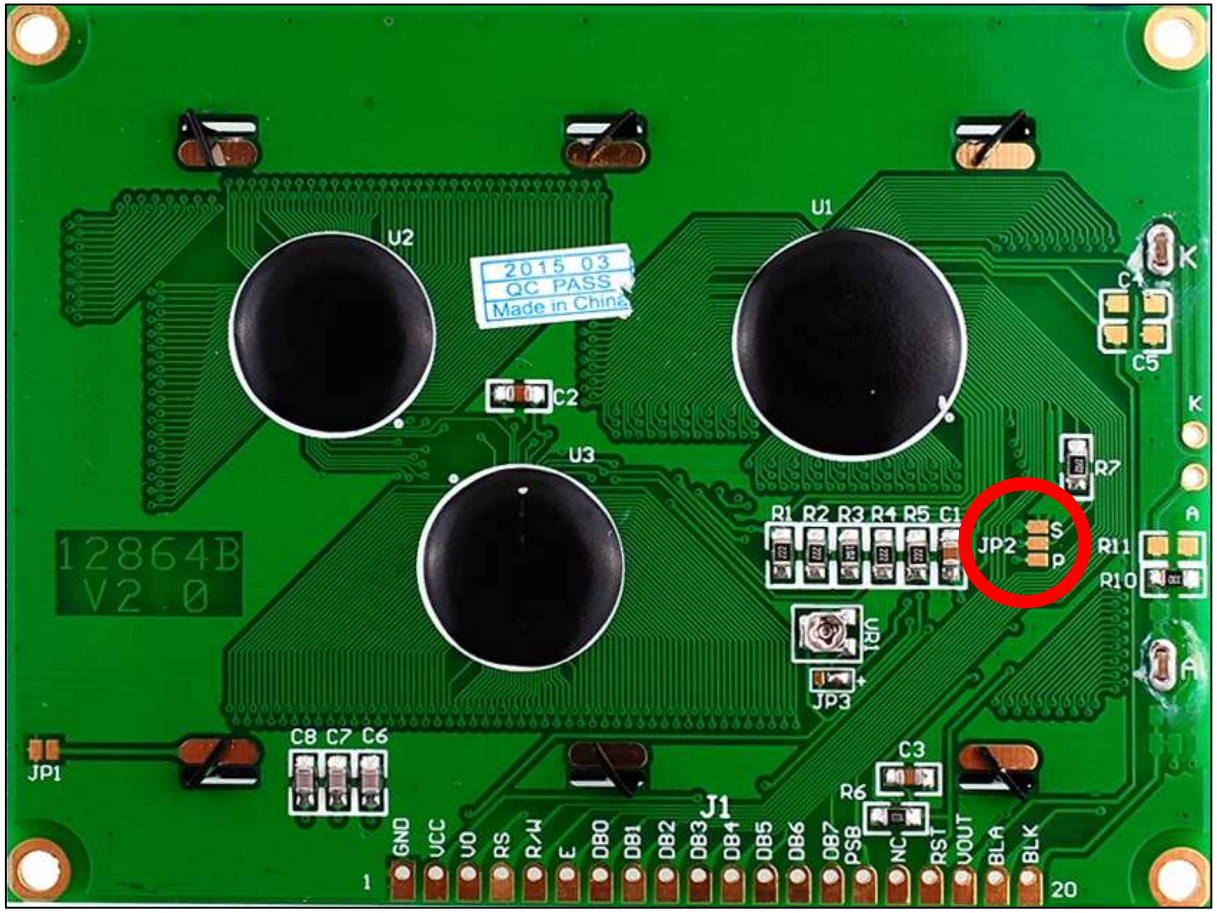


Your second task, if you wish to be able to plug and unplug the display easily (most people do), solder a length of header pins (20 pins) to the interface holes as shown.

Alternatively, the interface cable wires could be soldered directly to the holes in the display PCB to save space in the case but any subsequent fracture in the cable or solder joint would be a pig to repair. Also hard-wiring (hard soldering!) the cable would make swapping displays far more difficult.

If you have an agnostic (not preset) display you need to set the parallel/serial jumper on the underside of the display.

This is a typical display and inside the red circle you can see the three gold 'lands' of JP2. Other displays have the jumper position located elsewhere on the board but it always takes the same form, comprising three lands, with the outer two of these marked P and S, plus the central 'common' land unmarked.



Typical LCD with the parallel/serial jumper 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.

- Finally 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.
- Now set the display aside in a safe place, leaving the clear plastic film covering the liquid crystal screen in place to protect it from accidental scratching.

Some more variants follow, with information of how to deal with them.

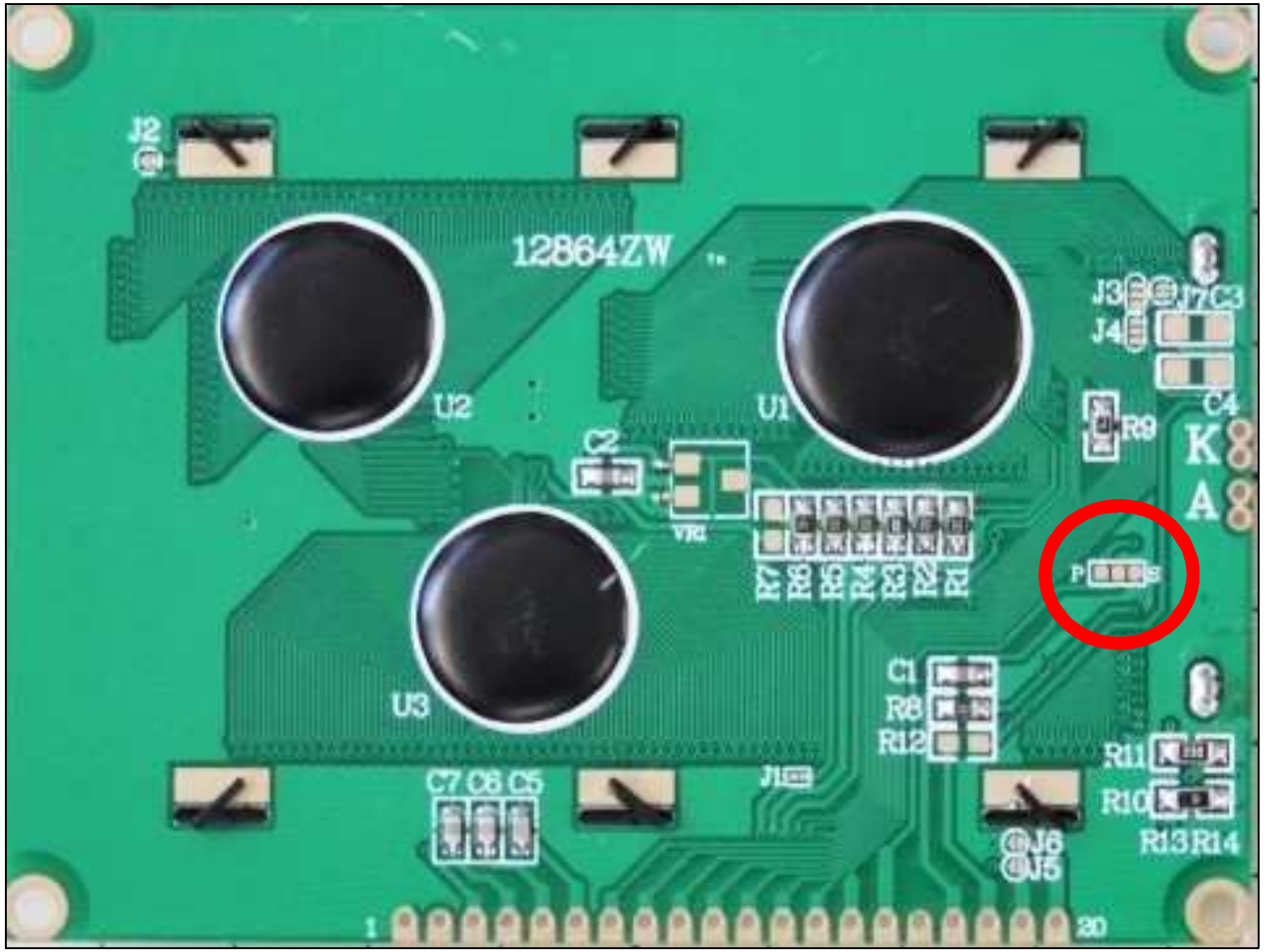
In this case (above) we have two golden 'jumpers' with a minute separation between the two hemispheres. Heat the left-hand jumper, marked S, and apply a tiny bit of solder so as to link the two halves.

Although this board differs in some respects, the S and P jumpers are in the same place. So perform the same operation to set the display to Serial.

One more variant…

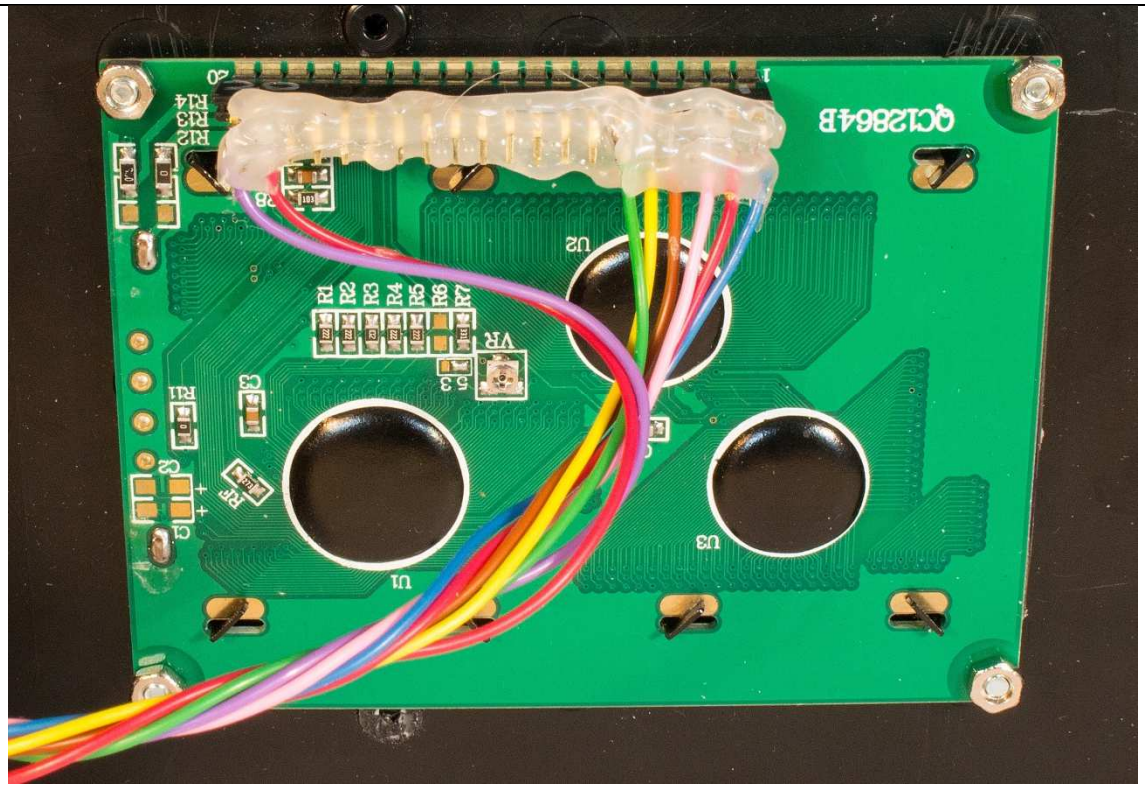
- ***Text continues on next page.***

Here we tin the central ‘gold circle’ and the right-hand one (marked S), then link them with a deftly positioned blob of solder.



There may be other variations still but they will almost certainly observe the same sort of way of selecting Serial mode.

Having sorted out the minutiae of which LCD display you have bought, you need to attach a 20-pin male pinheader strip to the gold-plated terminals marked 1 to 20, a simple task after all this head-scratching.

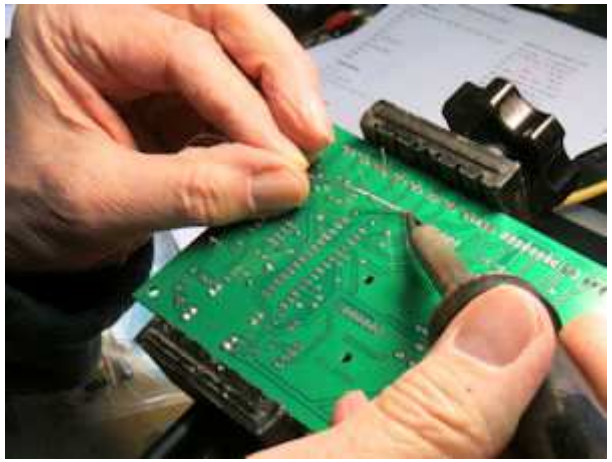


The shorter ends of the pins (left-hand photo) are pushed into the board and are soldered to the gold-plated contacts on the display screen side of the PCB. The long pins project from the rear side of the PCB (right-hand photo).

73.7 Fitting the components

Let's start by quoting from Sam Hallas, a major collaborator on this project. In his words:

I find it most frustrating when I fit components to a circuit board. They sit nice and flat against the board — until you turn it over for soldering. Then they either drop out entirely or slip to an ungainly angle. I got round this problem by holding parts in place with sticky tape. Masking tape has the right sort of stickiness — not very sticky. I used Micropore surgical tape because I had some in my workshop. The picture shows the group of resistors at bottom left of the board held in place prior to soldering.



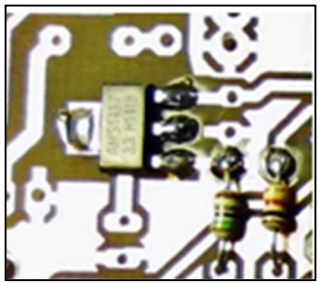
Then it's just a matter of soldering the parts in a few at a time and cropping the leads. The instructions, wisely, tell you to fit the low rise parts first. This is very practical as the taller components would get in the way if you put them in first. You'll find, as I did, that soldering to points that are on the ground plane take a while to heat up, as the copper plane acts as a heat sink. I'm not sure whether it's worthwhile holding the soldering iron on a joint for slightly longer than normal to allow the solder to wick its way through the plated holes.

Here's Sam trimming off the excess length of wire component leads. He is using proper end cutters, which do a rather better job than the usual side cutters that most folk have in their workshops. Whichever type you use, make sure they are sharp and cut cleanly. After carrying out this amputation, brush off the offcuts into the waste bin and double check that there are no short snippets of wire remaining. Sometimes they do not drop off by gravity alone.	

*It is **extremely important** to fit the components in the correct sequence.*

*If you don't follow this sequence you may find it **impossible** to fit some parts later on!*

1. Start by fitting all of the **resistors**, also the small 1N4148 **diode** (D6). The **TIM 2015 components by type** list and placement pictures given earlier in this chapter will assist you.



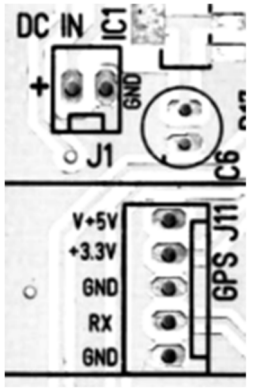
2. Then fit the surface mount IC1, a 3.3V voltage regulator (see picture above). This is a surface mount device (SMD) component but don't worry, it's the only SMD and it's not too difficult if you have a small tip for your soldering iron (if you don't have one yet, you will probably find you can buy a suitable tip — try looking on eBay). Roll up your sleeves, take a deep breath and start by tinning the three solder pads, the rectangular 'land' provided for the heatsink tab, the heatsink tab on the IC and the three leaves of the IC. 'Tinning' is described at http://www.mediacollege.com/misc/solder/tinning.html. In a nutshell, whatever it is you are soldering, you should 'tin' both contacts before you attempt to solder them. This coats or fills the wires or connector contacts with solder so that when you apply the soldering iron, the two pre-soldered surfaces will melt and fuse together easily. To tin a component lead or area of the PCB apply the tip of your iron to the item for a second or two, then once it has heated up, apply the solder to the wire. The solder should flow freely onto the object and cover it completely. Finally solder all three leads of the IC and its heatsink tab onto the PCB. Do this deftly and don't hang about as you may otherwise damage the IC. After the solder has cooled, poke the IC with the tip of a small screwdriver to make sure that all of the solder joints are solid.

3. Now fit the four small 0.1μf decoupling capacitors.

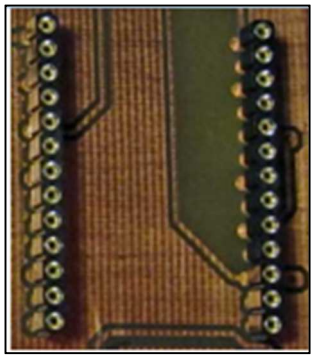
4. Fit the two small 1nF capacitors (C10 and C11).

5. Fit the 28-pin IC socket for the microcontroller, IC2. See the Location of components plan and the PCB with the smaller components in place photo shown earlier. The IC socket has a small notch at one end and this notch should be at the upper end when fitted on the PCB.

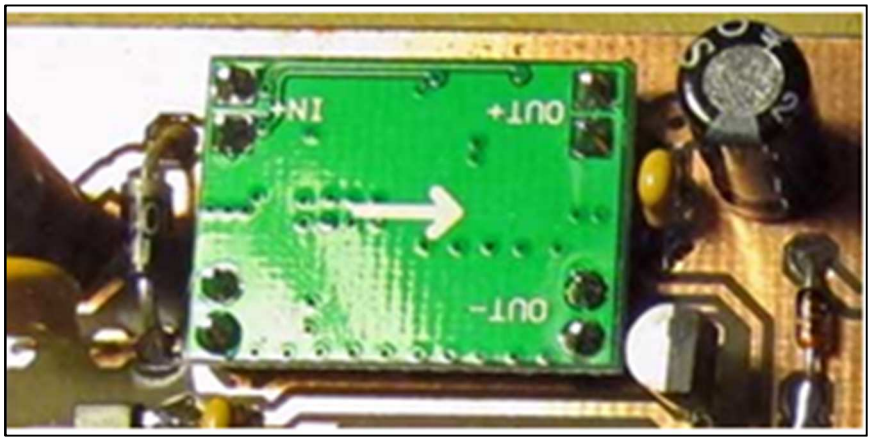
6. Fit the fifteen Molex header sockets (ensuring the locking flanges are all correctly positioned). Inspect the photo that shows the PCB with the smaller components in place, where you will see which way round these retaining latches are placed. The technical description of these parts is 'Molex Unshrouded, Straight PCB Header' and their appearance is as in the photo below.

	This photo (see left) is a three-pin header. The actual number of pins varies according to the function of the connector; on our board these connectors have between two and eight pins. Note the projecting latch, which mates with a flange on the corresponding female connector to prevent accidental disconnection of the male and female connectors. On our PCB all Molex headers have the latch 'below' the pins, like J1 (right-hand picture). The only exception is J11, where the latch is to the right of the pins, facing the centre of the PCB (see picture, right).	

7. Now fit the 8-way header socket for the Wi-Fi module.



8. The Mitel modem requires a 26-pin socket that is not available commercially. Take a strip of SIL (single inline, i.e. single-row) female headers (2.54mm pitch between 'holes') and cut it into lengths of 13 pins. Then solder the two strips to the board, making sure that they stand absolutely vertical. See photo above.



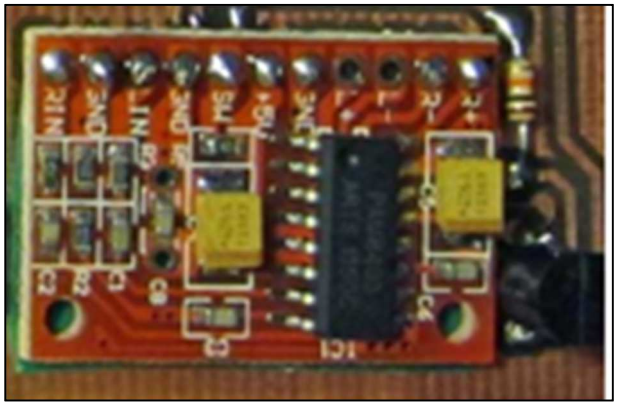
9. Solder the D-Sun voltage regulator to the board with its component side facing down and the white arrow pointing towards the diode D6. See photo above.

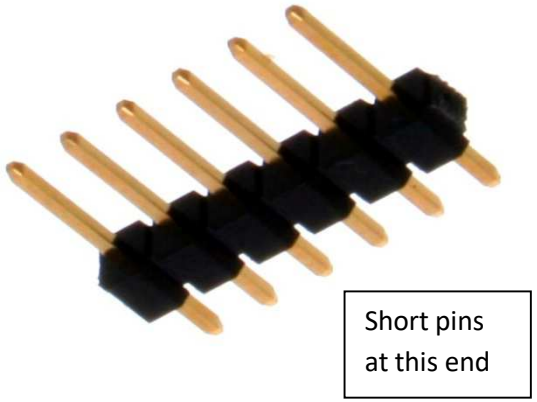
10. Now fit D3 and the two 100μf electrolytic capacitors (C1 and C2), ensuring correct polarity.

11. Carefully solder fuse F1 (do not apply excessive heat).

12. Fit the only PNP-type transistor T4 (BC327), located near to the D-Sun module.

At this point you still have the opportunity to check that the regulator is correctly set to 5 volts without risk of damaging any sensitive parts. Plug the output of a 9 to 12V DC supply into J1 and measure the voltage across the **Out –** and **Out +** pins of the D-Sun module.
If the voltage is correctly 5V then disconnect and proceed with the next stage of assembly.





13. You now have to fit the PAM8403 Audio Amplifier module (left-hand photo above). Its connections are not spaced at the normal 2.54mm pitch, meaning that a standard 0.1 inch header pin strip (right-hand photo above) won't fit the holes provided. Fortunately there is a simple workaround!

First apply a piece of insulating tape or masking to the underside of the module (this is not essential but might provide protection against possible short circuits). Now break off a strip of nine header pins using side cutters, then divide these into nine individual pins. Although the little board has eleven holes, there is no need to connect the L – and L+ holes, as we use only one channel (the right-hand one) of this stereo amplifier.

Using the photo as a guide, start from one end and fit one header pin at a time. Push the short pin end of a header pin through the R IN contact hole from the underside of the board so that the scrap of black plastic is flush against the surface of the underside of the board. Check that the pin is properly perpendicular, at 90 degrees to the board. With a hot iron solder the protruding end of the pin to the square plated hole. Give it time to cool and check that the pin is still perpendicular. If not, melt the solder to get it right. Remove the scrap of black plastic.

Now insert another pin into the GND hole and repeat the exercise. Carry on and place pins into every hole except L+ and L –. You will now have nine rigid pins that will fit the holes drilled in the main PCB. Leaving a small gap between the module and the board, place the module in position on the main board. Solder each pin in place, keeping the iron on each pin for the minimum time necessary (this is why a hot and properly tinned iron is recommended), as the last thing you want is the other (short) end of the pin becoming unsoldered. Deftly does it!

14. Fit the remaining four transistors, ensuring you place them correct way round.

15. Solder the Catalex sound module to the board and connect the audio output either using a stereo jack or direct wiring as described earlier.

16. Fit the 8-pin IC2 (for best audio quality this can be soldered direct to the board instead of using a socket).

17. Fit the two pre-set resistors (note they have different values, 10k for the LCD contrast (R13) and 50k for the headphone monitor volume (R20).

18. Fit the 10μf electrolytic capacitors, ensuring correct polarity.

19. Solder-in the DS3231 RTC module and insert the Mitel modem module carefully into its socket. Check visually that all 26 pins are fitted in the socket holes. It is very easy for one or two pins to be bent flat, making no contact. A tiny LED torch is good for making things clearer.

20. Fit the large 0.47μf capacitor next to the Mitel modem module.

21. Insert the microSD card into the holder on the Catalex module. The side of the card with the maker's name on it should face upwards. The gold pins are on the underside and will face towards the centre of the board. Ensure you have pushed the card fully in and that the holder is retaining it. A second push will release and eject the card.

22. Insert the microcontroller (PIC) chip with pin 1 nearest to the D-Sun regulator.

23. If you have ordered a pre-programmed Wi-Fi module, plug this in with the antenna section near the left edge of the main board.

24. Insert the CR2032 coin-cell into the RTC module (with the **+** marking visible on top).

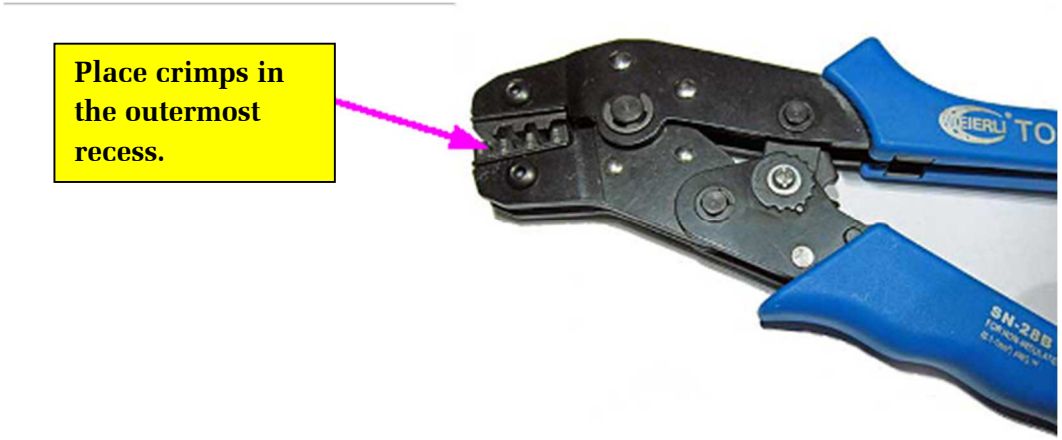
Chapter 4 Wiring

We now come to the task of making the wiring connections that link the main PCB to the display, to the front panel controls and to the rear panel connectors. For this we use readily available flexible wire of the type known as **7/0.2mm**. The flexible 7/0.2mm stranded core gives this wire the flexibility needed for use in tight spaces, whilst the 0.3 mm PVC outer sheath in various colours lets you identify the separate wires easily. You can buy this from numerous eBay suppliers, Maplin shops and all the big electronics distributors. At the time of writing the wire sold (by the reel) by Rapid Electronics is keenly priced and of good quality (some brands have rather thin plastic insulation that melts and runs during soldering and unfortunately this includes the wire sold by Maplin in our experience).

Obviously the choice is yours as to which colours you use for the wiring but you may find it simplest to use the recommended colours shown in our wiring diagrams. Colours used are **black, white, grey, red, yellow, orange, green, blue** and **mauve**. You will probably end up buying more than you need for this project but what you don't use this time will always come in useful for other work.

4.1 Tools required for wiring

Technically you need a crimp tool for wiring the Molex receptacles but personally I find I can do the task just as well with some fine-tipped pliers. The choice is yours but bear in mind that a suitable crimp tool will set you back around £15. On eBay search for **Weierli Dupont Pin Terminal Crimping Tool 0.1 - 1.0mm² Capacity 18-28 AWG SN-28B**. The SN-**48**B is **not** suitable and any crimp tool costing significantly less than £15 is probably to be avoided. You will be doing a lot of squeezing to achieve tightly-made crimps and this task is a lot easier to do with a tool having soft handles rather than hard-as-nails ones!

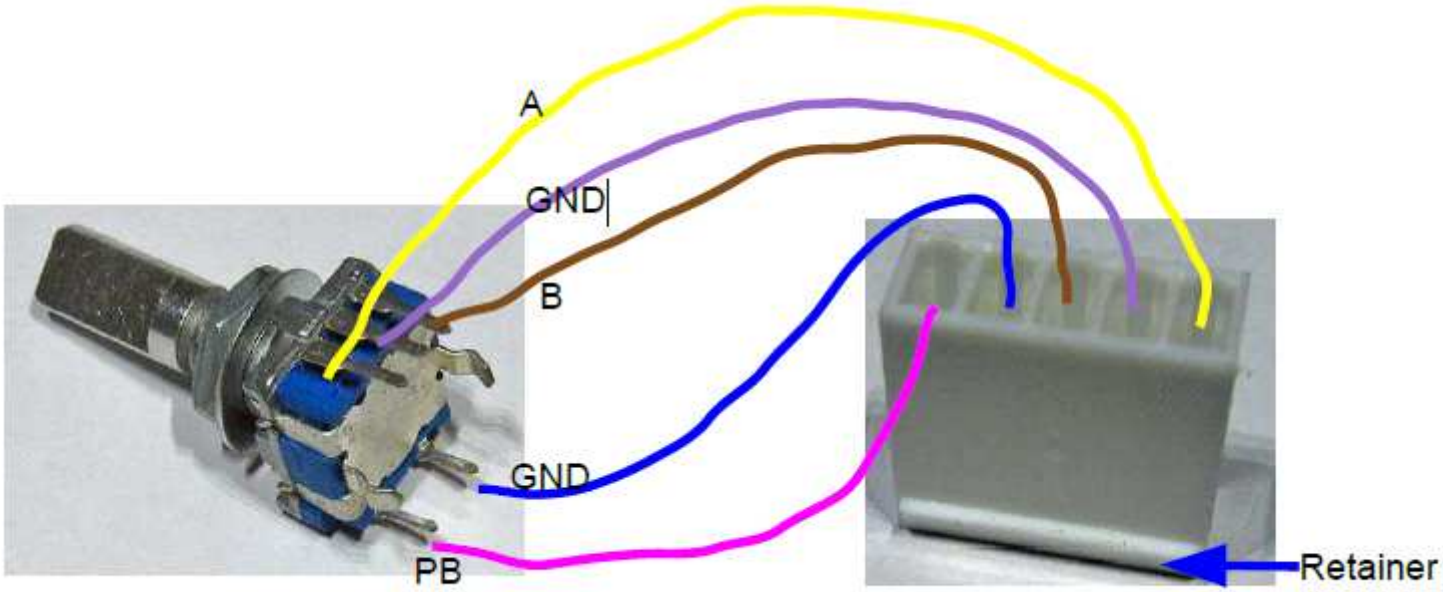


If you are unsure how to crimp Molex connectors, you can read or watch (or both!).

- **Read** the two instructional articles on the data disc (**Molex.pdf** and **Crimping and IDCS.pdf**). Both of these are written by experts and very well illustrated. You will a goodly number of other articles there that I have saved off the Internet courtesy of the kind people who have made them available.
- **Watch** this short video on YouTube.com; the filming and precise explanation by Manchester University are utterly superb:

  https://www.youtube.com/watch?v=8jcfD1UW8SE

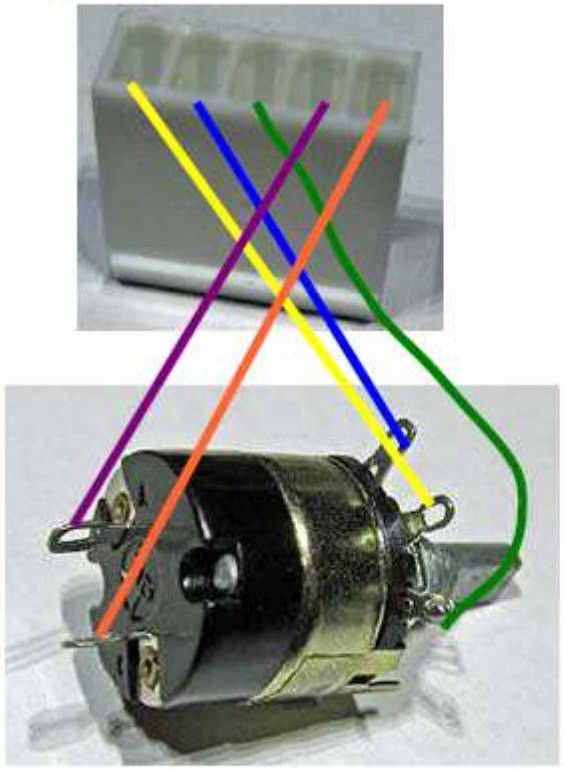
4.2 Wiring the encoder



4.3 Wiring the volume control

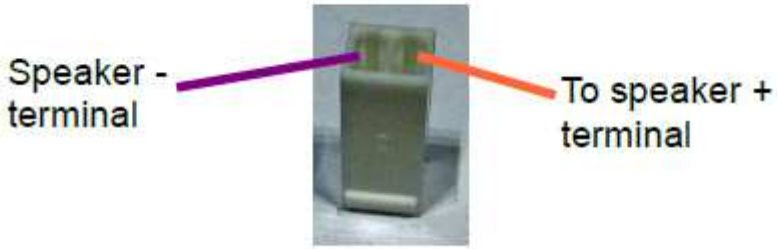
The volume control incorporates a switch to turn the amplifier off into standby mode for power saving.

(Screened cable could be used for improved audio quality)

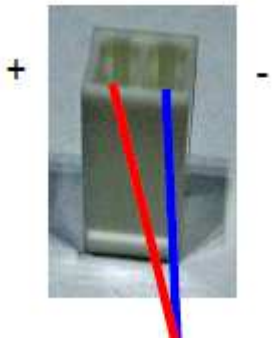


Note: There are several styles of switched volume controls. Not all of them look as in the photograph shown above.

4.5 Wiring the loudspeaker connector

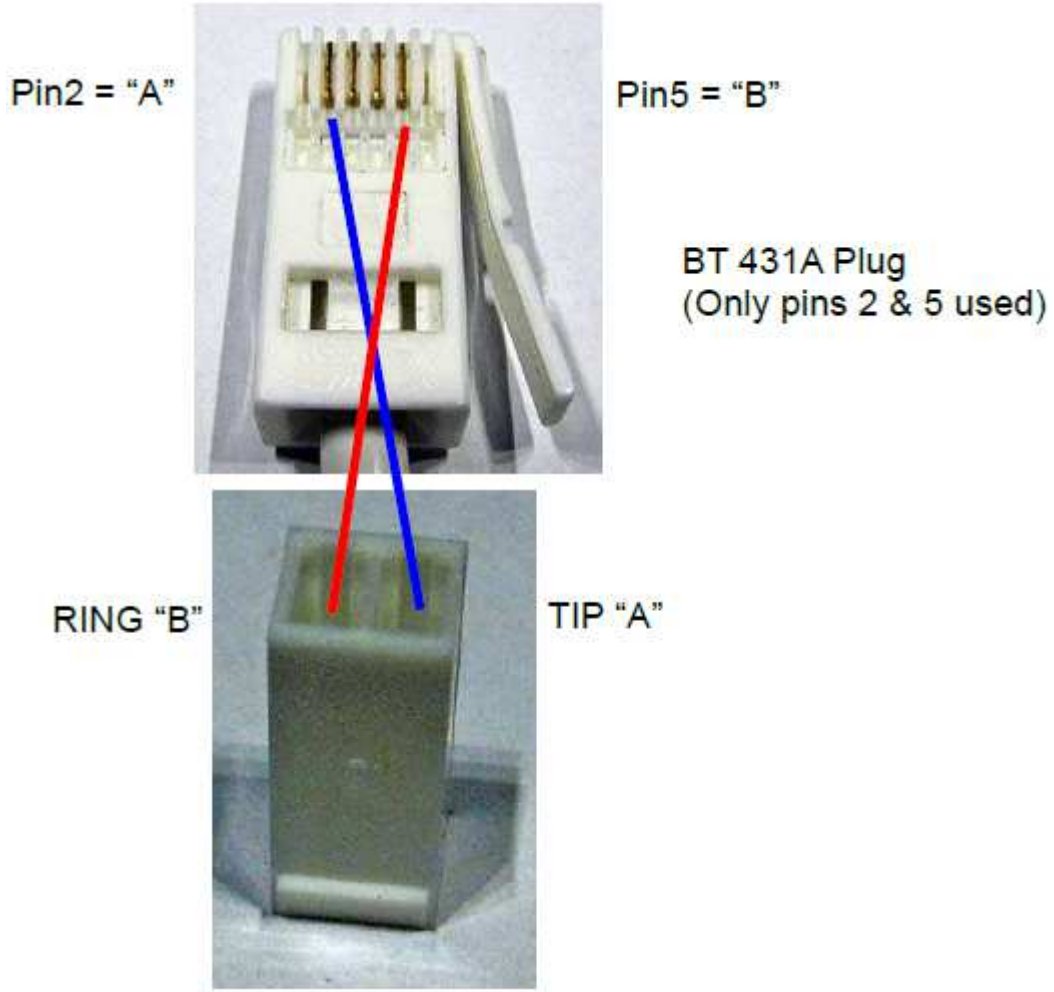


4.6 Wiring the power connector



4.7 Wiring the telephone connector

This example shows the British BT431A plug but the Western Electric RJ-11 can be used, as can any other two-wire line cord. Your task will be simplified if you use a cord already fitted with a telephone plug fitted at one end.



4.8 Soldering to the LEDs

There are two levels of brilliance for LEDs: standard brightness and high brightness, although many sellers do not state the brightness of their LEDs. TIM 2015 is designed to use the high brightness variety, so we suggest you look out for this type. You can of course the standard brightness type but they may appear a little dim and gloomy.

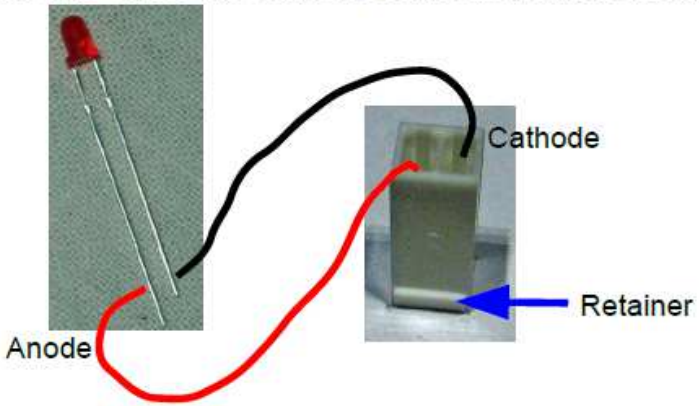
The legs of the LEDs can of course be shortened prior to soldering, to make installation easier. Do remember which is which, as an LED will not work if connected the wrong way round (the longer leg is connected to the positive side of the circuit). Some people argue that they do work when connected the wrong way round but then give off negative light, which is invisible to humans.

The LEDs can either be fitted into chrome bezels or glued to the front panel holes with hot melt glue.

If using a bezel the led may have to be fitted into the plastic holder section of the bezel before soldering.

The Cathode "C" connection is usually indicated by a shorter LED lead and a flat area on the side of the LED.

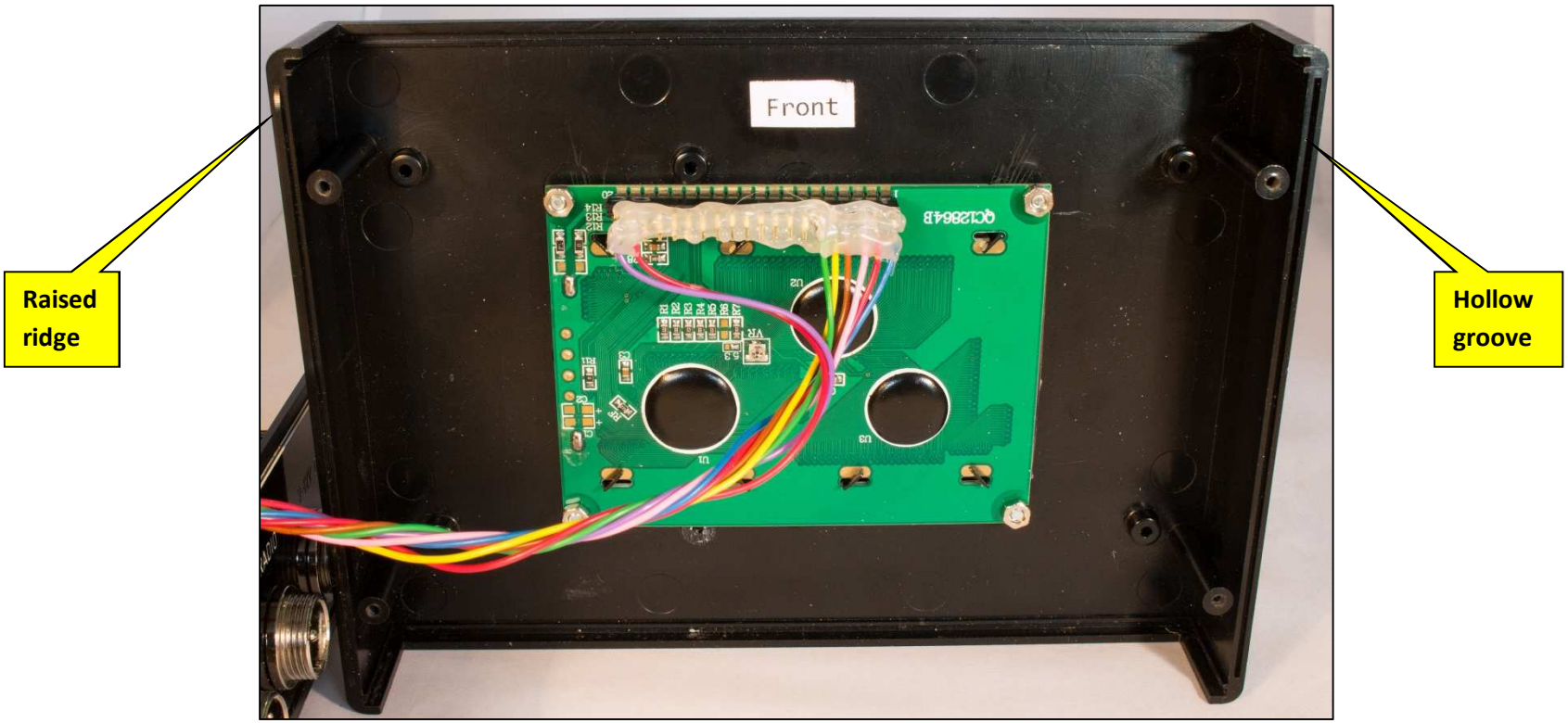
Solder a black or blue wire to the Cathode connection and a suitable colour to the Anode connection.



Each LED lead needs sleeving with 2.4mm heat-shrink tubing.

4.9 Fixing the display

This is where you hope to goodness that you drilled the fixing holes and made the opening in the top of the case correctly! We'll do this in steps.



1. Put the upper and lower parts of the case on the bench. Ensure that the ridge at the left-hand end of the upper part aligns with the corresponding groove in the lower part. You can see the ridge in the photo above, although you will not have fitted the display yet of course. If you followed the instructions in Chapter 2 of these instructions, you will have stuck temporary labels saying 'L/H END' on the upper and lower parts of the case.

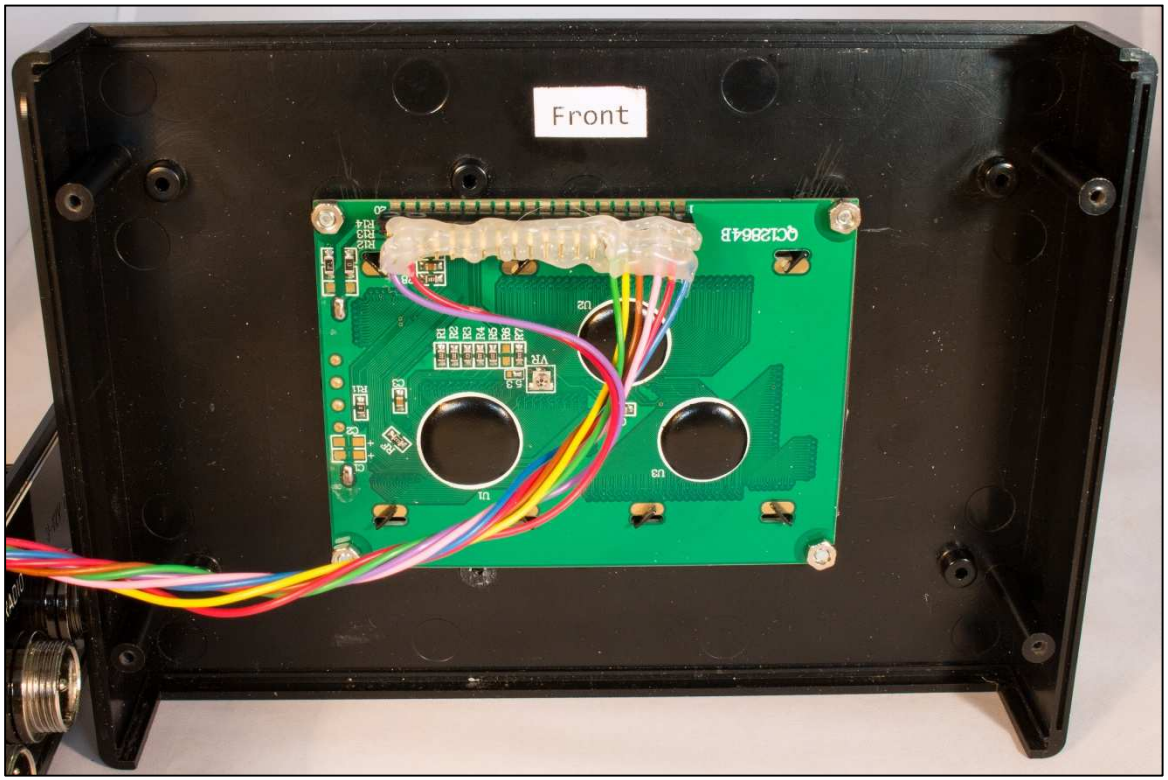
2. The display and bezel are fixed using black plastic screws (15mm long, 3mm diameter) that pass through 4mm holes in the case. The screws are made of black nylon to match the colour of the case and bezel. The use of 3mm screws in 4mm holes gives us a little flexibility (wriggle room) in case the holes are not drilled with total accuracy. The not-quite-rigid nature of the nylon plastic material used for these screws provides further flexibility.

3. Take the display and offer it up to the underside of the top of the case, so that the screen projects through the rectangular opening. If this is unsuccessful you will need to enlarge the opening with a coarse file. If all is well, hold it in place temporarily.

4. Take the pre-drilled bezel and place it on the upper surface of the top of the case, so that it falls over and around the display screen that projects through the top of the case. Now drop four plastic screws through the fixing holes and slide the screen and bezel around for best fit. Hold the bezel in place, remove the screen gently and thread four steel M3 nuts onto the screws from below to secure the bezel in place. Tighten to finger-tightness; do not over-tighten the nuts or you may distort the bezel.

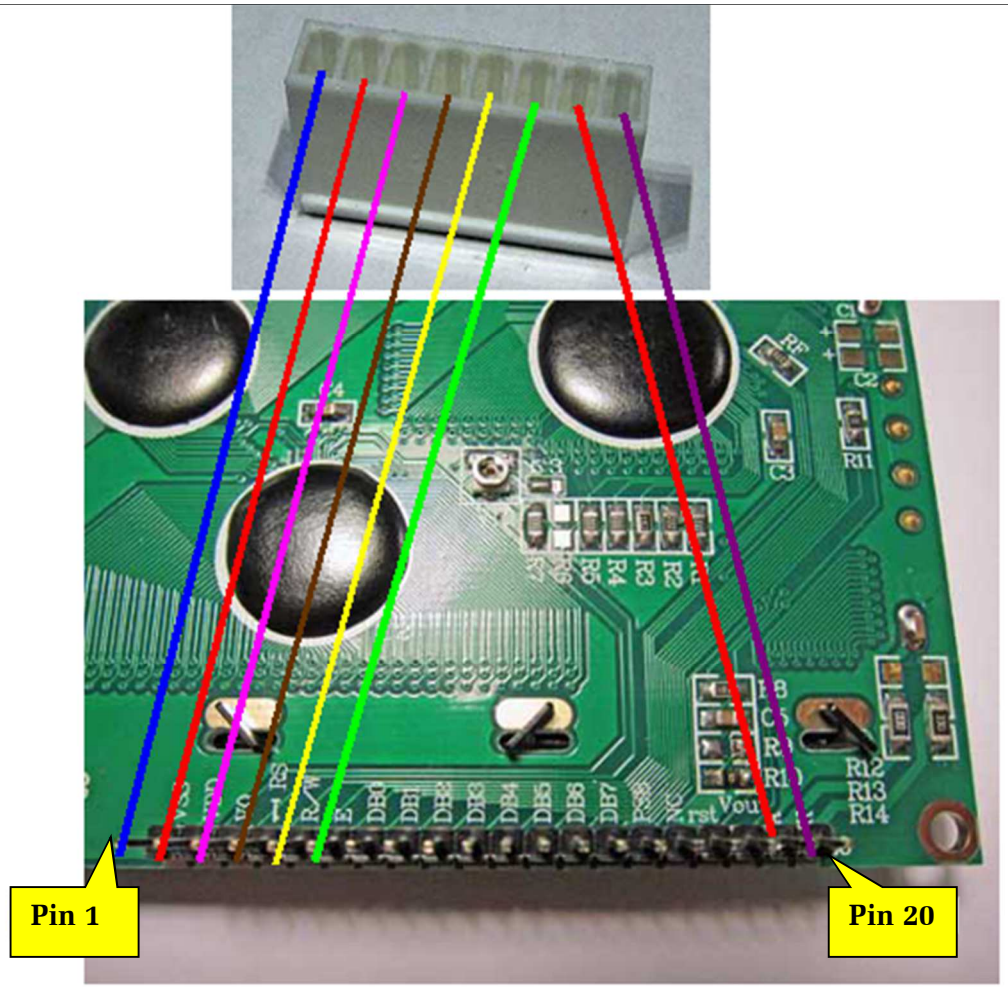
5. Now offer the display (the right way up!) onto the four screws and fix in place with four more M3 nuts. You can see the correct orientation of the display in the photo below. Tighten the nuts to slightly more than finger-tightness but do not over-tighten the nuts or you may damage the board that holds the display. You can discourage the nuts from undoing by using some thread lock (e.g. Loctite) or a flexible 'soft' glue such as UHU.

6. You should end up with something looking similar to the picture on the next page. The photo shows the first construction prototype and may look a little rough.



4.10 Connecting the display

The sketch following shows how we make the flylead that connects the display to the main board. On way of doing this is to use loose individual wires, as shown in the photo below, following the colour coding shown in the table on the next page. An alternative method is described after this and many users may prefer to use this system.



Separate wires

Wire 1	**BLUE**
Wire 2	**RED**
Wire 3	**PINK**
Wire 4	**BROWN**
Wire 5	**YELLOW**
Wire 6	**GREEN**
Wire 19	**RED**
Wire 20	**MAUVE**

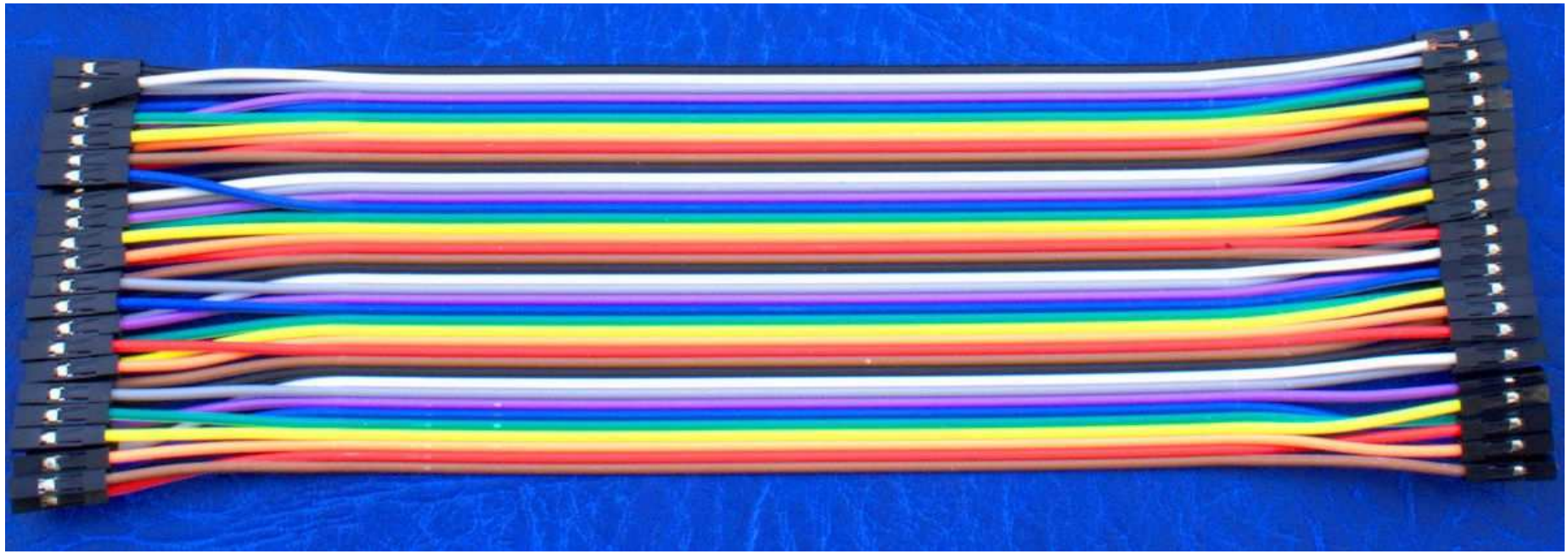
8-way ribbon cable

Wire 1	**BROWN**
Wire 2	**RED**
Wire 3	**ORANGE**
Wire 4	**YELLOW**
Wire 5	**GREEN**
Wire 6	**BLUE**
Wire 19	**MAUVE**
Wire 20	**GREY**

A simpler method uses ‘female-to-female Dupont jumper cables’, either 20cm or 30cm long. These are widely available on eBay at modest prices and although you will end up with far more jumpers than you need for this project, you will doubtless find a use for the other unused cables. They have the advantage that each end has a female connector already fitted that will make a tight fit onto the pin header on the

liquid crystal display and onto the header pins of the 8-way Molex connector marked LCD on the main PCB. Make sure you buy female-to-female cables, not male-to-male or male-to-female.

These jumper cables are made out of ribbon cable that you can separate and pull apart with your fingers. You need to make an 8-way cable with the consecutive colours brown (1), red (2), orange (3), yellow (4), green (5), blue (6), mauve (7) and slate/grey (8). These will fit the 8 pins of the LCD connector on the PCB. Wire 1 (brown) is the far left-hand pin (GND) and wire 8 (slate) is the far right-hand pin (BL–).



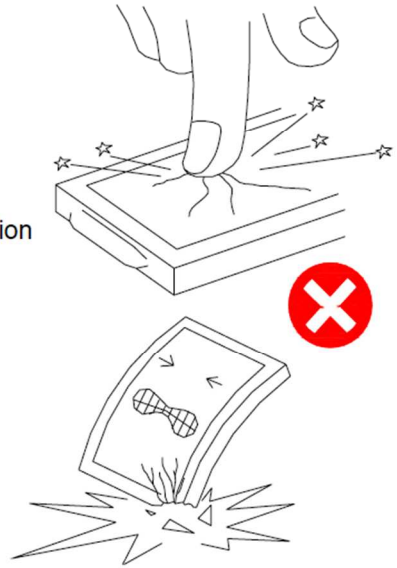
We recommend that you do not remove the clear protective film covering the display screen until you are ready to use TIM 2015. A good way of keeping the screen clean afterwards is to use the spectacle wipes sold at pound shops, supermarkets and on eBay.

4.11 Taking care of liquid crystal displays

This advice comes courtesy of the Optrex Corporation (nothing to do with the eye drops people). Be gentle with your little LCD and don't upset him (or is it her?)!

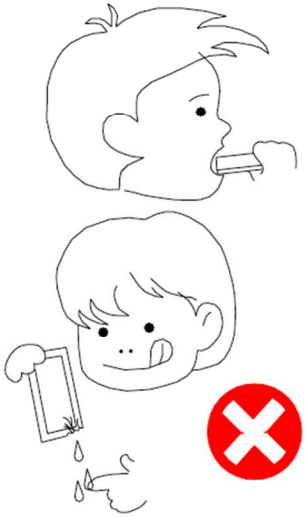
No Press and Shock!

If pressure to LCD, orientation may be disturbed.
LCD will broken by shock!



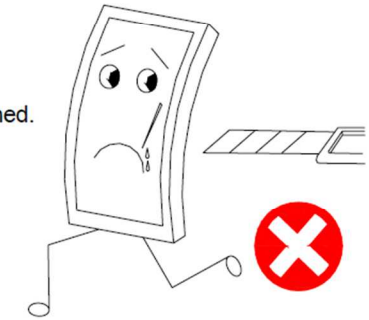
Don't Swallow or Touch Liquid Crystal!

Liquid Crystal may be leaked when display is broked.
If it accidentally gets your hands, wash then with water!



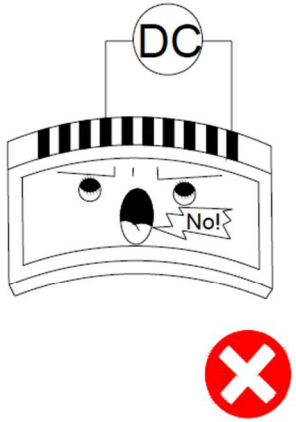
Don't not Scratch!

Polarizer is a soft material and can easily be scratched.



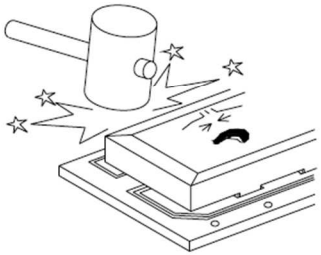
No DC Voltage to LCD!

DC volrage or driveing higher than the specified voltage will reduce the lifetime of the LCD.

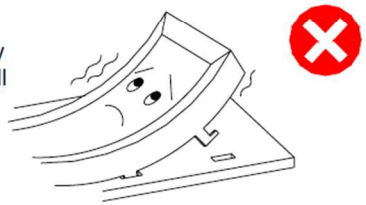


Don't Press the Metallic Frame and Disassemble the LCM

Pressure on the metallic frame and PCB may deform the conductive rubber or break the liquid crystal cell and back light, which will cause defects.



LCD may be shifted or conductive rubber may be reshaped, which will cause defects.

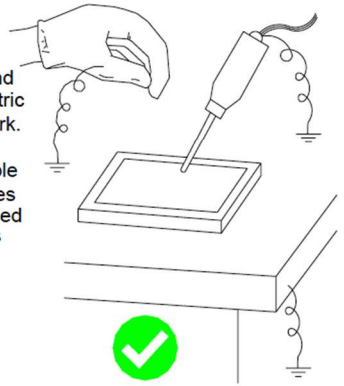


Slowly Peel Off Protective Film!

Avoid static electricity.

Avoid Static Electricity!

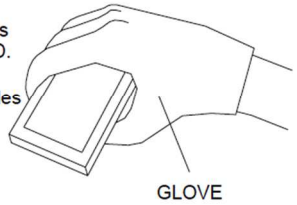
Please be sure to ground human body and electric apploances during work.
It is preferable to use conductive mat on table and wear cotton clothes or conduction processed fiber. Synthetic fiber is not recommended.



Wear Gloves While Handing!

It is preferable to wear gloves to avoid damaging the LCD.

Please do not touch electrodes with bare hands or make them dirty.

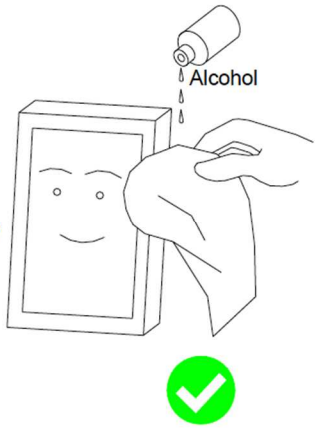


Keep Away From Extreme Heat and Humidity!

LCD deteriorates.

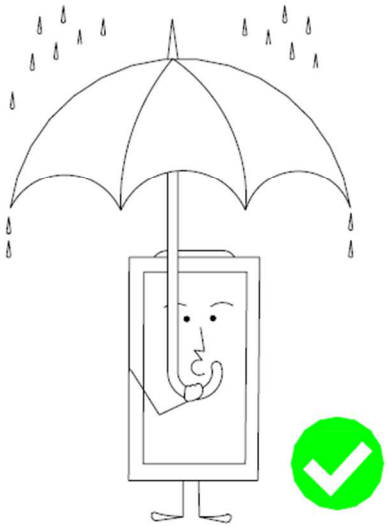
Use Alcohol to Clean Terminals!

When attaching with the heat seal or anisontropically conductive film, wipe off with alcohol before use.



Don't Drop Water on LCD!

Note that the presence of waterdrops or dew in the LCD panel may deteriorate the polarizer or corrade electrode.



Never, ever corrade (or even corrode) electrodes!

Chapter 5 | Making external connections

5.1 The main connectors

TIM 2015 needs to be equipped with cables for connecting the power supply and the 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 also 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. The 16 and 12 designations relate to the diameter of the fixing hole in millimetres by the way.

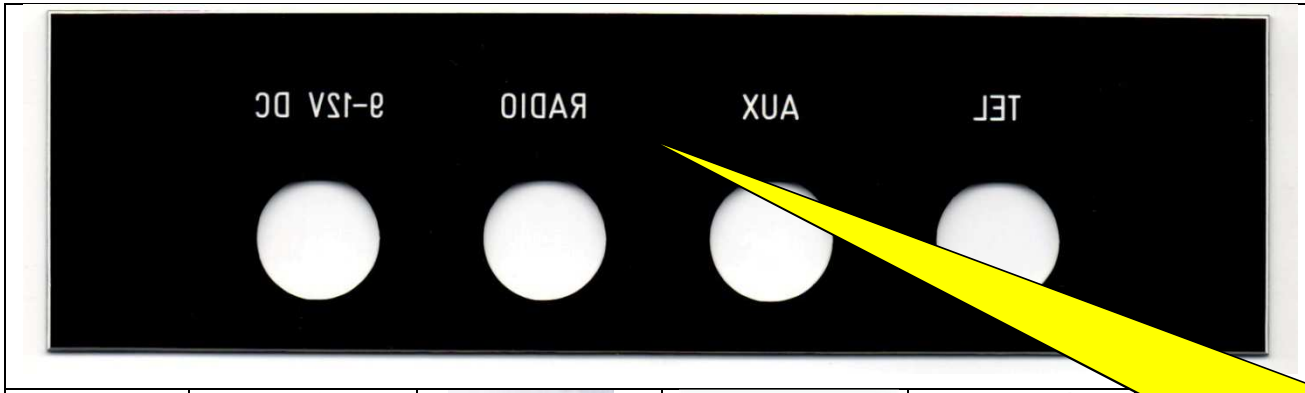
A selection of GX16 connectors. Illustration courtesy of tech999 on eBay.

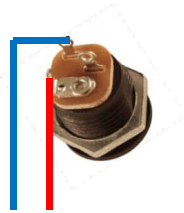
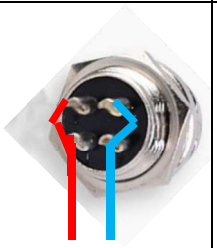
For maximum reliability on TIM 2015 we use locking connectors: GX16-2 for the telephone line, the GX16-3 for the radio time signal or GPS receiver, the GX16-4 for the 9 to 12V DC power supply (on some models) and the GX16-5 or GX16-6 as an auxiliary connector for optional audio and/or serial or pulse 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. Using the GX16-4 connectors (with four pins) for the DC input socket ensures that the power connection cannot be pulled out by accident. With two pins used for each of the plus and minus wires also assures minimum voltage drop and maximum reliability. However, many users said they preferred a standard ROKA connector (as used on all wall-wart power supplies), so we usually employ ROKA connectors now.

- *Continued on next page.*



					
	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.	
			Assembled units supplied since April 2018 are wired as follows: YELLOW Mon (J13) O/P GREEN Mon (J13) GND		

Many users have found that GPS is the cheapest and most efficient means of synchronising the clock (see Section 14 of the **User Manual**). For this reason it is worth fitting an **extra socket** on the rear panel at the point indicated for plugging in a GPS receiver. More information in the text below at **Fitting the GPS socket**.

	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 narrow size is good for insulating the soldered wire connections made to the pins of GX chassis connectors. The latter size is good for protecting the cable entry into GX connectors (see photo below). Black sleeves of this type are 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.

5.2 Fitting the GPS socket

If you intend fitting this socket to you will need to drill a hole in the rear panel at the location indicated on the previous page. This is for a plastic-bodied 3.5mm socket (look on eBay for **3.5mm stereo headphone socket**). To avoid shattering (and ruining!) the somewhat brittle top surface of the engraved overlay, proceed **exactly** as follows.

1. Fix a small piece of masking tape over the panel where you will be drilling. This will help the drill grip better and will make it easier to remove any small fragments of plastic created by the drilling process.

2. Mark the position of the hole with a pen and using a sharp scriber (see **Tools required** in Chapter 2), press just hard enough to make a small indentation (after doing this, try shifting the scriber gently to see if the point is 'catching' in the tiny hole. Leave the masking tape in place.

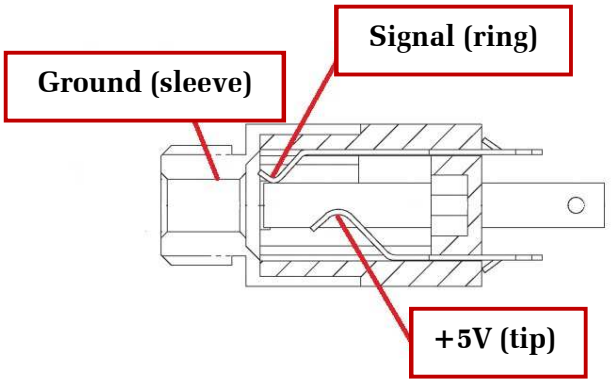
3. Using a 1mm drill bit and a pin chuck (see **Tools required** in Chapter 2), drill a 1mm hole slowly and gently from the masking tape side of the panel, *not* from the rear side.

4. From now on you can use the cordless screwdriver and enlarge the hole to the required 8mm diameter (assuming you are using the recommended plastic-bodied socket).

5. Do this in steps: 2, 3, 4, 6 and 8mm and do not press hard, otherwise the surface of the plastic **will** shatter.

6. Finally remove the masking tape and push the 3.5mm socket through the hole.

7. Retain socket in place by fitting the locking nut on the rear of the socket. Do not over-tighten.

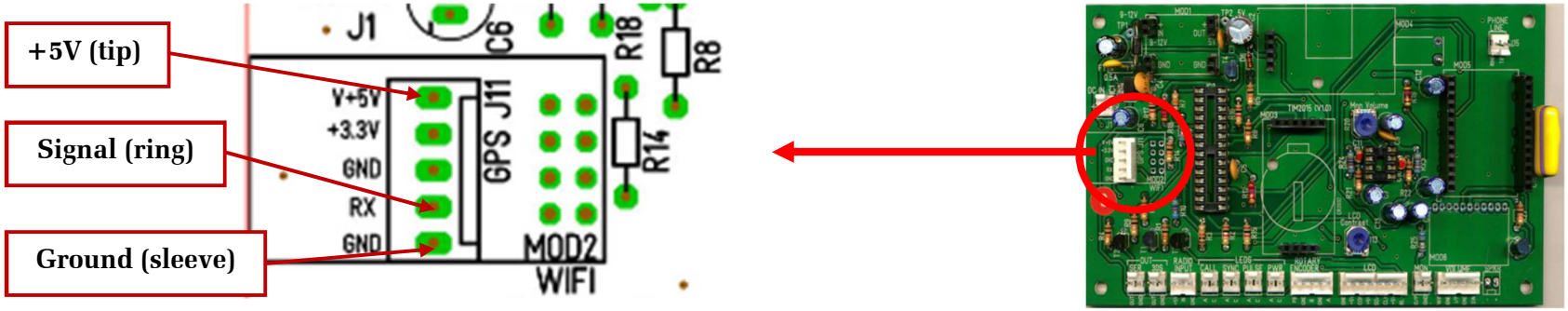


3.5mm socket (jack) connections

Recommended type of 3.5mm socket

The **additional wiring** necessary is made as follows. Take three wires from the socket to a 3-way Molex connector that fits into the corresponding Molex header connector located at J11 on the left-hand side of the main board. **Pin 1** of J11 (+5V switched) goes to the **Tip** connection of the 3.5mm socket. **Pin 4** of J11 (data signal) goes to the **Ring** connection of the socket and **Pin 5** (ground) goes to the **Sleeve** connection of the socket.

The choice of wire colours is yours but we suggest red for **+5V**, black for **Ground** and blue for the **Data** signal.



J11 connections

Chapter 6 Testing

6.1 Preliminary work

1. Connect the encoder, LEDS, Speaker, volume control and LCD. Do not connect the telephone line cord yet.

2. Connect a 9 to 12V regulated DC power supply rated at 1 Amp or better.

3. The green power LED should light up, also the back-light of the LCD.

4. All the other LEDs should also light briefly for a few seconds on power-on to indicate they are working.

5. If the LCD appears to be blank, adjust the contrast pre-set near the LCD Molex connector until the display text is visible.

6. Press the encoder button on the left-hand side of the front panel to enter the menu.

7. Now turn the encoder left or right to navigate the LCD menu. Set the time and date (see summary below).

8. 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.

9. 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 doing 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.

10. If you have fitted the headphone monitor socket, plug in and adjust the headphone volume using the pre-set near the Catalex module.

11. Disconnect the power, then re-connect and check the time is still valid.

12. If everything works so far, disconnect the power then connect the telephone wire Molex connector and plug in to a telephone connection.

13. Switch on power again and try calling the phone number from another telephone or your mobile. It should answer and light the red **Call** LED.

14. Wipe plastic case with duster to remove any plastic swarf or finger marks.

15. Apply the adhesive labels provided to the underside of the case (Isolate before opening, Made in Britain).

*To set the date and time, configure menu settings and set up the radio timecode, Wi-Fi or GPS modules, please see the companion **User Manual**. There is a summary below.*

6.2 Setting user preferences (summary only, see also User Manual)

You will 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 Chapter 2 of this Manual.

6.3 Final checks

Things to check are as follows:

1. Do all four LEDS light briefly at switch-on? Is the green *Power* LED illuminated all the time that the clock is powered?
2. Turn on the audio from the loudspeaker by turning the right-hand knob clockwise. Does turning the knob further clockwise increase the volume? Press the left-hand control knob to see the Settings menu, select *Change Voice*, turn the switch clockwise and confirm that a different voice is heard.
3. Have you fitted the coin cell in the RTC module? TIM 2015 will not work if you do not do this.
4. You will need to set the date, time, time zone and DST (daylight saving time/summer time) zone in the Settings menu. You will find details in the companion **User Manual**.
5. You must fit the microSD card containing voice files.
6. Plug the telephone line cord of TIM 2015 into a phone socket. Ring your number using a mobile phone or a different landline number. TIM 2015 should answer the call and tell the time before ending the call after about 90 seconds.
7. If you are using Wi-Fi, GPS or a radio time signal receiver (described in the companion *User Manual*), check that TIM 2015 synchronises to the time source within five minutes. If it does not you may be in a weak sign area.

Finally you may wish to tick each item in this checklist as appropriate.

All LEDS light at switch-on		Date and time adjusted	
Audio functions tested		Micro SD card fitted	
Coin cell fitted		Knobs fitted	
Labels under case fitted and signed		Cosmetic appearance of case OK	
Works correctly with Wi-Fi or MSF or DCF receiver		Answers calls when connected to telephone line	

Chapter 7 | 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 and identified further on.

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

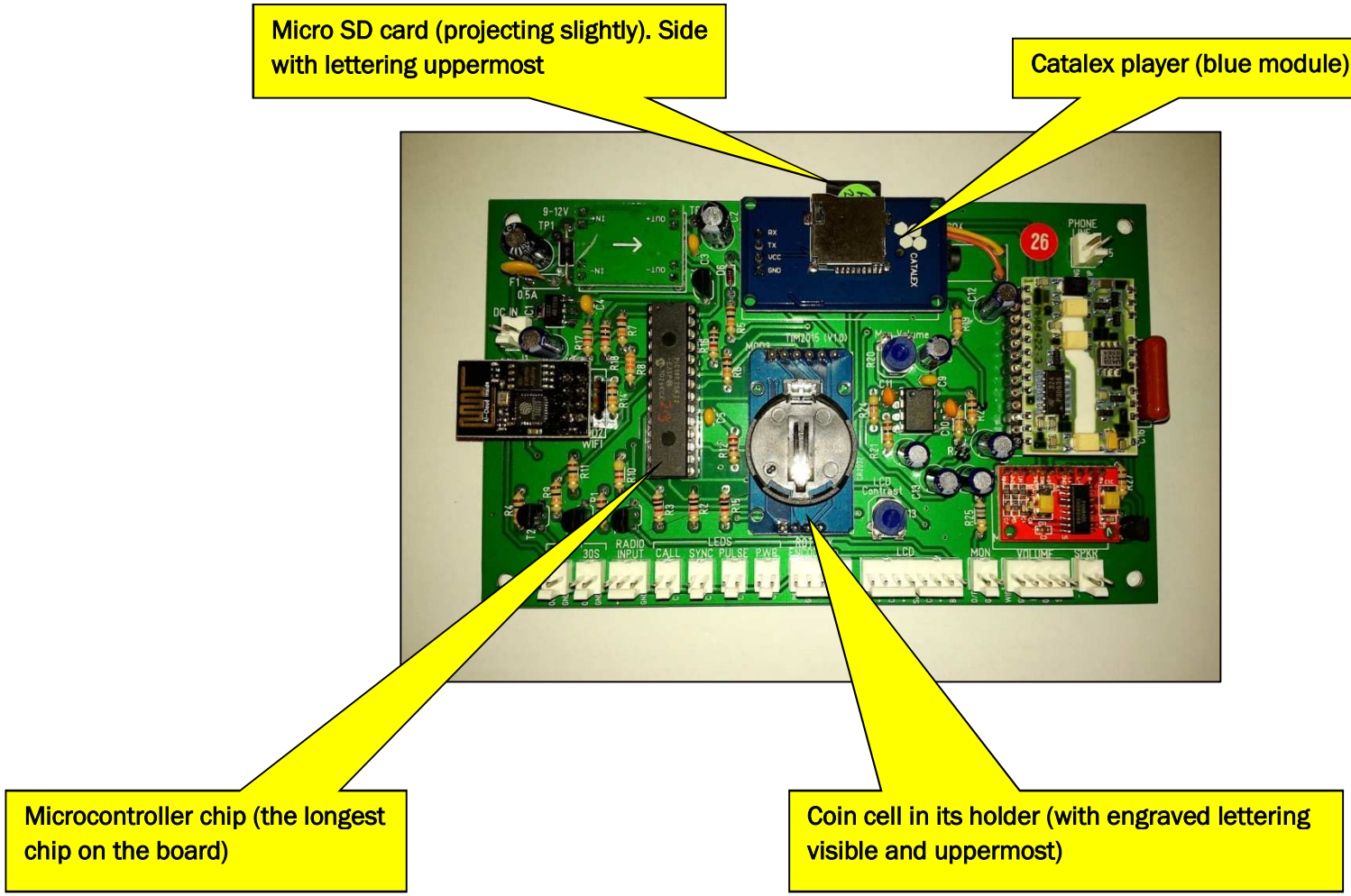
There has been an error with the RTC time or date (this message may also be reported while the clock is running, with all four LEDs flashing).

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, try replacing the coin-cell with another one of a different make. Not all coin-cells are equal.

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 8 Troubleshooting

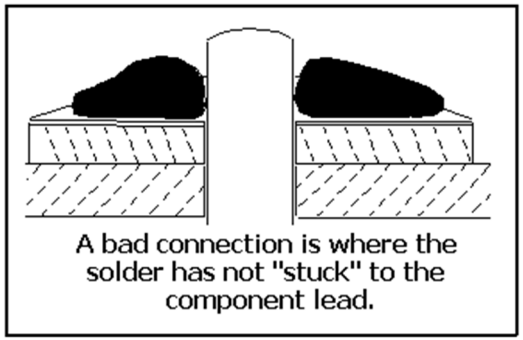
This chapter is in several part. The first two parts list faults that may occur during construction and prevent you from getting TIM 2015 to work at all, whilst a later section covers things that may come to light once you start using the completed clock.

The companion User Manual lists other problems that may crop up while using your TIM 2015.

8.1 Soldering shortcoming

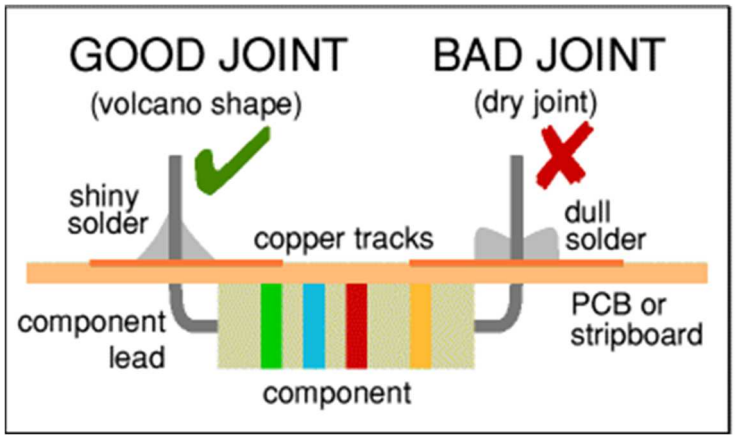
Note that problems are frequently caused by **unsoldered or badly soldered joints** on the track side (underside) of the PCB. Visual examination with a magnifying glass in bright light is the way to go. These words on good soldering are adapted from a Wikipedia article.

> 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.

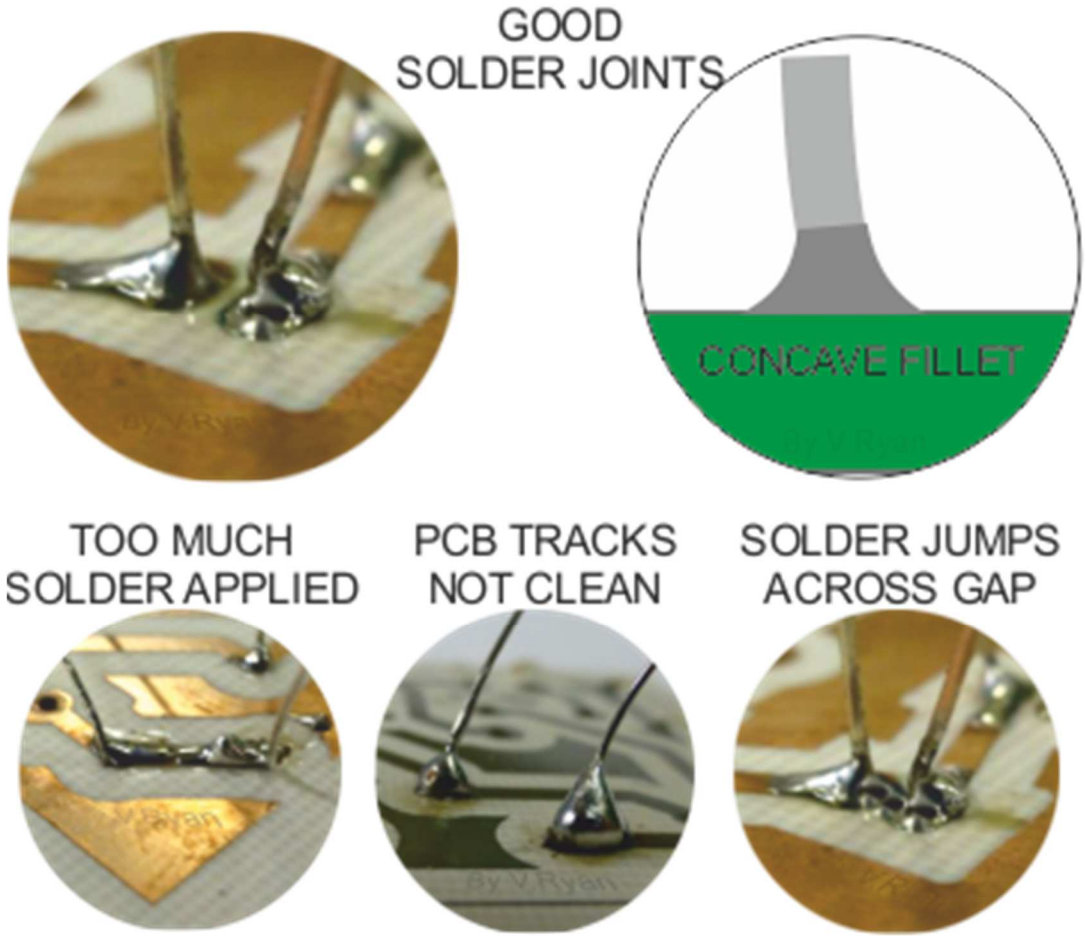


Graphic courtesy of Quora.com

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.

8.2 Assembly errors

1. **No volts on the +5V or +12V rails, polyswitch (self-resetting fuse) is too hot to touch**

   There is a dead short between the power rail and ground. Disconnect power connector on rear panel immediately. But before getting out the magnifying glass to search for solder splashes between tracks (a tedious and thankless task), get hold of suede shoe brush with brass bristles (also sold in car part shops for cleaning battery terminals and spark plug contacts) and brush along all of the tracks. If you are lucky this will clear the problem (a tiny speck of loose solder).

2. **Faulty connections in Molex connectors**

   Excellent as these Molex connectors are, they can sometimes 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.

3. **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.

4. **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*.

5. Turning the left-hand control knob clockwise has the wrong effect.

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*.

6. 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 might switch on TIM 2015 at any random moment, a delay of up to eight seconds could occur until the next pips or toneburst moment.

7. The liquid crystal display does not illuminate at all.

This could occur 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.

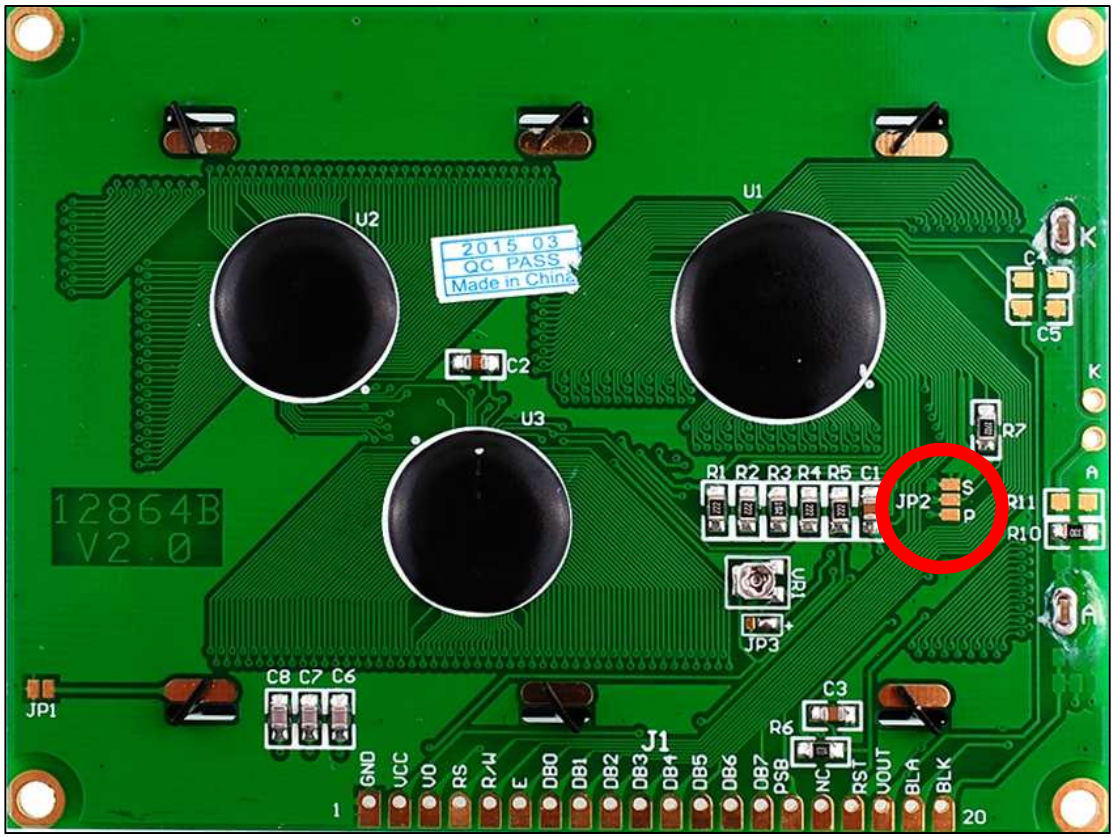
(2) Accidental solder splash bridging two or more pins of the plug at the display end of the cable.

(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.

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

This is usually caused by a loose wire connection in the flylead connecting the LCD to the main PCB. Alternatively the serial/ parallel selector on the rear of the LCD is connected wrongly or not at all. It should be set as S (for serial). See previous page.

9. The LCD display looks wrong (too dark/too pale/wrong contrast)

Try adjusting the contrast control (trimpot) on the rear of the LCD board with a watchmaker's screwdriver. There is a second trimpot marked **LCD Contrast** on the main PCB at lower centre and you may find altering the setting of this control may help too. There is also a software control for backlight control. Press the left-hand control knob in briefly and scroll through all of the **Settings** options by rotating the knob clockwise. The setting comes immediately after the setting for **Call Duration.**

Incidentally, one customer asked why we bothered to provide adjustment controls. This is because the brightness of the backlight varies from one display to another, so there cannot be a single default setting. There are many different makers or models of these displays, all with differing characteristics. Then you have the various colours of display: blue, yellow-green, red and white. Those are just the main ones; I have seen others. So we have to accept that there is no single optimum value.

10. The time on the LCD display appears frozen and does not increment

This could be caused by a faulty RTC module, because after the PIC chip gets the initial time from the RTC module, it uses the 1 second pulse from the SQW pin on the module to time the subsequent updates. If that is not working, then the display won't update properly. There is a tiny SMD pull-up resistor on the module's SQW pin, so maybe that is faulty or there is a break in the connection of the pin to the PIC. If you can't see anything obviously wrong and there is no pulse on the pin, then try changing the RTC module.

Dave Thorpe, who designed TIM 2015, adds:

> I think the LED below the Catalex player is normally lit when it is ready (the microSD card has been initialised OK) and it flashes when it is busy playing (the LED is controlled by the Catalex player alone). The lack of time update is most likely due to the 1Hz pulse from the SQW pin 5 of the RTC module not reaching pin 21 of the PIC. I read recently that someone who uses a lot of those RTC modules said they sometimes have bad soldering reflow or parts attached incorrectly. Or else they are simply counterfeits! The author says he has also heard rumours about 'ghost' shifts, where legitimate manufacturer plants/equipment are used off the clock to produce extra parts. Or legitimate production runs which test out defective (if 10% of a run's chips are bad, they often scrap the entire run) but someone intercepts the chips before they can be destroyed, and they resurface on the grey market. (https://thecavepearlproject.org/2014/05/21/using-a-cheap-3-ds3231-rtc-at24c32-eeprom-from-ebay/). It may be worth checking the RTC module with a magnifying glass).

The 1Hz pulse from the RTC module is essential for the time updates and voice triggering. You may be able to check if the Catalex player is working by checking the files play in the voice audition menu.

One poster on the WWW states: It's very simple, a lot of this kind of [DS3231] chips are from older PCBs and de-soldered and recreate the surface to make it can be resell on the market, most of these kind of people are in GuangDong Prov. China, especially from the ShanTou city, it's a huge industry in GuangDong, China, you can find a lot of the fake/retread chips from Taobao [Chinese clone of eBay], most of the sellers are also from ShanTou, GuangDong City if you check the location of the sellers.

The price of on DS3231 retread chips are less than 0.1~0.2usd after been cleaned, plating the legs, and recreate the surface marks, and of course if the can send it to you via HONGKONG, the int-mail price can low down to started from ~1/6usd. That is why you can find a lot of the sellers who can give you the price like $2 even with the free shipping from HongKong. So if the price is too low, and the sellers' location is GuangDong or written like HongKong, 90% are made by retread chips. But it does not mean all the stuffs are unsaleable. buy it or not depends on yourself.

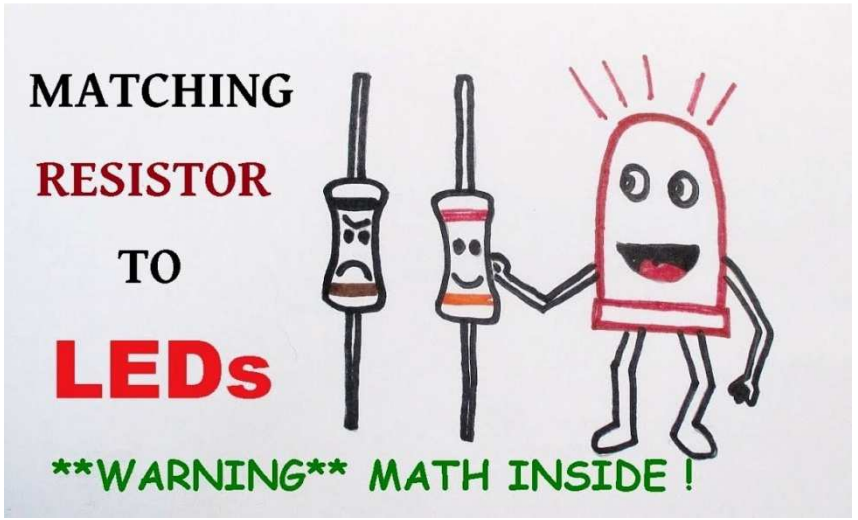
11. One of the LEDs lights up brighter/dimmer than the others.

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 correctly for the LEDs that our designer used but you may like to SOT (select on test) the resistors you use.

If you find the brightness a bit excessive you can try altering the value of the series resistors (R2, R3, R12 and R15) but only try higher values, never lower (as that might damage the LED). 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/ and a helpful YouTube explanation at

https://www.youtube.com/watch?v=hduuUDiku80



12. Incoming call causes red LED flash in time with the ringing current but call is not answered. Caller hears ringing tone but not time-of-day announcement. Replacing PIC chip and Mitel hybrid does not remedy the problem.

Maybe insufficient ringing current voltage is reaching the Mitel hybrid. Measure AC voltage with 'scope. Look for leaks to ground from the ringing current path. Check PCB tracks for short circuits, solder splashes, etc. Reflow solder joints. Are any adjacent solder pads bridged that should not be? Check for resistors and capacitors having the wrong values. Use multimeter to test Ring line (from pin 11 of PIC to pin 7 of Mitel hybrid) and Seize line (from pin 12 of PIC to pin 5 of Mitel hybrid). Measure voltage on these lines. Are they pulled High or Low, or are they floating? Are any pins of the PIC chip or the Mitel hybrid not properly seated in their sockets?

If the red LED is lighting, the PIC just have detected the incoming call. It should then take the Seize line (PIC pin 12) LOW. Check this. Check continuity along the entire Seize line, also for shorts to any adjacent PIC pins. Other possibilities include a high-resistance connection between the telephone Tip and Ring lines (at J15) and the corresponding pins of the Mitel hybrid (Tip, pin 26 and Ring, pin 16).

8.3 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).

3. **Occasional loss of power or restart**

A customer reports a happening that he ran across while playing with the DC input plug and socket (ROKA type) when he had the unit on the bench. He uses a 2.1mm pin panel socket and found that by moving the plug around, the power would be momentarily interrupted, thus causing a restart and having to wait for the GPS to lock on again. The socket has a split centre pin that was not applying sufficient pressure on the inside barrel of the plug, so he spread the pin a bit and that appears to have fixed the problem.

8.4 User feedback

Ross Herbert *in Australia reports:*

I ended up using a Hammond 515-0940 sloping front case. It costs less than AUS$50 from RS https://docs-apac.rs-online.com/webdocs/0062/0900766b80062c50.pdf . There is plenty of room inside as you will see from the pictures. Now some points to note:

While playing around with both halves of the case separated, I found that moving the DC input plug around caused a momentary open circuit of the power to the unit which naturally resulted in a reset condition. I had to re-tension the spring which makes contact with the outer sleeve of the DC plug and I also spread the split in the centre pin of the DC socket to ensure good contact with the inside of the centre connector on the plug. It should also be noted that since these connectors rely on a simple riveting procedure to make connections to the solder tabs it is always possible that there can be some movement of the metal parts which will also cause a momentary break in power to the unit. If possible a more reliable (or better quality DC plug and socket) arrangement should be used to eliminate this sort of problem. I eventually achieved a good connection and couldn't induce any further power interruptions when moving the DC plug in the socket.

If you use a metal enclosure then the DC input socket will invariably be of the type which connects the outer sleeve (DC 9V negative) of the power plug to the chassis (It is possible to buy insulated DC input sockets). This means that when choosing a chassis connector for the telephone line input (I used a 6.35mm Tip/Ring phono plug and socket), the socket must be an insulated type.

Initially, I used an un-insulated socket which connected the Ring of the plug to the chassis, and this resulted in hum being present whenever a call was established to TIM due to the potential difference between the telephone line Ring polarity and the 9V -VE potential connected to the chassis via the un-insulated DC input socket. I changed the phono socket to an insulated type and the hum disappeared.

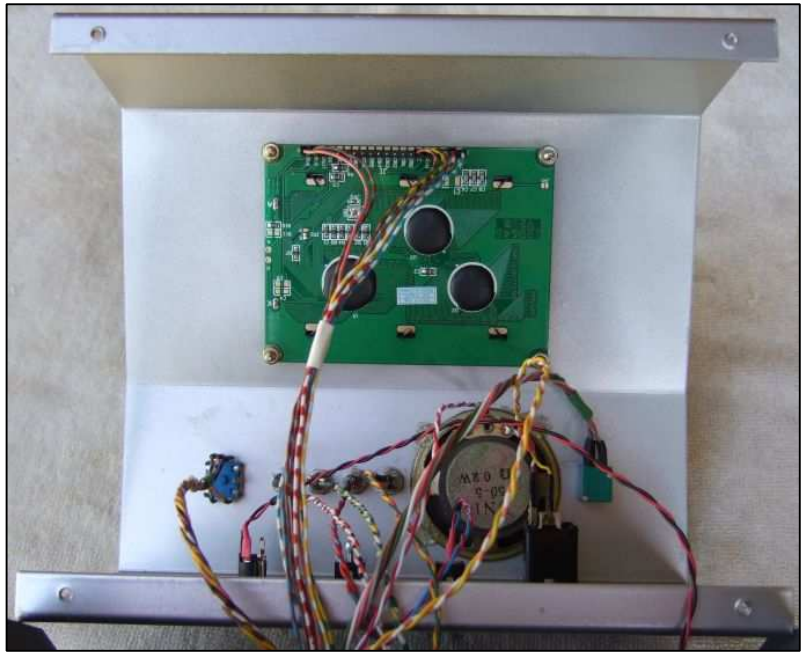
Since I am a believer in single-point earthing of any equipment, I ensured that the chassis was only connected to the 9V -VE from the DC supply via the DC input socket and nowhere else in the system. This meant that I had to use nylon stand-offs for the TIM board in the bottom half of the enclosure. If metal stand-offs are used then the GND plane on the TIM board will be connected via the stand-offs to the metal enclosure and when the two halves are screwed together there will effectively be a ground loop formed by the chassis connection at the DC input socket and the TIM board ground plane via the stand-offs.

I use the Zarlink version of the telephone line interface module, which has a slightly different component layout to that of the original Mitel unit but it works the same. I have wired in a momentary break press button switch in series with the 3-volt coin cell on the RTC module. This makes it easier to reset the RTC when a fibrillation error occurs and avoids having to open the case and remove the battery.

In the attached pics you will see how I mounted the GPS receiver just outside the instrument case, using double-sided foam tape.

Front view

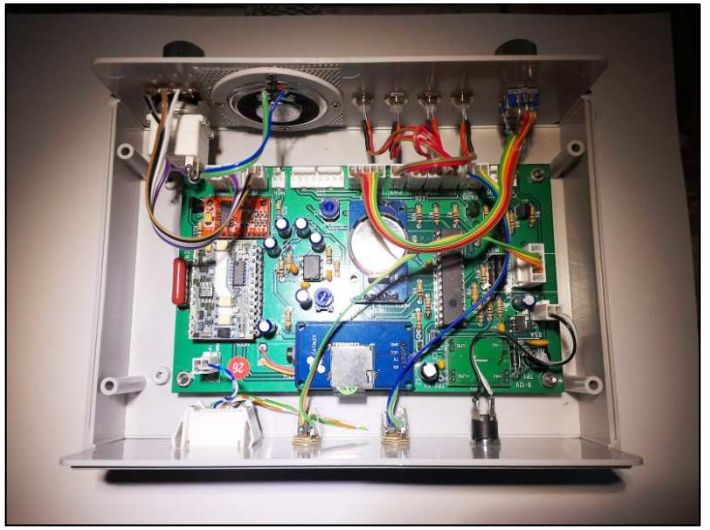
Rear view



Interior

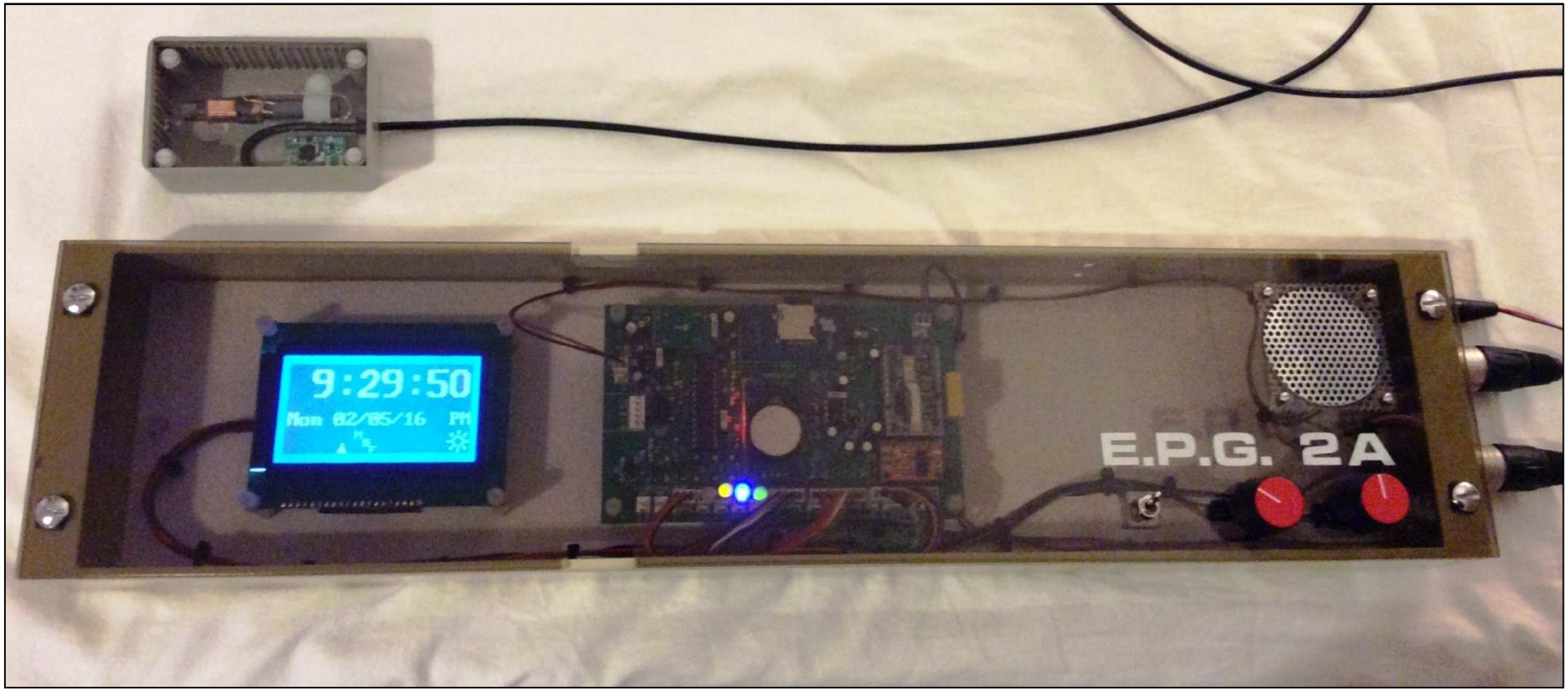
GPS receiver module fixed outside the casing

Dave Whistler *used a pale grey case for his very tidily constructed unit:*



John Novack *in the USA put his TIM 2015 clock into a 19-inch rack module:*

John Cossins *'repurposed' a BT Electronic Pulse generator rack module for his TIM 2015:*



Mike Fletcher *reports:*

I thought I'd just offer you a little feedback on how pleased I am with the TIM 2015, I'm really chuffed. Once again, well done to yourself, Unusual Electronics and everyone else involved. My TIM 2015 has now been up and running for around three and a half weeks, has taken 880 calls and hasn't missed a beat! I'm so delighted that once more, after all the years since MSF moved from Rugby, that I have an accurate clock once again. The only minor gripe I've discovered is if you unplug the power supply the time remains set by the back-up battery but most of the calls information history reverts back to zero, is this normal? [**Yes, unless you provide a 12Vbattery as well**]

As you can see from the attached photo I have installed my old TIM 2000 into a similar Maplin case and I've endeavoured to make it look similar to TIM 2015, although my label printer doesn't make it look quite as professional as the engraved panel and I'm not so good at the hole drilling as you are. My TIM 2000 clock is now able to operate in two modes – slave and master. In slave mode the front end is disabled and the more accurate feed from TIM 2015 is fed through to the amplifier and phone line. In master mode it reverts back to using all the original 2000 circuitry, meaning that in the unlikely event that the 2015 clock should fail I can revert back to the 2000 clock.
The two clocks are connected to two separate Sipgate VoIP lines meaning that if the main line to the 2015 is engaged then the call diverts through to the secondary line connected to the 2000. This doubles my capacity for callers to my Speaking Clock which is a great bonus.

Chapter 9 Background information

9.1 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 confirm 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.”

9.2 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.

9.3 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.

9.4 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.

9.5 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.

9.6 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.

9.7 CE status

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

Chapter 10 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 below at **PIC chip — firmware versions**. To establish which version is installed in your TIM 2015 simply rotate the menu knob two notches to the right and read the listing **Information**. The version number is also written on the PIC chip itself.

If you wish to upgrade your PIC chip 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.

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 11 Revisions to this manual

V 1.0 Original version.

V 2.0 Major re-write.

V 3.0 Additional chapter.

V 3.1 Note added on an alternative case (see next page).

V 3.2 Reformatted.

For further information please re-read this document.

An alternative case

Ross Herbert informs us helpfully of the sturdy aluminium case by Hammond (order code 515-0940). It is available from numerous suppliers in Britain, North America and Australia. He writes:

> If you are building the short form kit for TIM2015 then the recommended case from Maplin (now deceased) is not entirely necessary. See attached pics of my finished unit. Case is Hammond 515-0940.
>
> Note the GPS receiver is mounted externally on the right-hand side. It cannot be mounted internally since the metal case shields the receiver and it cannot lock onto satellites.

Rear view

End view with satellite receiver

Front view of Ross Herbert's construction

Chapter 12 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. 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 TIM 2015 team, the Telecommunications Heritage Group nor Unusual Electronics will take responsibility for user misadventure or other consequences of anything done or omitted to be done wholly or partly in reliance upon any part of this publication.

LONDON LAUGHS: The Golden Voice

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

Courtesy of BT Archives