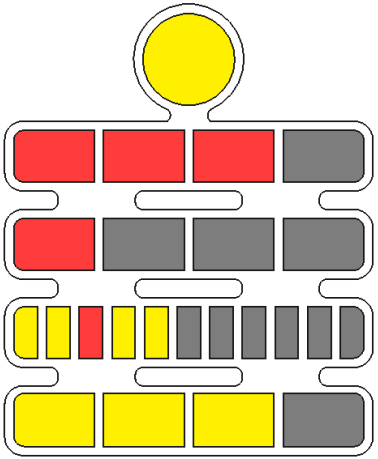
TD-FBUH01A



User Manual

General

Features

The TD-FBUH01A is a small scale replica of the iconic Berlin Uhr. The clock can display the current time, in 24h format, thanks to an ingenious set of coloured lights. The colours used in the original are red and yellow, and this is the default colour schema the face kit is shipped with. Thanks to its 36 RGB LEDs though, you can choose to personalize the clock to your liking.

The TD-M5037 movement gives this clock the ability to keep track of time even when the main power is removed. Additionally, the movement can automatically switch from/to DST (EU rules only), manual switchover is also possible, see TD-M5037 User Manual for all details.

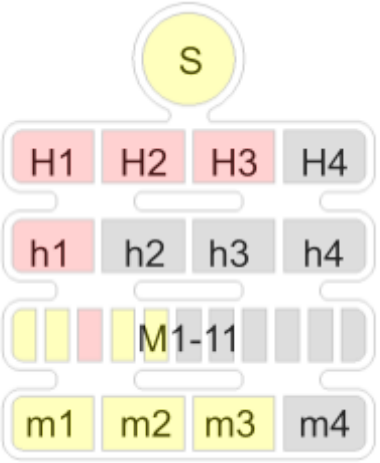
About the Berlin Uhr

The name translates literally to “Berlin Clock”. However, the real name of this timepiece is far less readable for the non German speakers as it originally was called Mengenlehreuhr. This less friendly name translates to “Set Theory Clock” and we will see soon why.

The unique time telling device was the only, when it was installed in June 1975, to show the time by means of coloured illuminated fields. At that time it sat on Uhlandstraße, in West Berlin. It’s since been relocated to Budapester Straße, on one side of the Europa Center shopping mall where it can still be admired in all its glory.

Reading Time

The “S” round light at the top blinks on and off signalling the seconds, it alternates one second on and one second off during normal operation. When the clock is in time set mode, this light will be steady and red.



Hours are displayed in the two rows of red lights H1-H4 and h1-h4. Each of the H1-H4 lights is worth 5 hours, while each of the h1-h4 is worth 1 hour. This is not a positional system so, theoretically, any of the lamps could be in a given row, just their count matters. In practice though, the Berlin Uhr keeps things neat and lamps always start lighting from the left.

In the example above we have 3 lit lights on the first row (3 X 5 = 15) and one in the second row. So the shown time hours are 15 + 1 = 16.

The other two rows indicate minutes and work exactly in the same way. M1-M11 lights are worth 5 minutes each, and m1-m4 1 minute each. So, the first row is 5 x 5 = 25 minutes, and the second 3 minutes for a total of 28 minutes.

If we put all this information together, we can tell the clock above shows 16:28.

There's a peculiarity of row M1-M11: every 3rd light is red. This allows us to avoid counting all the lights, which might be tedious and error prone past the 30 min mark. We can instead count 15 for each red light lit and then just add 5 for each following yellow one. The larger spacing between two red lights on this row makes it quite fast to read minutes at a glance this way.

It should now be clear where the "Set Theory Clock" name comes from as each group of lights is a set of items with the same values (5 or 1).

Setting Time

Time set mode is entered with a **long press** on the **A** button. The first settable value (the hours) will start to flash on the clock face. Additionally the round light at the top will glow steadily in red.

NOTE: Upon entering time set mode you will not see any lights flashing if the current hours are "0". Just press B or C to increase/decrease and you will see some values flashing.

Once time set mode is entered use **B and C to increase/decrease** the value being set respectively. **To move to the next value** (minutes) just **press once A.** Pressing again the A button will bring you back to hours.

Once you are done setting the time, **long press** again **A** to **exit time set mode.**

Hint: to achieve a second-accurate setting, set the clock to the next minute. Then wait in time set mode until your reference clock shows :59 seconds, only at this point long press on A to exit time set mode. This works because, upon exciting time set mode, the clock always starts from second :00.

Display Test Mode

It's possible to **enter test mode** by **long pressing** on the **C** button. In this mode your clock will light all LEDs regardless of current time. This can be useful to ensure all LEDs are functioning and to test your power supply and ensure it can provide enough current. **Long press** again **C to exit test mode.**

Assembling the Board

Packing List

Before proceeding with the assembly of the components on the board, double check the packing list to make sure you have received all components and that everything is in good order.

Bag	Content
A	36 x 5mm WS2812D LEDs
B	1 x Pin 1x5 Vertical Male 1 x Pin 1x6 Vertical Male 3 x Tactile Push Buttons
	1 x PCB TD-FBUH01A REV.A

Top Assembly

Insert all LEDs paying attention to orient the LED flat side as indicated by the silk screen. Ensure LEDs are all sitting at the same height. This will ensure a more consistent illumination of the different sections. Notice how the LED pads are staggered (see picture below).

This facilitates manual soldering, given the relatively small clearance between the pads, it would otherwise be quite easy to create solder bridges. I found that the most convenient way to solder the LEDs is to put in a whole row and then solder first the square pins using a wider gauge tin (0.8mm worked very well for me). Next flip the board and make sure all LEDs are vertical, at the same height and generally well aligned. If something is off it’s very easy at this stage to rework it by just heating the single soldered pad holding them in place.

Once happy with the alignment, solder the pins opposite the square ones using the same 0.8mm tin. When this is done, before doing the two middle pins, it helps to clip all the terminals close to the board. In this way it’s possible to solder the middle pins working from top, and not the side of the pin, minimizing the chances of a bridge forming. For this step it’s best to use a smaller gauge tin (for instance 0.2mm, but you might find other sizes working better depending on your solder tip).

Bottom Assembly

Once all the LEDs are in place, you can add the pin strips that allow the movement to be plugged in. Make sure they are installed on the opposite side of the LEDs, as per silk screen.

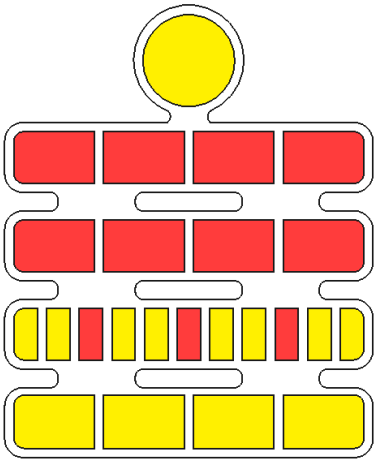
You can finally then solder the 3 push buttons.

There are no other components on this PCB.

Testing

Since you will be potting the LEDs in resin it's a good idea to first ensure everything works fine. For this purpose the clock provides a test mode which lights up all the lights at the same time. To enter test mode just long press C for a couple of seconds. Test mode can be exited by long pressing C again or by power cycling the clock.

It's strongly recommended to keep the clock powered in test mode when doing the resin pour, this way the lights will serve as a colour guide and prevent you pouring the wrong colour.



Face Assembly

Once the electronics are good and tested it’s time to assemble the face plastic cover and do a resin pour to complete the clock. To complete this operation you will need the following materials that are not part of the kit:

- 2 part epoxy resin ready to mix
- Suitable resin dyes (white, yellow, and red for the classic look)
- Disposable plastic cups
- Disposable wooden or plastic sticks
- Large plastic syringe with no needle
- Working gloves to protect your hands when handling resin
- Paper towels and q-tips to clean spills
- Glue suitable for plastic

Plastic Face

The first step is to glue the plastic face to the PCB, LEDs side. While using superglue is tempting, I suggest using a bit slower and weaker one as you might misalign the face and need to relocate it. Keep in mind that glueing at this stage serves only the purpose to keep things in place during the resin pour, so it doesn’t need to be extra strong.

Note: the plastic face has two recesses on one side, this is the side that should go towards the PCB as the recesses are meant to leave room for the pin headers solder bubbles.

Seal the wells

Before you can pour resin you should seal the wells into which the resin will be poured. Not only can resin leak in gaps between the PCB and the plastic, it can also make its way to the other side of the PCB through vias. I had good results pouring melted wax in the wells covering up to about half of the height of the LEDs and then letting it cool before proceeding. If some wax leaks through cracks it can be easily cleaned later without damaging the face. A long, straight candle, kept at an angle is a good source of a continuous stream of melted wax. You might also want to consider melting some wax in bain-maire, just pay extra attention not to burn yourself! Also, don't pour all wax at the same time in all wells as that might overheat and warp the plastic.

Resin

Note: before committing to a colour by actually doing a pour, consider if you want your clock with the standard red/yellow colour scheme, or you want to make it unique and use a different colour pair. Read the "Advanced" section to familiarize yourself with the serial interface through which you can change registers to achieve this and perhaps experiment with different colours. You can also choose to make the resin milky white, with no tint, so that you can change the colour scheme as you see fit for the day and mood.

For the resin pour I recommend mixing a 100g batch of resin. You will have some left at the end, but you will have peace of mind in case of small spills and you will be able to work more comfortably. If you want to keep it lean and mix a smaller batch, consider that, if you run out towards the end, it might be hard to mix a new small batch that matches in colour perfectly.

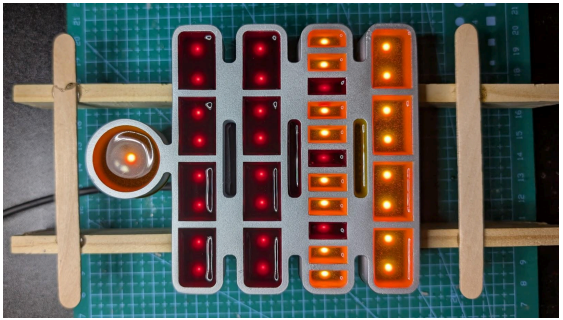
Start by mixing the base. Check carefully the instructions for your resin. If, for instance, your resin is meant to be mixed in a ratio of 4:1 by weight, that would mean 80g resin and 20g hardener. Pour both in a disposable plastic cup and mix well with a disposable wooden or plastic stick.

I like the Berlin Uhr face to have coloured filling of the wells, which closely resembles the original where, even when the lamps were off, the colour of the glass could be seen. It's up to your taste how you want your clock to look but, in my opinion, leaving the resin transparent doesn't work well as you see straight down to the PCB and the LEDs. Also the light won't be diffused.

For the resin not to be transparent you will need to add white dye to it. You can then decide to fill all wells with white or to further mix in yellow and red (my favourite option). With all these options, and variability of dyes, it's absolutely necessary that you first do some tests with smaller batches and let them harden on a test surface. Once you are happy with the tint and milkiness of the resin, mix the full batch following the same recipe.

With the products I used I started from the yellow using, for a 100g resin batch, 20 drops of yellow and 30 of white. You can start from fewer drops, mix and pour a small amount on a disposable surface to get a better feeling of the actual colour and milkiness.

Once you are ready to start the pour place the assembled clock face on a surface where it can be perfectly flat and where you can leave it for at least 24h untouched. I found it useful to build a temporary support out of scrap wood and hot glue, as seen below.



Familiarise yourself with a picture of the Berlin Uhr and make sure you know which wells are red and which yellow! Best of all you should power the clock, set it in test mode with all the lights on, and use them as a colour guide.

Load a large syringe with part of the resin. Always wipe the syringe outer surface completely clean with a piece of paper towel when you load it so you don’t have drippings on the clock face.

Start the pour from the large circular well at the top. This will give you a good indication of how flat the face is positioned. If you notice the level of the resin is higher on one side, prop gently the support by adding some thin cardboard or wood stick on the correct side until the resin sits completely flat.

Start to pour the resin EXTREMELY SLOWLY, almost a drop at the time. Due to the high viscosity of the resin, **if you put too much pressure the plunger will give way suddenly and spill out a large amount of resin**. If this happens and resin goes where it shouldn't, don't panic. Suck back with the syringe as much of the spill as you can then proceed to clean all surfaces that got stained with paper towel and q-tips. Remember resin takes 24h to harden, so in the first hour or two you can still clean off pretty much any spilling. If some yellow has poured into a well that should be red make sure you clean extremely well the whole well down to the bottom with a q-tip otherwise when you pour the red some yellow streaks might appear. Make a note also of the wells where this happened and, when you proceed pouring the red, pour first only half and mix well with a stick to prevent streaks.

As you pour drop by drop, notice how the surface of the resin is concave. This meniscus is formed due to the viscosity of the resin. If you like the effect you might want to try to pour all wells to such a level where the meniscus is of the same depth. Personally, I prefer to keep pouring (tiny drops!) until the meniscus disappears and the surface is completely flat. Be careful at this stage you can afford only an extra drop or two before the resin starts to overflow.

Once you are done with the yellow double (triple!) check all yellow wells are filled and that you are satisfied with the level and the uniformity of the pour. If you notice any bubbles in the resin you can pop them by inserting and gently moving a needle in the bubble.

Start now to add red to the same resin, a few drops at the time and repeat the test on a disposable surface until you are satisfied with the colour. Red is overpowering yellow easily, so you can minimise the waste. With the dye I used I had to add 30 drops of red and 15 more of white to achieve a colour I liked. Use the same technique and a lot of patience as before to fill all the red wells.

Advanced

Your clock comes with a UART that you can use to send commands to it via a terminal program. This is not only an alternative way to set time, it's also a way to change the clock colours. See the TD-M5037 User Manual for details on how to connect, send commands and alter register values.

Registers Map

0x00 - 0x3F Movement Registers	See TD-M5037 User Manual for usage.		
0x40 - 0x7F Face Registers	0x40 - 0x42	Colour for LEDs that are "off". This can be used to have the wells that are off still glow, perhaps with a very faint colour.	Default is 0x000000 (black)
	0x43 - 0x45	Colour for LEDs that are red in the original Berlin Uhr colour scheme (hours and every 3rd in the first minutes row).	Default is 0x050000 (red)
	0x46 - 0x48	Colour for LEDs that are yellow in the original Berlin Uhr colour scheme (top round light, minutes).	Default is 0x050500 (yellow)
	0x49 - 0x7F	Not used	

Appendix A - HW Revisions

REV.A	First version.