debug innovations

Mataki Support Board User Guide

Version 1

This document describes the Mataki Support Board hardware and how to use it with Mataki-Classic and Mataki-Lite tags.

Version History

Version	Date	Changes
1	7 March 2018	First Release

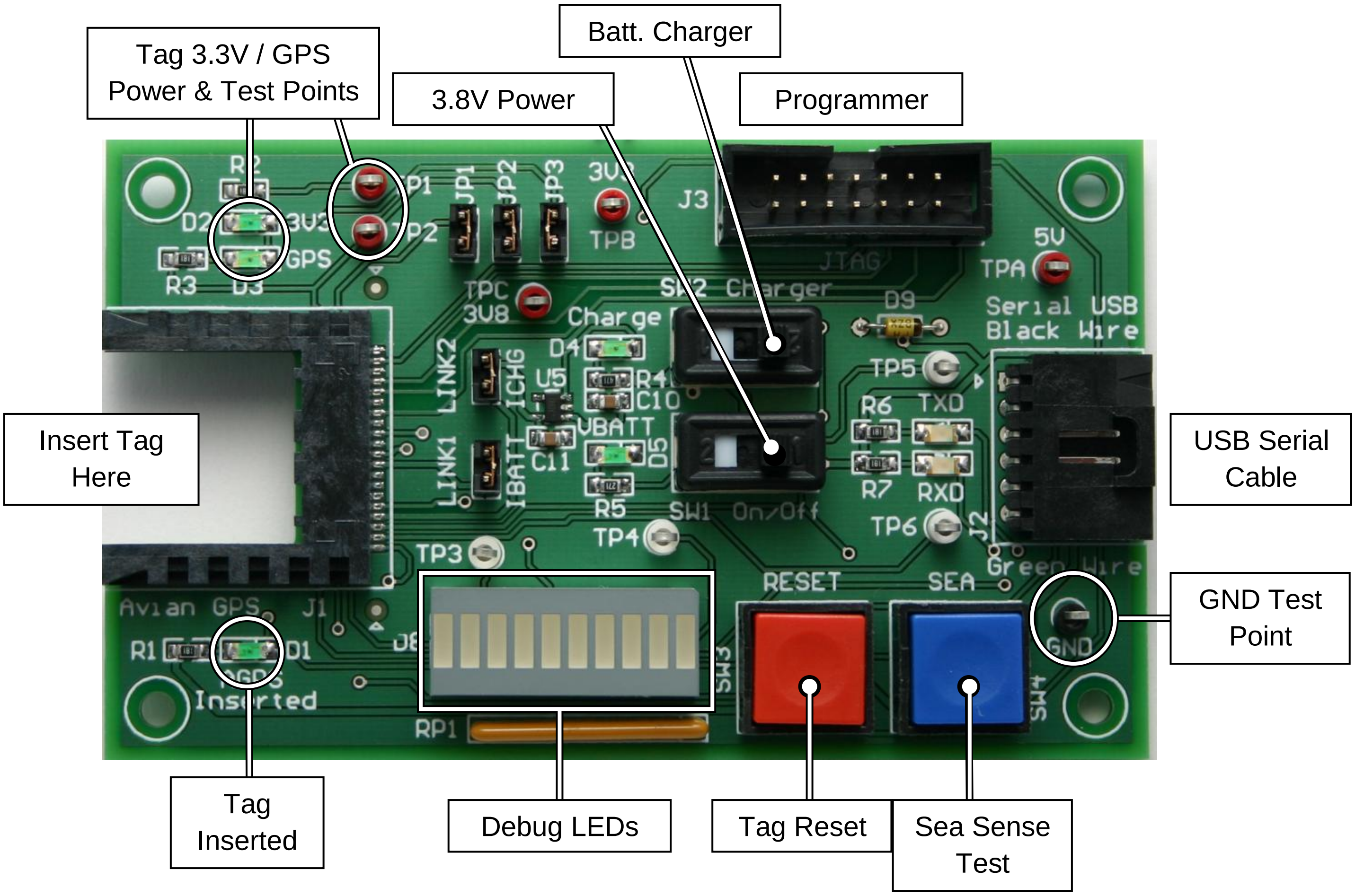
Related Documents

PuTTY Installation and Configuration
Mataki-Classic User Guide
Mataki-Classic Programming Guide
Mataki-Lite User Guide
Mataki-Lite EMBASIC Reference
Mataki-Lite Programming Guide

Contents

1. Support Board Hardware

The main features of a Mataki Support Board are shown below...



Mataki Support Board V2

A support board can be used to:

- Change tag settings
- Read the tag's log
- Develop and test Mataki-Lite scripts
- Re-program the tag's firmware
- Test the tag hardware
- Charge tag batteries

It is compatible with:

- Mataki-Classic V5 and above (the latest at time of writing is V5.4)
- Mataki-Lite V1.0 and above (the latest at time of writing is V1.2)

1.1. Tag Connector

The tag slides into connector J1 (on the left of the photo above) in the direction of the arrows on the edge of the tag. The tag can be inserted with or without a battery connected. Some Mataki-Classic tags can be a tight fit due to the proximity of the GPS module to the connector edge. When fully home, the 'Tag Inserted' light (D1) should be on.

WARNING

Be careful not to pull up the tag when inserting it as the connector is quite delicate and only pressed home at the PCB edge.

If you have any difficulty communicating with the tag, try re-inserting the tag as the contacts tarnish over time.

1.2. USB Serial Cable

The support board comes with a USB Serial cable and is powered from your PC's USB port. The cable plugs into J2 (on the right of the photo above). It is an FTDI TTL-232R-3V3, Farnell part number 132-9311 or RS part number 429-307. There are also 5V versions of this cable in common use. The Mataki Support Board requires the 3.3V version of the cable which uses 3.3V signal levels which can be seen on the test points marked TP5 (TXD) and TP6 (RXD) and provides 5V power which can be seen on the test point marked 5V.

The cable contains a USB to Serial converter chip. It plugs into a USB connector on your PC and, once the drivers are installed, looks like a serial 'COM' port to the PC. All tag operations are controlled using a PuTTY terminal connected to this COM port. See the PuTTY Installation and Configuration document if you do not have this installed.

WARNING

The connector on the USB Serial cable is unpolarised. Ensure it is plugged in to J2 the correct way round (use Black Wire / Green Wire guides on board).

1.3. Tag Power

The support board can also power the tag. There are 2 switches SW1 and SW2 in the centre of the support board. SW1 (On/Off) supplies 3.8V to the tag in place of a battery and SW2 (Charger) turns the battery charger on and off. Tags use the two sources of power in different ways:

- With a **Mataki-Classic** tag, the position of the tag's On/Off switch (the red slide switch on the tag) determines which support board power to use:
  - In the ON position, the tag's power comes from the battery / charger output. A battery is optional - if it is attached to the tag, the charger can be used to charge the battery. If not, the charger can supply enough power for the tag.
  - In the OFF position, the tag's power comes from the 3.8V battery replacement supply (SW1). SW2 (Charger) will also charge the battery if there is one attached to the tag.
- With a **Mataki-Lite** tag, SW1 is not connected to the tag, so it does nothing and SW2 is connected to the tag's battery connector and can be used to power the tag. If a battery is connected to the tag, SW2 will also charge the battery but the tag cannot be switched off. This difference is because Mataki-Lite doesn't have an On/Off switch on the tag.

Without a battery, it is safe to turn on both SW1 and SW2 for either type of tag. No damage can be done to the tag.

1.4. Battery Charger

The battery charger is designed for Lithium-Ion or Lithium-Polymer batteries and will supply a maximum of 100mA, so it is safe to turn the charger on for batteries with a capacity of 100mAh or more. Do not use the support board charger for batteries with less than 100mAh capacity.

The LED marked 'Charge' to the left of SW2 illuminates when the charger is operating (supplying power) and goes off when the battery is fully charged (assuming the tag is not taking charger power).

1.5. Tag 3.3V Supply

Regardless of what method is used to power the tag, the tag will receive a 'battery supply' of 3.5V to 4.2V which is a normal range for a Lithium chemistry battery.

This power is regulated down to 3.3V by the tag and used to power the CPU and other tag components. It is also sent back to the support board where it lights the LED marked 3V3 (D2) and can be measured on TP1.

1.6. Tag GPS Supply

The battery supply is also used to power the GPS module which is different between tag types:

- On a **Mataki-Classic** tag, the GPS module is powered from a separate 3.3V regulator which is turned on when the GPS is needed. The LED marked GPS (D3) lights when the GPS power is on and TP2 can be used to monitor the GPS power if required.

- On a **Mataki-Lite** tag, the GPS module is powered from a 1.8V switched-mode power supply. It is turned on and off by the user's script, see Mataki-Lite EMBASIC Reference for more information. The GPS power is connected to the support board and can be measured on TP2. However the GPS LED (D3) will not light as the forward voltage required to light a green LED is higher than 1.8V.

1.7. Programming Connector

The 14 way connector marked JTAG (J3) can be used to program tags with new firmware. Note that it is not required for changing settings or loading Mataki-Lite scripts.

The JTAG connector is directly compatible with the MSP430 programmer used for Mataki-Classic. To program the ARM on Mataki-Lite requires an adaptor which we can supply. See the Mataki-Classic and Mataki-Lite Programming Guides for detailed instructions.

1.8. Push Buttons

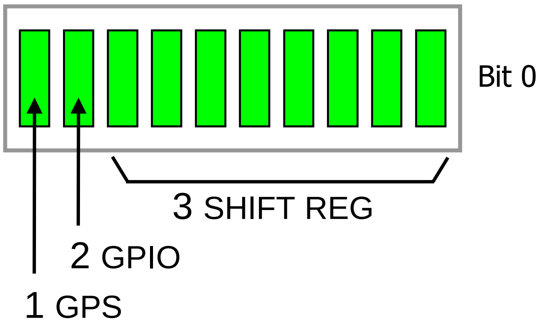
There are two buttons on the support board:

- The RED button (SW3) resets the CPU on the tag

- The BLUE button (SW4) generates a test signal to emulate the sea-sense function (see the Mataki-Classic and Mataki-Lite User Guides). Sea sense is an analogue input to the CPU. In Mataki-Lite scripts, the value can be read and the button used for any purpose e.g. triggering something to happen in a test script.

1.9. Debug LEDs

There is a block of 10 debug LEDs (D8) that can be used by the tag firmware. The diagram below is oriented the same way as the photo in section 1.



1. The first LED is connected to the GPS module on the tag:
   - On Mataki-Classic, the LED flashes once a second when the module is getting a fix, then goes solid when a fix is obtained.
   - On Mataki-Lite, the LED is connected to the 1PPS output and can be measured with a scope on the board but the LED doesn't light for the same reason the GPS LED doesn't (see section 1.6).
2. The second LED is connected to a GPIO pin on the tag's CPU:
   - On Mataki-Classic, the current firmware doesn't use this LED
   - On Mataki-Lite, the LED can be controlled by the user's script for any purpose required
3. The other 8 LEDs are connected via a shift register to the tag's CPU and behave as a block of 8 bits, with the least significant bit (bit 0) being the LED on the far right of the block:
   - On Mataki-Classic, these LEDs reflect the state of the boot process when the firmware starts up. They are also used as a bar graph when testing the light sensor in the Service Application.
   - On Mataki-Lite, the LEDs can be controlled by the user's script for any purpose required. They are always written as a complete byte.

2. Circuit Operation

The support board schematic is shown in section 3. This section describes the various interfaces and how the board works, referring throughout to the schematic.

2.1. USB 5V Power

The whole board is powered from the USB 5V (V_{bus}) supply which comes in on J2 pin 3. TPA (5V) is the supply to the voltage regulators and C4 provides bulk decoupling for the regulator inputs.

2.2. Board 3.3V Regulator (U2)

U2 is a 3.3V linear regulator which provides power to the support board components. This is to avoid the tag's regulator having to provide power for the LEDs, particularly D8. The output is available on TPB (3V3).

2.3. Battery Regulator (U1)

U1 is an adjustable voltage linear regulator which supplies the 'substitute battery' supply. R16-R18 set the voltage at 3.8V which is available on TPC (3V8). SW1 turns the supply on and off. D5 (VBATT) lights when the battery supply is on.

LINK1 can be used to measure the battery supply current. See section 2.12.2 for further information.

2.4. Battery Charger (U5)

U5 is a Lithium battery charger chip which is compatible with Li-Ion and Li-Po batteries. The maximum current is set at 100mA and, since batteries often have a '1C' (1 x capacity) limit, this means charging batteries with a capacity of less than 100mAh is not recommended. As the battery charges, the voltage will rise and the current will fall until, in a fully charged state, the voltage will be 4.2V and current will be almost zero.

SW2 turns the charger on and off. D4 (Charge) lights when the battery is drawing current (charging) but, since we often have a tag connected at the same time, it will also light due to the tag's supply current even if the battery is fully charged. As a result of the tag going in and out of sleep mode (where it draws very little current) D4 can also blink quite a bit.

LINK2 can be used to measure the charger supply current. See section 2.12.2 for further information.

2.5. JTAG Programmer Interface (J3)

2.5.1. Mataki-Classic (MSP430 CPU)

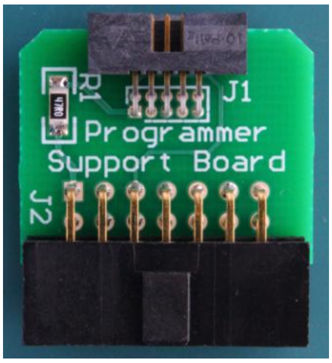
The type and pin-out of J3 matches the MSP430 programmer used for Mataki-Classic. The standard JTAG signals TCK, TMS, TDI and TDO are routed directly to the tag. The programmer also drives the CPU reset signal but doesn't use the nTRST JTAG signal.

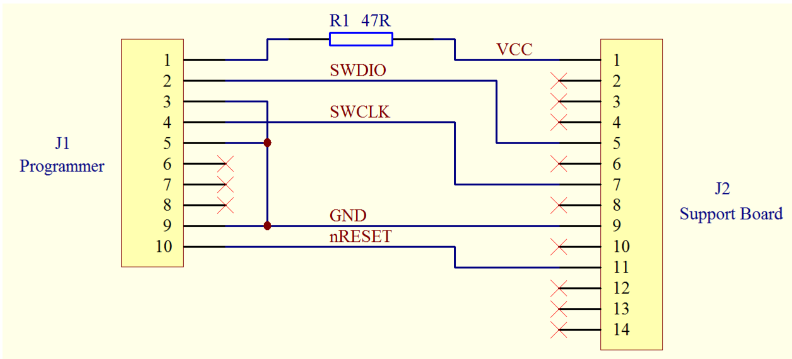
2.5.2. Mataki-Lite (ARM CPU)

The ARM CPU on Mataki-Lite uses the Serial Wire Debug (SWD) interface requiring 3 signals:

- SWCLK connected to TCK
- SWDIO connected to TMS
- The CPU reset

Because the programmer is different, an adaptor is required (see below) which simply plugs into J3.





The ARM programmer also needs to sense the interface signal levels, which requires connecting 3.3V to one of the programmer's connector pins. To accomplish this without changing the pin-out of J3, the TDO pin is connected to 3.3V on a Mataki-Lite tag and then routed to the sense pin on the adaptor via a 47Ω resistor to limit the current if the HD ribbon cable is plugged in the wrong way (some programmers don't use polarised connectors).

2.6. CPU and Board Reset (SW3)

D10 OR's together the reset from the programmer (J3) and the reset button (SW3). The nRST signal is sent to the tag's CPU and can be asserted by the reset button and the programmer. The nBRST (board reset) is only asserted when the button is pressed and resets the shift register for the Debug LEDs (U3).

2.7. USB Serial Interface (J2)

J2 is a 0.1" pitch 6-way connector which mates with the FTDI USB-Serial cable.

TXD and RXD are the UART signals for the PuTTY terminal. They are buffered by U4A and U4B to drive LEDs D6 (TXD) and D7 (RXD) which flash when there is data being transferred. TP5 (TXD) and TP6 (RXD) can be used to monitor the UART signals if required. L1-3 and C1-3 filter RF signals which might be picked up by the cable to reduce the chance of interference when the tags are transmitting.

Although J2 is polarised, the mating connector on the cable is not, so we have carefully designed the board so incorrect mating doesn't do any lasting damage. By not using RTS (pin 6), we remove GND from the interface if the connector is reversed. Although unusual voltages may appear on other pins, the lack of a GND return path should limit the current flowing.

Pin 3 (V_{bus}) supplies 5V but the rest of the signals are at 3.3V logic levels. R9 and D9 ensure that TXD doesn't exceed 3.3V if the connector is plugged in the wrong way (TXD will be connected to V_{bus}) or if the wrong type of cable is used (using 5V signal levels). This only occurs if there is an alternative ground path e.g. a piece of test equipment attached to the GND test point.

There is no flow control (RTS / CTS) on the UART interface. However CTS is asserted (LOW) when the tag is inserted so that a PC application could detect a tag being plugged in if required.

2.8. Debug LEDs (D8)

There are two individual LEDs in D8 and the rest are an 8-bit block driven by shift register U3. See section 1.9 for their usage.

Signals DCLK and DDAT on TP3 (DCLK) and TP4 (DDAT) are the clock and data signals for the shift register. The tag's firmware drives these to get the appropriate LEDs to light. On Mataki-Lite, TP3 and TP4 can also be driven directly by the script, in which case the LEDs may assume random patterns.

R19 and R20 stop DCLK and DDAT floating when there is no tag inserted.

R13 and C7 reset the shift register on power up. C7 is discharged at power up and slowly charges through R13. At this point the nCLR input to U3 is low briefly and the LEDs all turn off. Once C7 has charged, U3 can be driven by the tag's firmware. When the support board is turned off, the top diode in D11 conducts and discharges C7 instantly so the circuit is ready to be used again at power up.

The bottom diode in D11 allows the user to clear the LEDs with the reset button.

2.9. Tag Interface (J1)

Power to the Tag (pins 4, 9, 11 & 18)

Battery and charger power are supplied to the tag through pins 9 and 4 respectively. Pin 18 is the power GND. Pin 11 is also grounded but is not used (open circuit) on current tags.

Power from the Tag (pins 13 & 15)

The tags have a 3.3V regulator, the output of which appears on pin 15. The 3.3V supply is sent to TP1 and LED D2 (3V3). All the logic signals between the tag and the support board have 3.3V signal levels.

The tag also has a GPS power regulator, the output of which appears on pin 13. The GPS supply is sent to TP2 and LED D3 (GPS). On Mataki-Classic tags this is 3.3V and on Mataki-Lite tags this is 1.8V. Due to the V_f of green LEDs, 1.8V is not sufficient to light D3 with a Mataki-Lite tag.

Tag Insertion Detection (pins 1 & 20)

Tags have a connection between pins 1 and 20 of J1 with a 10k pull-up to the tag's 3.3V supply. When both sides of the edge connector are fully inserted, the GND on pin 20 lights LED D1 (Inserted) at the same time as pulling the tag's internal signal low. In this way, both the tag and the support board know the tag is inserted.

TXD and RXD (pins 2 & 3)

These are the UART signals for PuTTY, see section 2.7 for more information.

DCLK and DDAT (pins 5 & 6)

See section 2.8.

nLED and nFIX (pins 7 & 8)

These signals drive the left most two LEDs in D8. See section 1.9.

SEASENSE (pin 10)

On the tag there is a 30K pull-up on this pin, which is connected to an analogue input on the CPU. Pressing SW4 (SEA) applies a 30K pull-down resistor (R8) which should reduce the voltage to around 1.65V. See section 1.8 for usage.

nRST (pin 12)

This is connected to the tag's CPU reset, see sections 2.5 and 2.6.

JTAG (pins 14, 16, 17 & 19)

These signals are used to program the tag's CPU, see section 2.5.

2.10. Test Points

Test points are colour-coded:

- Black for GND
- Red for power
- White for signals

Name	Label	Colour	Function
G1	GND	Black	Ground (0V)
TPA	5V	Red	5V USB Power (V_{bus})
TPB	3V3	Red	3.3V Support Board Power
TPC	3V8	Red	3.8V Battery Replacement Power
TP1		Red	Tag's main regulator output (3.3V)
TP2		Red	Tag's GPS regulator output (3.3V on Mataki-Classic, 1.8V on Mataki-Lite)
TP3		White	DCLK (Debug LEDs shift register clock)
TP4		White	DDAT (Debug LEDs shift register data)
TP5	TXD	White	TXD (data from PC to a tag)
TP6	RXD	White	RXD (data from tag to a PC)

2.11. Jumpers

Name	Function
JP1	Supplies power to the second debug LED
JP2	Supplies power to the first debug LED (GPS FIX)
JP3	Supplies power to the 3V3 and GPS power LEDs (D2 & D3)
LINK1	Can be connected to an Ammeter to measure the current drawn from the battery supply
LINK2	Can be connected to an Ammeter to measure the current drawn from the charger supply

2.12. Power Consumption

2.12.1. Minimising Support Board Current

If you intend to run the tag from the support board e.g. as a base station where you can observe the PuTTY terminal, then you may want to minimise the support board power consumption.

- Removing JP1 - JP3 stops the support board LEDs drawing current, reducing current consumption by up to 100mA.
- Use just one power source and remove the LINK jumper for the other.
- Unplug J3 to prevent the programmer drawing current through the JTAG signals.
- Remove any connections to the board or the tag e.g. on the test points.

2.12.2. Measuring Tag Current

If you want to measure the tag's current consumption using LINK1 / LINK2, first apply the measures above. When the tag is active (GPS and/or radio are on), simply connecting an Ammeter in place of the LINK pins will give reading accurate to around 0.5mA.

However, making an accurate measurement is tricky at low currents (sleep mode) because there are a few paths where additional current will flow:

- The insertion detection mechanism (see section 2.9) causes 330µA to flow from the tag's 3.3V supply, through the 10k pull-up on the tag, to J1 pin 20, which is grounded. The only way to stop this is to cut J1 pin 20 and ground J1 pin 1, which will disable the tag insertion detection.
- D9 draws around 100µA with 3.3V on it. This is a protection component and can be removed if necessary, see section 2.7 for an explanation.

These add to the tag's current consumption when it is inserted in the support board. When the tag is sleeping, the extra current dominates the measurement. Future versions of the support board may have extra jumpers to prevent this problem.

For this reason, we recommend measuring sleep currents when disconnected from the support board - just put an Ammeter in the battery lead.

If necessary, a comparison with the same measurement in the support board can be made. The difference is around 400-500µA and is fairly constant.

3. Support Board Schematic