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Building the FreeStation NanoPro Data Logger (v5.x, Arduino)

You should be able to build this FreeStation from the step by step instructions given here, without assistance. In the case that the instructions are not clear on any aspect the designer of this FreeStation is mark.mulligan@kcl.ac.uk. **If you deviate from this design we may not be able to help and your station may not build or work as expected. Those building this open source hardware must agree to the FreeStation terms and conditions.**

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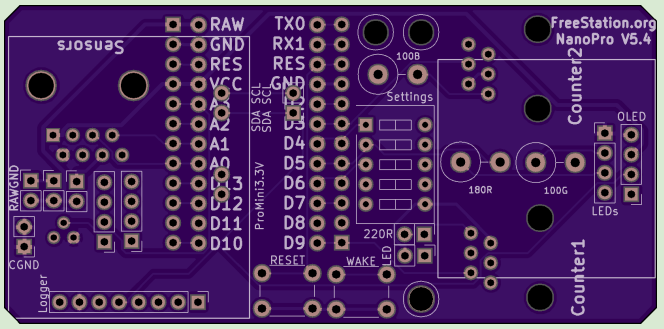
FreeStation NanoPro Data Logger

The FreeStation NanoPro is a small, Arduino based data logger with built in OLED screen OR multicolour LED that can be used to record a digital channel (rainfall, fog), I2C sensors (temperature, humidity) and analogue sensors (soil moisture, wind speed and direction). They are designed for cheap, quick build for multiple deployments of few sensors per logger. The FreeStation Meso on the other hand is more suitable for full monitoring stations. By default, the logger reads all instruments every 10 minutes and writes a record to the SD card every hour.	
The logger is not usually solar powered and requires replacement of batteries for continuous operation. A NanoPro logger can be built in a couple of hours. It is deployed on instruments using a simple enclosure with roof as with this fog gauge deployment	

Bill of Materials

The bill of materials lists the components that need to be purchased, with images and links to vendors. You will need to purchase from each tab for a full station. Total cost approximately: **USD 32 per logger**

PCB Order

The FreeStation NanoPro printed circuit board can be ordered here from OSHPark[1]. Only one is required per station, but the minimum order is three. OSHPark is based in the USA. Total cost approximately: $27 (**$9 per logger**). It looks like this:	

Tools required

The full range of tools required to set up a FreeStation workshop are listed here with names, images and links to vendors. Total cost approximately: **$827 one off but most home, school or university workshops will already have much of this**. Adjustments to the build can be made if certain tools are not available but should ensure that the high quality of build is maintained in order to collect good quality data. Only certain of these will be required for this build, see below.

Safety

You are responsible for your safety and those working with you. Building FreeStations requires the use of drills, angle grinders, soldering irons and punches. Always wear protective gloves and goggles and take care that all equipment is safe and functioning properly and that you have an appropriate working space. Keep your workspace clean and orderly ♦ Make sure your work space has enough light and ventilation ♦ Always wear safety glasses ♦ Wear hearing protection when using power tools. ♦ Wear closed-toe shoes ♦ Keep long hair tied back ♦ Do not wear jewellery or loose clothing (roll up sleeves, tuck in ties and hoodie drawstrings) ♦ Make sure others in the area wear safety glasses, close-toed shoes and follow all other precautions ♦ Have a charged fire extinguisher and first aid kit handy ♦ Don't overload outlets and use Ground Fault Circuit Interrupters (GFCI) ♦ Minimize distractions while you are working (pets, young children etc.) ♦ Make sure others know you will be working to minimize interruptions-use a sign at the entrance of the work area if needed ♦ Keep young children away from the work area ♦ Carry tools with blades, bits and other sharp parts pointing down and away from body ♦ Clamp material you are working on to keep hands free and safe from tools ♦ Make sure all machine guards are in place ♦ Concentrate on your work ♦ Only use tools that are properly maintained Make sure all power tools are grounded or double insulated ♦ Make sure all power tools are turned off after use

Build instructions

Logger and enclosure

The FreeStation NanoPro logger uses the widely available ProMini 3.3V. The FreeStation can use either an OLED or a multicolour LED to communicate its status. If connecting a number of instruments a multicolour LED should be used as there is insufficient chip memory for an OLED alongside the station instruments. If connecting only one instrument there is sufficient memory for an OLED.

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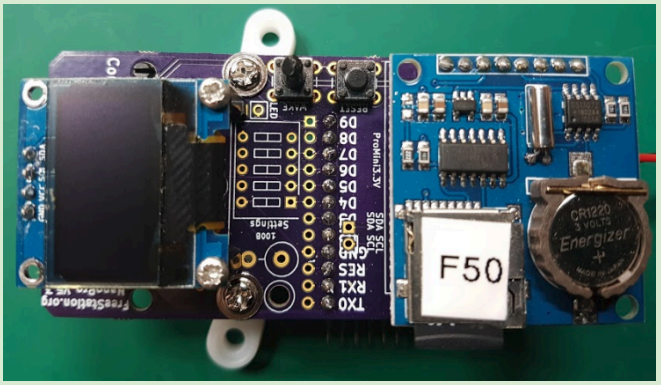
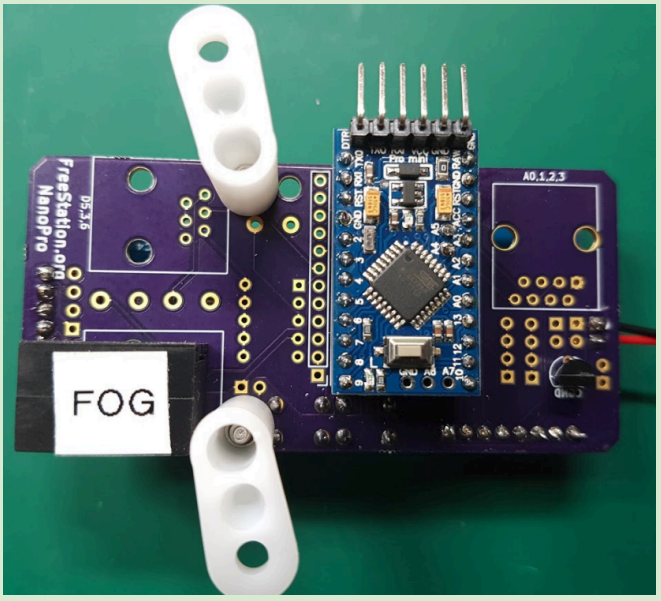
[1] FreeStation has no commercial link with OSHPark, and obtains no commission from this order, and cannot help with enquiries on any order you may have made with them.

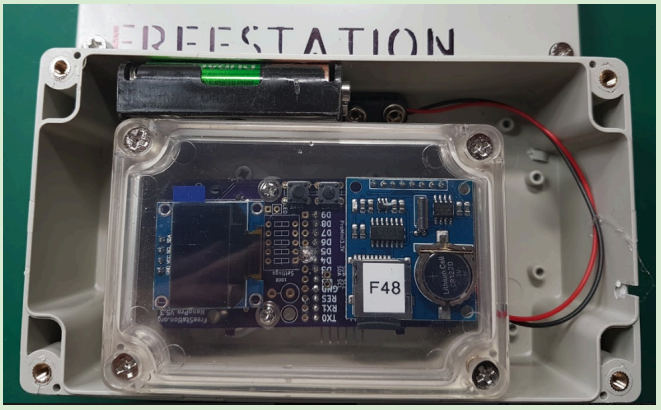
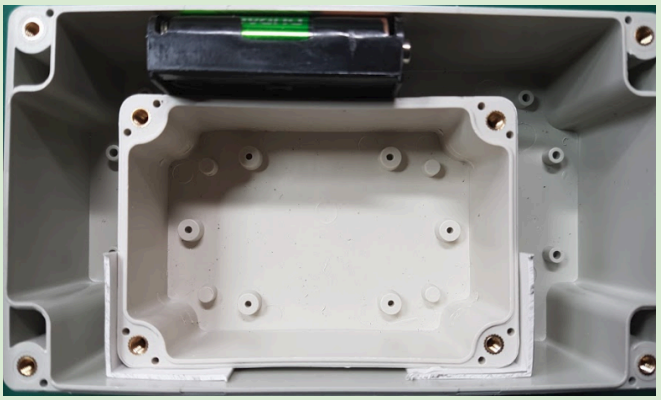
- The multi-functional FreeStation NanoPro v5.10 board is described here.

- Parts are listed here
- The PCB is populated as shown here
- The Arduino pins must be soldered to the Arduino and the two LEDs present on the board pushed off with a hot soldering iron as these will consume a lot of power if left on. The LED on the RTC or multilogger should be left in place as it will be de-powered in sleep mode and will flash indicating normal operation.
- It is critical to avoid solder bridges and to check the board fully for these before powering on
- All components with male headers are connected via female headers on the FreeStation PCB so that components can be easily replaced
- Solder the female headers logger shield (8 pin), OLED (4 pin), Pro-mini (2x12 pin and 1x2pin).
- Components are attached to **both** sides of the PCB as indicated by the labels (Wake, RESET etc)
- **Image shows the top side of the PCB with OLED and logger shield visible but no settings switches soldered**



- The connectors that you solder depends on the instruments that you want to deploy. For a digital channel (raingauge, fog gauge, WDR gauge solder the RJ12 (D7,8,9, counter 1). For another digital channel solder RJ12 (D5,3,6, counter 2). For analogue or I2C channels, solder RJ45 (A0,1,2,3,sensors). Use these RJ12s and RJ45s
- Solder the wake and reset buttons (the wake button is the 8mm tall one)
- If using a multicolor LED instead of an OLED screen solder the 1x100 ohm resistor and the 2x180 ohm resistors as well
- Solder the 2N3904 transistor and the 2 pole screw terminal for the power connection
- Add logger shield (see photo, add a CR1220 3V Lithium cell), multi-colour LED (LED towards board edge) or OLED and pro mini (communications headers to board edge)
- Connect the power jack to the power input
- **Image shows the underside of the PCB with 1 RJ12 in place, Arduino pro-mini and PCB feet**



• The RJ12 and RJ45 connectors should be labelled using a label printer to avoid damage resulting from incorrect connection • The board sits within a transparent enclosure which then sits within a larger enclosure as shown. Use a handheld nibbler to make a small notch in the short end of the transparent enclosure to pass the PP3 cable and the RJ12 or RJ45 through • Attach the logger PCB to the transparent enclosure using two PCB feet, aligned to coincide with the appropriate holes, and M3 6mm self tapping screws • **Image shows the logger within an enclosure with transparent lid and connected to battery enclosure with 3xAA. All are mounted within the logger enclosure**	
• If connecting to a raingauge or fog gauge (RJ12) then a cable gland on the large enclosure is not needed, simply use the handheld nibbler to make a small notch in the short end of the large enclosure and pass the cable through it. • If connecting an RJ12, first use a 22mm flat drill bit to cut a hole in the end of the enclosure to accommodate the datainputs and then add the 20mm compression gland to the appropriate hole • Two 40mm lengths of 30x30 PVC equal angle are glued to the side of larger enclosure using a glue gun to hold the transparent enclosure in place (the transparent enclosure can also be glued to the PVC equal angle). The 3xAA (side by side) battery holder is held in place by the transparent enclosure • **Image shows how the transparent enclosure is held in place**	
• The FreeStation label jig can be used to label the enclosure lid with the FreeStation name. Carrying this name is a condition of your use of these open source instructions. The jig is 3D printed and a black fine tip permanent marker (eg a 'Sharpie') used to mark the enclosure. Please also ensure that the rubber seal is attached to the inside of the lid to ensure protection from water.	

• To install the FreeStation firmware use either the GUI method or the command line method • To communicate with the Pro-mini you will need an A to mini-B USB cable and an FTDI • Connect the USB to the computer and the FTDI and connect the FTDI to the header on the Pro-mini, observing the correct connections (you may wish to label the FTDI). • The Pro-mini will start. • FreeStation NanoPro firmware files (v5.3) are listed here • Now upload the FreeStation NanoPro v5.3 programme to set the logger time (the screen will indicate when the logger time is set) • Now upload the FreeStation NanoPro v5.3 firmware. • When complete the FreeStation will cycle through the OLED or multicolour LED startup.	

NanoPro Station Housing

The FreeStation NanoPro housing is made from aluminium sheet and is designed for compact and easy carriage and to protect the logger from rain and sun. The logger housing comprises a roof and a frame for attachment to a post.

• Parts are listed here • Cut a 27cm length of equal angle with the stand mounted angle grinder • Use two M5 15mm bolts to attach to the left side of the large enclosure as shown • Use the aluminium bending jig to bend a 2cm, 90 degree lip on the 15x15cm aluminium sheet to make the hood • **Image shows the enclosure stand for mounting on a post or tree and the enclosure roof**	
• Punch a 4mm hole using the metal punch set 50mm from the left edge of the lip. Use thin nosed pliers to bend over the corners of the hood • Use an M4 10mm bolt to attach the hood to the frame]. • The enclosure is now ready for mounting in the field • **Image shows the stand, roof and enclosure in place**	

Sensor building and wiring

Sensor	Notes for use with FreeStation NanoPro
Pyranometer	Not possible (no ADC)
Temperature Humidity Sensor (T/RH) coupler	**To Sensors1 (RJ45) (via TRH coupler)**
Raingauge	**To Sensors1 (RJ45) (via TRH coupler)**
Wind speed and direction	**To Sensors2 (RJ12)**
Soil moisture ● The sensor may be calibrated (but can also be used uncalibrated). To calibrate, switch the calibrate switch to on and reset the logger. Ensure that the probe is in dry air and not touching any surface. The OLED will state *"waiting for dry". Now,* switch the Action switch on. The OLED will state *"Reading"* and then *"Waiting for wet".* Place in water until the sensing area is fully submerged. Switch the action switch back off. The OLED will state *"Reading".* The logger then continues to setup and the calibration is complete. The sensor is now calibrated and the calibration stored in the permanent memory of the Arduino ● Now set the calibrate and action switches to off and reset the logger. It will now provide calibrated moisture. On reset the OLED will indicate *"Using calib...".* If there is no valid calibration in memory it will state *"Using default"* ● *Note that the calibration remains in EEPROM after power is removed and even after uploading new firmware*	● SoilWatch10 can connect to **Sensors1 (default), Sensors2** and **Sensors3** on the **NanoPro** ○ For **Sensors1** the wiring is: RJ45_1 Brown (VCC), RJ45_2 Green (GND), RJ45 ○ For **Sensors2** the wiring is: RJ12_2 White, RJ12_5 Green (GND), RJ12_6 Brown (VCC) ○ For **Sensors3** the wiring is: RJ12_1 Green (GND), RJ12_5 Brown (VCC), RJ12_6 (White) ● Wiring (VH400): * ○

Firmware and power up

If you are building your own stations or replacing the microcontroller, you will need to upload firmware. Firmware is uploaded as described below. The Pro-mini requires an FTDI (see bill of materials) and associated mini

USB cable. Software and instructions for firmware updating are shown here. Note that the FTDI should be set to output VCC 3.3V using the onboard jumpers

If you are building your own stations or replacing the microcontroller, you will need to upload firmware. Firmware is uploaded as described below. The Pro-mini requires an FTDI (see bill of materials) and associated mini USB cable. Software and instructions for firmware updating are shown in the installation guide here. Note that the FTDI should be set to output VCC 3.3V using the onboard jumpers. We distribute firmware as HEX code so as to ensure that all the myriad adapted library dependencies are properly factored in. The universal FreeStation code works for every type of station and sensor and is thus >1000 lines of **#ifdef**'ed code. Most FreeStation users are Arduino novices and the HEX file ensures trouble free installation. We know the HEX code works, but we cannot know that for code uploaded/adapted by users. The code also contains sensitive network and data encryption information.

Before powering up your board be sure that there are no short circuits in the soldering and that all the components are placed correctly and all of the cables are in the correct ports.

The default firmware uses FAT16 to save MCU memory so you must use SDCARDs that are 2GB capacity or less. The full configuration of the station is written in the top line of any output file saved to the SDCARD like this: **Station:Ver.:5.9 Config.:OLLMLOUAUNWASLSORFWISH S,L:360,3600** Station=station name (when set), Ver= firmware version, Config=two letter config codes, S,L = sample and log intervals (seconds) A series of two letter codes provide the configuration. Check that the firmware you have uploaded is the correct configuration for your hardware by copying the configuration to the interpret configuration tool and checking against your hardware. The station may not work properly if the configuration does not match the hardware.

Almost 100 stations have been made with these boards and code but if the code below does not function with your board as outlined in the installation guide then you need to check that all the components and solders are working. Look first for errors in your connections, solder bridges and cold solder joints. As a last resort use the code examples in the libraries below and their output to the serial port to check that each component works: Real time clock (RTCLib) SD CARD (FAT16). **Fully test your station before deployment in order to collect good quality and reliable data.**

Station Type	**Configuration**	**Code description**	**Firmware**
Any	**Factory reset code**	**This code is used to allow an Arduino to properly format SDCARDS**	Firmware V5.10
Standard NanoPro Fog	**Standard FreeStation NanoPro (DS3231 RTC, OLED) + Fog**	**OLLMF1LODSNATISLHO**	OLD: Firmware V5.9.8 **Firmware V5.10.1 (FAT16)**
Old NanoPro Fog	FreeStation NanoPro (Minilogger, OLED) + Fog		**Minilogger incompatible with sleep**
NanoPro Soil moisture (SoilWatch10) (FreeTheta)	**Standard FreeStation** NanoPro **(DS3231 RTC, OLED) + Soil moisture (SoilWatch10). Settings switches. NoCalib.**	**OLLMF1LOUADSNAWATISLSW**	OLD: Firmware V5.9.8 (FAT16) **Firmware V5.10.01 (FAT16)**

Old NanoPro Soil moisture (SoilWatch10) (FreeTheta)	**Standard FreeStation** NanoPro **(*Minilogger*, OLED) + Soil moisture (SoilWatch10) Settings switches. Calib**		OLD: Firmware V5.9.8 (FAT16) **Minilogger incompatible with sleep**
Old NanoPro Soil moisture (SoilWatch10) (FreeTheta)	**Standard FreeStation** NanoPro **(*Minilogger*, OLED) + Soil moisture (SoilWatch10).Settings switches. No Calib**		OLD: Firmware V5.9.8 (FAT16) **Minilogger incompatible with sleep**
NanoPro Scale (FreeScale)	**Standard FreeStation NanoPro (DS3231 RTC, OLED)+ Weighing sensor**	**OLLMF1LOUADSNA DOWATISLLC**	OLD: Firmware V5.9.8 (FAT16) **Firmware V5.10.1 (FAT16)**