DWM (Digital Watt Meter)
User Guide

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Important Notes

Lithium Battery Safety

The DWM's lithium battery still comes with all of the dangers of using lithium batteries! It is important to **always be vigilant** and check for potentially damaged battery connections caused by **excessive heat** from the environment or **pinched wires** from tools or housings.

Please be careful when modifying or replacing components to not cause shorts in the battery connections as a battery fire may occur!

Do not abuse your batteries! i.e. do not discharge them all the way down until the device shuts off. This will degrade and can damage the battery over time.

These warnings may seem excessive, but people often do not understand how many devices contain these types of batteries in their sites and labs and the true dangers behind them. They all require attention.

Protect your workshop! No matter the time it takes.

Ground Loops

When connecting multiple devices to the DWM, something called ground loops may occur. This is when the negative or ground of one connection has a different voltage potential than the grounds or negatives of other connections. This may cause some error in the readings.

Example:

A line-section output is connected to the DWM (grounded well or not) and a grounded USB charger is connected to the battery charger port. Because the both connections are somewhat grounded, there may be a potential difference between their grounds causing a ground loop to occur.

A good way to prevent ground loops is to have connections grounded to a single point on the negative binding post on the back of the device or externally. Another way is to make sure all connections other than line-section have floating grounds. Most USB wall adapters produce a floating output. For computer connections, a USB isolator can be used in the event of bad ground loops.

Definitions

1. **DWM:** Digital Watt Meter
2. **Line-section:** The device connected into the transmission line between the transmitter/ radio and the load to allow elements to read the power being applied to the transmission line location in a given direction.
3. **Element:** The device inserted into the line-section for measuring power in a given direction based on its orientation in the line-section that outputs a given voltage/current for the DWM to calculate power from.
4. **Meter Calibration:** The process of correcting the DWM's internal components to read the correct voltage/current from an element.
5. **De-Embedding:** The process of mathematically removing the effects of a device in a test setup leaving only the behavior of the system being measured.
6. **Coefficients:** Numbers that are multiplied with the input of an equation to obtain a specific output value. For example, if a coefficient a equals to 2.5, when applied to the equation $y = a * x$, you get: $y = 2.5 * x$. So, if we make x equal to 2, then the equation becomes: $y = 2.5 * 2$ which equals to 5.
7. **De-Embedding Coefficients:** The coefficients that are used in the voltage to power conversion equation to obtain the corrected power value for a given element's output voltage.
8. **Element Slot:** 1 of 8 memory allocations in the DWM that contain the information of an element (element power rating and de-emdedding coefficients).
9. **Hamburger Icon:** The symbol used to designate the menu/back button.

1 Introduction

1.1 Purpose

The DWM was inspired by the lack of easy-to-read power readouts being used in large scale broadcast sites where at least 15 transmitters are being combined to one antenna array with full redundancy. Along with forward and reflected measurements being taken at each transmitter, combiner stage, and reject/test load, the shear rack space occupied by power meters and the time it takes to read over 60 analog movement needles (that might not even be accurate or precise) with their own scales labeled with stickers was highly inefficient.

The DWM is designed to help make the process of reading power levels as easy as reading a number on a screen. It can be used for the most layman of users to the most experienced who are willing to go the extra mile to obtain the highest level of accuracy and control over their site.

1.2 Element Variance

Element variance is a large problem in the line-section element technology. Depending on the environment and power levels an element has been subjected to, drift in the power to output current curve is a certainty. This means that each element will give a different reading from the next over time. It becomes rather time-consuming and expensive to always need to send back elements and meters for calibration. That's why in-the-field element de-embedding capabilities need to be fulfilled in this product space. It saves everyone time, money, and headaches.

As can be seen in the following image (*Figure 1.1*), a 5W element has been de-embedded using a 10-point de-embedding (refer to section *14 Element De-Embedding*). Then, the same de-embedding coefficients are used for each of the other 5W elements and it becomes quickly noticeable how far they can vary from one another. Even between 3 elements of the same power rating and model number, they are differing up to 18% from one another (at these power levels). This is why element de-embedding is crucial when using line-sections and elements.

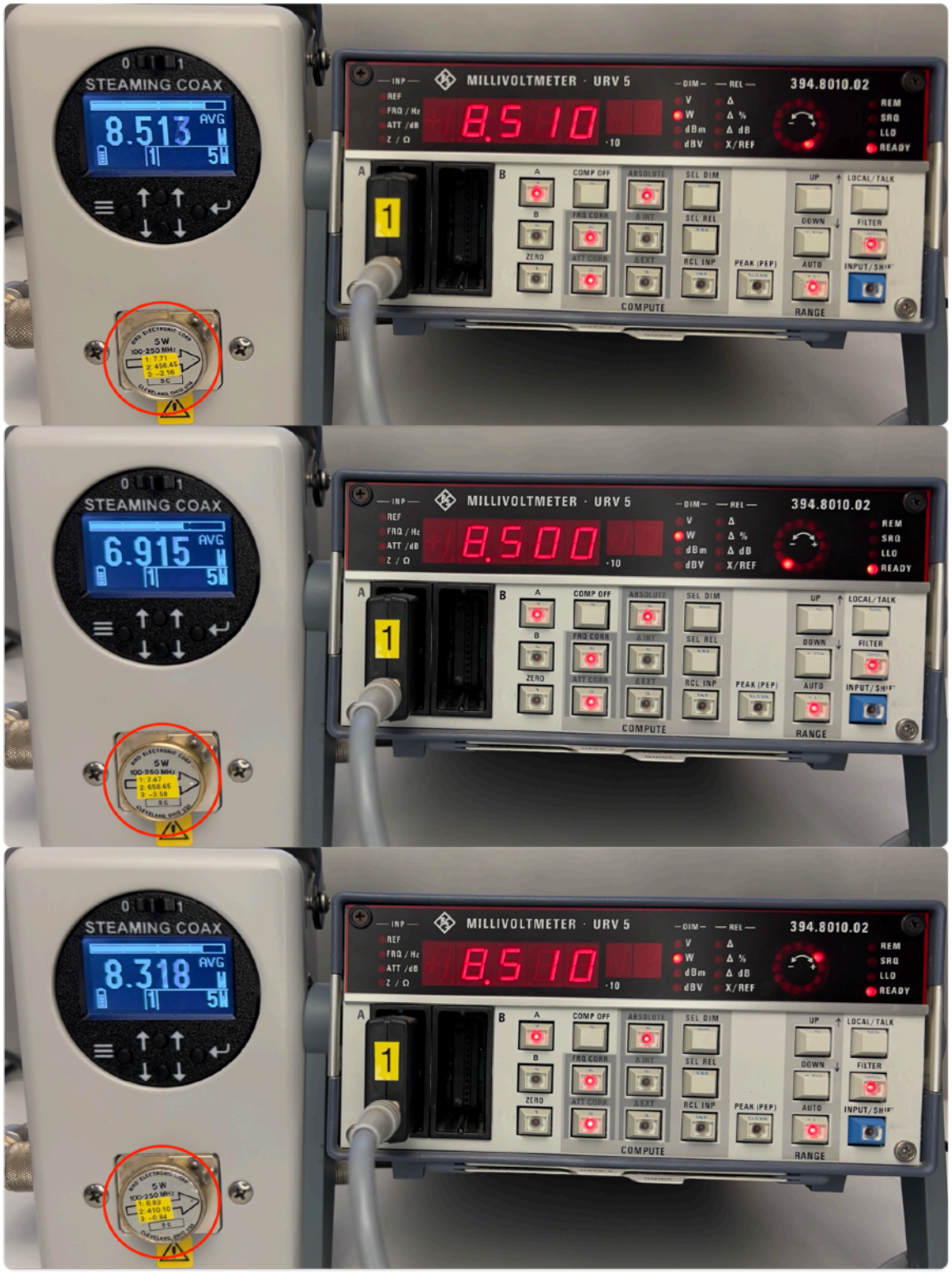


Figure 1.1: Element Variance Comparison

2 Features

2.1 Hardware Features

- Wide supply input voltage range: 3-18V DC.
- Up to 150 hours run time (with standard 18650 3.5Ah battery pack).
- Interlock output for external device control.
- 50kHz sample rate for accurate peak-finding.
- Compatible with 30uA and 100uA line-section elements.
- Fits into Bird 43 style housing and rack panels.
- Compatible with all element power ranges (including custom elements) ranging from 10mW to 950kW.
- USB Type-C port for updates, data/control, and alternative power source.
- Easily replaceable lithium 18650 battery and USB Type-C BMS/charger with charge status indicator.

2.2 Software Features

- Ability to measure Return Loss and VSWR.
- Linear and logarithmic power scales (W and dBm).
- 16-bit ADC enables high dynamic range of measurements.
- Selectable 2x and 4x an element's power rating for wide range measurements.
- 8 element memory slots (each containing element power rating and de-embedding information).
- Element de-embedding capabilities for increased power accuracy.
- Extended frequencies range for elements (when using de-embedding).
- 6 power statistic types (Instantaneous, Average, Temporary Peak Hold, Maximum, Minimum, and Deviation).
- Event logging with relative time-stamped entries.
- Designed with repairability in mind.
- Self-hosted GUI for controlling via remote computer.

3 Characteristics

3.1 Electrical Characteristics

Table 1: Electrical Characteristics

Parameter	Min.	Typ.	Max.	Unit	Test Condition
System					
Operating Supply Voltage	3.0	—	18.0	V	Note 4
Supply Input Current	Note 1		Note 2		Display Brightness:
	20	—	54	mA	0
	40	—	73	mA	5
	95	—	130	mA	10
Sampling Input Voltage	0.0	—	1.0	V	
Sample Rate	—	50	—	kHz	Note 3
Dynamic Range	—	45	—	dB	Note 3
Display					
Refresh Rate	—	15	—	Hz	Note 3
Interlock					
Voltage Rating	—	—	30	VDC	
	—	—	50	VAC	
Current Rating	—	—	1.0	A	30 VDC Applied
	—	—	0.3	A	50 VAC Applied
Added System Current Consumption	—	35	—	mA	When Activated (Otherwise 0 mA)
Lithium Battery Pack					
Rated Capacity	—	3.5	—	Ah	Note 4
Voltage	3.3	—	4.2	V	
Charge Current	—	—	1.0	A	

3.2 Temperature Characteristics

Table 2: Temperature Characteristics

Parameter	Min.	Typ.	Max.	Unit	Test Condition
Operating Temperature	0 (32)	—	45 (113)	C (F)	
Storage Temperature	-15 (5)	—	55 (131)	C (F)	

Notes:

1. With the interlock not triggered.
2. With the interlock triggered.
3. Adjustable through firmware updates.
4. At 21°C.

4 Element & Line-section Types

Not all line-sections and elements designed equally. There are two main categories of elements, 30uA and 100uA. Both have their own impedance that they should be terminated with in order to operate correctly.

4.1 30uA Elements

Both Bird and Coaxial Dynamics make 30uA elements. All elements made by Coaxial Dynamics are 30uA output. But, only elements made by Bird that fit into the 7/8" line-section are 30uA output. All other Bird elements are 100uA output. (There are some strange exceptions… Please refer to Bird's website for more information on your elements)

30uA elements must be terminated with a 1400 ohm resistor (internally selectable in the DWM, see section *11 Meter Input*).

The 7/8" line-section is what comes in the classic Bird 43 wattmeter.

4.2 100uA Elements

All Bird elements that are designed to work with line-sections greater than 7/8" are 100uA output (again, there are some weird exceptions).

100uA elements must be terminated with a 3000Ω resistor (also internally selectable in the DWM, see section *11 Meter Input*).

5 Installation

Note: *Do not use any power tools or force components into place for installation. Everything should be an easy fit.*

5.1 Bird 43 Housing

Figure 5.1: Bird 43 Before DWM Install

Figure 5.2: Bird 43 Installation Steps 1-4

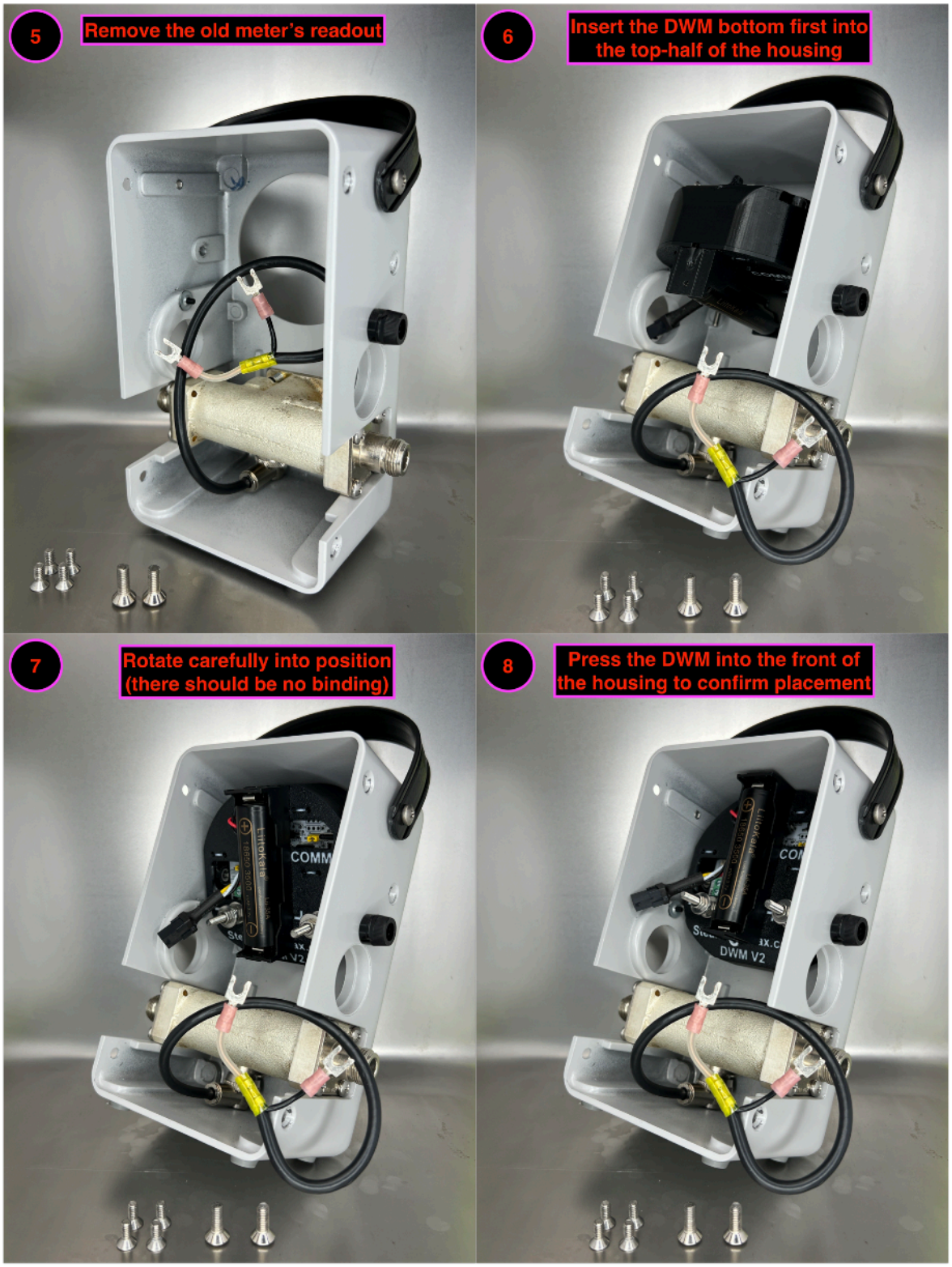


Figure 5.3: Bird 43 Installation Steps 5-8

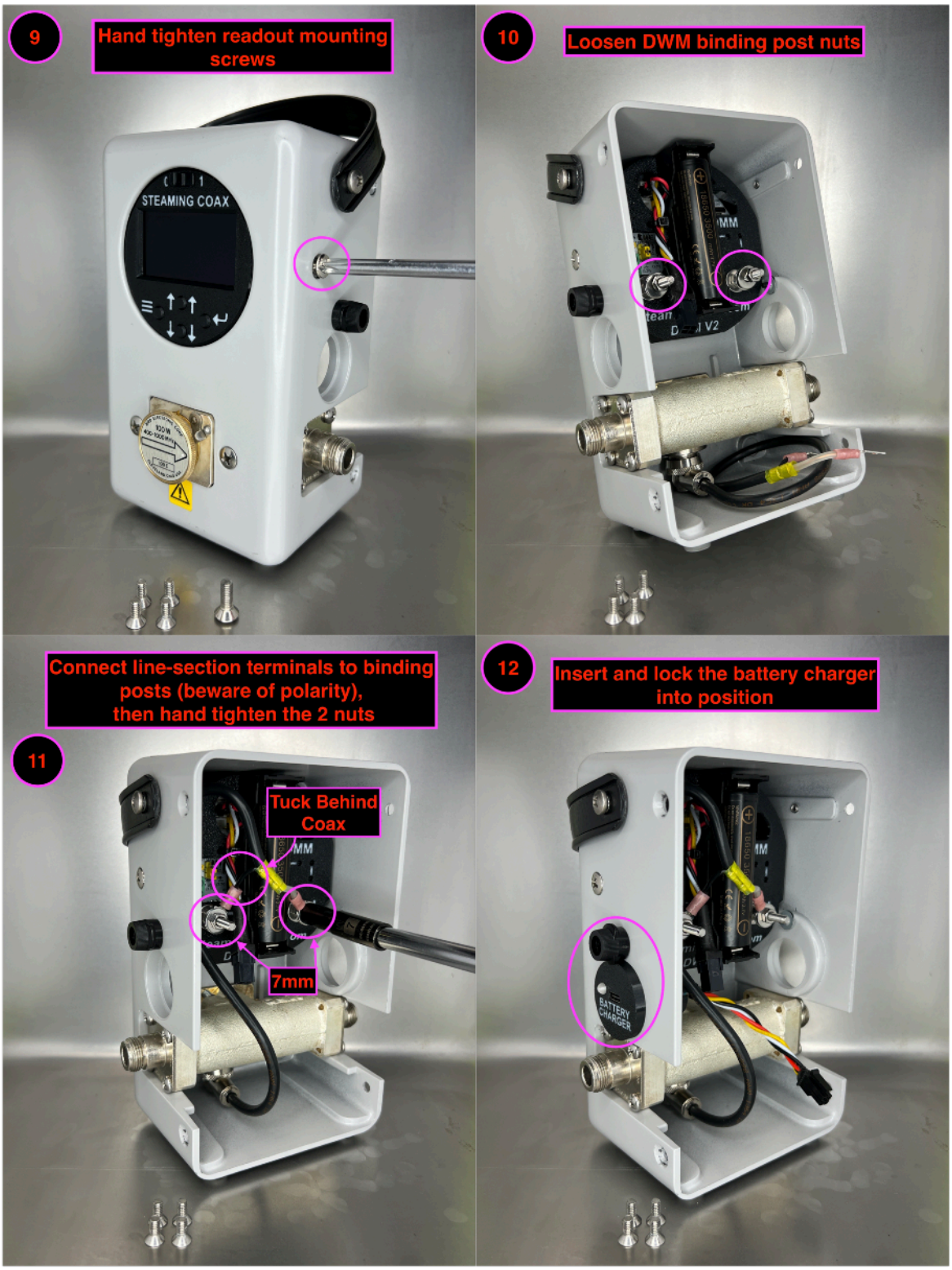


Figure 5.4: Bird 43 Installation Steps 9-12

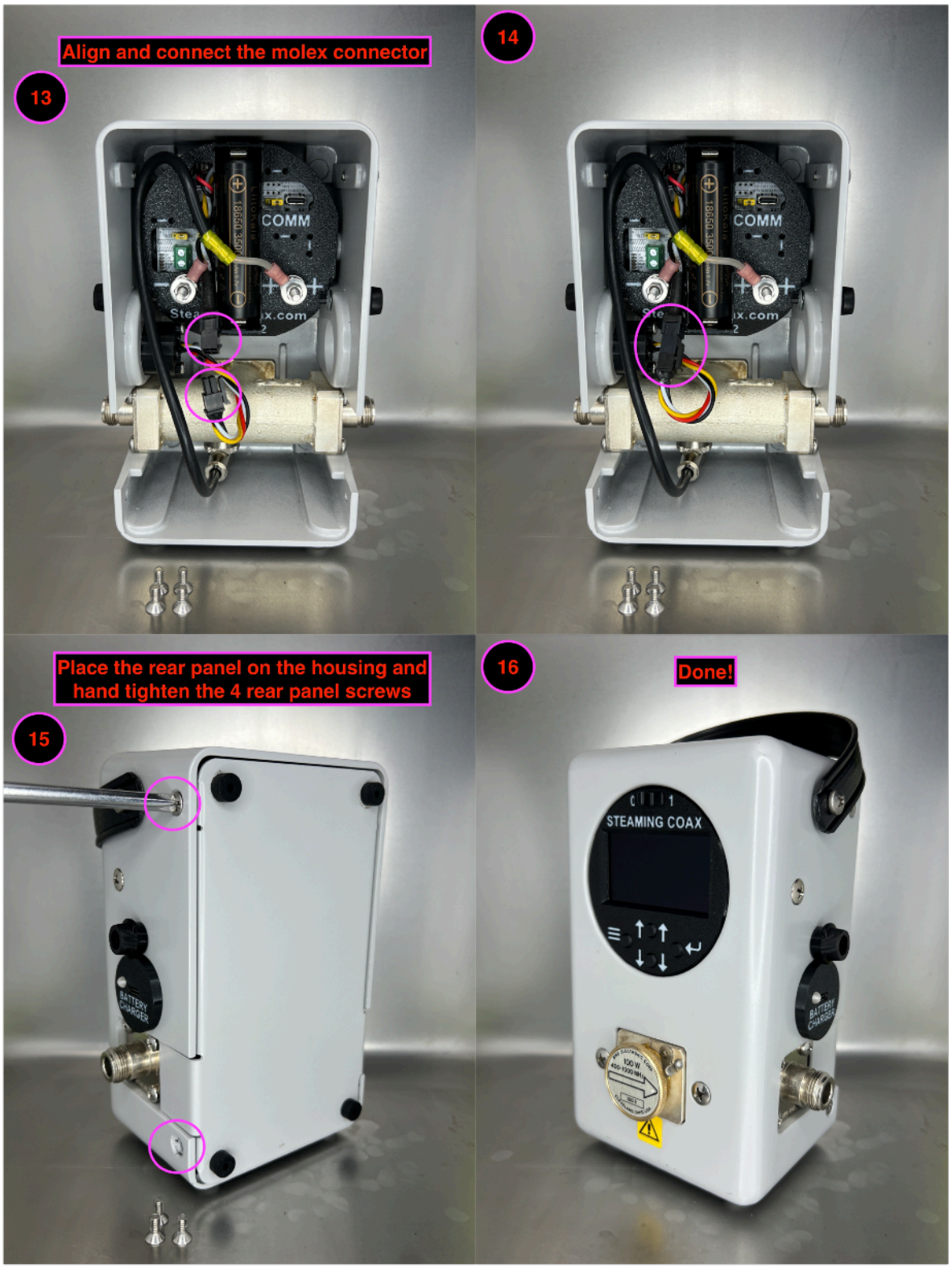


Figure 5.5: Bird 43 Installation Steps 13-16

6 Board

6.1 Overview

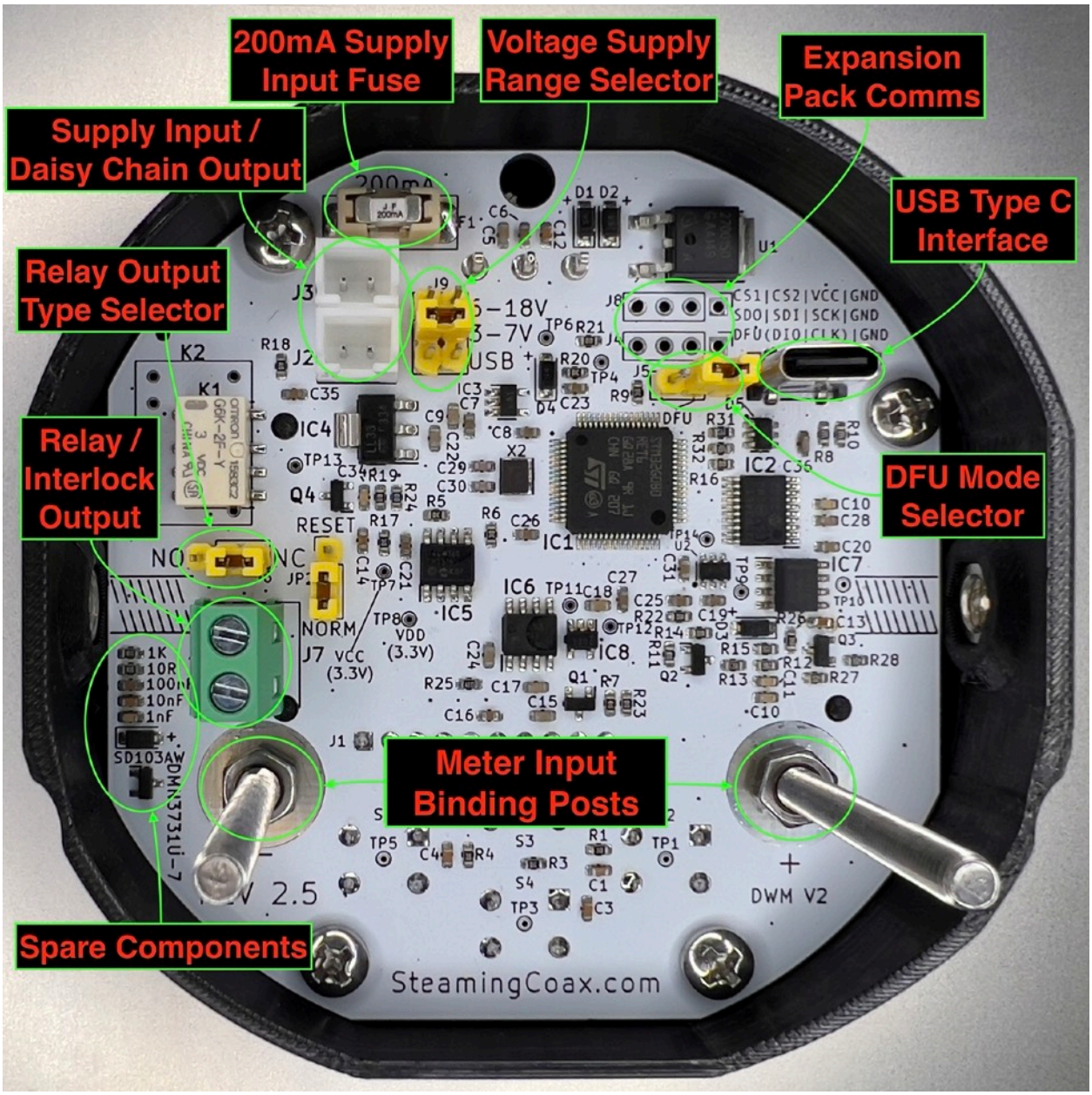


Figure 6.1: Board Overview

7 Powering the DWM

DANGER: *The DWM's lithium battery still comes with all of the dangers of using lithium batteries! It is important to* ***always be vigilant*** *and check for potentially damaged battery connections caused by* ***excessive heat*** *from the environment or* ***pinched wires*** *from tools or housings.* ***Please be careful when modifying or replacing components to not cause shorts in the battery connections as a battery fire may occur!*** *Protect your workshop! No matter the time it takes.*

The DWM can be powered by any relatively stable power source from 3 to 18V DC through the two JST connectors (J2 or J3) on the top left of the board. The device can be powered by a battery, a power supply, or a USB cable depending on the user's needs and use case.

7.1 Power Sources Selection

Before powering the DWM, please ensure the *Voltage Supply Range Selector* is set to the correct voltage range/source. The three jumper positions are: USB, 3-7V, and 7-18V.

7.2 USB

When the jumper is set to USB, the device will be powered by only the *USB Type C Interface* connector on the top right of the board (see *Figure 6.1*). When powered this way, the front power switch will not be able to turn the device on or off. The device will automatically turn on when the USB cable is connected and turn off when the USB cable is disconnected.

7.3 3-7 VDC

When the jumper is set to 3-7V, the device is powered by the *Supply Input* connector (J2 or J3) on the top left of the board (see *Figure 6.1*).

This mode is useful when the device is powered by a low voltage source such as a single cell Lithium-Ion battery or an alkaline battery pack. The jumper must be in this setting when using the Lithium-Ion battery pack option.

7.4 7-18 VDC

When the jumper is set to 7-18V, the device is powered by the *Supply Input* connector (J2 or J3) on the top left of the board (see *Figure 6.1*). This mode is useful when the device is powered by a higher voltage source such as a 12V wall adapter or a 12V battery from a car or mobile station. Do not exceed 18V as this may damage the device.

7.5 Input Protection

The input protection for the DWM is designed to protect against reverse polarity using reverse polarity protection diodes. These diodes will short out the power source and blow the *200mA Supply Input Fuse* if the power source is connected in reverse.

In the event of the fuse blowing, a replacement is supplied in the spares bag. But, if a replacement is needed, the part number is: 0448.200MR. The part number is also located on the board.

7.6 Daisy-Chaining

Warning: Do not daisy-chain more than 5 DWM's together or overload the chain by exceeding 1 Amp.

Daisy-chaining allows for multiple meters to be powered from the same power source. This is useful when multiple meters are being used in a single location and only one power source is available.

Daisy-chaining is done by connecting the power source to J3 on the first meter and then connecting the JST jumper cable to J2 on the first meter, then connecting the other end of the JST jumper cable to J3 on the next meter. This process is repeated for each meter in the chain.

Note: *J2 and J3 are interchangeable and can be used for either the power source or the JST jumper cable as they are connected in parallel.*

8 Navigation

8.1 Button Layout

The DWM is controlled via 4 buttons on the front panel.

Button combinations allow for advanced features to be accessed like resetting statistics, entering Reflection mode, and viewing element information on the spot.

Figure 8.1: Button Layout

8.2 Examples

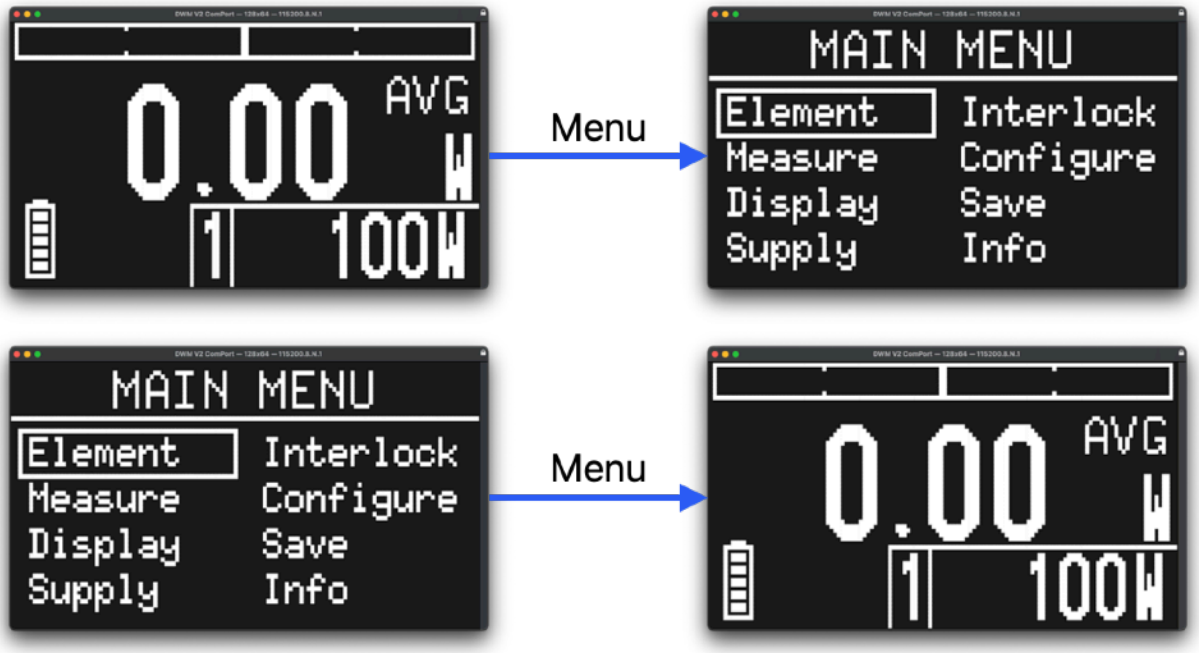


Figure 8.2: Entering and Leaving Main Menu

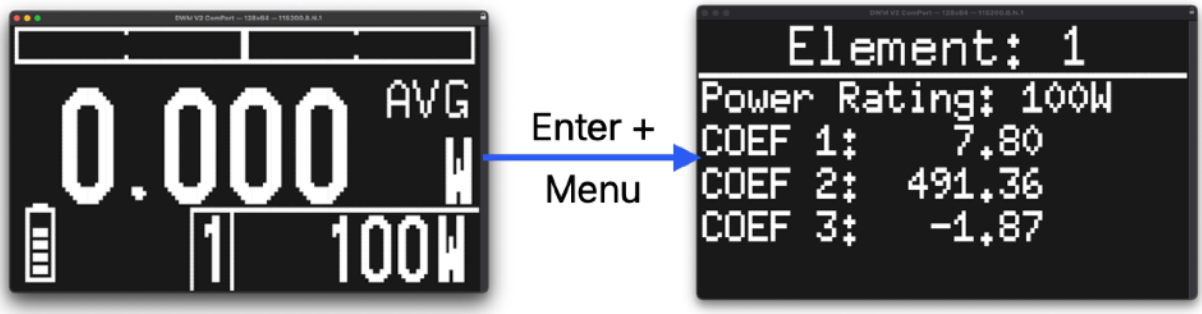


Figure 8.3: Quickly Viewing Element Information

8.3 Element Setup

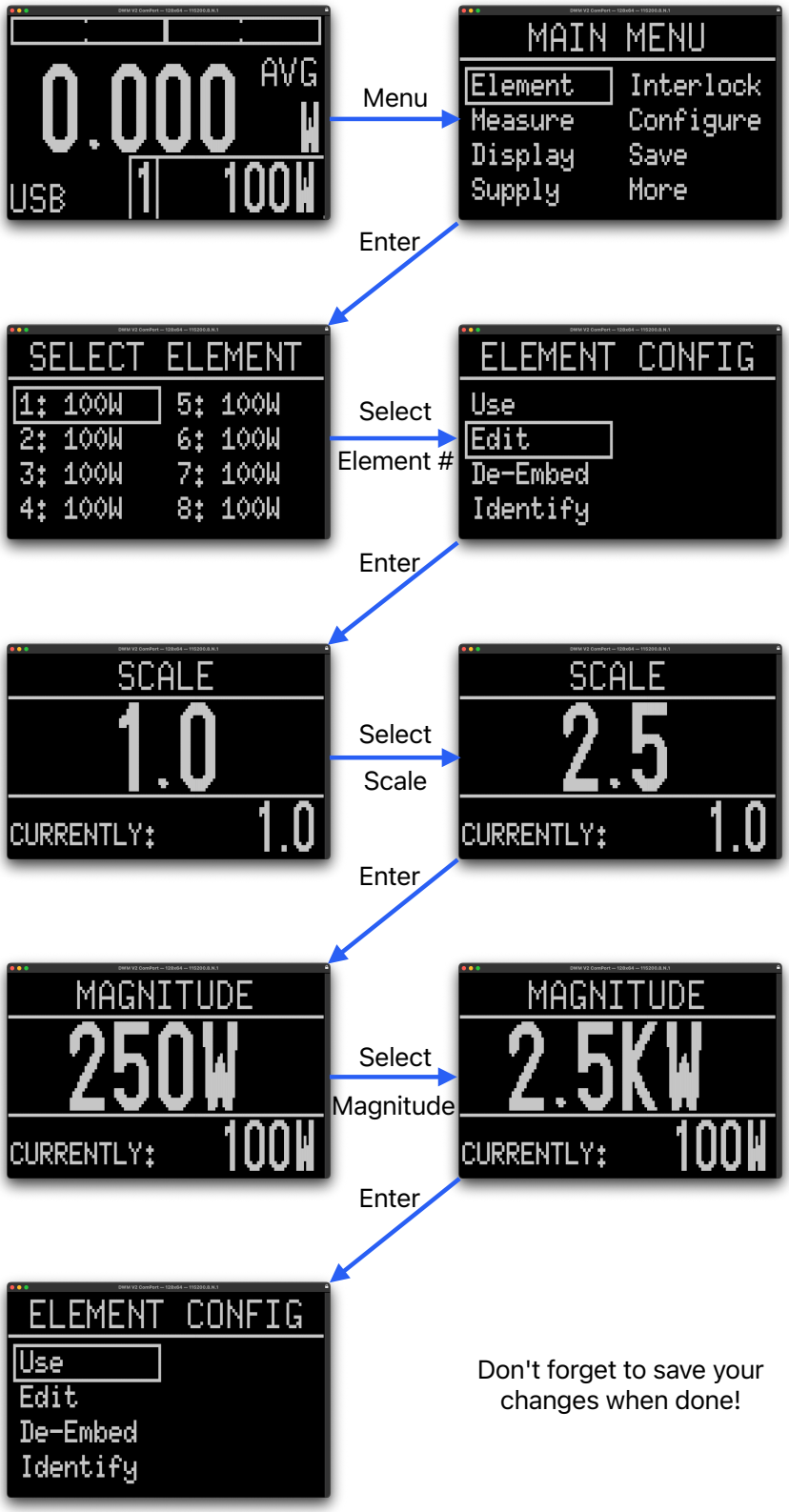


Figure 8.4: Setting Up an Element

9 Power Readings

Power statistics give the user a variety of ways to measure a waveform's power and characteristics. Each of the power statistics were inspired by experiences in the radio broadcasting industry as well as the amateur radio hobby. If more statistics are desired, they may be added in future firmware updates.

9.1 Range

The DWM can be configured to read power in 2x or 4x mode (5x is coming in a future firmware update).

For example, if an element has a rating of 250 watts and the DWM is in 4x mode, then a reading of up to 1000 watts can be measured.

9.1.1 Selecting the Power Range

To choose the power range, navigate to: *Main Menu* → *Measure* → *Range*.

Don’t forget to save your new configuration!

9.2 Selecting a Power Statistic Type

Selecting a power statistic type is done in the main power display screen. To cycle through the available power statistic types, click the UP or DOWN buttons.

9.3 Types of Power Statistics

9.3.1 Instantaneous (INS)

Gives the power reading for that exact moment in time. This mode is primarily used for power-stable waveforms. For example, FM and CW waveforms.

9.3.2 Average (AVG)

Gives an average power reading of the power over a set period of time (can be adjusted by navigating to: *Main Menu* → *Measure* → *Averaging*, then adjust the averaging time in seconds). This mode is excellent for measuring all sorts or power-fluctuating waveforms.

9.3.3 Temporary Peak (PEP)

Temporarily holds the maximum detected power for a set period of time before returning to the current power reading. The peak hold time can be adjusted by navigating to: *Main Menu* → *Measure* → *Peak Hold*, then adjust the peak hold time in seconds. This mode is excellent for measuring very narrow pulses in power or the peak envelope power of an AM or SSB waveform.

Resetting the statistics will clear the peak hold value if the user does not want to wait for the peak hold time to expire if a very long wait time is set.

9.3.4 Maximum (MAX)

Gives the maximum power reading since the last reset. This mode is perfect for detecting any spikes in power that may have occurred when the operator is not present.

This value is temporarily stored until the next statistics reset.

9.3.5 Minimum (MIN)

Gives the minimum power reading since the last reset. This mode is great for detecting any dips or power loss that may have occurred when the operator is not present.

This value is temporarily stored until the next statistics reset.

9.3.6 Deviation (DEV)

Gives the difference between the maximum and minimum power readings since the last reset. This mode is primarily for measuring an AM envelope to determine if the waveform is under-modulated or not. Secondarily, this statistic helps with looking at the ripple in a waveform that may be caused by power supply with bad output ripple.

This value is temporarily stored until the next statistics reset.

10 Reflection Mode

10.1 Configuring Reflection Type

There are two types of reflection measurements that can be performed with the DWM: Return Loss and VSWR. To change the reflection type, navigate to: *Main Menu* → *Measure* → *Refl Type* and select the desired reflection type.

10.2 Entering Reflection Mode

To enter reflection mode, press and hold the UP and DOWN buttons simultaneously for about 1-2 seconds. The meter will capture the current forward power reading (of all power statistics, AVG, PEP, MAX, MIN, DEV, and INS) and temporarily store it as a reference to perform the reflection measurement.

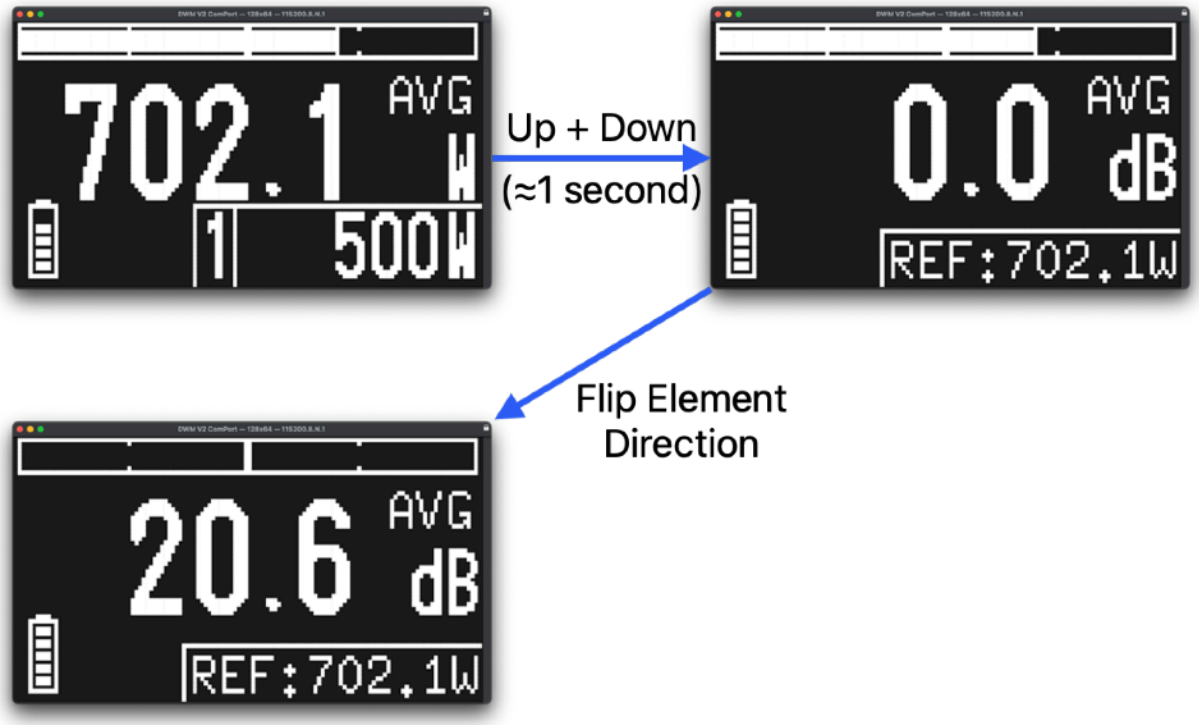


Figure 10.1: Entering Reflection Mode

When in reflection mode, the power statistic type (e.g. AVG, INS, etc...) can be changed. This change not only affects the current reflection reading but also the temporarily stored forward power reference.

Quick Tip: *98% of the time in this mode, you will want to use the AVG power statistic type for reflection measurements. This is because the AVG power statistic type is the most stable representation of the forward power. Meanwhile, the other power statistic types are for highly specific use cases like measuring gain compression in an amplifier.*

10.3 Exiting Reflection Mode

To exit reflection mode, press and hold the UP and DOWN buttons simultaneously for about 1-2 seconds. The meter will return to the normal operation screen and the temporarily stored forward power reference will be cleared.

11 Meter Input

The meter's (DWM) input is referred to the connection to the two binding posts on the rear of the meter as indicated by *Figure 6.1*.

11.1 Input Resistance

The DWM can be configured to have its input resistance set to either 1400Ω (for 30uA elements) or 3000Ω (for 100uA elements) by navigating to: *Main Menu → Configure → Meter Imp*.

Note: *This does not change automatically with the types of element being used. It must be manually set through the menu system.*

11.2 Input Filtering

A low-pass filter is implemented on the DWM to reduce any high-frequency noise that may be present on the input signal that is not part of the element's output signal.

11.3 Input Protection

Both over voltage and reverse polarity protection are implemented on the DWM to help protect from any surges that may occur like static discharges or incorrect connections.

Note: *The input protection is designed to mitigate the risk of damage to the input of the DWM, no more than ±1 volt should be applied to the input or damage may occur.*

12 USB

12.1 Serial Console Mode

This is the default mode for the DWM. It allows for the user to communicate with the DWM via a serial monitor application like Tera Term or PuTTY (or some other MacOS compatible equivalent like Serial, SerialTool, or through the native Terminal (CLI)). The user can send commands to the DWM to change settings, view power statistics, logs, and more.

The DWM will appear as “DWM V2 ComPort” when connected.

12.2 Configuration

It is recommended to set the communication speed to 115200 baud to allow for the fastest communication speed. This can be done in the serial monitor application settings. Also, the terminal window size must be set to 128 (width) by 64 (height) when in screen mirroring mode to properly view the mirrored display.

12.3 Screen Mirroring

Screen mirroring allows the user to remotely view the DWM's display and control the DWM from a computer using the arrow keys and a few other keys. This can prove extremely useful if the meter is in a hard-to-reach place or in a remote site where a remote connection is available (i.e. a networked site computer with a USB port).

When in screen mirroring mode, the user can press the "?" key to view a list of commands that can be used to control the DWM.

12.4 DFU (Device Firmware Update) Mode

DFU mode is used to update the firmware of the DWM. There are two ways to put the DWM into DFU mode. Once the DWM is in DFU mode it will be recognized as a DFU USB device by the computer and the user can use the STM32CubeProgrammer application to update the firmware. Please refer to section *17 Firmware* Update for more information.

13 Interlock

WARNING: *An interlock system should never be used as a safety mechanism. Please use proper precautions like shutting off power to a transmitter completely before working with or near potentially life-endangering equipment.*

An interlock is a way of enabling and disabling a transmitter in the event of an issue with the transmitted signal. Typically, an interlock is used to disable a transmitter if the reflected power is too high. It can also be used to disable a transmitter if the forward power falls outside an acceptable range which may be an indication of an amplifier malfunctioning or beginning to fail.

13.1 How it Works

Typically, a transmitter has two wires or connections that must be connected together for the transmitter to operate. This forms a closed circuit. If the closed circuit is interrupted by a portion of it being disconnected, the transmitter will disable itself as the circuit is no longer complete. This is referred to interlocking.

The standard method of completing and interrupting the loop is by using a dry contact device such as a relay. The DWM contains a relay and terminal block for this purpose.

13.2 Board Configuration

The DWM offers the choice of the interlock to be configured as normally open (NO) or normally closed (NC). This means if the interlock is configured as normally open, the relay will connect the two terminals when the interlock is triggered. If the interlock is configured as normally closed, the relay will disconnect the two terminals when the interlock is triggered.

This is configured via the jumper (J6) on the left side of the board as can be seen in *Figure 6.1* labeled "Relay Output Type Selector".

13.3 Software Configuration

13.3.1 Type

There are three trigger type settings for the interlock. The first is simply "*Disable*", this will make the interlock not trigger under any circumstance (Use this setting if the interlock functionality is not need as it will conserve power). Next is "*Lo Power*", this will trigger the interlock if the measured power ever falls below the threshold. Finally, "*Hi Power*", this will trigger the interlock if the measured power ever exceeds the threshold. The trigger type is set by navigating to: *Main Menu* → *Interlock* → *Type/En*.

13.3.2 Threshold

The threshold is the power level at which the interlock will trigger. This value is adjusted by navigating to: *Main Menu* → *Interlock* → *Threshold*. Then, the amount in which the trigger value will be adjusted by (in the *Incrementation* menu) can be set. Then, trigger value can be adjusted by pressing the ENTER button and using the UP and DOWN buttons to adjust the value. The user may go back and forth between the *Incrementation* and *Trigger Value* menus to fine-tune the trigger value. The trigger value is set when the user presses the ENTER button again. Don't forget to save the settings by navigating to *Main Menu* → *Save*.

13.3.3 Resetting the Interlock

To reset the interlock, leave the menu system (return to the power screen) and press and hold the ENTER button for 2 seconds or until the *Stats Reset* message appears on the screen. This will reset the interlock and the power statistics.

14 Element De-Embedding

Beware: *Element de-embedding is not necessary for 99% of situations. The default de-embedding values that are already in each meter are already quite good and will have an accuracy the same or better than a standard Bird meter. Only do this if you need better than 5% accuracy!*

Element de-embedding involves finding the values (or coefficients) for the voltage to power equation that will allow the meter to correctly calculate the applied power to the line-section from the voltage that is read from the specific element being used.

This is crucial as every element will output a slightly different voltage/current for a given applied power to it! This is why de-embedding is needed for each element to have the best accuracy possible.

Note: *We call this process "de-embedding" and not "calibration" as the element itself is not being calibrated, rather the DWM is trying to compensate for the inaccuracies in the element's output voltage/current for a range of power input levels.*

Another Note: *The term "accuracy" used here should technically be replaced with the term "error". But for the sake of simplicity, we will just assume they are the same. (Sorry to the bean counting people)*

14.1 How it Works

De-embedding an element as mentioned previously involves finding the values (or coefficients) for the equation that will allow the DWM to accurately convert the voltage read from an element to the power that is being applied to the line-section it's installed in.

A bit of math here for context:

$$Power = a_2 * Voltage^3 + a_1 * Voltage^2 + a_0 * Voltage$$

The following numbers (or coefficients) a_2, a_1, and a_0 will allow the equation above to output the correct power value for a given element's output voltage (in millivolts).

These values are found using by measuring the voltage applied at the DWM's input and the power that is being applied to the line-section. The DWM has a built-in voltmeter function (*mV Read*) that must be used to measure the voltage from the element. Also, a trusted power meter must be used to measure the power that is being applied to the line-section. This "trusted power meter" will be what the DWM will match its power readings to for the given element being used.

Note: *A "trusted power meter" does not need to be a precision power meter that costs thousands of dollars, it can also just be another Bird meter and the exact element inserted into that meter. However, this does not mean that the DWM will show the ACTUAL power being applied to the line-section, it will do it's best to match the power readings to the "trusted power meter's" readings.*

14.2 Preparation

1. Open the *Element De-Embedding Calculator* spreadsheet in Microsoft Excel. (Download Here or from: www.steamingcoax.com)
2. Enter the element power rating information onto the "*Element*" field (cell F26).
3. Connect the trusted power meter and the line-section the DWM is operating with into the transmission line between the transmitter and the load.
4. Insert the element being de-embedded into the line-section.
5. Ensure the meter's input impedance is set to the correct type based on the element and line-section being used. See the *Element & Line-section Types section Element & Line-section Types* for more information.
6. Go to: *Main Menu → Element → (element slot to be used for this element) → De-Embed → mV Read* to directly read the voltage from the element. (Shown in the following figure)

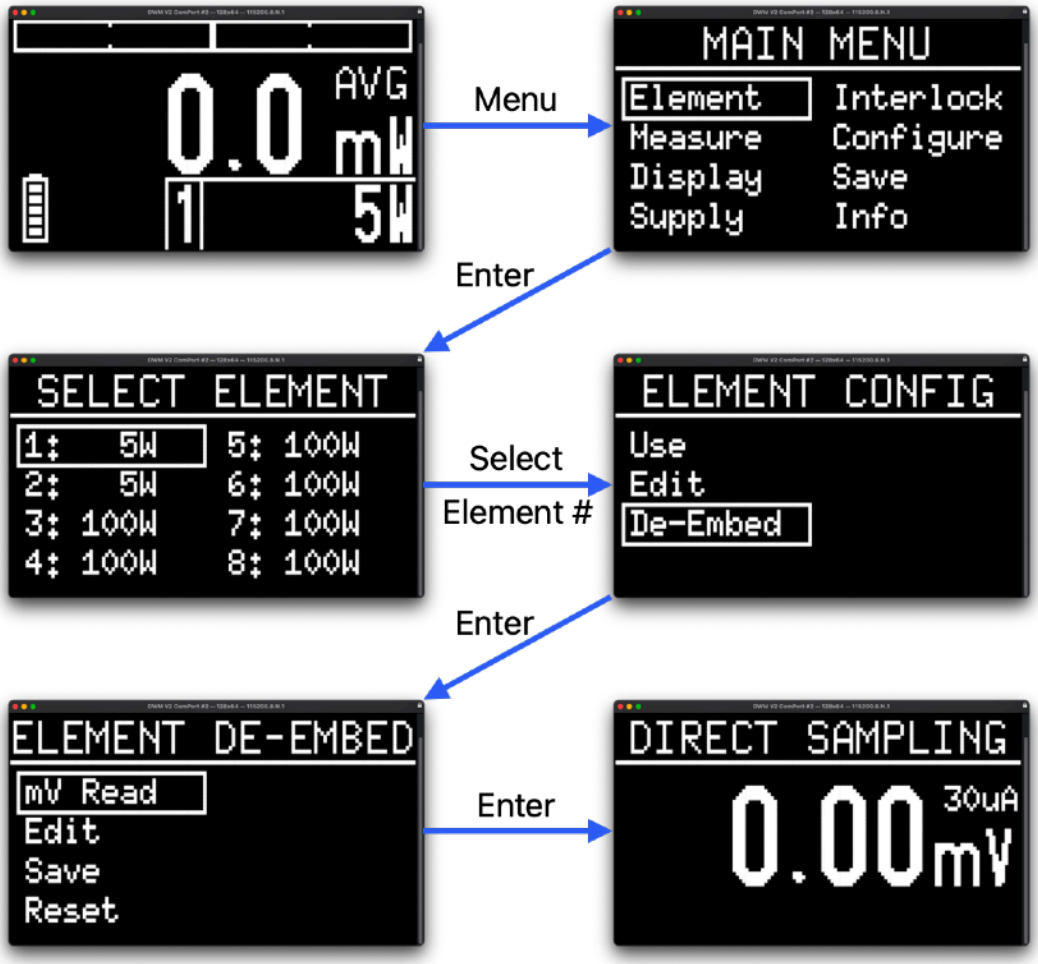


Figure 14.1: DWM Element De-Embedding Preparation

Figure 14.2: Element De-Embedding Setup

14.3 Data Sampling & Collection

Both the DWM's voltage and the "trusty" power meter's power readings are to be entered into the *Element De-Embedding Calculator* spreadsheet in the yellow fields under "*mV*" and "*W*".

There are recommended power levels to take measurements at that should be followed. However, these recommended values are only there as a reference for the user. The user can measure at whatever power levels they choose, as long as the values are increasing in power or voltage as the data is filled when going from the top of the table to the bottom.

14.4 Analyzing the Data

Before entering the calculated de-embedding values into the DWM, the user must review the data and ensure there were no errors in the data sampling & collection step.

The best way to know if there are any problems with the gathered data is to see if there are any bulges or significant warping in the dark blue line. This would indicate that an incorrect voltage or power value was entered into the spreadsheet. Another quick way would be to observe the R^2 value and ensure that it's at least greater than 0.999. The higher the R^2 value is, the more accurate the DWM will be over the points measured.

The following is an example of a badly collected data sample:

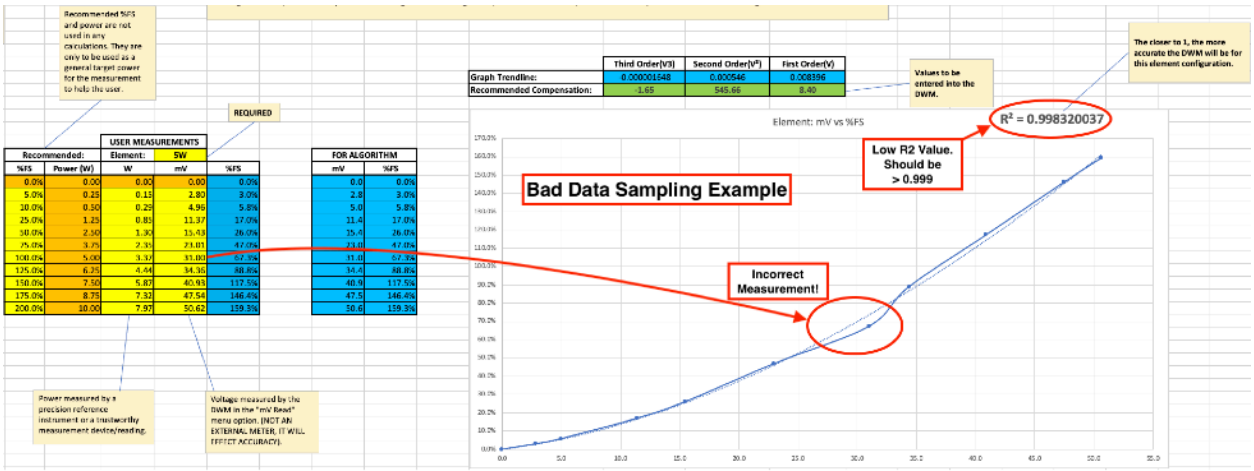


Figure 14.3: Bad Data Sampling Example

The following shows the corrected data sample:

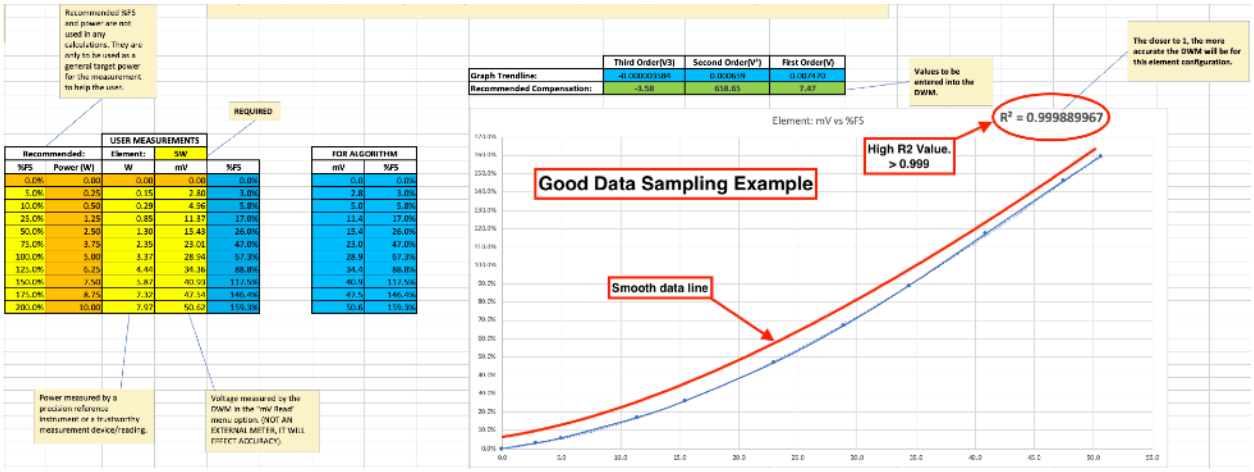


Figure 14.4: Good Data Sampling Example

14.5 Validating the De-Embedding Values

This step is only those who want to double check what the accuracy will be at different power levels.

The following image shows the areas where the DWM's de-embedding (of the 5W element) accuracy will be at its highest and lowest (very useful for knowing if there will be high accuracy in the user's main operating region):

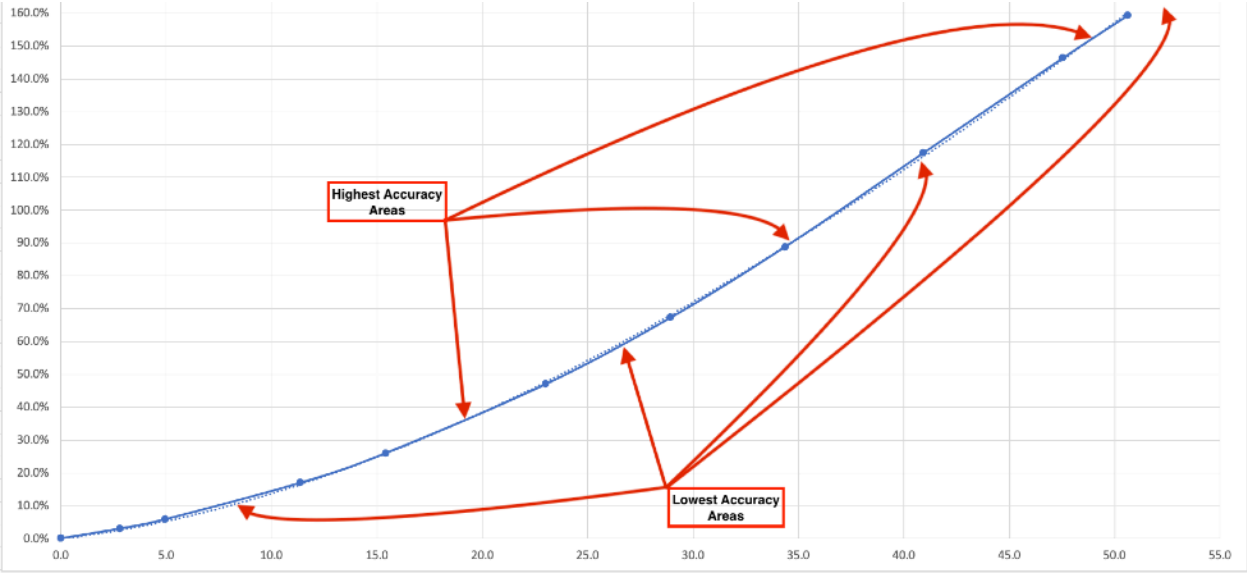


Figure 14.5: High and Low Accuracy Power Regions

This can be validated by setting the RF source to what the % full scale (of the used element power rating) value is on the graph and comparing the DWM's reading with the "trusted" power meter's reading.

Note: *Because math, the accuracy will be typically lower at lower power levels as we are comparing more and more sensitive values! This is very normal.*

14.5.1 Worst Case Accuracy Area

As an example, here is a validation measurement (for the 5W element) taken at what appears to be the lowest accuracy area on the graph of *Figures 14.3 & 14.4*:

Figure 14.6: Worst Case Accuracy Measurement

Based on these values, we can calculate the worst case accuracy (technically error) between the DWM's measurement and the "trusted" power meter's measurement at this particular power as follows:

$$Accuracy = 100 * \frac{DWM - TRUSTED}{TRUSTED}$$

So,

$$Accuracy = 100 * \frac{0.5276 - 0.5582}{0.5582} \approx 5.5\,\%$$

14.5.2 Best Case Accuracy Area

As an example, here is a validation measurement (for the 5W element) taken at what appears to be on of the highest accuracy areas on the graph of *Figures 15 & 16*:

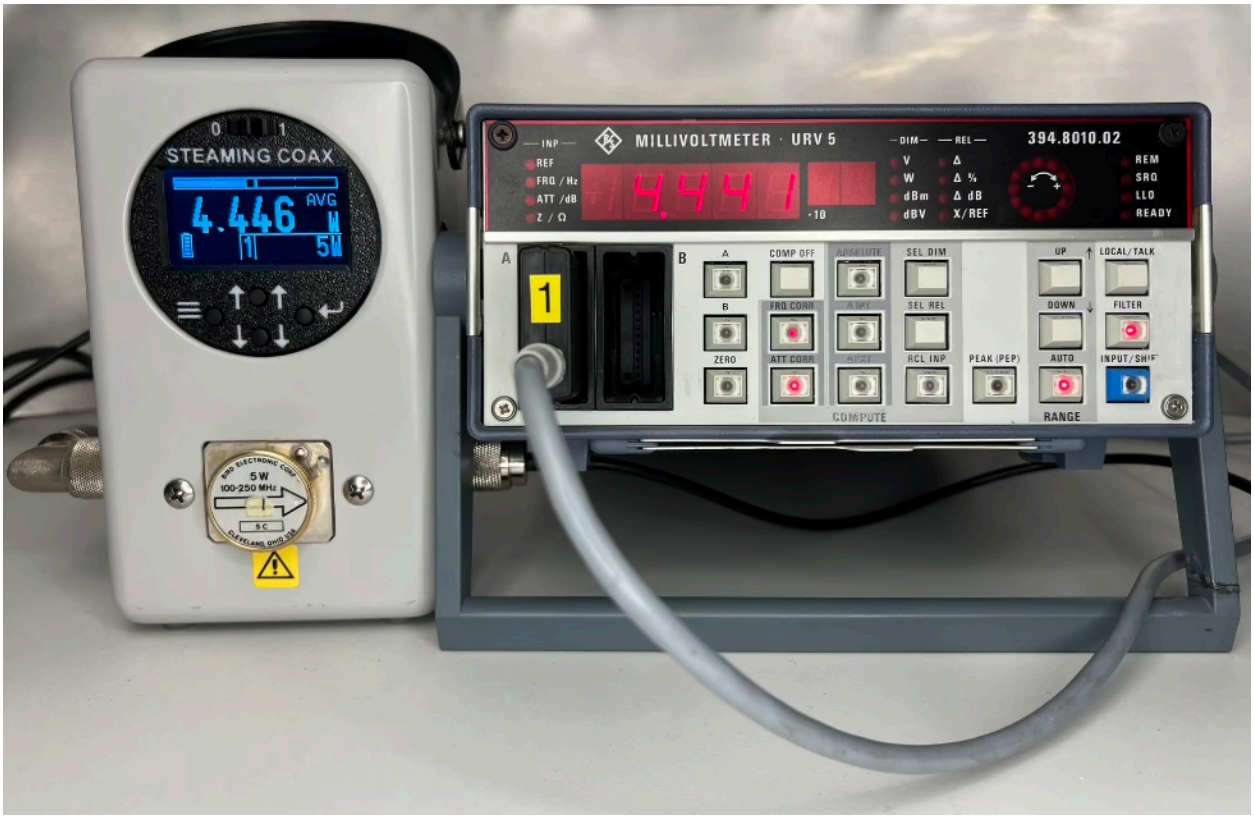


Figure 14.7: Best Case Accuracy Measurement

Based on these values, we can calculate the best case accuracy (technically error) between the DWM's measurement and the "trusted" power meter's measurement at this particular power as follows:

$$Accuracy = 100 * \frac{DWM - TRUSTED}{TRUSTED}$$

So,

$$Accuracy = 100 * \frac{4.446 - 4.441}{4.441} \approx 0.1\,\%$$

14.6 Keeping Track of Data

Now that the element de-embedding coefficients have been calculated for the element, they must be recorded somewhere to be able to refer to the data later in case if a tremendous amount of elements are being used or to keep track of drifting elements.

The first way, is to record them into one of the pages of the Element De-Embedding Calculator spreadsheet. This is great for referring to the data in the future and makes it easy to compare between many elements. This is mainly useful for those interested in statistics and data.

The second, is to record them using a piece of tape or a label maker directly on each element. This is very practical when using many elements for the same DWM. (I use both methods)

Quick tip: *Click both the MENU and ENTER buttons at the same time on the power screen to view the current element's information to quickly make sure the correct coefficients are being used.*

Figure 14.8: Element Coefficients Tracking Technique

15 Meter Calibration

Aside from the element de-embedding, there is the calibration of the DWM meter itself to ensure that it is reading accurate voltage coming from the elements. The DWM has its own algorithms and parameters for accurately reading element voltages regardless of ambient temperature.

15.1 Input Offset Calibration

The ability to perform an offset calibration is offered to the user in the event of the meter reading a non-zero voltage at its input when nothing is connected. Over the years, the input op-amp buffer's input offset may begin to drift a bit. The following steps provide a way to correct for this:

1. Power down the input by disconnecting the DWM's input binding posts from the line-section element output cable or by rotating the element 90° to the vertical position to short the connection (results may vary to if the transmitter is still operating at high power as stray RF may make it onto the cable [unlikely but still possible]). If the user wants the meter to compensate for the noise in the system, leave the element pointing left or right in the line-section.

2. On the DWM, navigate to: *Main Menu* → *Configure* → *Cal* → *Input* → *Auto Cal*.

3. A message asking the user to power the input down will appear (already performed in step 1). Press ENTER to continue.

4. Select YES if you are sure you wish to proceed and are ready for the calibration to take place.

5. Once the calibration completes automatically, the user will be asked to save the configuration. Press "YES" to save.

15.1.1 Manually Adjust Offset Calibration

After the auto calibration takes place, the user may observe a small amount of power being present on the power screen. This is due to the noise on the input line and the line-section element. If the user prefers to see an exact value of zero on the power screen, they should adjust the offset calibration value to a lower value in the "*Edit Cal*" menu until 0.000mV is observed.

15.1.2 Reset Offset Calibration

Resetting the offset calibration sets the offset calibration values for both meter impedance types to zero.

15.2 Supply Voltage Calibration

Note: *This calibration field does not affect the actual operation of the device and is purely for the users feedback on the device voltage. The default battery calibration is typically just fine.*

Because the DWM allocates all of its precision ADC measurements to measuring the line-section input, a less accurate ADC is used to sample the supply voltage input. This means that depending on the temperature, input voltage range used, and device to device variance, the supply voltage reading can be off by about 5%. This does not matter much when using higher voltage inputs like 12 volts. But, this can seem large when using a low voltage input like a lithium battery.

15.2.1 Manually Adjust Calibration

This method will be made easier or automated in future firmware updates.

1. Navigate to: *Main Menu* → *Supply* → *Direct*. (Remember the originally used supply type)
2. Return to the main power screen.
3. Measure the supply voltage at the battery or supply input connector (be careful to not short any connections) with a multimeter.
4. Take note of the DWM's supply voltage reading.
5. Navigate to: *Main Menu* → *Configure* → *Cal* → *Supply*.
6. If the DWM's supply voltage reading is higher than the multimeter, increase the calibration value. If it is lower, then decrease the calibration value.
7. Repeat steps 3 through 6 until the DWM's supply voltage reading is the same as the multimeter's reading.
8. Navigate to: *Main Menu* → *Supply* and select the original supply type and voltage ranges (refer to step 1).
9. Save the new calibration and configuration.

16 Logging

Logging allows the DWM to keep track of events that occur on the system over time. These events can be used to diagnose issues with the DWM or a transmitter. The events that the DWM are not stored when the DWM is powered off. The DWM can store up to 99 events. When the DWM reaches the maximum number of logs, the logging configuration specifies what to do.

16.1 Log Severity

16.1.1 INFO

Linked to events that are informational. These events are not errors but are useful to know. Examples include when the DWM is powered on or when the USB has been connected or disconnected.

16.1.2 WARNING

Linked to events that are not errors but are important to know. Examples include when the input supply voltage has become critically low or when the interlock has been triggered.

16.1.3 ERROR

Occurs when a part of the DWM in not functioning as it should but, it is still possible to use the device to perform measurements. For example, if EEPROM memory corruption has occurred.

16.1.4 CRITICAL

Occurs when the DWM is malfunctioning and is unable to perform measurements. For example, if the ADC is not functioning correctly. Please reach out for repairs or assistance.

16.2 Logging Configuration

To configure how the logging system will work when the number of total logs has reached 99, go to: *Main Menu → Configure → Logging → Preserve*.

16.2.1 Only New

When a log count of 99 is reached, the DWM will only store new logs and delete the oldest logs.

16.2.2 Newest 10

When a log count of 99 is reached, the DWM will store the newest 10 logs and delete the oldest logs.

16.2.3 Oldest 10

When a log count of 99 is reached, the DWM will store the oldest 10 logs and delete the newest logs. This mode is useful to know what the first logs were when diagnosing an issue.

16.3 Viewing Logs

To view the logs, go to: *Main Menu* → *More* → *Logs*. The logs will be displayed in order of most recent (high number) to oldest (low number). To Clear a specific log, press the ENTER button on the log you want to clear. To clear all logs, go to: *Main Menu* → *Configure* → *Logging* → *Clear All*.

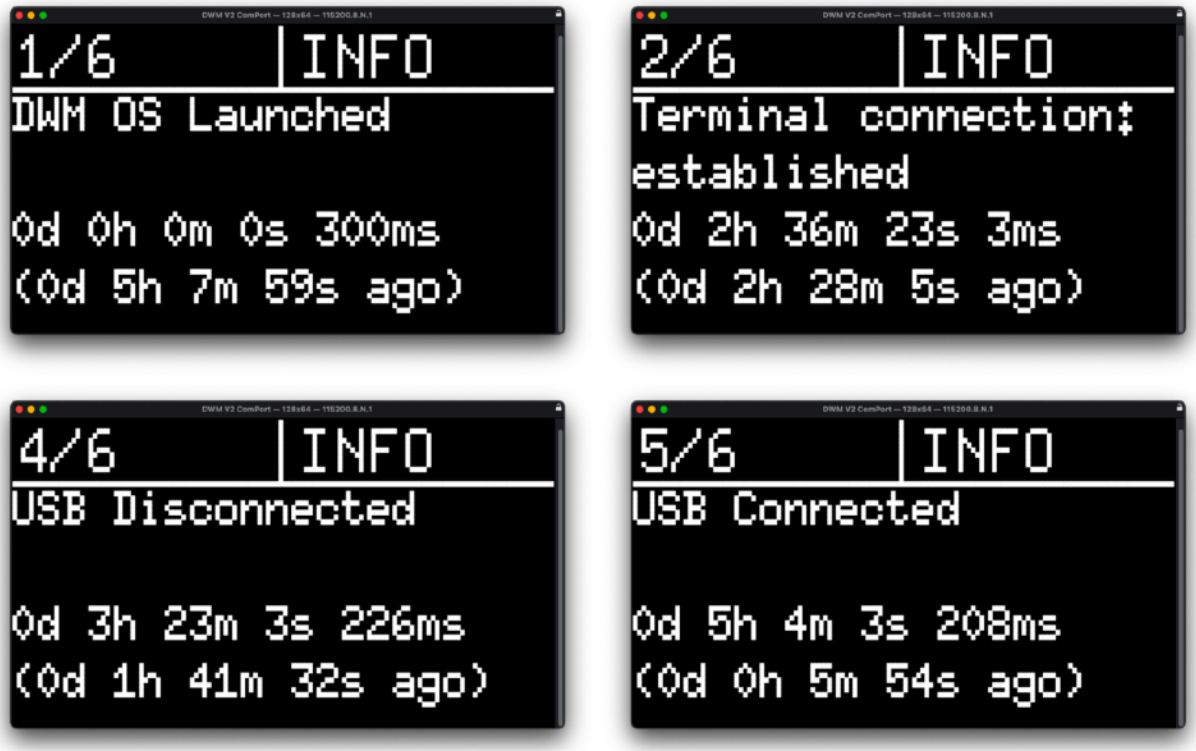


Figure 16.1: Log Examples

17 Firmware Update (DFU) Mode

To perform a firmware update, the following is needed:

- USB Type-C cable
- Needle nose pliers (for the jumper method [*Section 17.2.2*]

17.1 Connections

17.1.1 USB Cable

A standard USB Type-C cable is required to connect the DWM to the computer. This cable is the same as the one used to charge the lithium battery backpack. Ensure the other end of the cable is compatible with the computer's USB ports (USB A or USB C ports).

Note: *Not all USB Type-C cables are created equal. There are some strange compatibility issues depending on manufacturers and specifications.*

17.2 Entering DFU Mode

17.2.1 Menu Method

Note: *This method requires at least the firmware version 2.3.0 or higher (Released on March 31st 2025).*

To enter DFU mode, navigate to: *Main Menu* → *More* → *Update*. Once entered into DFU mode, the screen will go dark and the DWM is ready to be updated.

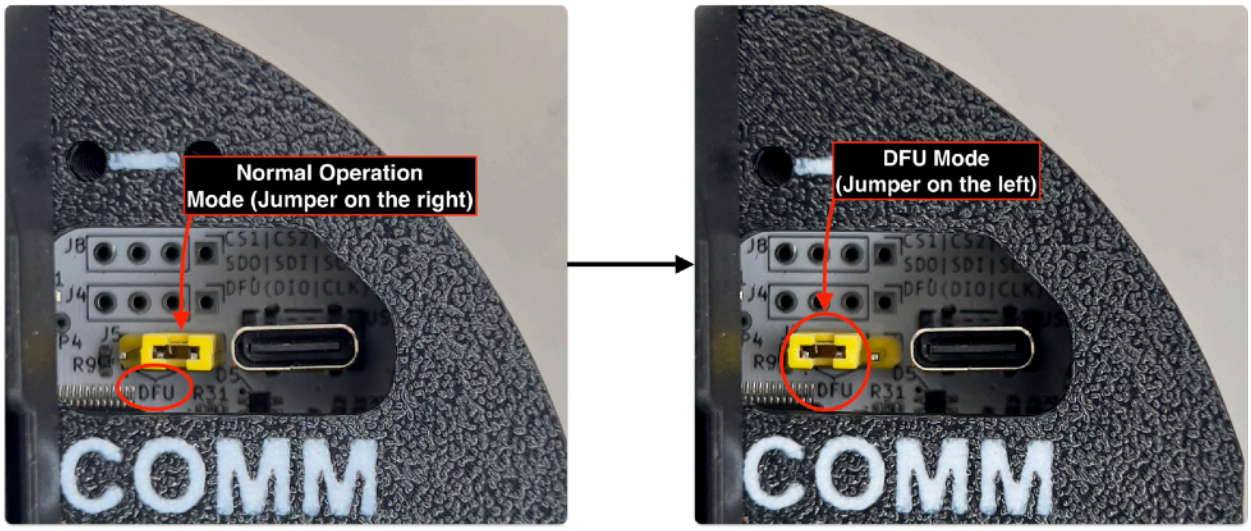
Note: *The order in which the USB cable is plugged into the DWM and when the DWM is entered into DFU mode does not matter.*

Another Note: *When using the DWM remotely at a distance that makes physical access impossible, DO NOT put the DWM into DFU mode! The only way to get the DWM out of DFU mode is by physically powering the device off, then on again.*

17.2.2 Jumper Method

1. Turn off the DWM.

2. On the back of the DWM to the left of the USB communication port, there is a yellow jumper. Use needle nose pliers to move the jumper from the right position to the left as follows:



3. Connect the USB Type-C cable to both the computer and the DWM (on the USB communication port on the back of the DWM).

4. Turn on the DWM. If the display remains off when powered on, then the DWM is in DFU (Device Firmware Update) mode and is ready to be updated.

18 DWM-Control Application

Note: *This is the preferred and most simple application used to update the DWM V2 meter.*

The DWM-Control desktop application works for both Windows and Mac. It is designed to control and update your DWM V2 meters all from your computer (and serve as an alternative to the STM32CubeProgrammer which has been very complicated to use [as can be seen in *Section 19*]). Currently, only the ability to update your meter is available.

The latest version of DWM-Control can be downloaded from:
https://github.com/SteamingCoax/DWM-Control/releases/latest

The source code to this application can be found at:
https://github.com/SteamingCoax/DWM-Control

18.1 Windows Users Setup

18.1.1 Driver Installation:

Because Windows needs drivers to do literally anything, a driver is needed for the DWM to be updated.

1. Download the Zadig USB Driver Installer from the official website: https://zadig.akeo.ie/
2. Set the DWM-V2 into firmware update mode (DFU mode).
3. Connect the DWM-V2 to the PC.
4. Open the Zadig App.
5. Make sure it says "DFU in FS Mode" for the device selection (circled in red below).
6. Click "Install Driver" and wait a few moments for the driver to install.
7. Done! You may proceed to the Installation section below!

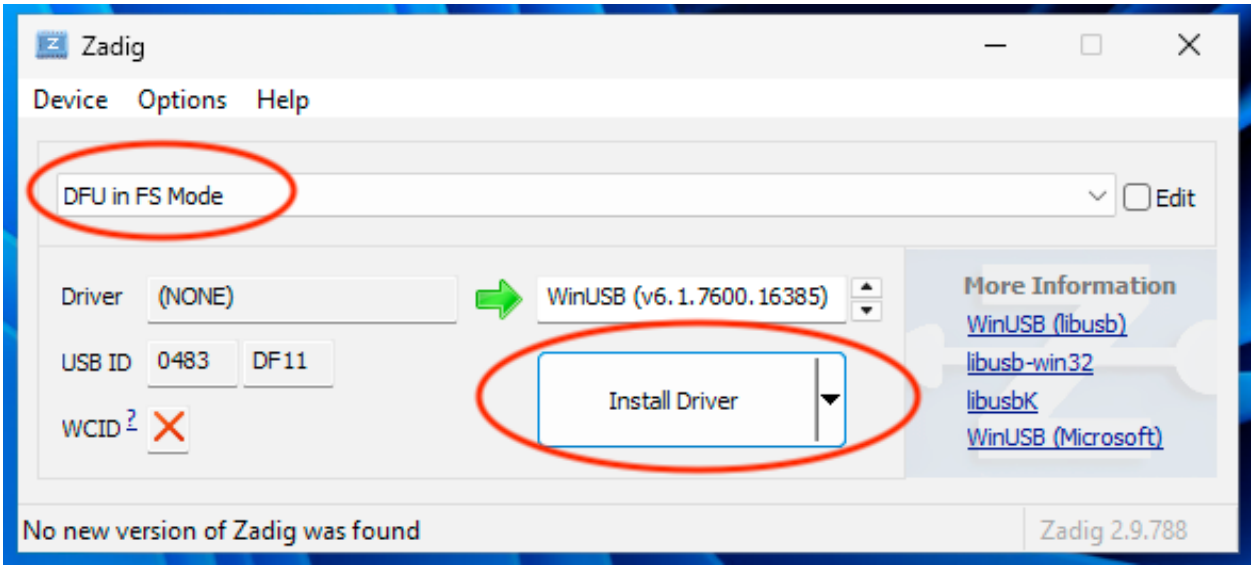
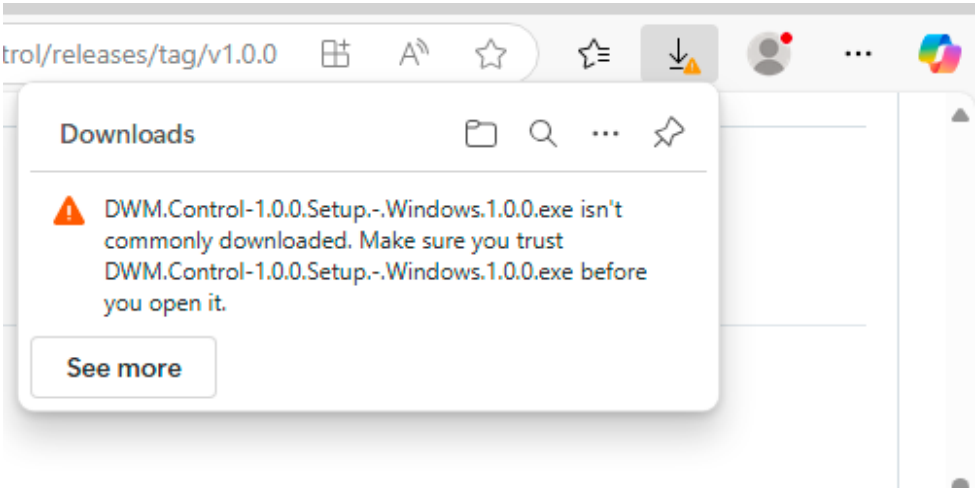


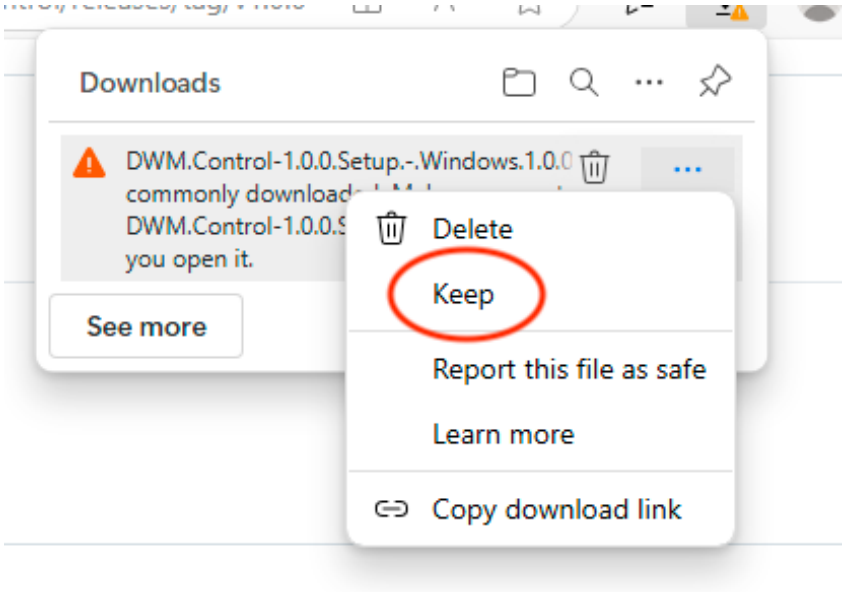
Figure 18.1 Zadig Driver Installer

18.1.2 Installation:

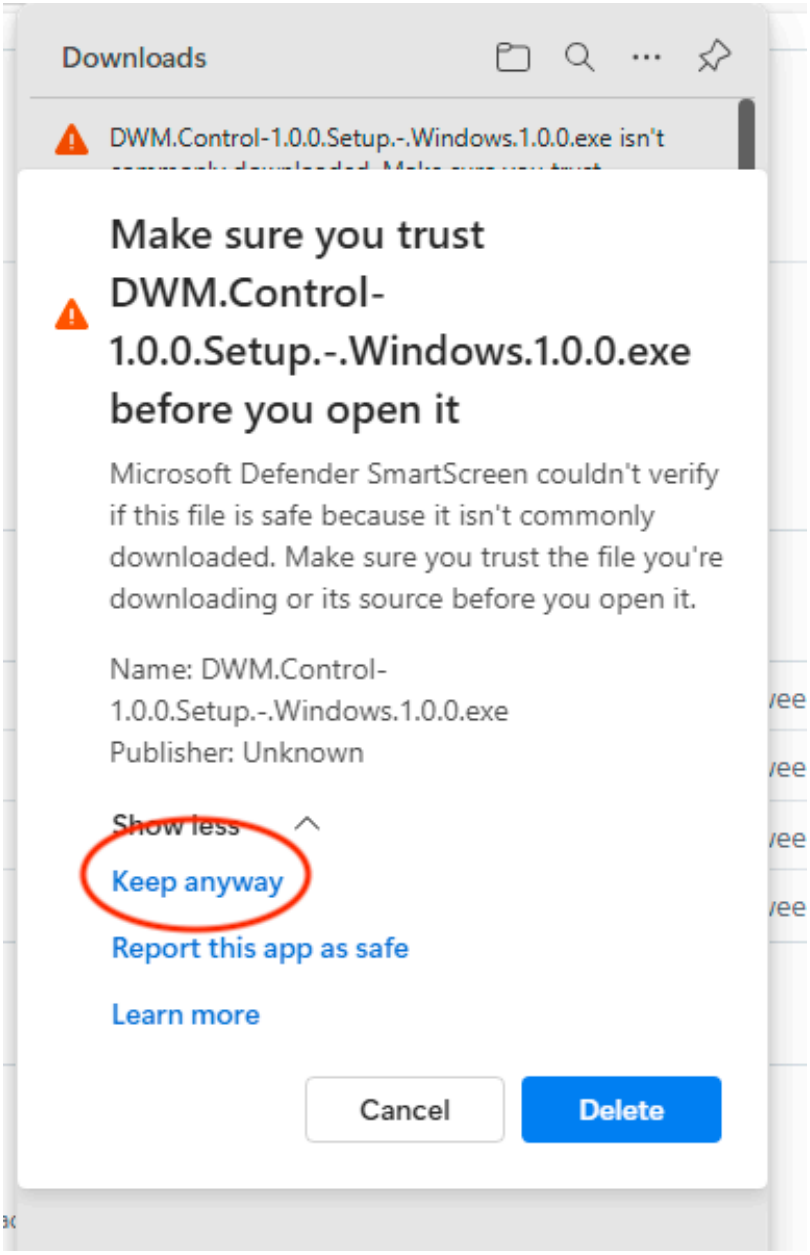
1. Once the DWM-Control app is downloaded, depending on your browser, it may show something like this:



2. Click the three dots. Then “Keep”.



3. Then, this message may appear. Click "Keep anyway".



4. Then, open the installer from where it downloaded to and follow the steps from the installer!

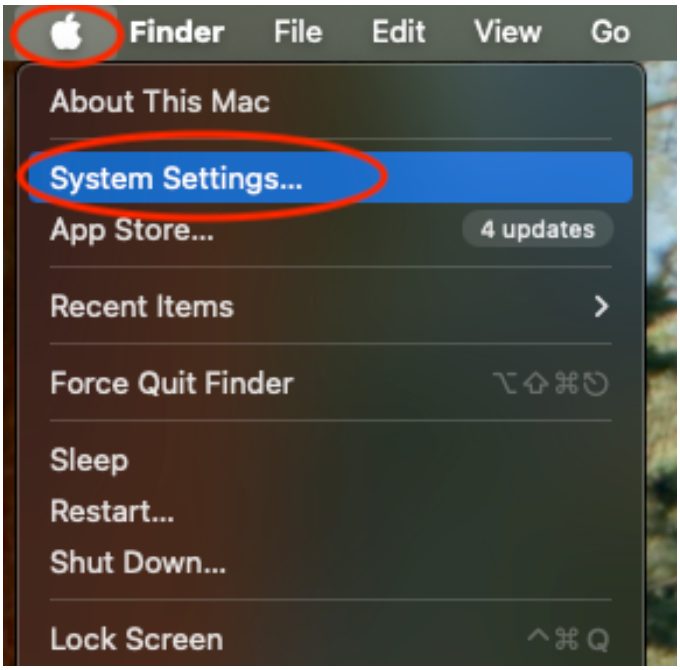
18.2 macOS Users Setup

18.2.1 Installation:

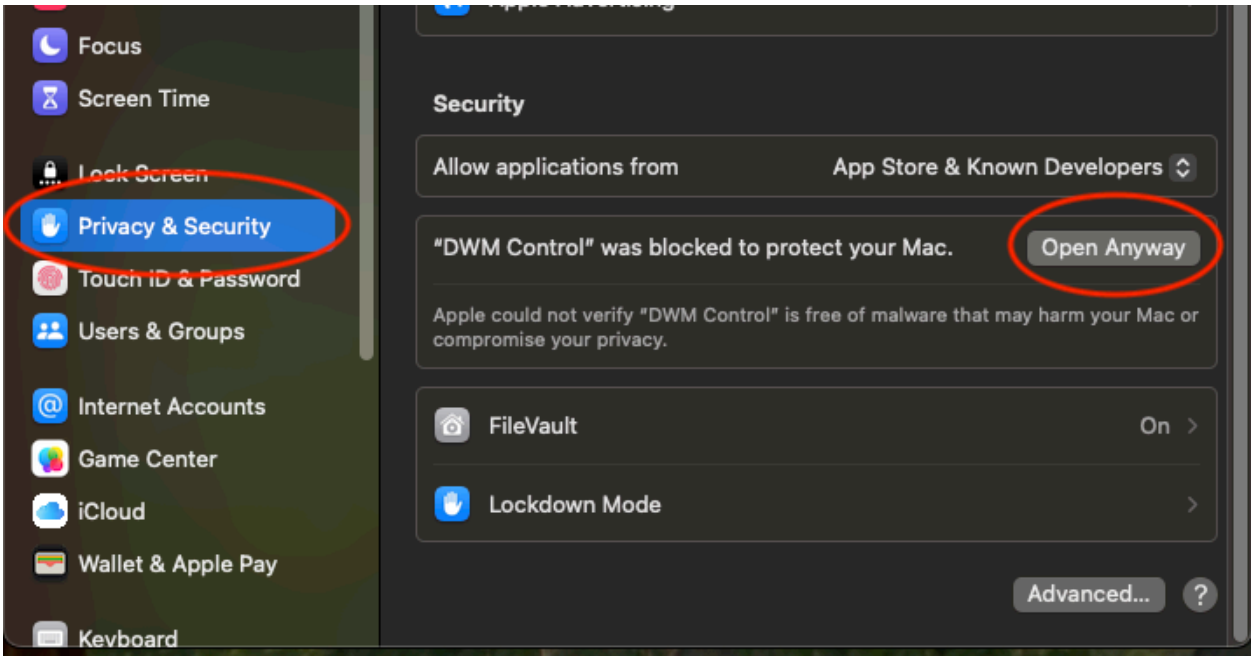
1. Once the app is downloaded, open the .dmg installer.
2. Drag and drop the DWM-Control app to the Applications folder.
3. Navigate to the "Applications" folder and open the DWM-Control Application.

When the app is first opened, you will most likely see this pop up due to me not being a "verified" developer yet:

4. Click "Done". Then click on the Apple logo on the top left of your screen, then click "System Settings":



5. Navigate to "Privacy and Security", then scroll all the way to the bottom and click "Open Anyway". There may be a popup that will ask this again, click "Open Anyway. You may need to confirm this with your system credentials.



6. Done!

The app should open and you can now update your DWM V2 meter.

Remember, on Mac, no drivers are needed. Everything should just work!

18.3 Updating Firmware

The Firmware Upload tool works from top to bottom.

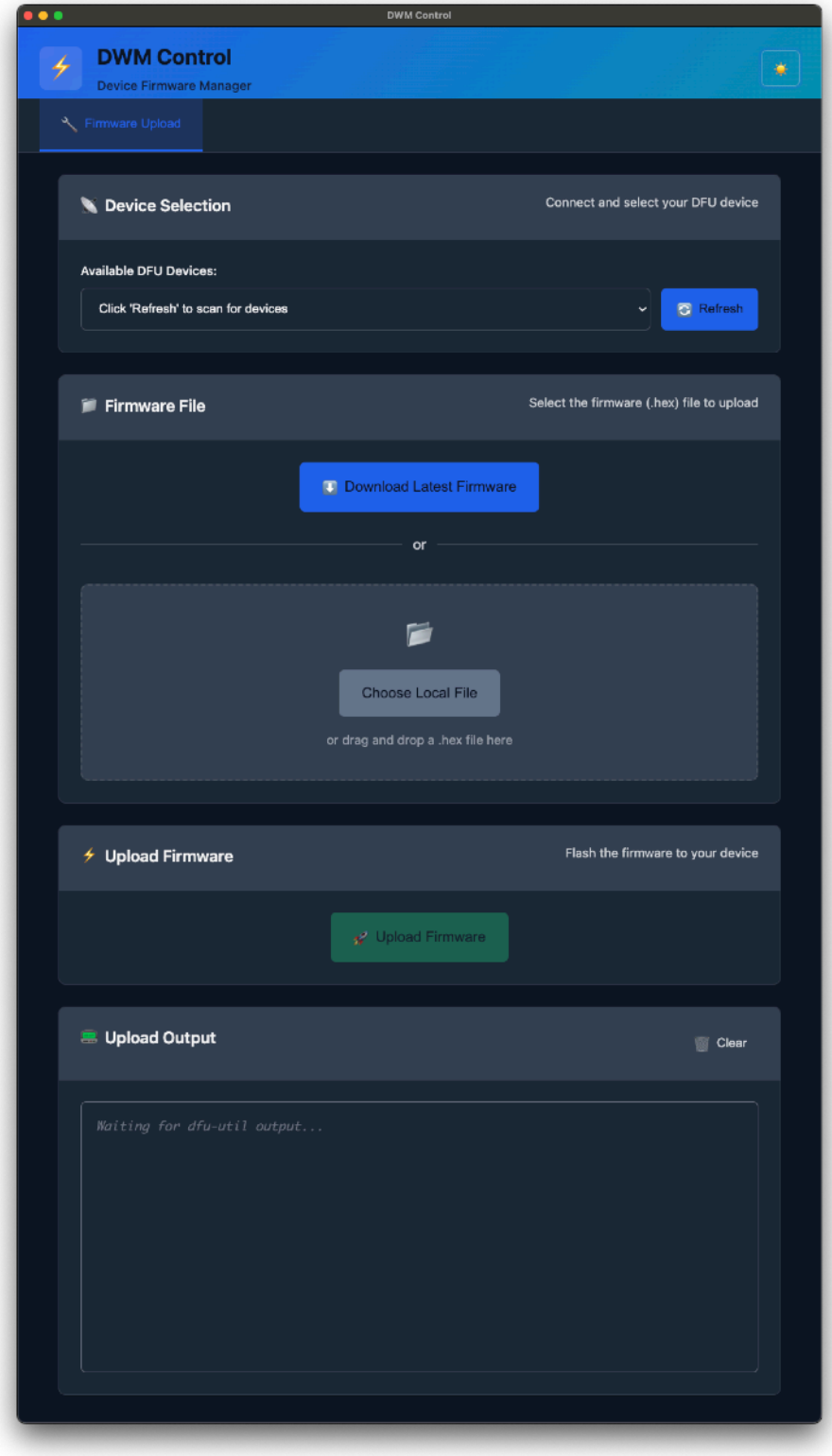
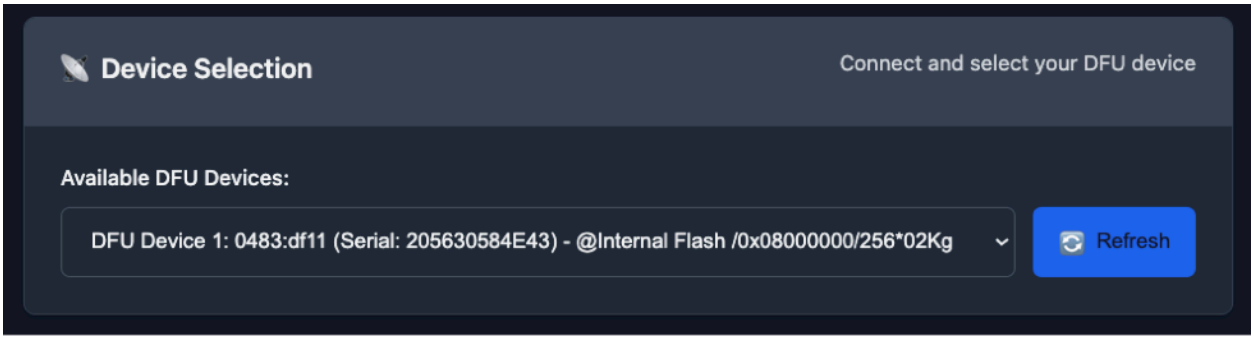
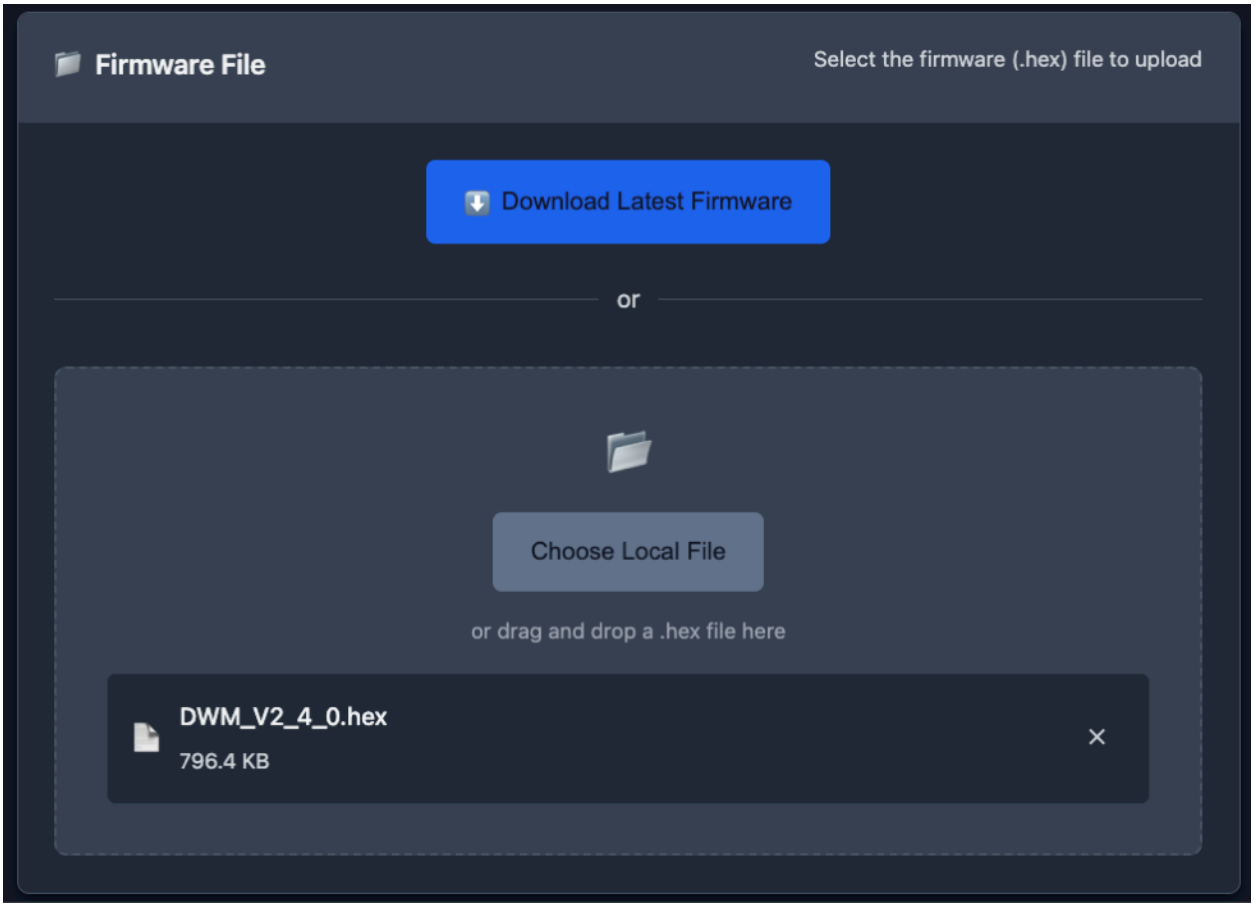


Figure 18.1 DWM-Control Firmware Upload Tool Page

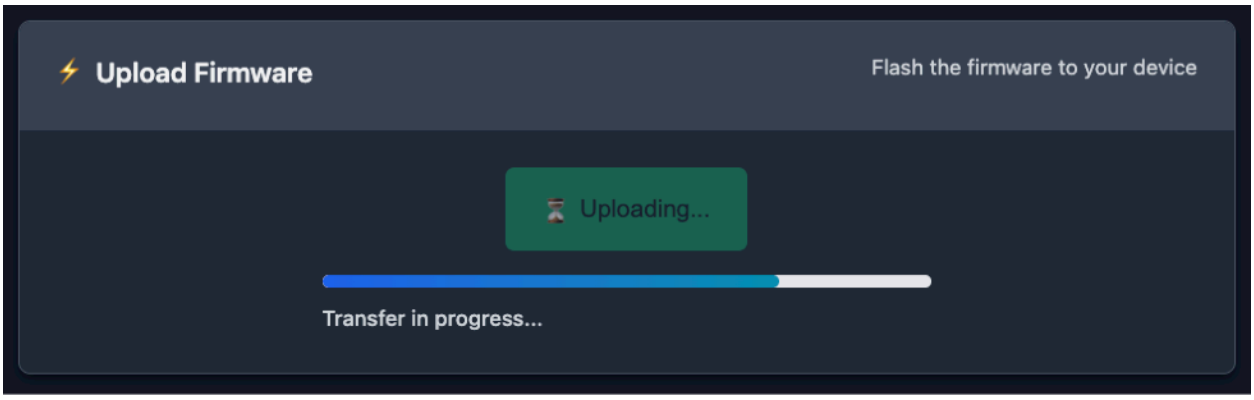
1. Click the “Refresh” Button if your device does not appear. If it still does not appear, ensure the DWM is connected and in firmware update mode (DFU mode) and if you are using Windows, ensure the driver is installed via Zadig (*Section 18.1.1*).



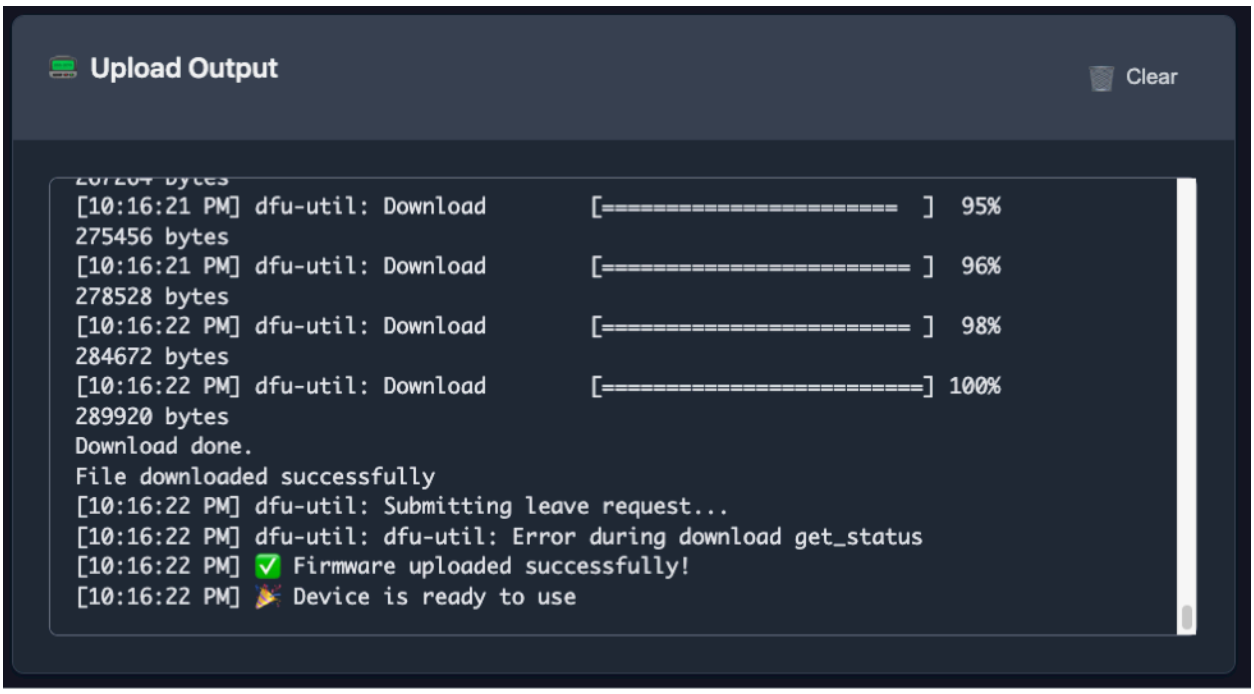
2. Click “Download Latest Firmware”. This will automatically find and download the latest firmware from the [DWM-V2_Firmware GitHub repository](). **IF** the firmware fails to download automatically, the latest firmware version can be found by following the steps in *Section 19.1* and choosing the downloaded firmware by clicking the “Choose Local File” button.



3. Click “Upload Firmware” to update the DWM. DO NOT disconnect or interrupt the firmware uploading process. **IF** the process is interrupted, the meter must be put into DFU mode using the jumper method (*Section 17.2.2*), powered off, then on again. Then, restart the upload process.



4. Once the transfer is complete, the DWM may be disconnected and power cycled. The Upload Output should look like this:



5. Done! You did it! Enjoy the new firmware!

19 Alternative Firmware Updating Method

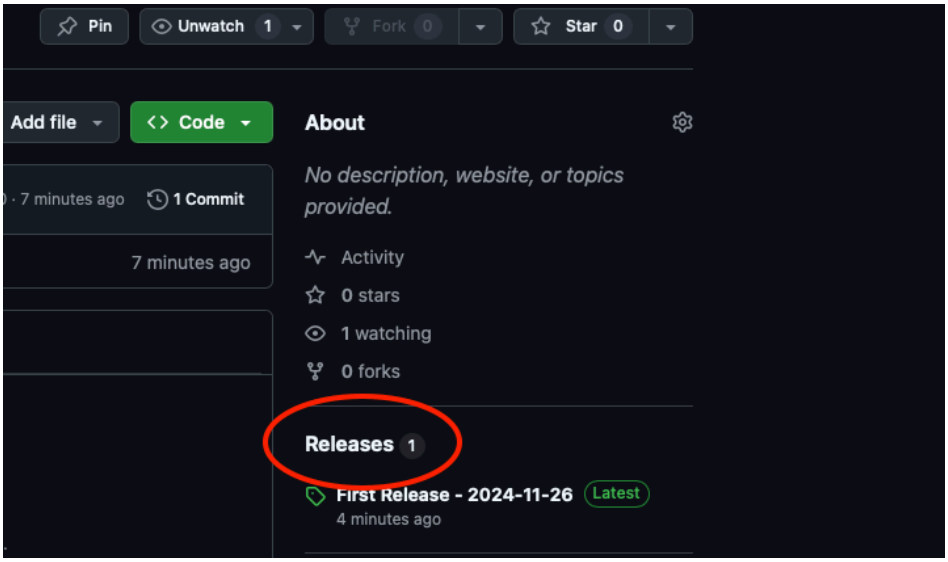
19.1 Getting the New Firmware

Beware: *This should only be done if the DWM-Control Application is not able to download the latest firmware version on its own or if the STM32CubeProgrammer application is being used to update the firmware.*

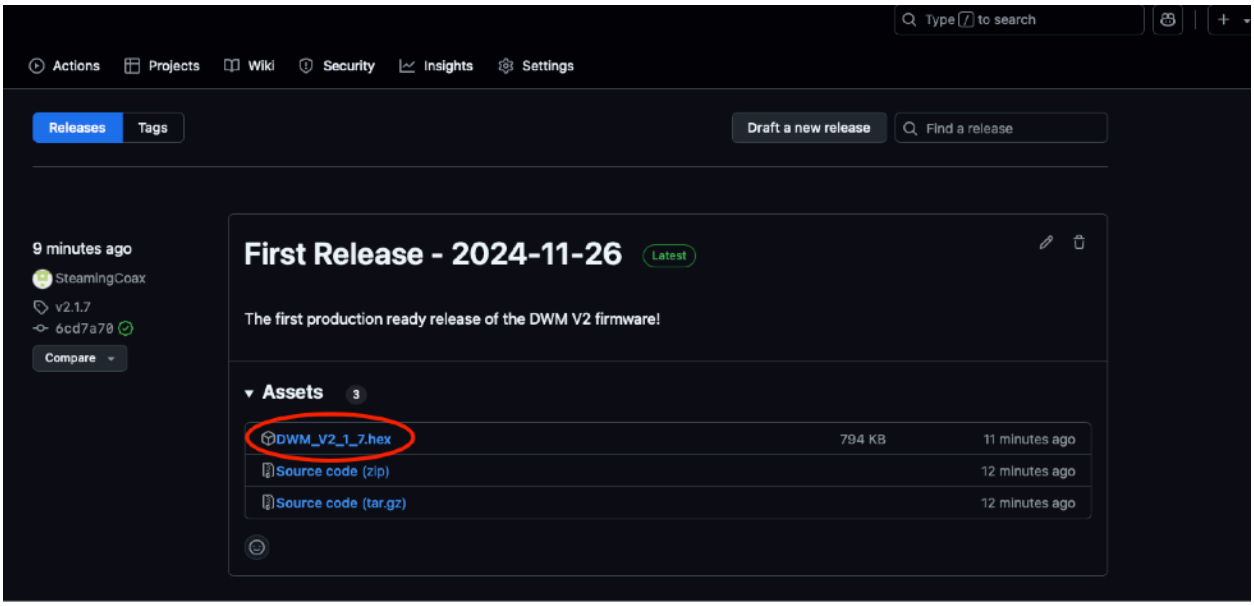
The file type that contains the update is a .hex file that can be obtained by navigating to:

https://github.com/SteamingCoax/DWM-V2_Firmware

1. Then click on “Releases” on the right side of the page:



2. Choose the latest firmware release version and click on the .hex firmware file to download it:



19.2 STM32CubeProgrammer Software

Note: *Only use this software of you are an advanced user or you are not able to get and use the DWM-Control App shown in Section 18.*

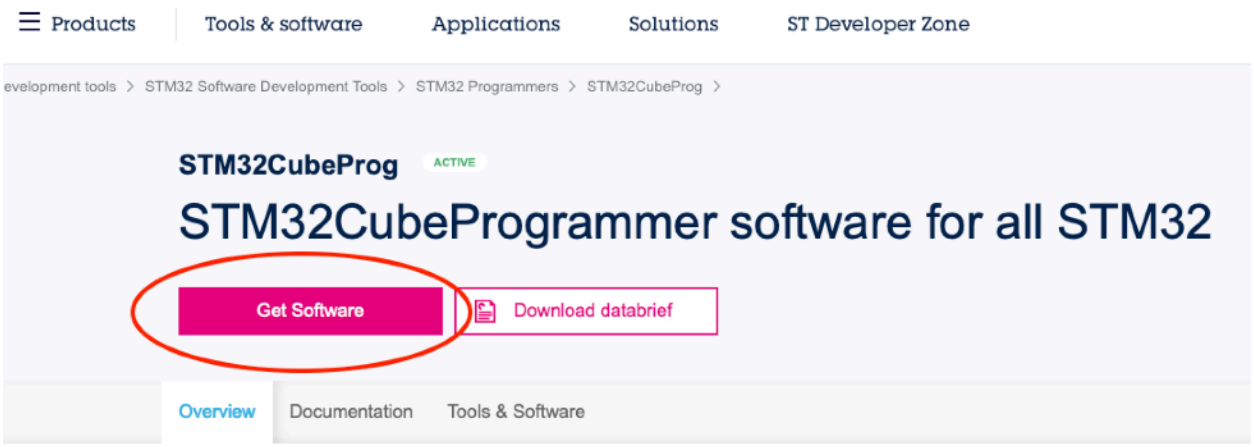
19.2.1 How to Get It

There are a few firmware uploader softwares available to use. This guide will be using the official STM32CubeProgrammer software provided by ST. The following are steps to prepare the software.

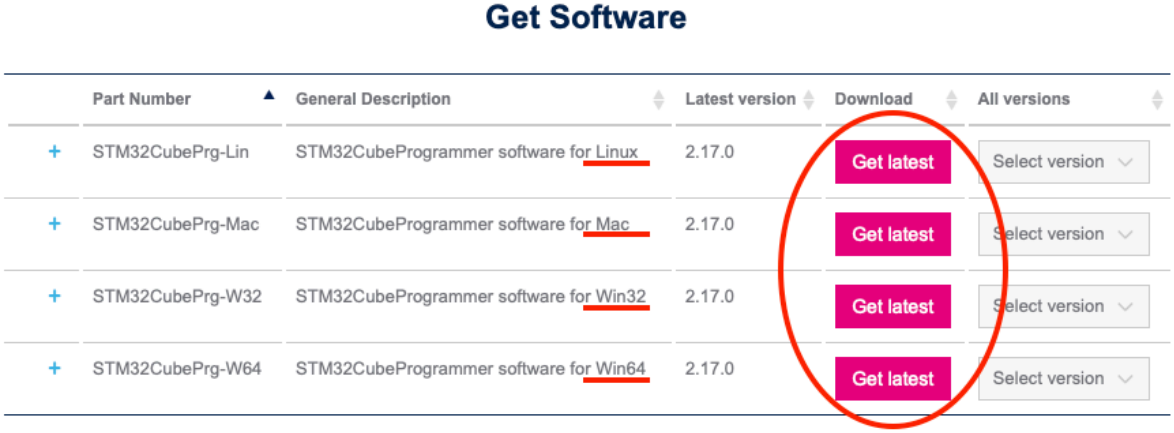
1. To download the programming software, please navigate to:

https://www.st.com/en/development-tools/stm32cubeprog.html

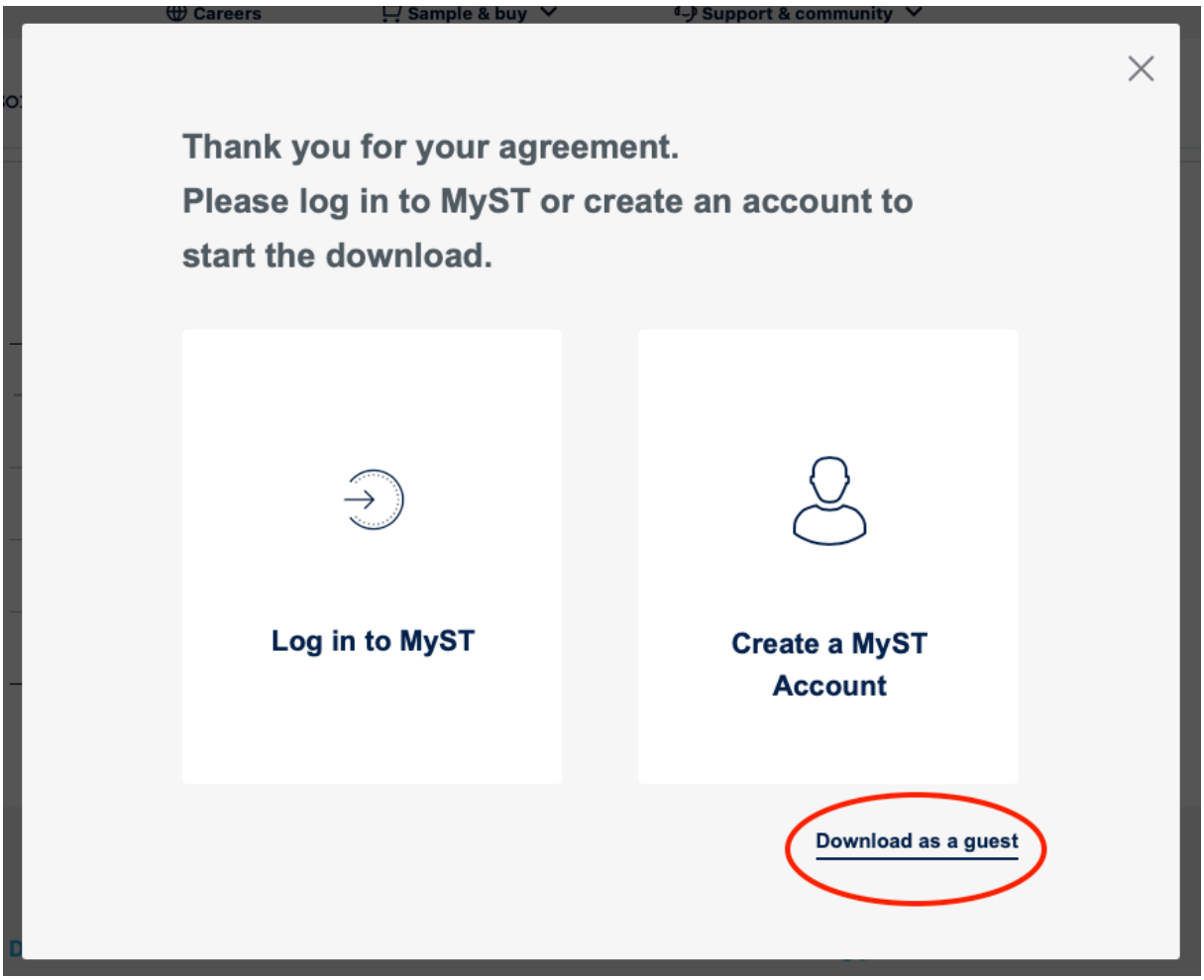
2. Click on “Get Software”:



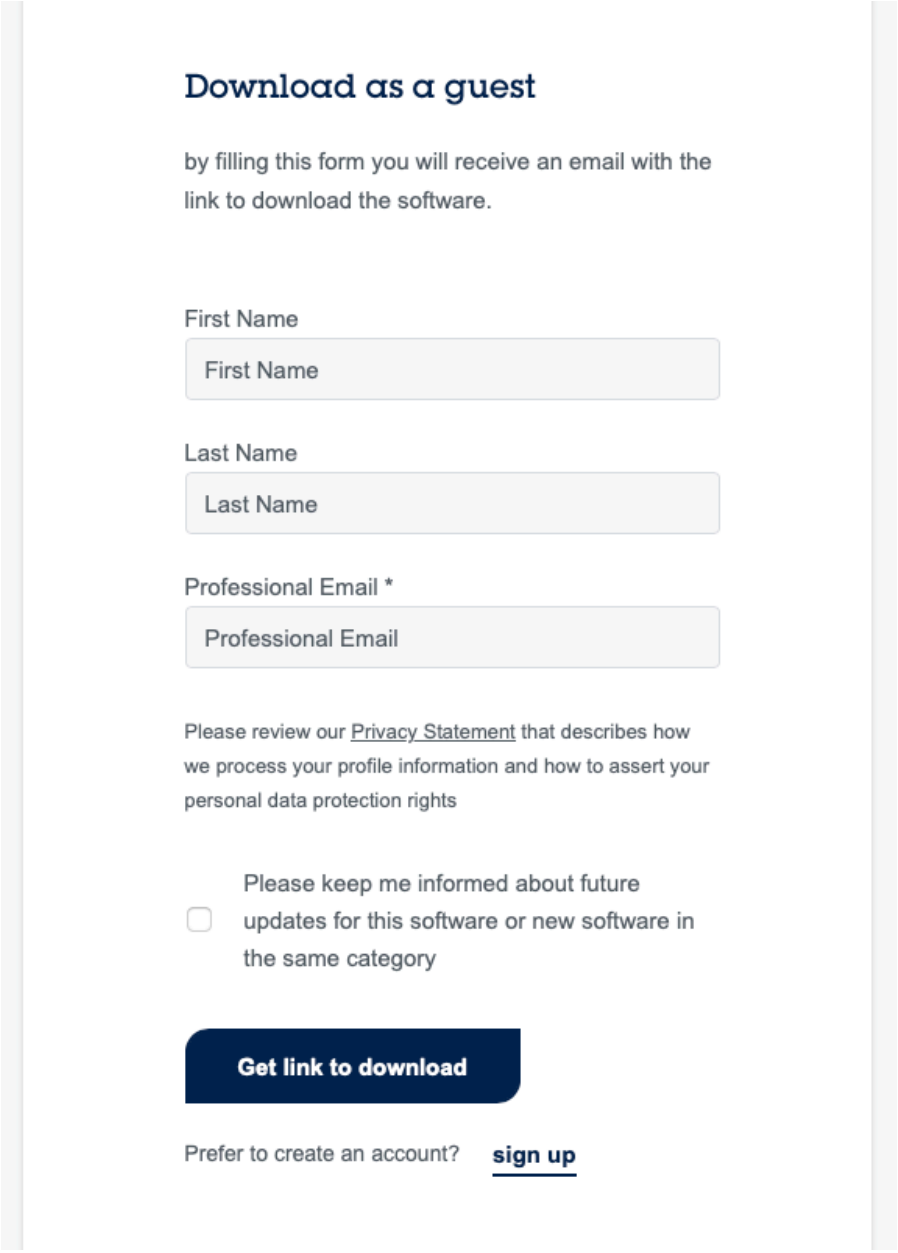
3. The page should automatically scroll down to the “Get Software” tab. Then, click on “Get Latest” for the operating system you are using. (If you are using windows, you will most likely need to choose the “Win64” version):



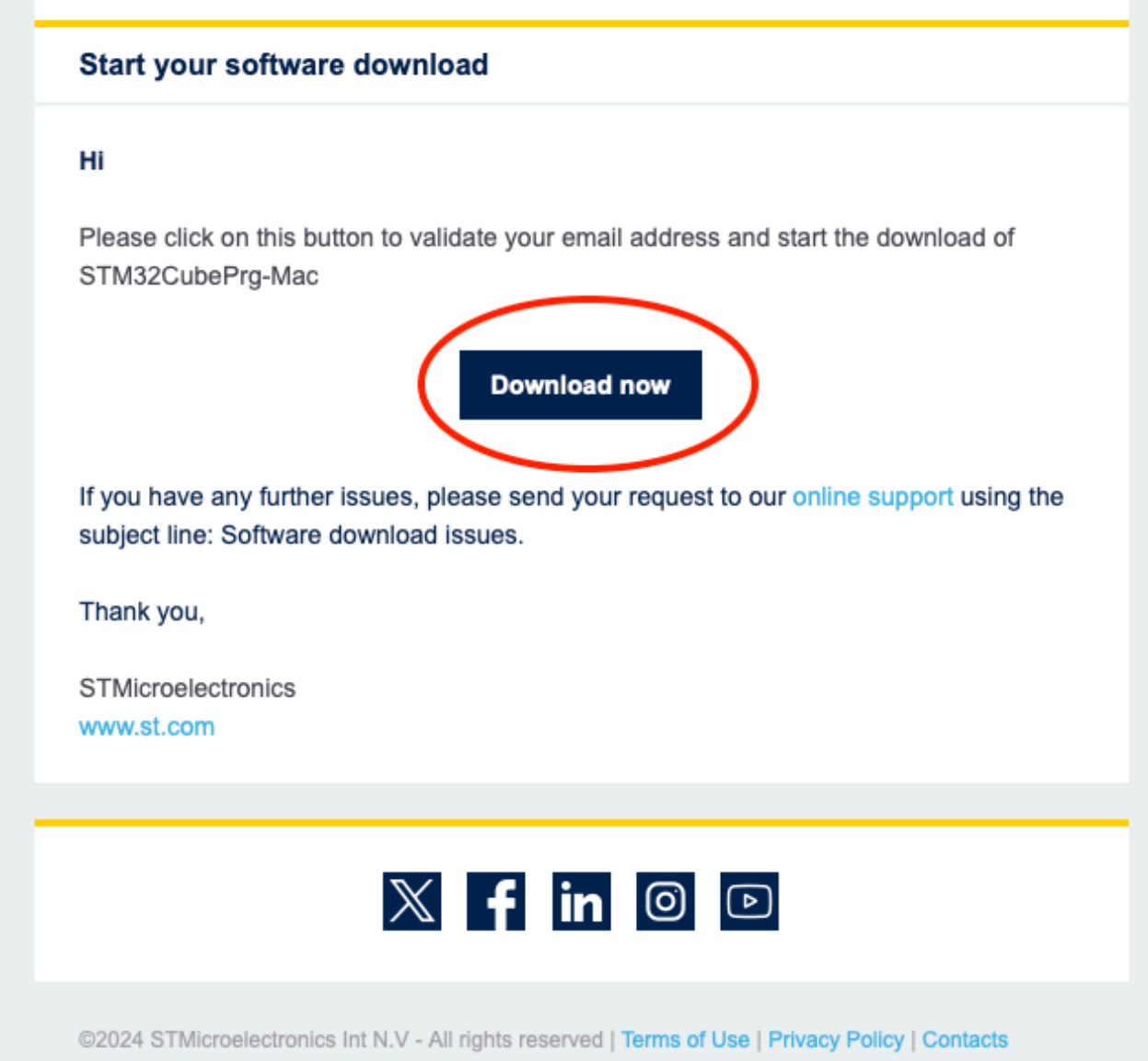
4. ST requires everyone to sign in or continue as a guest. Just continue as a guest:



5. Then enter your details (ensure at least your email address is accurate) and click “Get link to Download” to receive the download link via email:



6. Check your spam folder in case if the email was falsely flagged. Then, click on the “Download Now” button which will take you back to the webpage and automatically download the software after a couple moments:



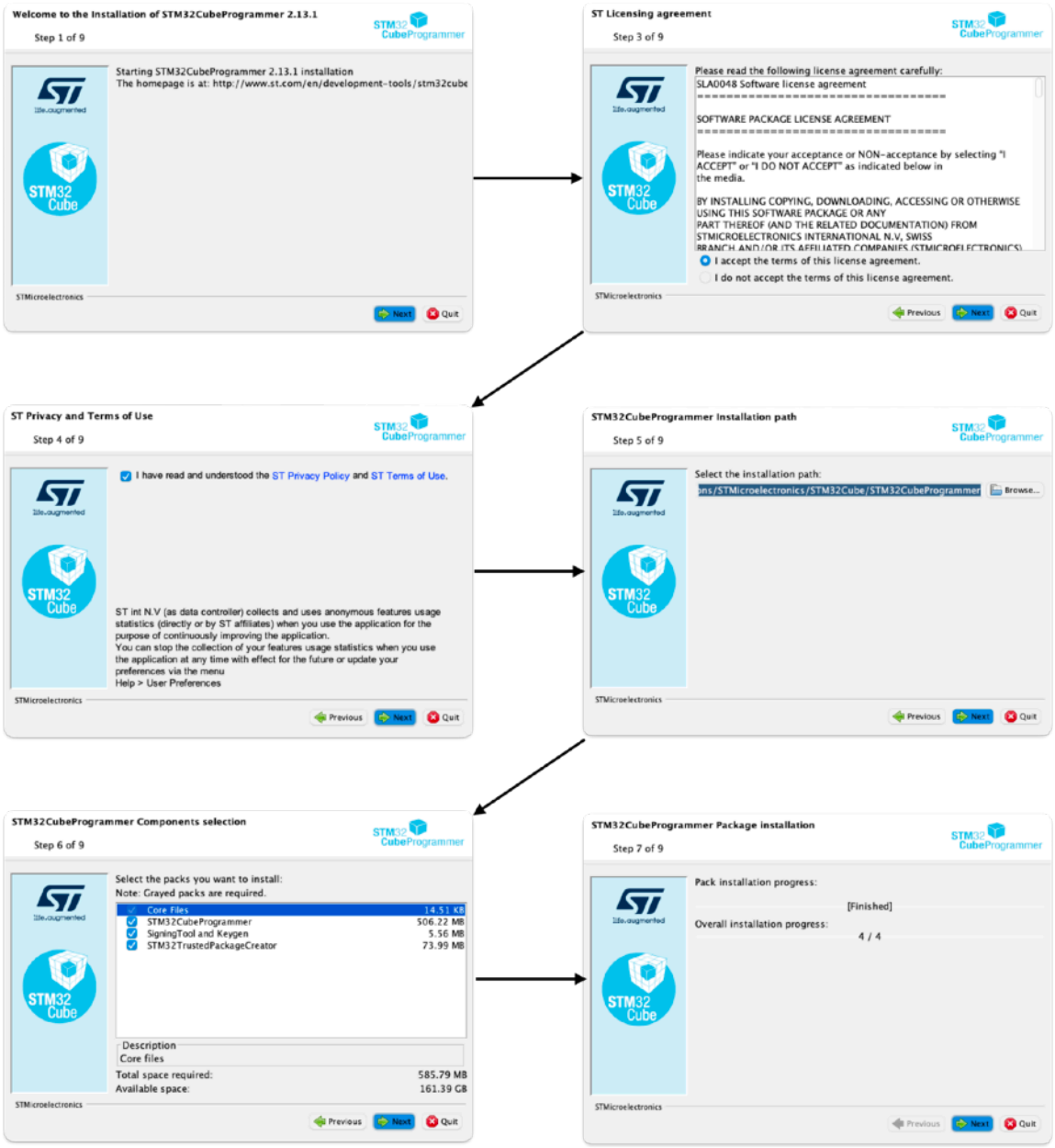
19.2.2 Installation

Once the download is complete, open the installer. The process will be generally the same for each operating system.

The default installation path it gives is good, so do not touch it unless you know what you are doing.

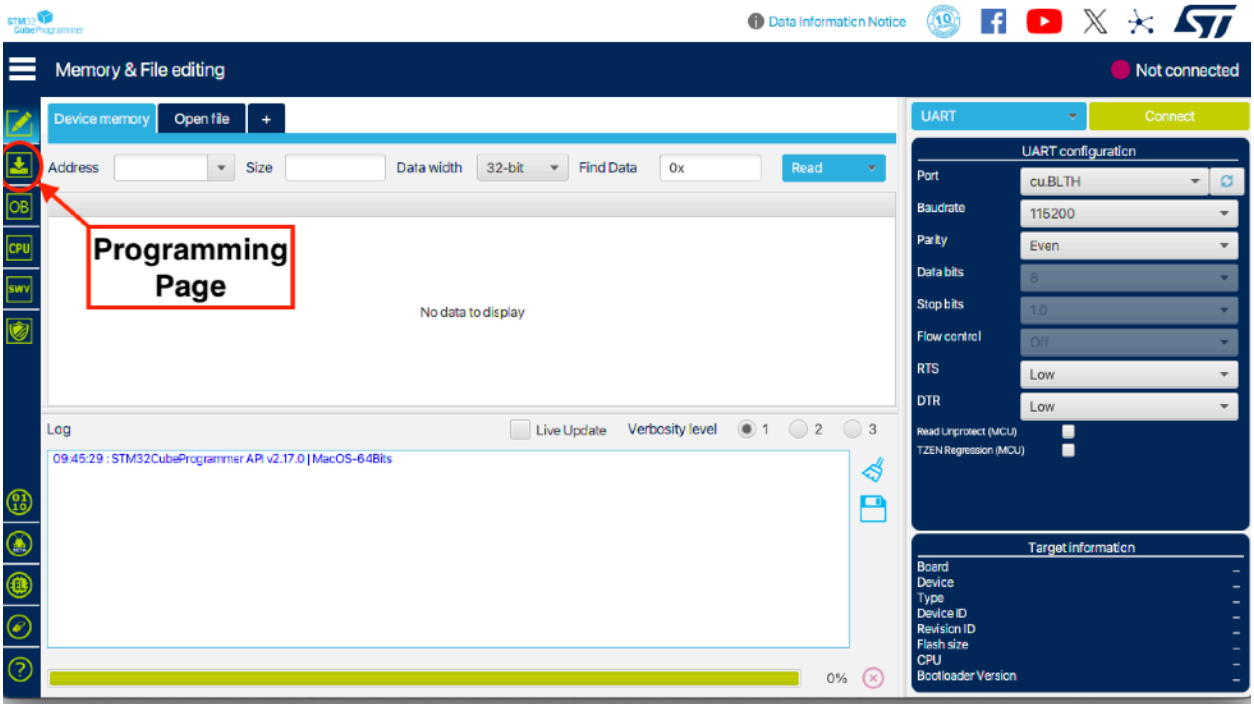
Click next and it will ask you to select the packs to install. Make sure all are selected just in case before continuing. The program will need about 600MB to install.

There may be a second installer window that may appear when installing on Windows. This is for the driver to allow for a programmer to connect. Install that as well.

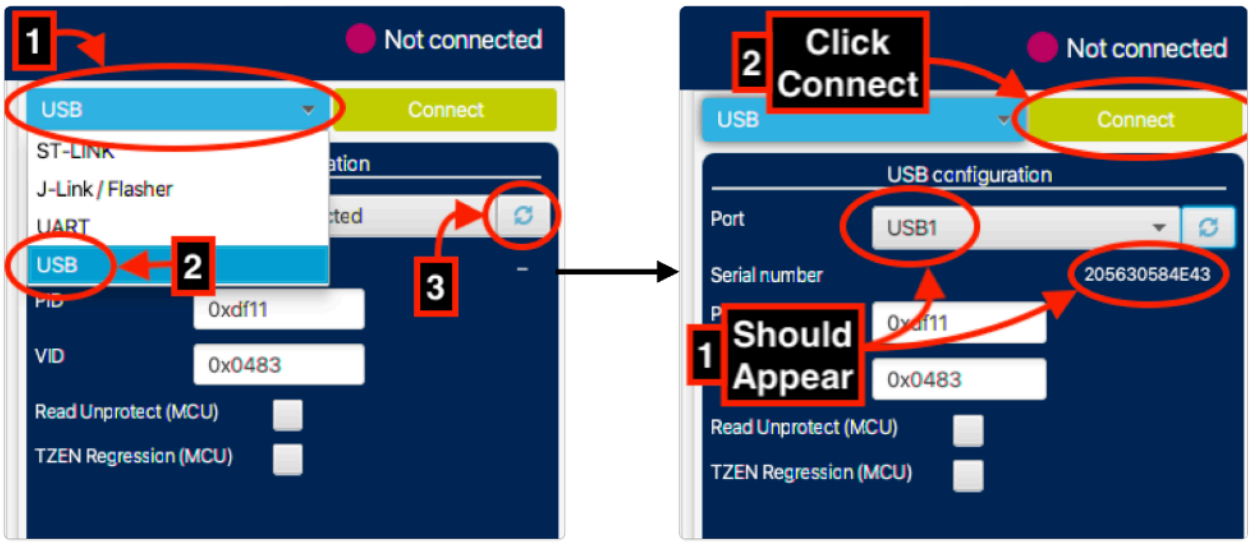


19.2.3 Setup

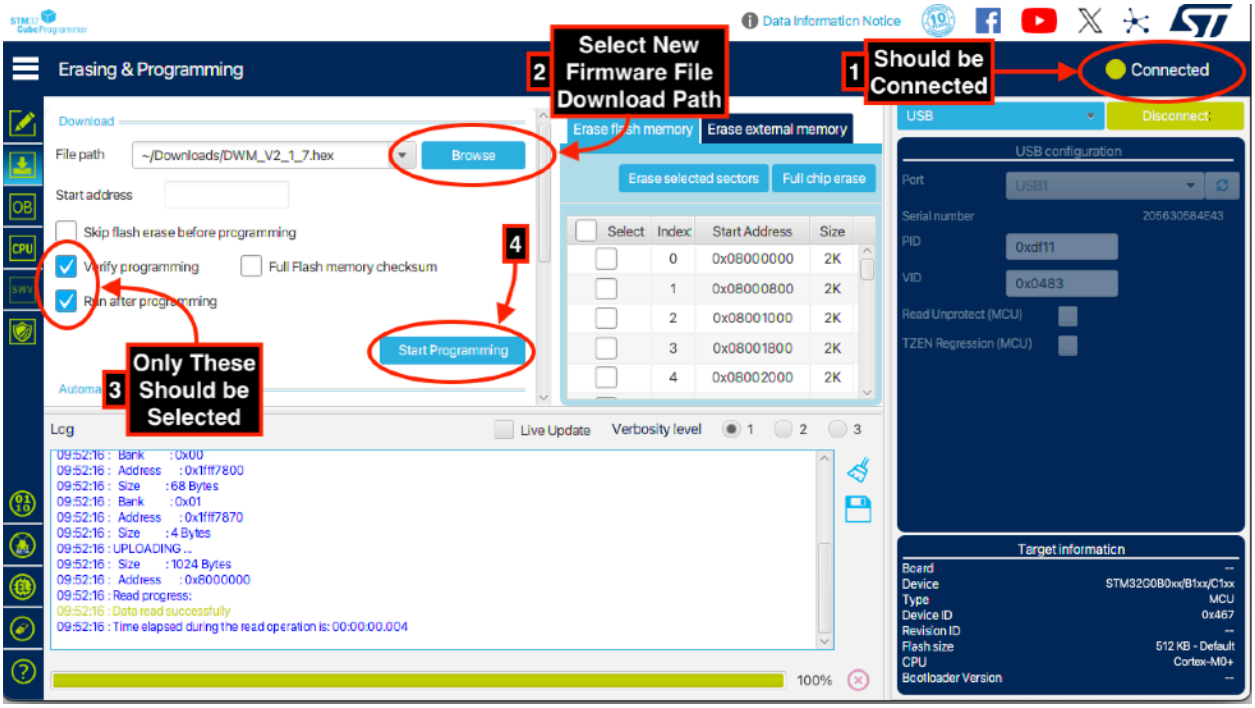
1. When opening STM32Cube Prog, the window like in the following figure will appear. Click on the download icon in green as indicated in the following figure to open the programming page:



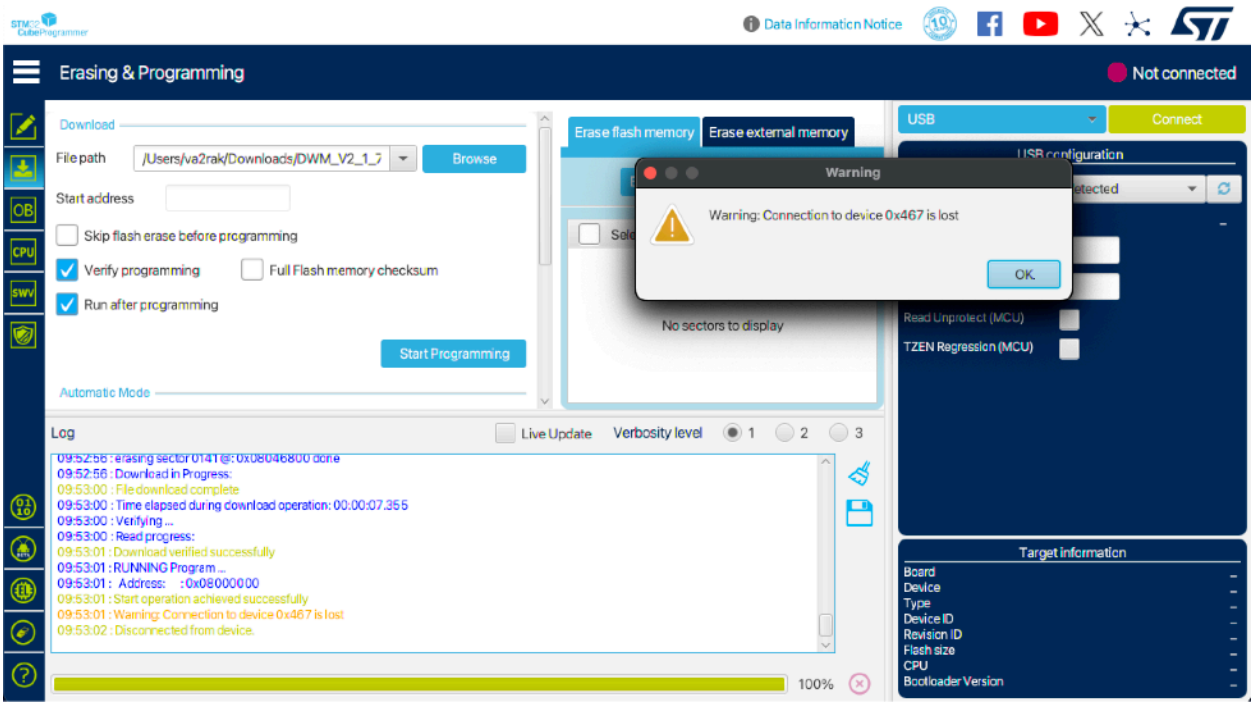
2. Connect to the DWM:



3. Select the new firmware file and click “Start Programming”:



4. Once the firmware programming is complete, clear the pop up messages.



5. Disconnect the USB cable from the DWM and move the DFU jumper on the back of the DWM back from the left to the right position (if the jumper method was used).

6. Restart the DWM and the display should turn on with the new firmware.

The firmware version can be checked by navigating to: *Main Menu* → *More* → *Version*. The FW line version number should match the one that was downloaded.

Enjoy the new features!