Advanced Printer Control

A project by IdeaGear Designs

IGD Project# IGD200603

Introduction

The Advanced Printer Control (APC) is a standalone system that controls the AC power to a 3D printer in order to reduce wear on the fans and power supply. Usually 3D printers are left on for long periods of time after a print completes due to the long print times of additive manufacturing and the uncertainty of slicing software estimations. This can lead to the printer being left ON but IDLE for many hours until someone attends to it.

The Advanced Printer Control measures the electrical current used by the printer and shuts down the printer once power consumption drops below a certain limit. This ensures that the printer is OFF minutes after print completion. A reduction in used AC power over long periods of time would be an un-intended but beneficial side-effect of using the APC.

Power Limitations

Please note that the following limitations are present when using the APC. These limitations shouldn't be a problem for most 3D printers on the market. Please check the label on the 3D printer power supply to ensure compliance.

Input Voltage Range

90VAC to 130VAC 60Hz (US/Canada)

WARNING: !!! DO NOT PLUG INTO 220VAC OUTLETS !!!

Max Current

A 10A 125V is installed inside the power input switch assembly on the back of the unit. 10A Max.

Electrical Installation

1. Place the APC out of the way of the printing mechanisms.

2. Ensure **switch on the back of the APC** is in the OFF position.

3. Unplug printer from the wall outlet and plug it into the APC's outlet (top).

4. Plug APC in the wall outlet with the standard AC cord provided.

5. Ensure **printer power switch** is in the ON position. You may leave this in the ON position indefinitely while using the APC.

6. Turn the **power switch on the back of the APC** to the ON position.

7. APC should turn on.

Important safety information: Always ensure printer and APC are unplugged from the wall socket, and each other, before servicing the printer. The APC has no user serviceable parts and should not be opened for any reason.

Quick-Start

This section allows the user to start using the APC immediately, using the default settings. We do encourage the user to read the rest of the manual in order to understand the operation and set up of the APC. Doing so will enable the user to better control the operation of the APC. This section assumes that the factory default settings are present.
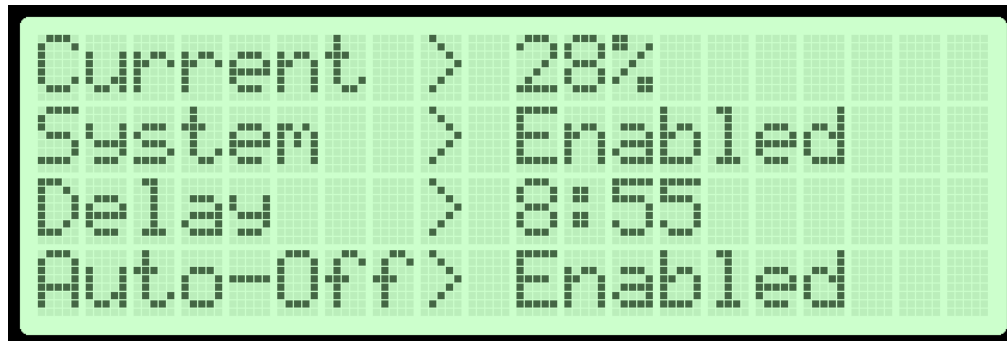
1. Press **power button on IR remote control**. Your printer will turn ON and the measuring process will begin. **DO NOT** WARM PRINTER UP OR MOVE AXIS until the measurement is complete. This process will take less than 30 seconds.

2. Once measurement is complete the **Current Sensing Page** will be displayed.

```
Current  > 25%
System   > Enabled
Delay    > 10:00
Auto-Off> Disabled
```
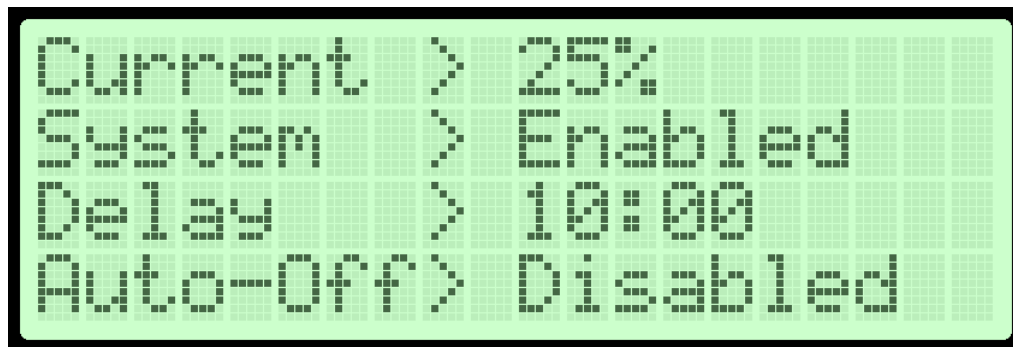
3. START your print as per the printer procedure. The load displayed on the first row should increase significantly once bed and/or nozzle heating starts. Do not be alarmed if load reaches values as high as 100%.

4. Press the **MUTE** button on the remote. This will change the status of the Auto-Off feature to ENABLED.

```
Current  > 88%
System   > Enabled
Delay    > 10:00
Auto-Off> Enabled
```
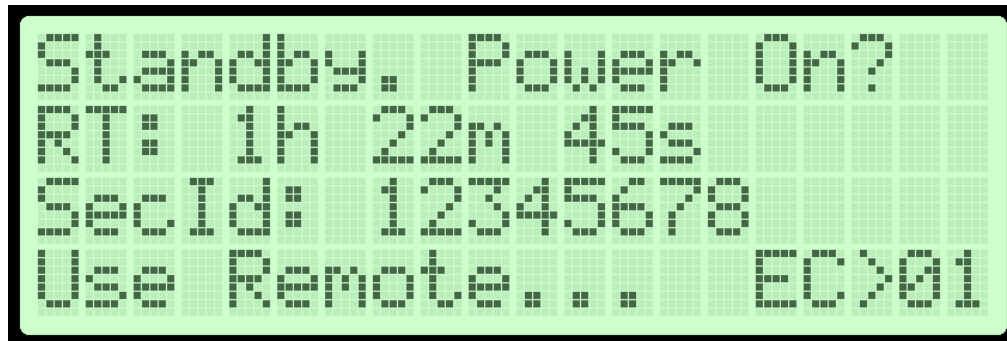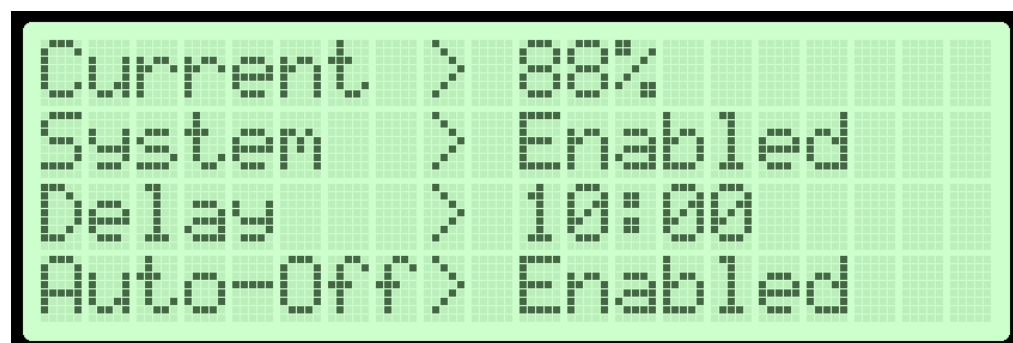
5. Allow the print to complete. The time that the print takes is not important. The APC is watching electrical power consumption, not time. Once print completes, the electrical load displayed on the first row will drop back down. Once this happens, the timer will start counting down.

```
Current > 28%
System  > Enabled
Delay   > 8:55
Auto-Off> Enabled
```

6. When the countdown runs out, the printer will be turned off. The APC will remain on but will enter Standby mode as if the power button was pressed. The **Standby Page** will be displayed.

```
Standby. Power On?
RT: 1h 22m 45s
SecId: 12345678
Use Remote...   EC>01
```

7. The process may be restarted by going back to Step 1. The "**EC**" reading at the bottom right of the Standby Page stands for "**Exit Code**" and indicates why the power to the printer was disconnected. To see what each code means please see the **Standby Page** sub-section in the **Software Setup** section.

How It Actually Works

The APC has two separate systems that can shut the printer off. This section will explain the operation of those systems and educate the user on setting them up so they are most useful to the situation at hand.

It should be noted that the systems on the APC are independent from one another. One or more systems can be active at the same time. The first system to achieve the conditions required for printer shutdown will do so, ignoring the state of the other systems.

Current Sensing System

The Current Sensing System is the primary system of the APC and will account for the majority of the cases where printer shut-down will be executed. We encourage users to get familiar with this system and its settings. This system offers the most flexibility and convenience. Below is a typical Current Sense shutdown sequence.

- The user presses the power button on the remote and the APC energizes the printer.

- During the first 15-30 seconds, it reads the electrical power consumption of the printer. This is called the BASELINE current of the printer.

    o Because this measurement is sensitive, it must be allowed to complete without interference from the user.

    o DO NOT start warm-up while measurement is in progress.

    o DO NOT move motors while measurement is in progress.

    o The BASELINE current is displayed in the **Current Limit Adjust Page**. See Software Setup Section for more information.

```
Measuring Base
Current Levels
25%
Please Wait...
```
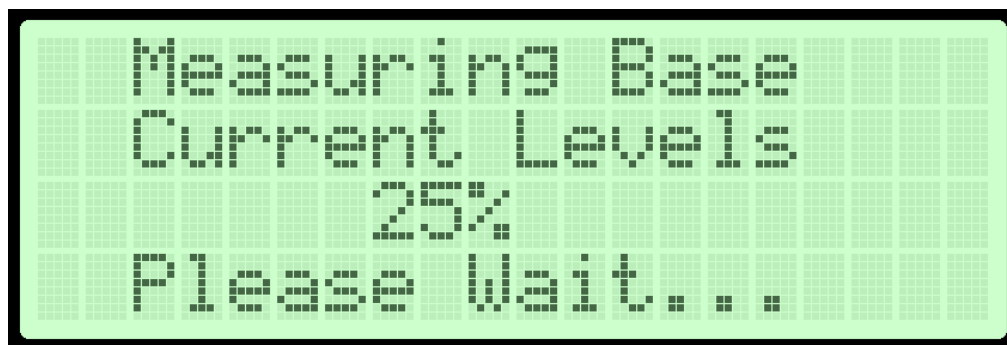
- Once measurement is complete, the APC calculates the LIMIT (or threshold) load that the printer will be allowed while still considered in operation.

    o The LIMIT current will always be greater or equal to the BASELINE current.

    o The **LIMIT** is calculated by using the *BASELINE* current and a parameter called the *Addition Percentage*. The Addition Percentage is adjustable. See Software Setup Section for more information.

    o The LIMIT current is displayed in the **Current Limit Adjust Page**. See Software Setup Section for more information.

- The user ensures the Current Sensing System is ENABLED in the second row of the Current Sensing Page.

```
Current   >  25%
System    >  Enabled
Delay     >  10:00
Auto-Off) Disabled
```

- The user starts the printer and the current should increase significantly.

- The Auto-Off system is engaged as indicated on the fourth line of the display.

```
Current   >  88%
System    >  Enabled
Delay     >  10:00
Auto-Off) Enabled
```

- Once the current drops below the LIMIT current, the countdown will start.

```
Current   >  33%
System    >  Enabled
Delay     >  8:55
Auto-Off) Enabled
```

- o If the current climbs back up above the LIMIT current, the countdown resets to the original setting.

- o If the countdown runs out, the printer is de-energized and the APC goes into Stand-by. Indication of the reason for de-energizing the printer is present in the "Exit Code" number on the Standby Page. The runtime of the printer is displayed.

```
Standby. Power On?
RT: 1h 22m 45s
SecId: 12345678
Use Remote...    EC>01
```
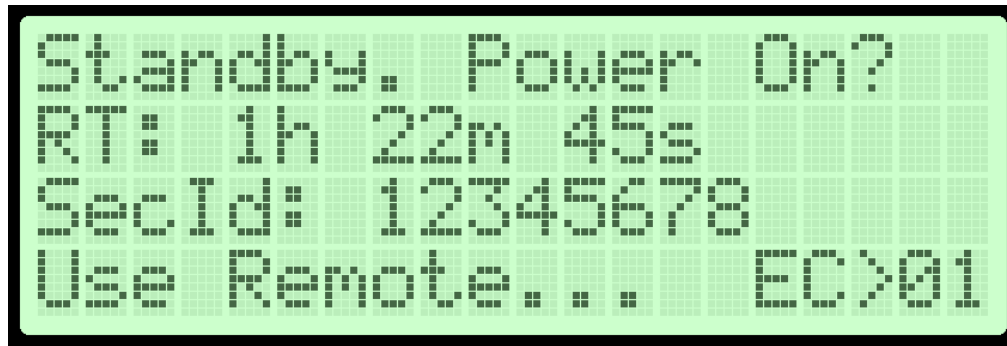
Tip: The runtime displayed is the measurement of the printer on-time – from the moment it was energized to the moment it was de-energized. This may include the warm-up time and surely includes the Auto-Off timer (in this case 10 minutes). The APC provides this runtime to give the user a safety-rated calculation of the time that the print took. The user may find this information important given that the time estimation of slicing software is notoriously inaccurate.

Input Sensing System

System Operation

The Input Sensing System is an auxiliary system and by default it is DISABLED. The Input Sensing System will shut the printer down when a certain electrical event has occurred. The most common use for this feature is a filament sensor – allowing the APC to shut down the printer when the filament has run out or has jammed. This system's operation is similar to the Current Sensing System in the sense that it will start the countdown once the proper condition is achieved.

If is VERY IMPORTANT to understand that the countdown for each system is independent. The remaining time on the Input Sensing System is not the same as the remaining time on the Current Sensing System. Each system can have its own independent delay set up and counts down independently from the other.

By allowing the user to select several modes of operation, the Input Sensing System can be adapted to a myriad of sensors and switches. The modes are as follows:

- **Active High** – If the input pin is connected to a voltage of 3.3V or more (max 24V), the countdown will start. If the pin goes low (ground) the countdown is reset to the original setting.

- **Active Low** – If the input in is low (ground) the countdown starts and continues for as long as the pin is low. If the pin goes high, the countdown is reset to the original setting.

- **Trig High** – The pin should be low when the Auto-Off is engaged. If the pin goes high, the countdown starts and it cannot be stopped even if the pin goes low again. The only way to stop the countdown is to disengage the Auto-Off.

- **Trig High** – The pin should be high when the Auto-Off is engaged. If the pin goes low, the countdown starts and it cannot be stopped even if the pin goes high again. The only way to stop the countdown is to disengage the Auto-Off.

- **Static** – The countdown starts when the pin has been at high or low level for a short time. If the state changes, the countdown is reset to its original setting. This is most useful for sensors containing an encoder or a pulse generating device.

Electrical Input Schematic and Advice

The schematic for the APC Input Sensing System is provided below. Ensure to always use connector **AUX_IN1** for this purpose. The pin location with the square pad is Pin#1.
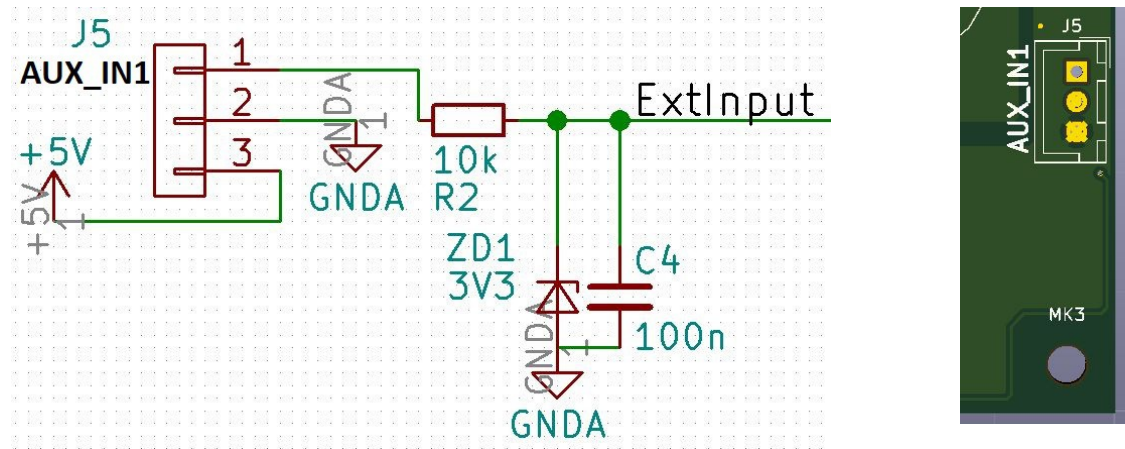
It is **HIGHLY recommended** that the sensor used for the APC's Input Sensing System be dedicated to the APC. Any electrical interconnection with the printer – like using a printer's existing limit switch – can lead to serious problems. This holds especially true if the frame of the printer isn't properly grounded.

If one wishes to use an existing printer sensor, it is IMPERATIVE that the printer DC ground be connected to the APC's DC ground. The input is capable of handling input voltages up to 24VDC. The 5V supply line is common to the APC and will damage the APC if overloaded. The current limit on this line is 200mA if one wishes to use it as a supply.

Finally, it is important to note that the APC DC ground is internally linked to the AC earth prong on the AC plug. This is a safety requirement in many countries and it is expected that the printer has this safety feature as well.

In reality, if you require this system to adapt to a specific and complex task, it is probably best to ask assistance from a friend or acquaintance that works in the electronics field. Usually an electrical engineer or technician is best suited for this task.

Electrical Safety

Please note that the +5V supply on the input connector is limited to 200mV. Plan accordingly.

It is important to note that the ground of the Input Connector (J6) is connected to the AC Earth conductor. As long as the 3D printer power supply has the same connection made, it should be safe to connect the signal ground of the APC to the ground or body of the printer and use one of the printer built-in sensors to signal the APC.

Software Setup

This section describes the features, functions and parameters of the APC.

Splash Page

While booting up the APC will display the following page. This is only displayed at initial power up. The saved data (parameters) are being retrieved from the EEPROM while this page is displayed. Once EEPROM loading is complete, the Standby Page will be displayed. No user actions are allowed in this page.

```
   IdeaGear Designs
Adv. Printer Control
        V1.00
     Loading...
```
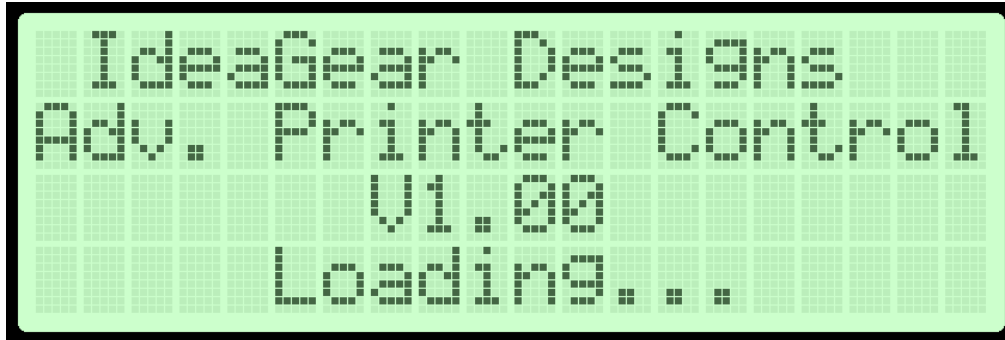
Standby Page

After boot-up, the Standby Page will be displayed. If this is the first time being displayed after power up, the line where the runtime is displayed will be blank. If this page is displayed after a controlled printer shutdown, it will display the Run Time (RT) of the system.

The Security Identification Number (SecId) is a unique number to each printer that may be requested in order to download new software or access any on-line features the printer may have. Please note that this number is determined by the main processor inside the APC and will only change if the main board – or the processor – is replaced.

While in this page, pressing the power button on the remote will energize the printer and begin the calibration process. The Calibration Page will be displayed.

```
Standby. Power On?
RT:  1h 22m 45s
SecId: 12345678
Use Remote...   EC>01
```
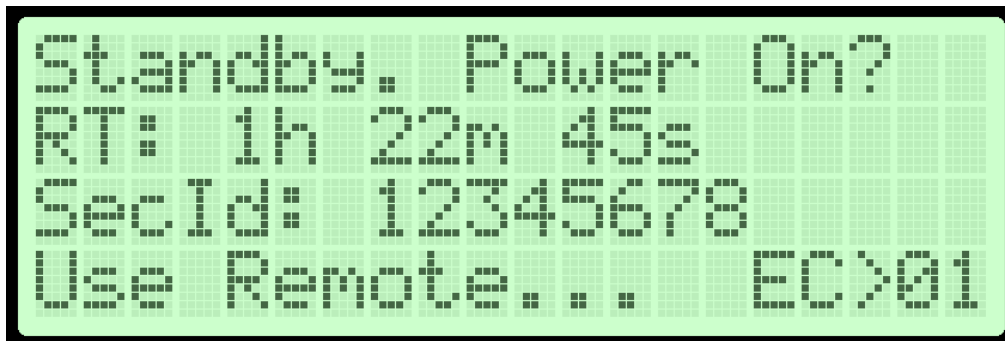
The Exit Code number (EC) in the lower right of the screen indicates to the user the reason for the last shutdown. The indications are as follows:

| Exit Code	Description
00	Power button pressed on remote. User initiated shutdown.
01	Shutdown initiated by Current Sensing System.
02	Shutdown initiated by Input Sensing System.
03 -> 98	Not Used – Reserved
99	Initial Boot / Power Up.

Calibration Page

The calibration page measures the BASELINE current. This calibration should take 30 seconds or less. DO NOT heat printer up and DO NOT move any motors. The processor needs to measure the electrical consumption of the printer at rest.

At first it may seem that nothing is happening during calibration, but after the consumption stabilizes, the BASELINE measurement will be displayed in the middle of the calibration page. Please be patient and allow the APC to do its job. Once calibration is complete, the Current Limit Page will be automatically displayed. No user actions are allowed in this page.

```
  Measuring Base
  Current Levels
       25%
  Please Wait...
```
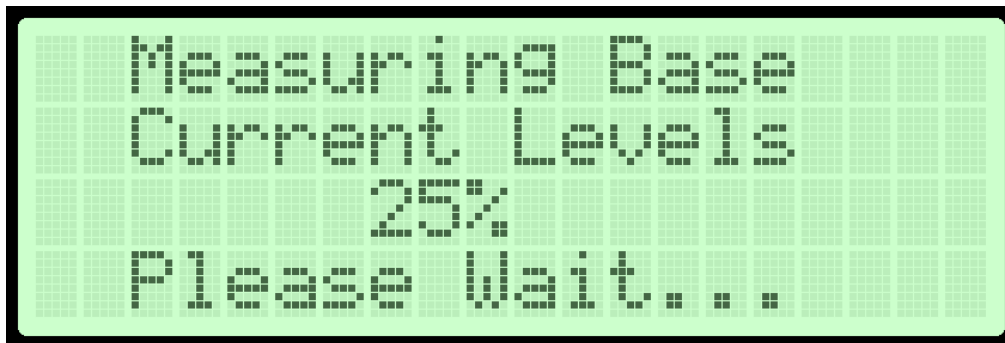
Current Sensing Page

The current sensing page displays up to date information about the electrical power consumption of the printer. With the printer at rest, the current consumption should be close to the measured BASELINE current level.

```
Current > 25%
System  > Enabled
Delay   > 10:00
Auto-Off) Disabled
```
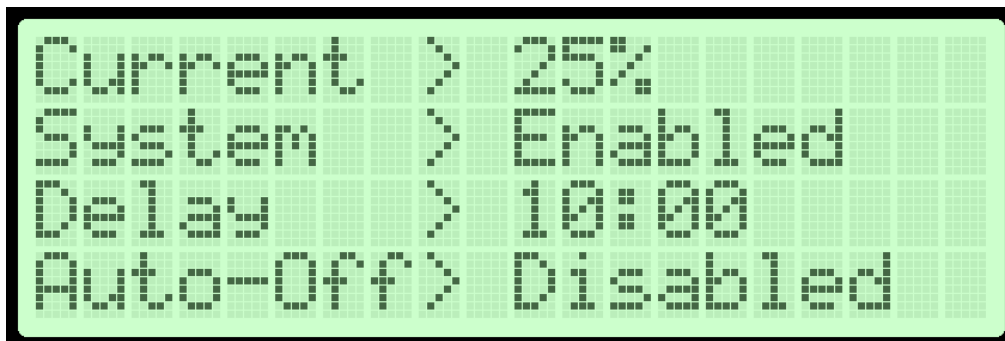
The user may now begin the printing process, including any pre-heating, calibrations or homing of the system. Once heating starts, the CURRENT level will go up significantly. This is normal and the user should not be alarmed if the CURRENT level sits steadily at 99% for periods of time. All this means is that the printer is drawing a lot of power.
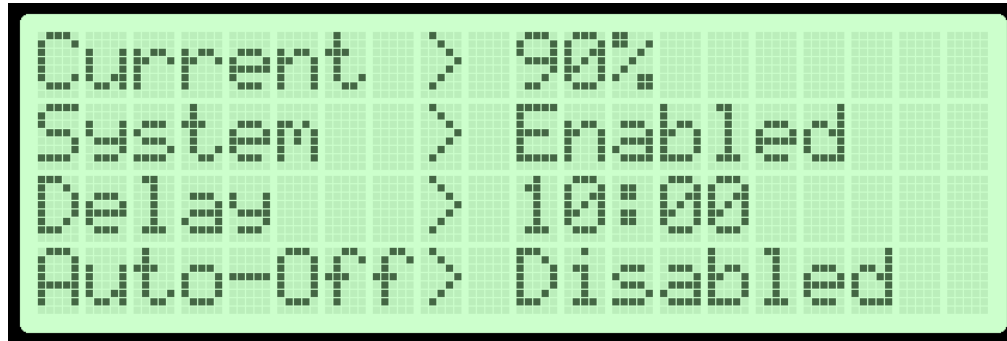
```
Current  > 90%
System   > Enabled
Delay    > 10:00
Auto-Off> Disabled
```

The following actions are possible on this page:

- Pressing the **Power** button on the remote puts the APC in Standby and shuts the printer off. Run Time is calculated and displayed in the Standby Page.

- Pressing the **Vol+ and Vol-** buttons on the remote increases and respectively decreases the delay time of the Current Sensing System. This delay is adjustable between 5 minutes and 60 minutes.

- Pressing the **SRC** button disables/enables the Current Sensing System. The Auto-Off can only be engaged if at least one system is enabled.

- Pressing the **Mute** button enables/disables the Auto-Off.

- Pressing the **Left** button brings the user to the Parameter Control Page.

- Pressing the **Right** button brings the user to the Input Sensing Page.

IMPORTANT - Software Setting Limitations
    In order to provide a safe and organized experience, the following simple limitations have been put in place. These limitations prevent the user from changing critical settings during printing and avoiding failed prints.

1. To enable the Auto-Off at least one of the systems has to be enabled. If all systems are disabled, the Auto-Off will not enable.

2. When the Auto-Off is ENABLED the following actions are not possible:

    - Navigation to pages other than the Current Sensing Page and the Input Sensing Page is not allowed.

    - Changing the Delay on any system is not allowed.

    - Enabling or disabling a system is not allowed.

- Changing the Input System Mode is not allowed.

- Should one wish to perform any of these actions, the Auto-Off should be disengaged, the actions should be performed and then the Auto-Off should be re-engaged.

3. The Auto-Off can be enabled only from the following pages:

- Current Sensing Page.

- Input Sensing Page.

Input Sensing Page

The Input Sensing Page displays information about the Input Sensing System. The Input Sensing System is by default disabled so the user has to expressly enable it. Once the system is enabled, the user may save the parameters so that way it remains enabled even if power to the APC is disconnected. To review the modes of the Input Sensing System please revisit the "How It Works" section of this manual.

```
Mode       > Act Low
System     > Disabled
Delay      > 10:00
Auto-Off)  > Disabled
```
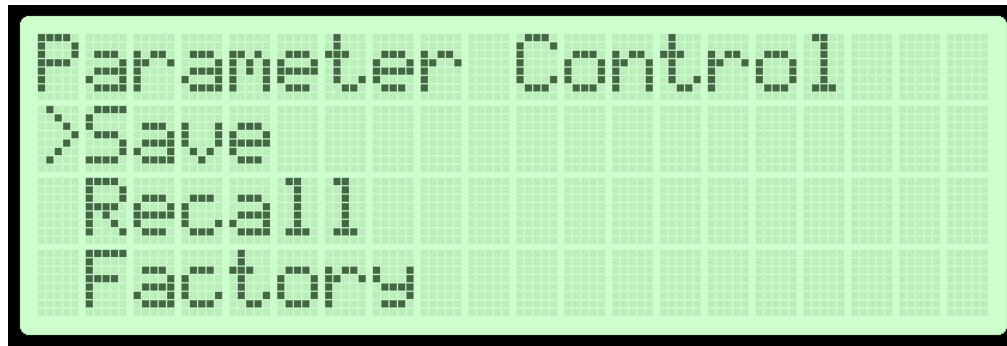
The following actions are possible on this page:

- Pressing the **Power** button on the remote puts the APC in Standby and shuts the printer off. Run Time is calculated and displayed in the Standby Page.

- Pressing the **Vol+ and Vol-** buttons on the remote increases and respectively decreases the delay time of the Input Sensing System. This delay is adjustable between 5 minutes and 60 minutes.

- Pressing the **SRC** button disables/enables the Input Sensing System. The Auto-Off can only be engaged if at least one system is enabled.

- Pressing the **Mute** button enables/disables the Auto-Off.

- Pressing the **Left** button brings the user to the Current Sensing Page.

Parameter Control Page

The parameter control page allows the user to Save and Recall the parameter set from the EEPROM. Simply put, it allows the user to save all the settings so they are not lost when power to the APC is lost or disconnected. The only caveat to be noted is that the Factory reset option resets all the parameters but DOES NOT SAVE THEM. Any changes must be SAVED BY THE USER.

```
Parameter Control
>Save
 Recall
 Factory
```

The following actions are possible on this page:

- Pressing the **Power** button on the remote puts the APC in Standby and shuts the printer off. Run Time is calculated and displayed in the Standby Page.

- Pressing the **Vol+ and Vol-** buttons on the moves the cursor to select the desired operation.

- Pressing the **SRC** button executes the selected operation. The APC will indicate the operation by displaying WAIT followed by DONE once the operation is complete. No other actions are possible while the operation is in progress.

- Pressing the **Left** button brings the user to the Current Limit Adjust Page.

- Pressing the **Right** button brings the user to the Current Sensing Page.

Current Limit Adjust Page

The current sensing page displays the calibration information and allows the user to set the Addition Percentage parameter. This may be the single most important setting of the APC.

```
Current Limit Adjust
Addition> 30%
Limit    > 54%
Base     > 24%
```
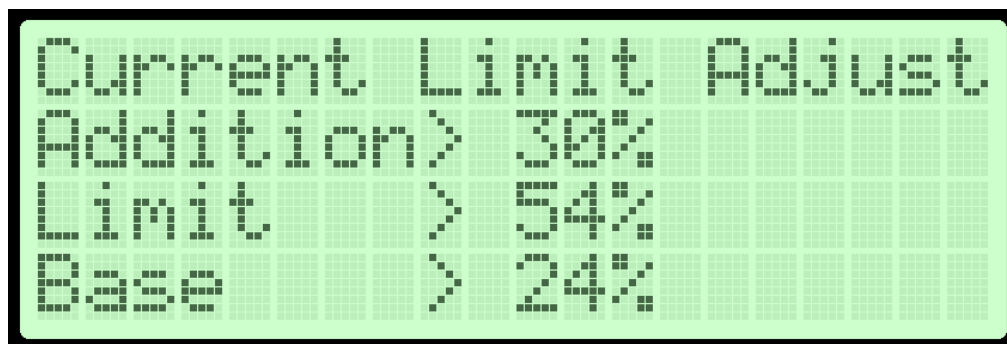
In the above display, the BASELINE power consumption of the printer was **measured** at 24%. The Addition Percentage parameter is **set** at 30% so the limit was **calculated** to be 24% + 30% = 54%. If the Auto-Off is enabled and the power consumption goes below the Limit Percentage, the countdown starts. If – while the countdown is going – the power consumption goes above the limit, the countdown stops and the countdown gets reset to the original value.

The system is set up in this way because a printer that is actively printing will have to occasionally turn on the heating elements for the bed and the nozzle to maintain temperature. When

that happens, the power consumption goes up dramatically leading to the countdown re-setting. Once the print is complete, the heaters will not turn on any more leading to the countdown expiring and the printing shutting down. For most commercial printers, the factory settings work just fine.

The following actions are possible on this page:

- Pressing the **Power** button on the remote puts the APC in Standby and shuts the printer off. Run Time is calculated and displayed in the Standby Page.

- Pressing the **Vol+ and Vol-** increases and decreases the Addition Percentage parameter. DO NOT FORGET TO SAVE PARAMETERS. Ensure that the Limit is not over 100% or the printer will never shut off.

- Pressing the **Left** button brings the user to the Backlight and Beeper Page.

- Pressing the **Right** button brings the user to the Parameter Control Page.
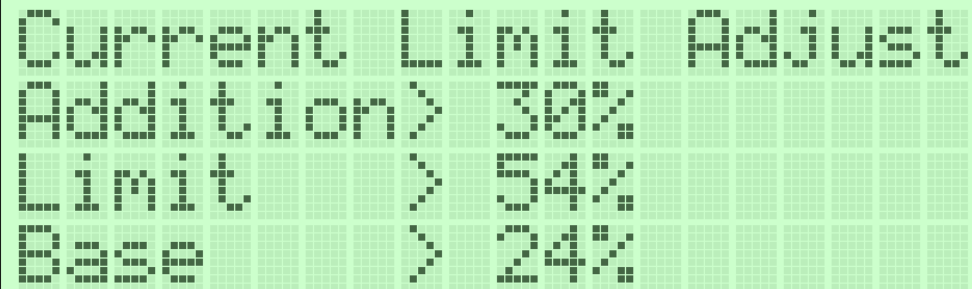
IMPORTANT – Setting the Current Limit

If the factory settings do not work well, there is a simple procedure for determining the proper Addition Percentage. This situation is more prevalent in printers that do not have a heated bed. Simply follow the below procedure.

1. Power up the printer using the APC.

2. Once calibration is complete, remain on the Current Sensing Page and start warming up the printer – PLA, PETG or ABS warmups are all ok. Note the maximum current percentage that it reaches during warm-up. Let's assume (for demonstration purposes) that the maximum is 88%. Write this value down.
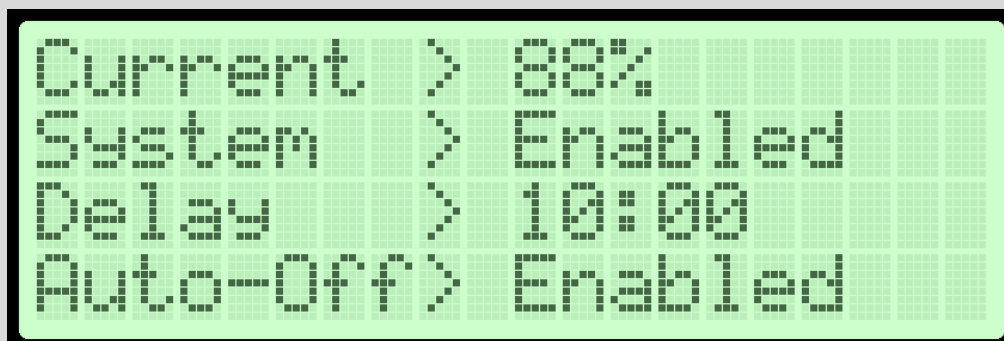
3. Navigate to the Current Limit Adjust page and note the BASELINE value of the calibration. Let's assume (for demonstration purposes) that this value is 24%. Write this value down.

```
Current Limit Adjust
Addition>  30%
Limit    >  54%
Base     >  24%
```
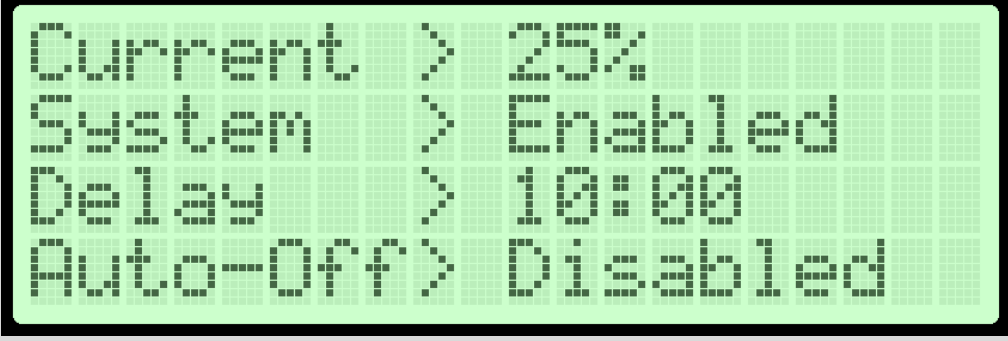
4. From the MAXIMUM value subtract the BASELINE value. Example: 88% - 24% = 64%.

5. Divide the result by two. Example 64% / 2 = 32%.

6. Add the result to the BASELINE value. Example: 32% + 24% = 56%. This is your target Limit for operation.

7. Adjust the Addition Parameter until the limit is between 50% and 60%. Since the Addition Parameter can only be adjusted in increments of 5%, get as close as you can to 56%.

8. DO NOT FORGET TO SAVE in the Parameter Control Page as to not lose this setting at the next APC power cycle.

IMPORTANT – Setting the Current Limit Countdown

In rare instances, the factory set countdown for the Current Limit System allows the APC to shut down the printer before the print has actually finished. This situation is typical on printers that are fully enclosed due to the heat being trapped inside the enclosure. The explanation is simple: the enclosure retains heat so well that the printer is not forced to turn the bed or nozzle heating element on very often. This leads to long periods of low power consumption resulting in the countdown expiring before the next heat-up event. There is a simple procedure for adjusting the countdown time.

1. Power up printer using APC.

2. Ensure any enclosures are fully closed, in the same position as they would be during normal printing.

3. Heat up printer to PLA, PETG or ABS temperatures.

4. Leave the printer alone (at temperature) for 30 minutes. This will allow the air inside the enclosure to fully warm up and reach a thermodynamic equilibrium with the environment outside the printer.

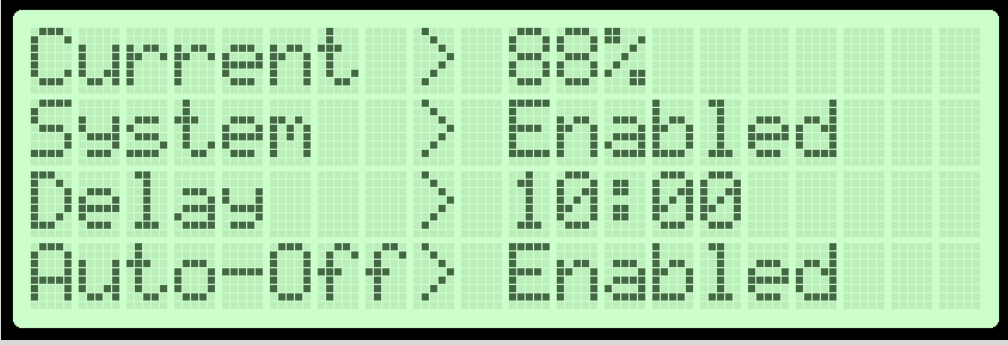5. Observe the power consumption of the printer in the Current Sensing Page. When current

consumption goes down and both heaters are off – start a chronometer (use a smartphone). It doesn't have to go as low as the BASELINE level but it must be significantly under the MAXIMUM level.

```
Current  > 25%
System   > Enabled
Delay    > 10:00
Auto-Off> Disabled
```

6. When the power consumption goes up again stop the chronometer. Let's assume that the time that has elapsed between these events is 8 minutes.

7.

```
Current  > 88%
System   > Enabled
Delay    > 10:00
Auto-Off> Enabled
```

8. Add 10 minutes to the measured time. In our example, this would result in a time of 18 minutes.

9. The delay for the countdown can be adjusted in 5 minute increments. Set it just above this result. In our case it would be 20 minutes. DO NOT FORGET TO SAVE the new delay by using the Parameter Control Page.

Backlight and Beeper Page

The Backlight and Beeper Page allows the user to control the LCD backlight and beeper settings.
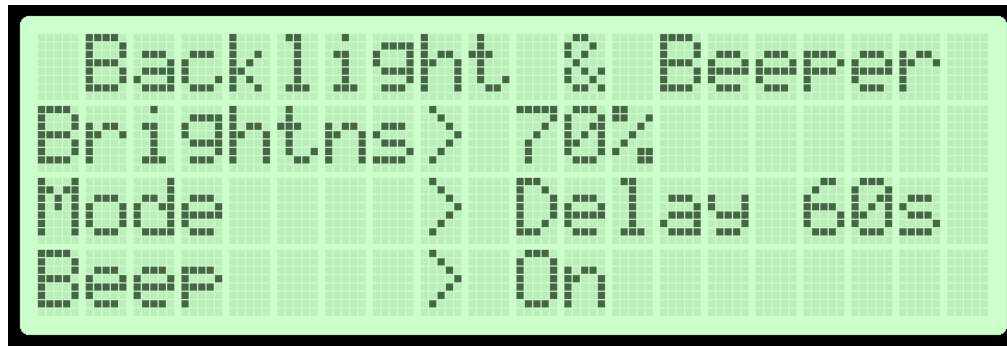
```
Backlight & Beeper
Brightns> 70%
Mode      > Delay 60s
Beep      > On
```

The following actions are possible on this page:

- Pressing the **Power** button on the remote puts the APC in Standby and shuts the printer off. Run Time is calculated and displayed in the Standby Page.

- Pressing the **SRC** button on the remote cycles through the LCD **backlight modes** as follows:

    o   OFF – backlight permanently off.

    o   ON – backlight permanently on.

    o   Delay 60 seconds – backlight shuts off 60 seconds after the last button press on the remote.

- Pressing the **AUDIO** button cycles between through a range of delays that are available. In order for this adjustment to be available, the backlight mode has to be set to delay. The range is 30s to 240s in 30s increments.

- Pressing the **Vol+ and Vol-** buttons adjusts the brightness of the backlight. This adjustment will have no effect if the Backlight Mode is set to OFF.

- Pressing the **Right** button brings the user to the Current Limit Adjust Page.

- DO NOT FORGET TO SAVE YOUR CHANGES.