Data I/O

UFS Programming in LumenX

Getting Started Guide

Part Number: 983-5093-001B

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Chapter 1: Introduction

This document provides instructions for programming a Universal Flash Storage (UFS) device using Lumen™X technology, including:

- Hardware installation of UFS Interface board
- Hardware installation of UFS socket adapter
- Software configuration of UFS programming job
- Verification of job completion

Simplified Ease-of-Use

To maintain consistency and simplify ease-of-use, LumenX streamlines the process of programming a Universal Flash Storage (UFS) device to be the same as programming a standard e-MMC device:

- Select the target device to be programmed
- Select the programming algorithm
- Configure job settings (ex. Load the data/img files to write…)
- Run the job (ex. Program, Verify…)

Benefits

The UFS programming process in LumenX Data Management Software (DMS) involves no learning curve for existing LumenX users who want to create and run UFS jobs, negating the need for training and transition. It also introduces new UFS users to the proven LumenX platform.

The same LumenX programming hardware used today is capable of programming and outputting an entirely new class of flash memory (UFS) without sacrificing any existing capabilities.

Document Scope

This document does NOT cover how to configure the hardware and software for running LumenX programming jobs (see the LumenX Getting Started Guide); this document focuses on the UFS-specific steps. It is also beyond the scope of this document to hype the speed and low-power advantages of UFS.

Intended Audience

Readers need the LumenX Getting Started Guide and some familiarity with:

- Configuring the LumenX programmer hardware and networking
- Running jobs in LumenX Data Management Software (DMS)

It is important that readers have a basic understanding of UFS programming.

Safety Precautions

To prevent personal injury, lost time, and damage to equipment, please use extra caution when handling the powered programming equipment.

 CAUTION: Electrostatic Discharge Hazard!

Electrostatic discharge (ESD) may damage equipment and integrated circuits. Always discharge static electricity to a common ground. Use ESD prevention devices that contain a 1 M-ohm to 10 M-ohm current-limiting resistor.

 WARNING: Electric Shock Hazard!

Injury or death may result from contact to parts inside the programmer. Do not remove covers. There are no user-serviceable parts.

 Excessive Socket Actuator Air Pressure

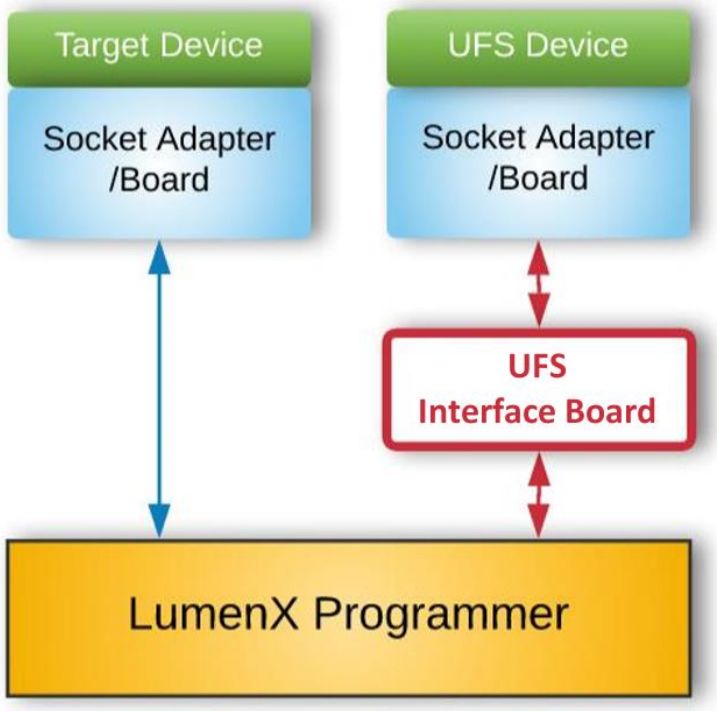
For automated systems (ex. PSV7000), adjust the socket actuator air pressure down to prolong parts longevity (one LumenX programmer supports 8 LumenX sockets but only 4 UFS sockets).

Refer to Chapter 4 of the PSV7000 Owner's Manual for instructions on adjusting the air pressure down: near the lower-left corner of the Power Panel, pull the collar on the black "Socket Opener Pressure Control" knob out, and then rotate it counter-clockwise to 0.3 - 0.4 MPa (MegaPascals). Ignore this note for Manual/Desktop programmers.

Conceptual Overview

To simplify programming and enable customers with UFS capability on their existing LumenX programmers, Data I/O built support for UFS by leveraging the existing LumenX programming model. This development extends the value of LumenX programmers because customers can use existing technology to program the newest class of flash memory devices.

The following diagram shows the key difference between standard LumenX and UFS programming models (note the **UFS Interface Board** highlighted in Red color).



The left side of the diagram above shows a standard LumenX programming job with a socket adapter/board that plugs into the programmer. The right side shows a LumenX programming job for UFS where an additional UFS Interface Board is introduced.

From bottom to top, the general process is the same from programmer to device. But with the UFS Interface Board, the resulting device is programmed with superior UFS capabilities.

***** Note that UFS support in LumenX requires the following minimum software versions:

- LumenX Data Management Software (DMS) version 1.5.1+.
- Automated Handler (AH700) version 2.6.2+ for PSV7000 automated systems
- CH700 version 2.9+ for PSV5000 automated systems

Chapter 2: Configure the Hardware

This Chapter provides instructions on configuring the UFS hardware, specifically:

- UFS Interface Board insertion
- UFS socket adapter installation
- Hardware validation

Installing UFS hardware is similar to installing LumenX hardware. First, follow the LumenX Getting Started Guide to ensure network connectivity between the programmer and Host PC. Then insert the UFS Interface Board into the programmer.

Inserting the UFS Interface Board

1. Open the socket clamp on top of the programmer.

2. Unwrap the UFS Interface Board from the packaging and handle carefully.

3. Rotate the orientation of the UFS Interface Board such that the notched/chamfered corners match the notched corners in the programmer.

CAUTION: Possible machine damage! Do not touch connector pins. Bent or damaged pins can cause programming malfunctions and/or reduced production yields.

4. Close the socket clamp after installing the UFS Interface Board.

If 4 UFS Interface Boards are not available, then use 2 boards in the same actuator position (orientation): insert the 2 boards such that they occupy sockets 1 through 4 on the programmer (or sockets 5 through 8). Placing the 2 UFS Interface Boards on the same side of the programmer provides equal mechanical loading of the socket actuator.

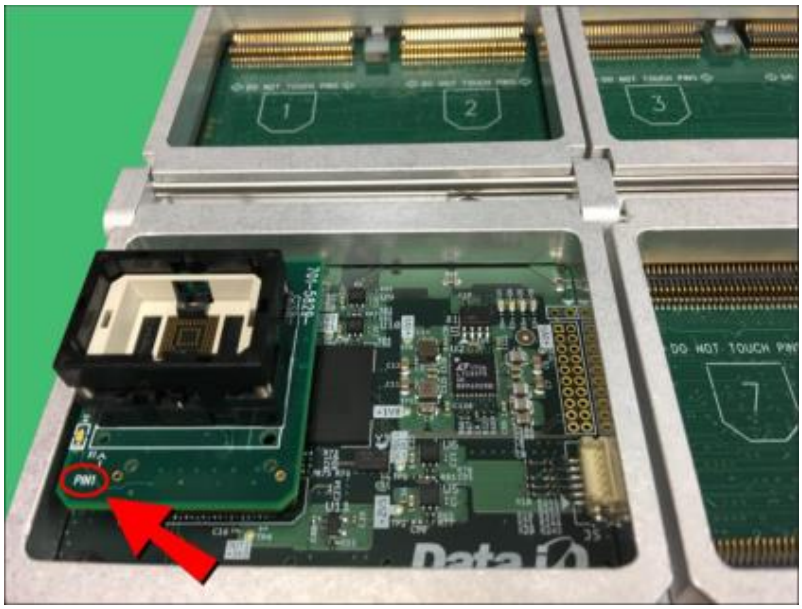
With the UFS Interface Board installed, your LumenX hardware is almost ready for UFS programming. To program a UFS device, you install a device-specific UFS socket adapter on top of the UFS Interface Board (the same as installing a standard LumenX socket adapter).

Installing a UFS Socket Adapter

1. Remove the UFS socket adapter from the packaging and note the PIN1 location.
2. Rotate the orientation of the socket adapter such that the notched/chamfered corners match the notched corner shape printed on the UFS Interface Board.

   NOTE: The PIN1 writing on the socket adapter reads in the same direction as "Data I/O" on the UFS Interface Board.

3. Gently press down on the socket adapter until it fits into the UFS Interface Board.



CAUTION: Possible damage may occur if the socket adapter is not rotated to the proper PIN1 orientation and/or excessive force is applied during insertion.

Validating the Hardware

Skip this section if using an automated system (such as a PSV7000). Otherwise, the UFS hardware configuration is complete. Before starting software configuration in the next Chapter, now is a good time to double-check that:

- The LumenX programmer is connected by network cable to a LumenX Host PC
- The LumenX programmer is powered on
- The LumenX programmer is reachable from the Host PC by:
- ***Ping*** command to the IP address of the programmer
- Programmer status in LumenX DMS (see next Chapter)

Note: Programming file sizes greater than 64GB requires a LumenX programmer upgrade to 128GB cache memory.

Chapter 3: Configure the Software

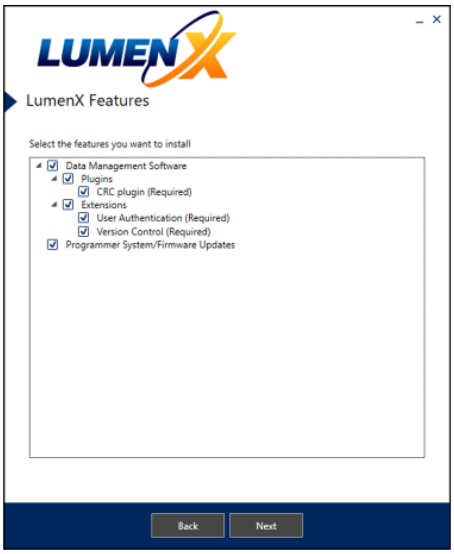
This Chapter provides instructions on configuring the software for UFS programming, specifically:

- LumenX Data Management Software (DMS) version 1.5.1+ update
- LumenX programmer firmware version 1.5.1+ update

Software configuration for UFS programming consists of updating the version of LumenX Data Management Software on the Host PC, and then updating the firmware on the LumenX programmer(s).

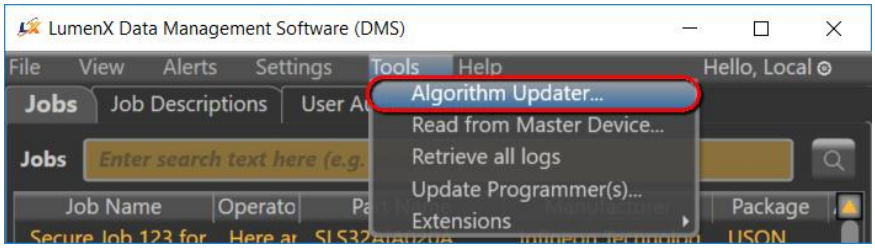
Updating LumenX Data Management Software (DMS)

1. Download and run the LumenX_DataManagementSoftware.exe file.
2. In the LumenX Setup Wizard, follow the prompts to complete the version update.

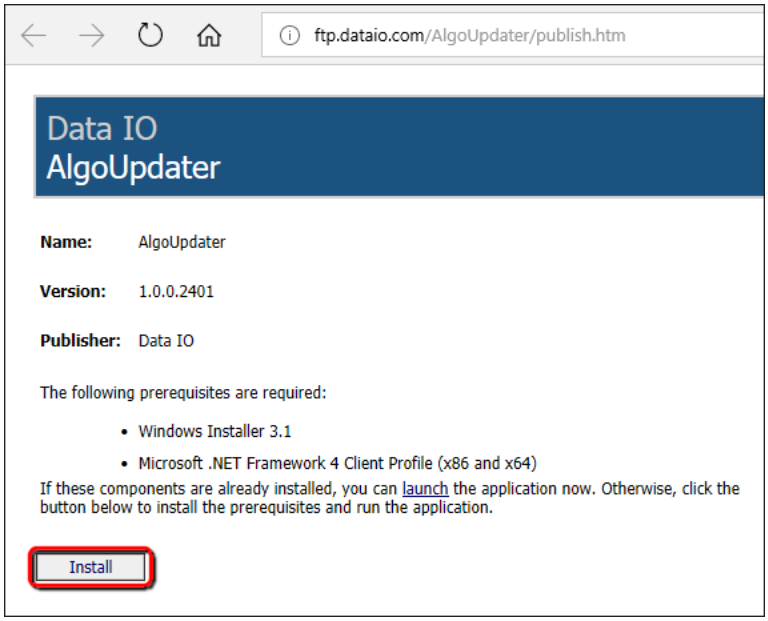


3. Restart the Host PC.

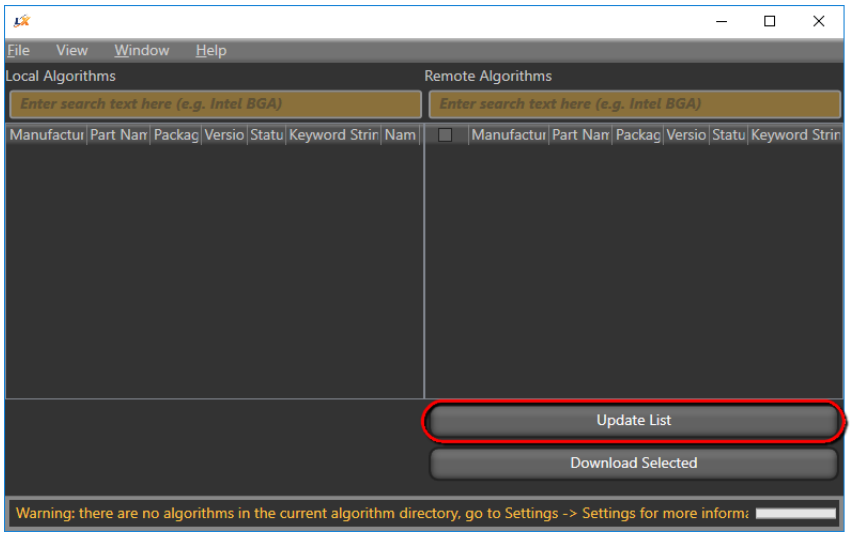
4. To complete the installation, start LumenX DMS (click **Start** > **Programs** > **Data IO** > **Data Management Software**), and from the **Tools** menu at the top, click **Algorithm Updater**.



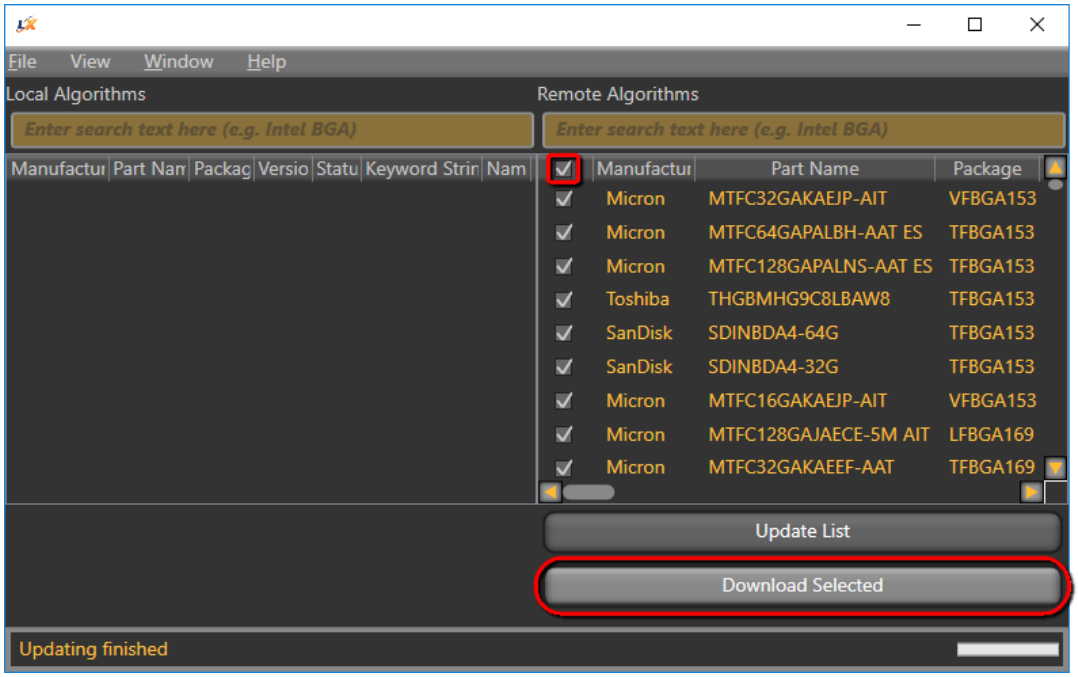
5. If prompted, click **Install** to install the AlgoUpdater.



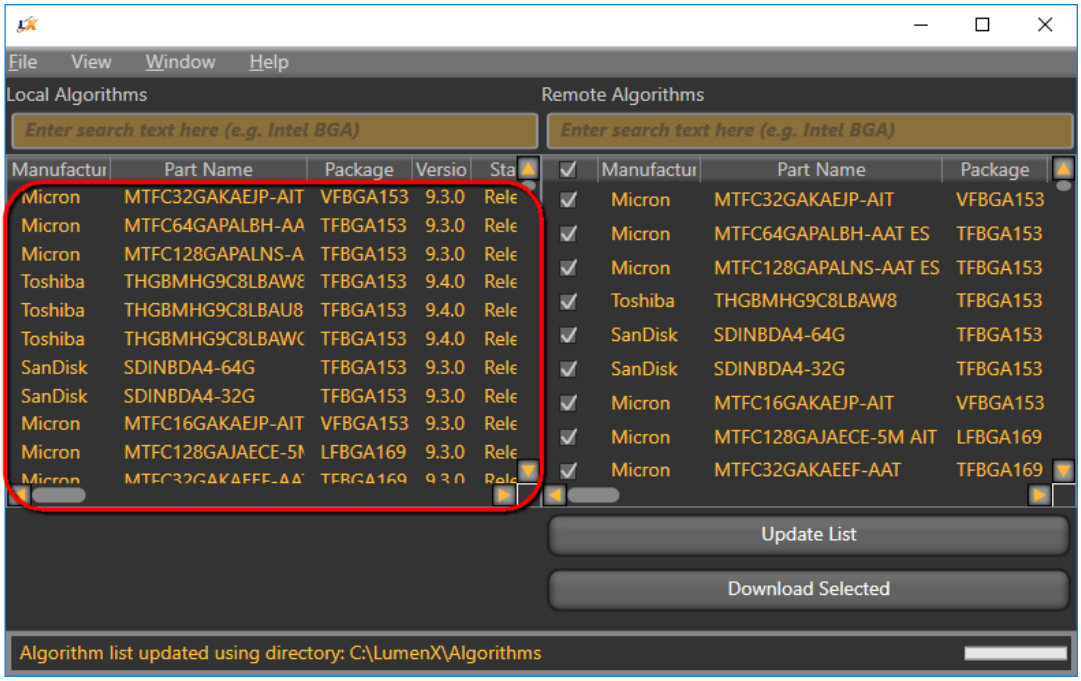
6. In the lower-right corner of the algorithms dialog box, click **Update List**.



7. After the algorithm list updates, under the **Remote Algorithms** column on the right, check the box in the upper-left corner (to select all algorithms), and then click **Download Selected**.



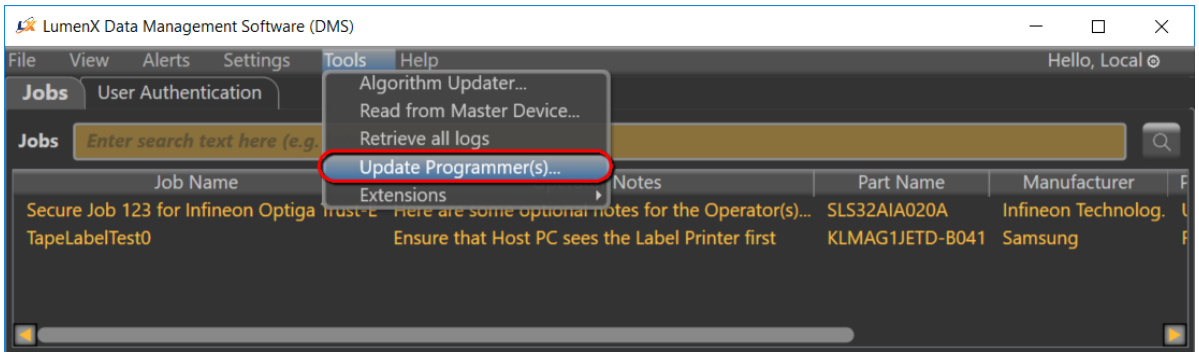
8. After the update completes, verify that the **Local Algorithms** column on the left is now populated, and then close the algorithms dialog box. effect



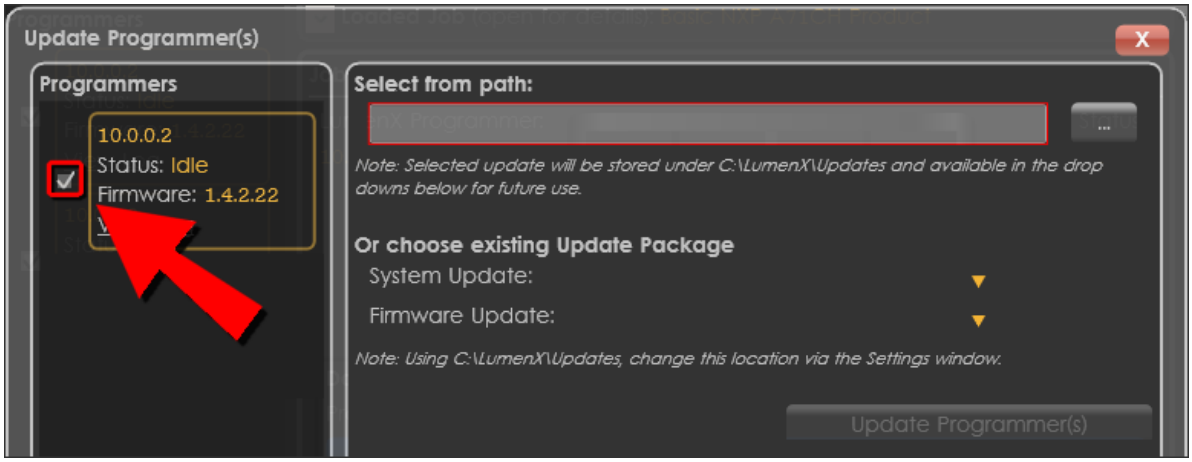
9. Close and restart LumenX Data Management Software (DMS) to recognize the algorithms.

Updating the Programmer Firmware

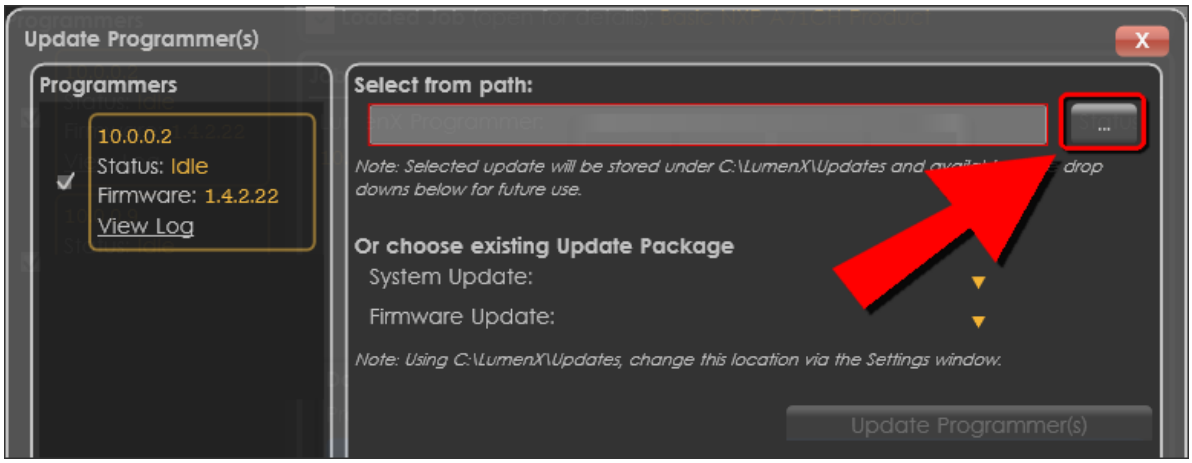
1. From the **Tools** menu at the top, select **Update Programmer(s)**.



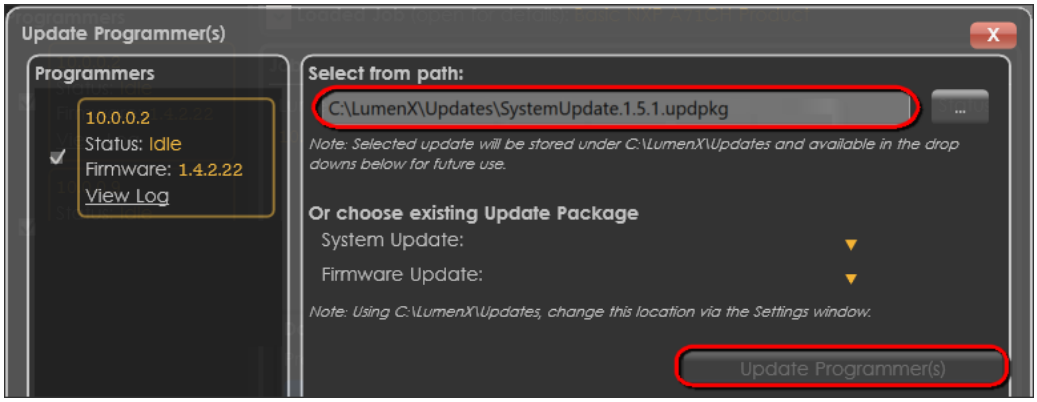
2. In the left pane, check the box(es) for the programmer(s) you want to update.



3. To the right of the **Select from path** box, click the ellipsis (**...**) button to Browse for an update package to apply.

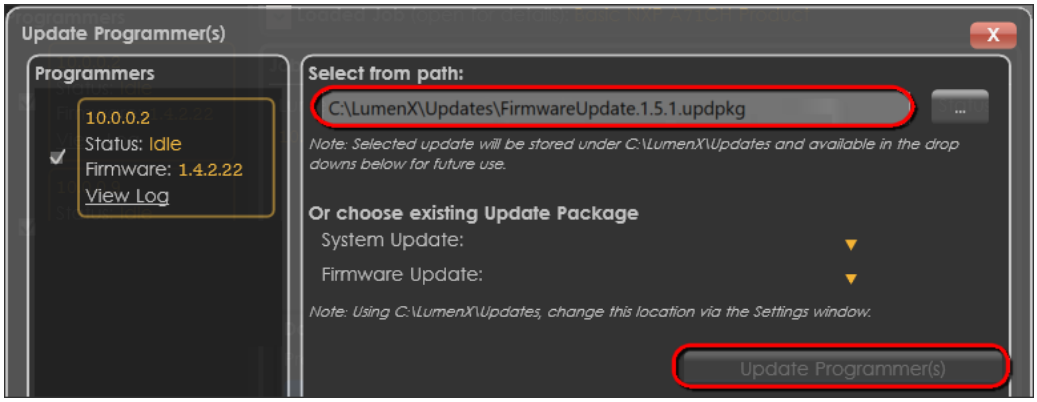


4. Browse for and select the System Update package to apply (System Update package must be applied BEFORE Firmware Update package), and then click **Update Programmer(s)**.



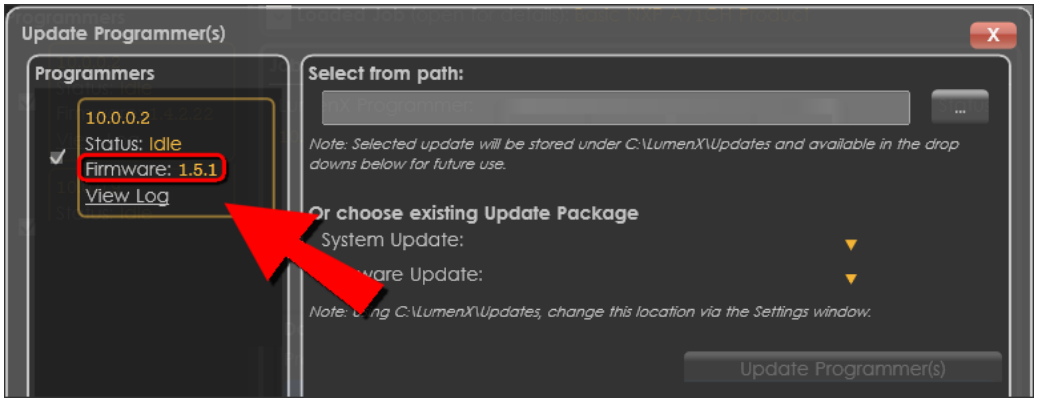
5. In the left pane, verify that the **Status** of each selected programmer changes state from:
    - Idle > Updating > Verifying > Rebooting > Idle

6. Repeat the previous steps to select and apply a Firmware Update package.



7.

8. In the left pane under **Programmers**, verify that the **Firmware** version is updated (you can also hover/mouseover **Firmware** to reveal the System version).



Chapter 4: Run the Job

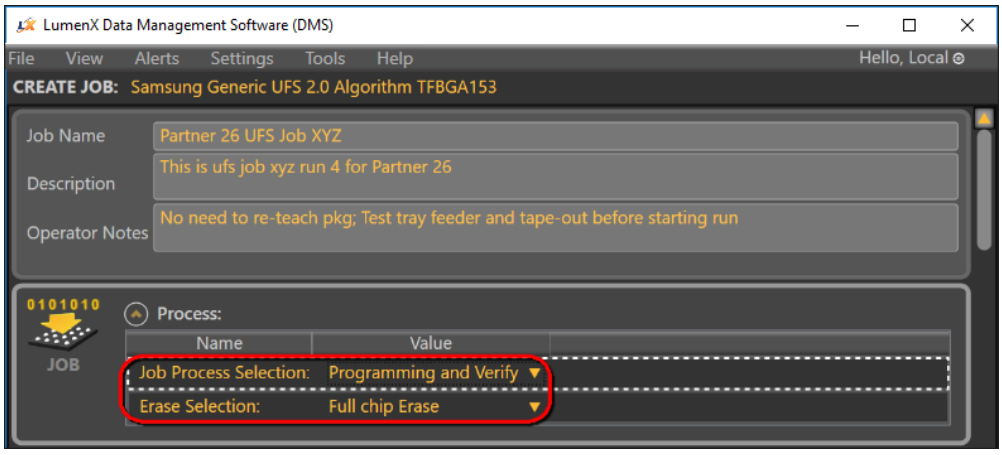
This Chapter provides instructions on running the UFS job, specifically:

- Job settings configuration
- Device settings configuration
- UFS Descriptors and Attributes configuration
- LUN settings configuration

With the software and firmware updated in the last Chapter, now configure UFS settings in LumenX Data Management Software (DMS) for the programming job.

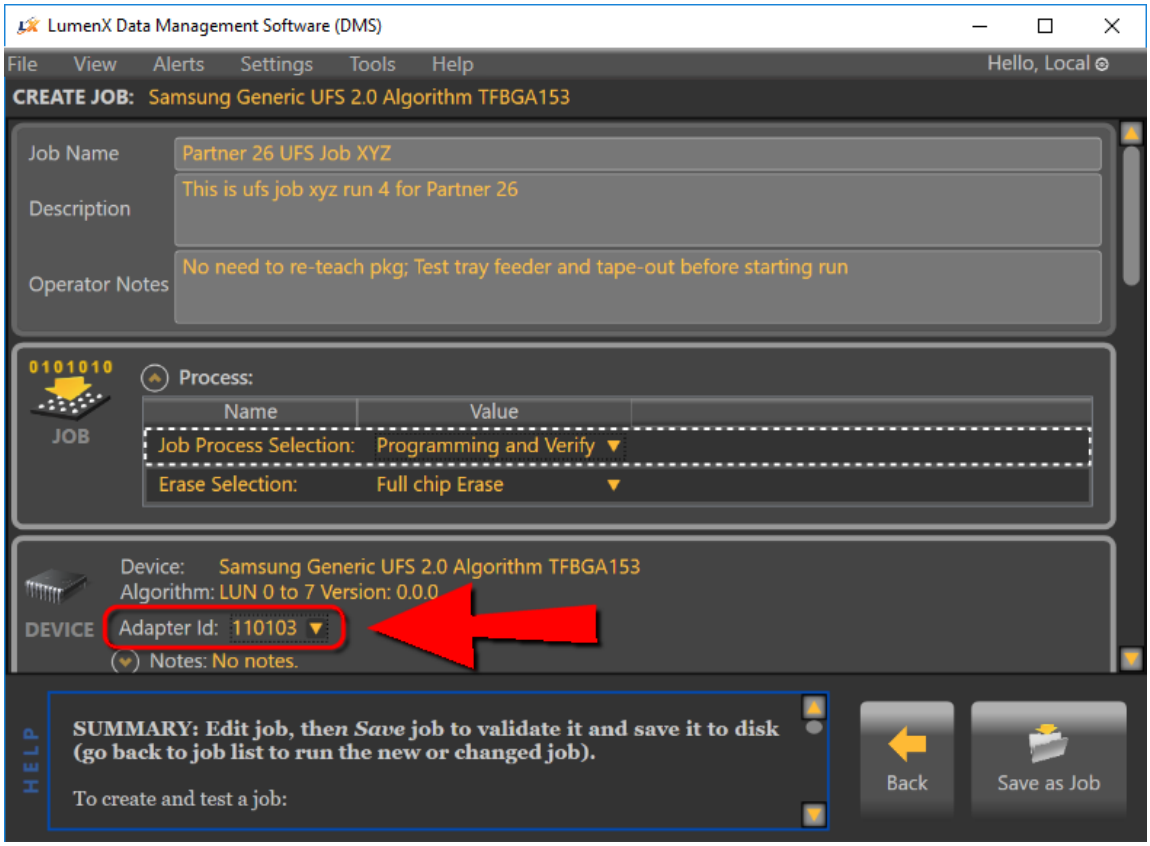
Configuring Job Settings

1. On the Host PC, start LumenX Data Management Software (DMS).
2. Near the lower-right corner, click **New** to create a job.
3. On the **Devices** screen, search for "ufs", select your target UFS device, and click **Next**.
4. On the **Algorithms** screen, select the desired algorithm to use, and click **Next**.
5. On the **Create Job** screen, in the **Job Name** box, type a name for the job.
6. In the **Job** section, make the desired job process selections from the drop-down lists.

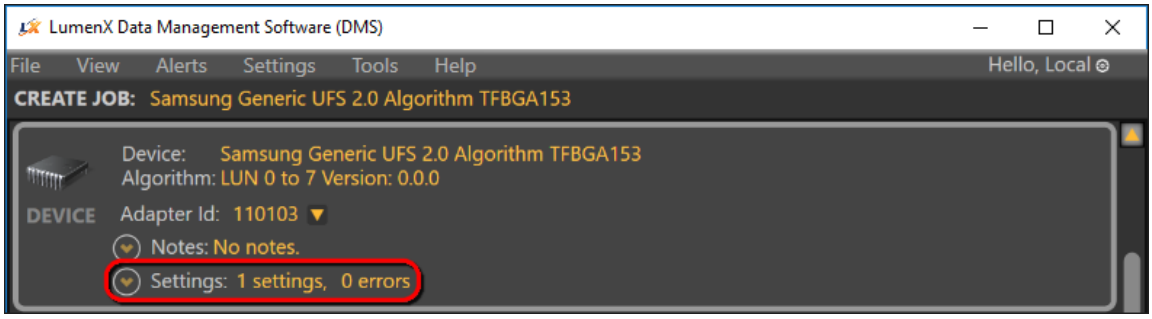


Configuring Device Settings

1. In the **Device** section, from the **Adapter Id** drop-down list, select the specific adapter.

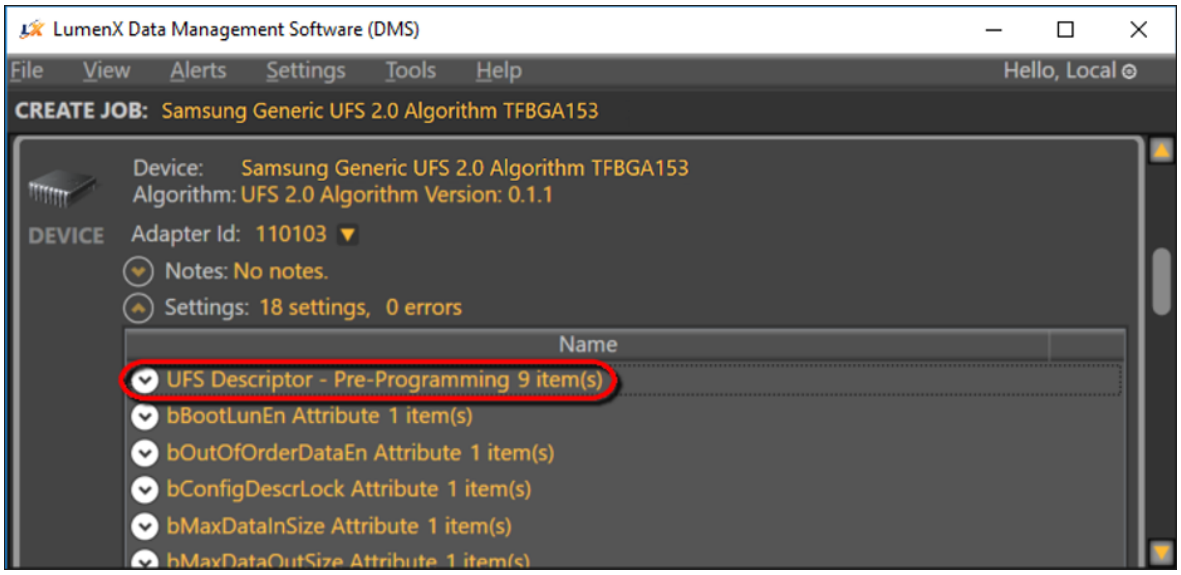


2. To expand the device-specific options, click **Settings**.

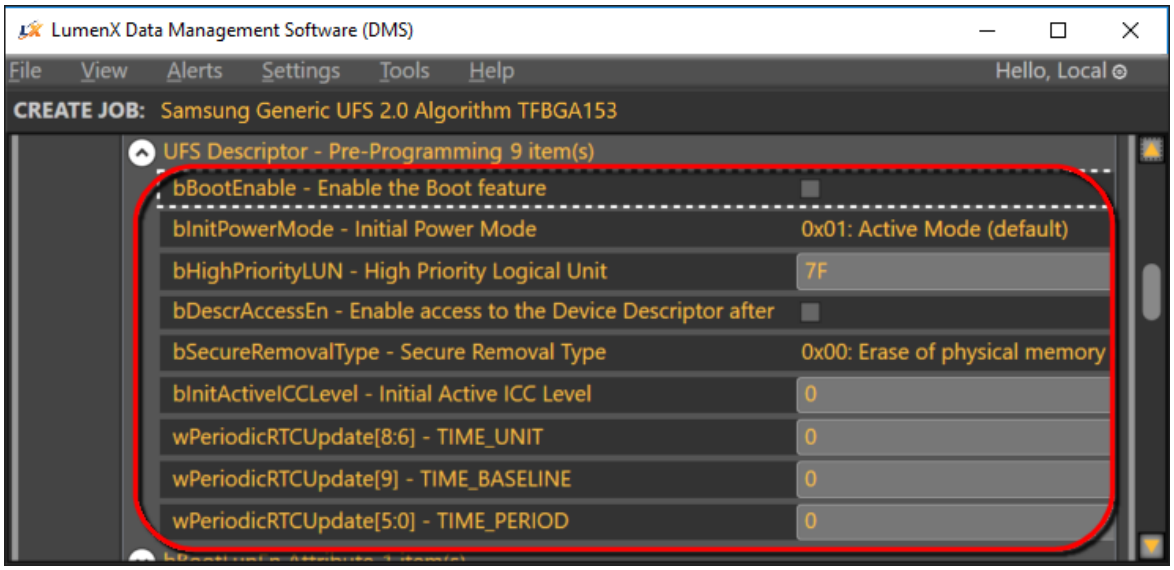


Note: The settings and their default values may vary slightly depending on the specific device and algorithm selected.

3. To expand the device-level UFS Configuration Descriptors, click **UFS Descriptor**.



4. Configure the UFS Descriptors as desired.



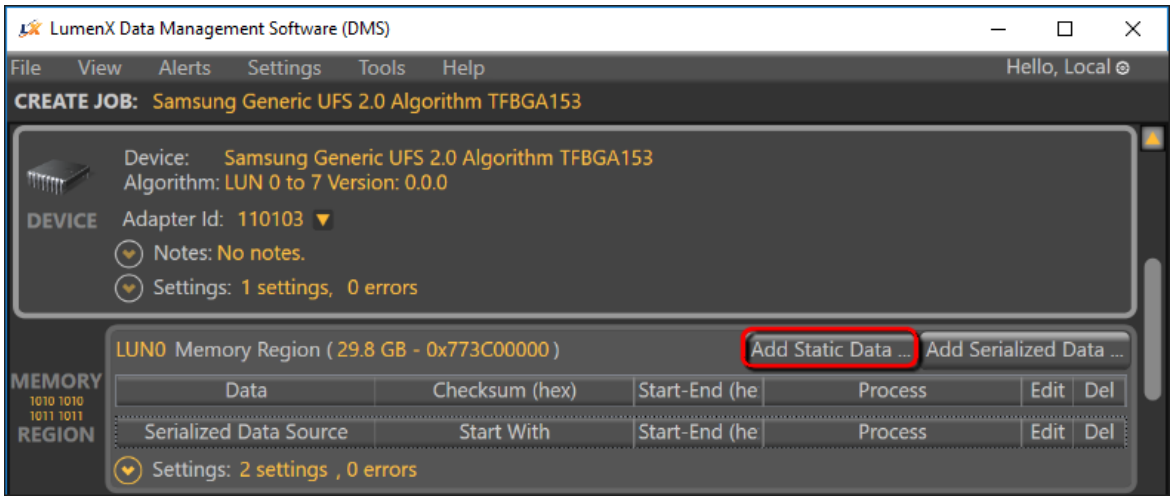
NOTE: LumenX Data Management Software (DMS) supports the standard set of descriptors defined by the JEDEC specification for UFS Version 2.1 (JESD220C, March 2016). For more information, see **Appendix B: Device Settings, UFS Configuration Descriptors**.

5. To set the UFS Device Attributes, expand the desired attribute and set appropriately.

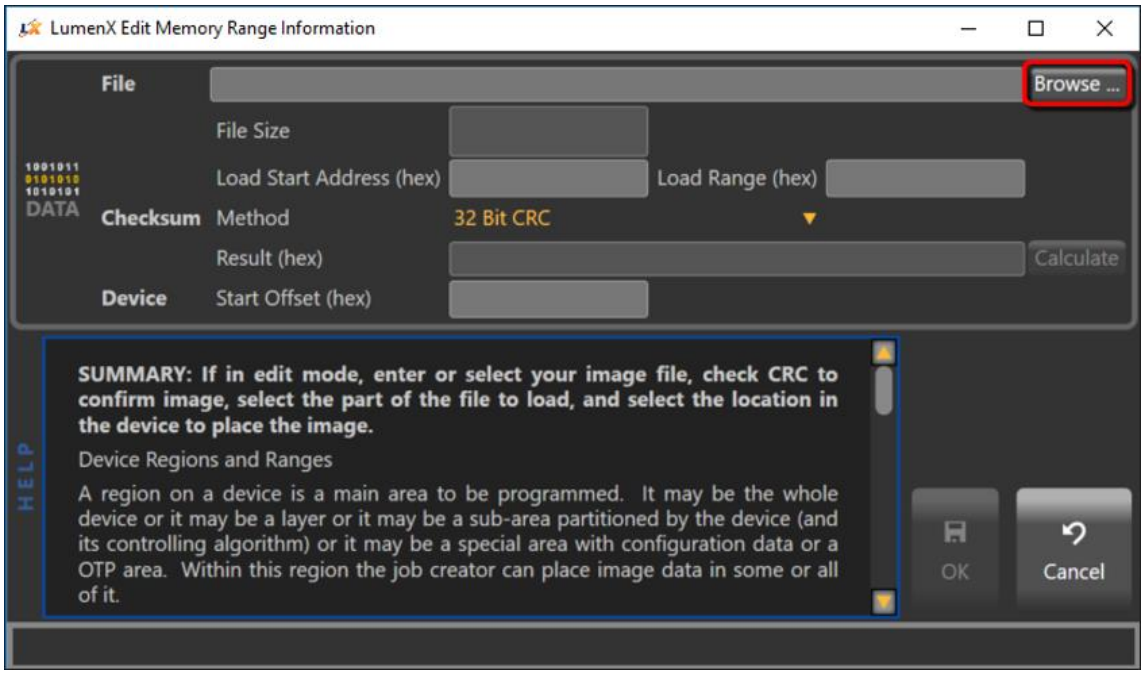
LumenX supports a standard set of device attributes. For more information about these attributes, see **Appendix C: Device Settings, UFS Device Attributes**.

Configuring LUN Settings

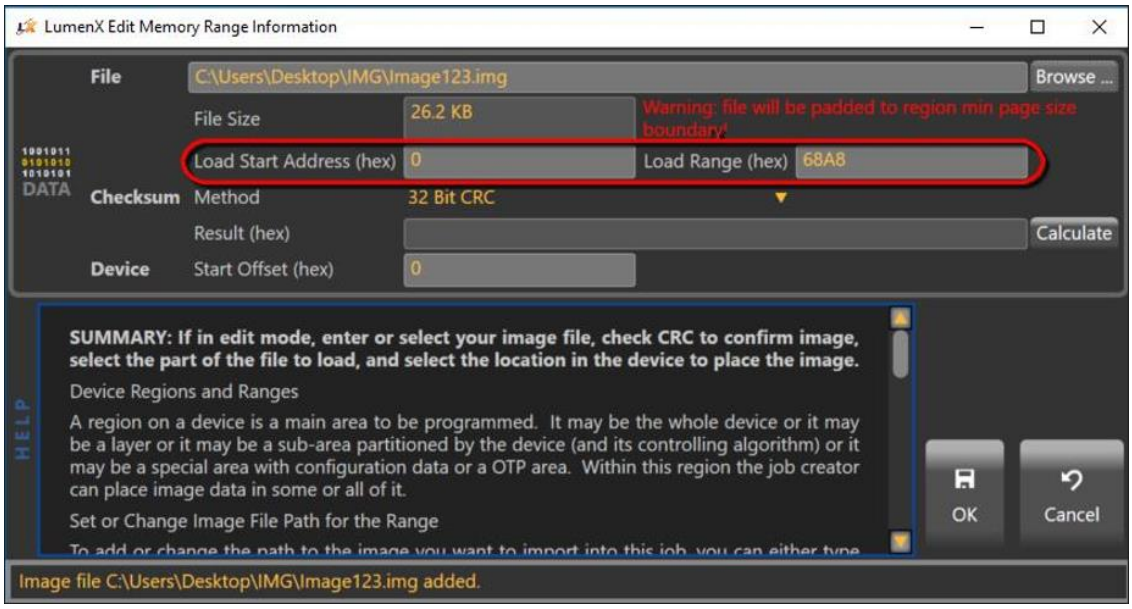
1. In the **Memory Region** section, click **Add Static Data** for the specific Logical Unit Number (LUN) to program (ex. LUN 0). The number of LUNs is dependent on the specific device.



2. In the **LumenX Edit Memory Region Information** dialog box, click **Browse** to load your data file.

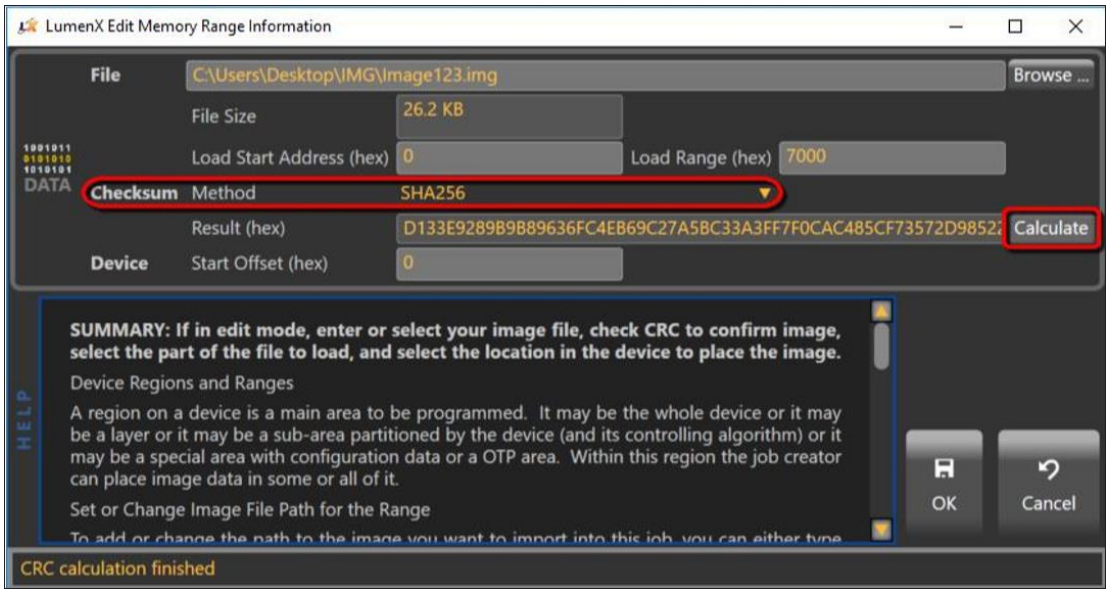


3. (Optional) To program only a specific segment of the loaded data/image file into the selected LUN, specify the starting address and data range.

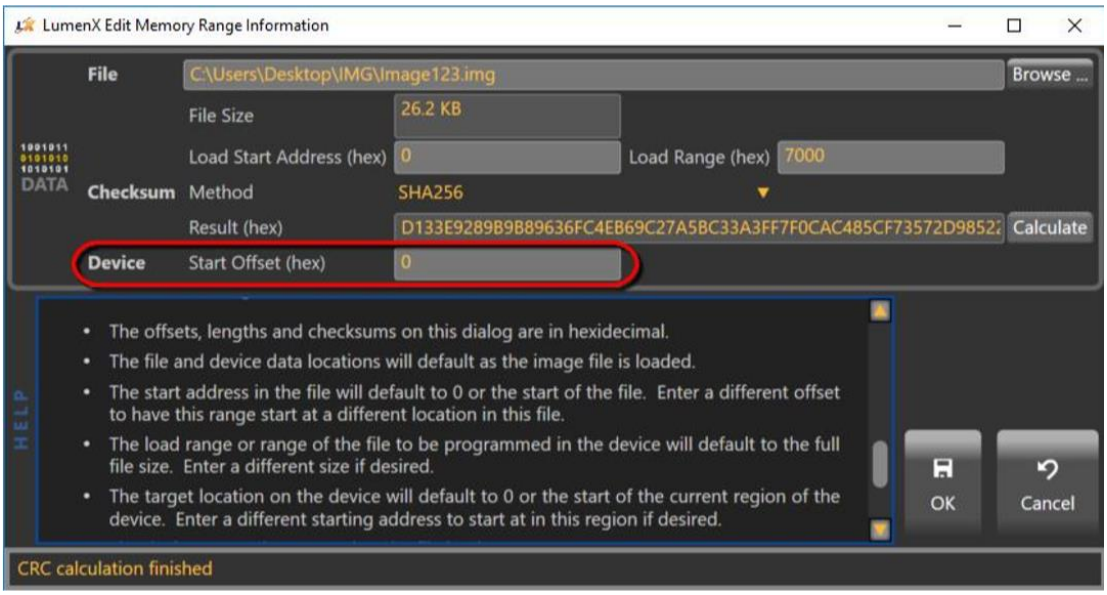


By default, LumenX writes the entire loaded data/image file starting at address 0x00 (and automatically calculates/populates the **Load Range** based on file size).

4. (Optional) To validate programmed data at the file level (checksum compare), select the desired **Checksum Method**, and then click **Calculate**.

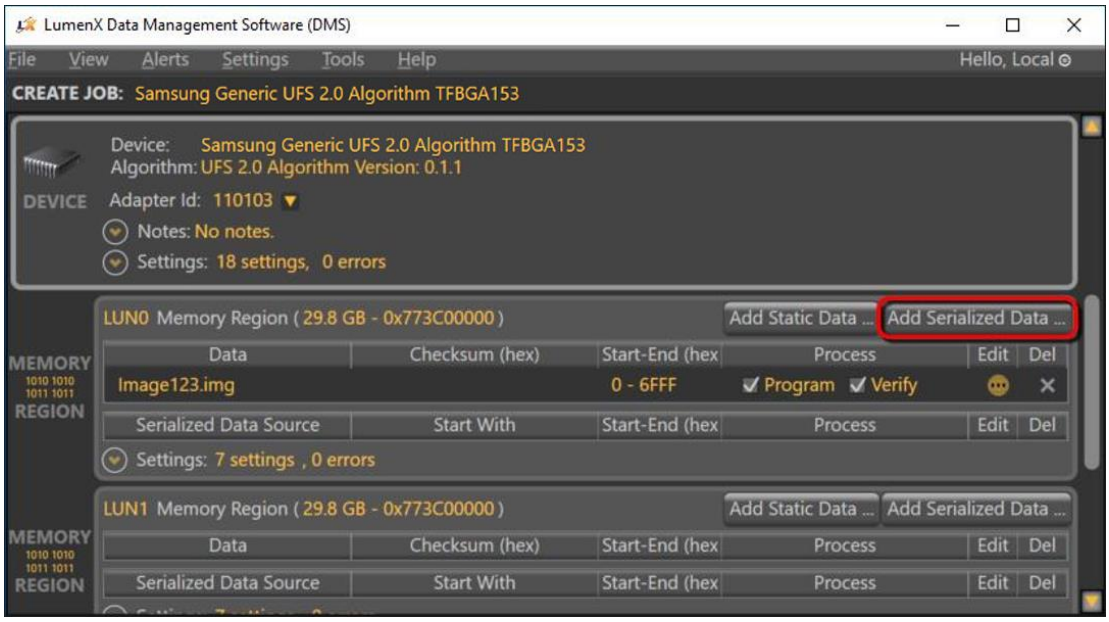


5. (Optional) To program data at a specific starting address on the UFS device, complete the **Device Offset** field. (By default, LumenX writes to the lowest available address on device.)

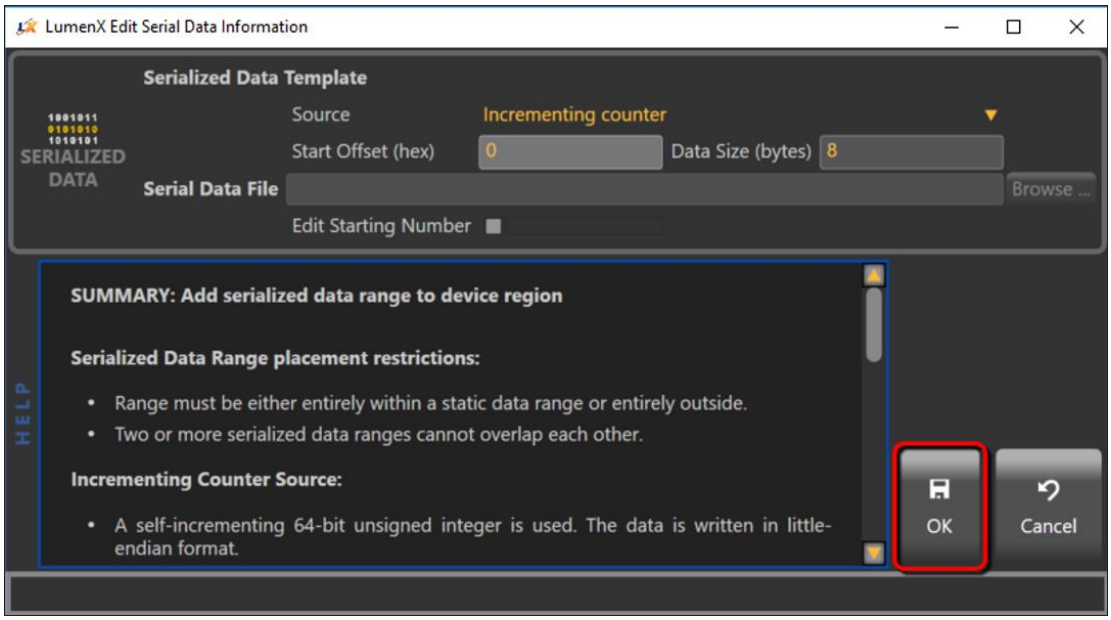


6. To include additional data in the LUN, repeat this procedure starting from Step 1.

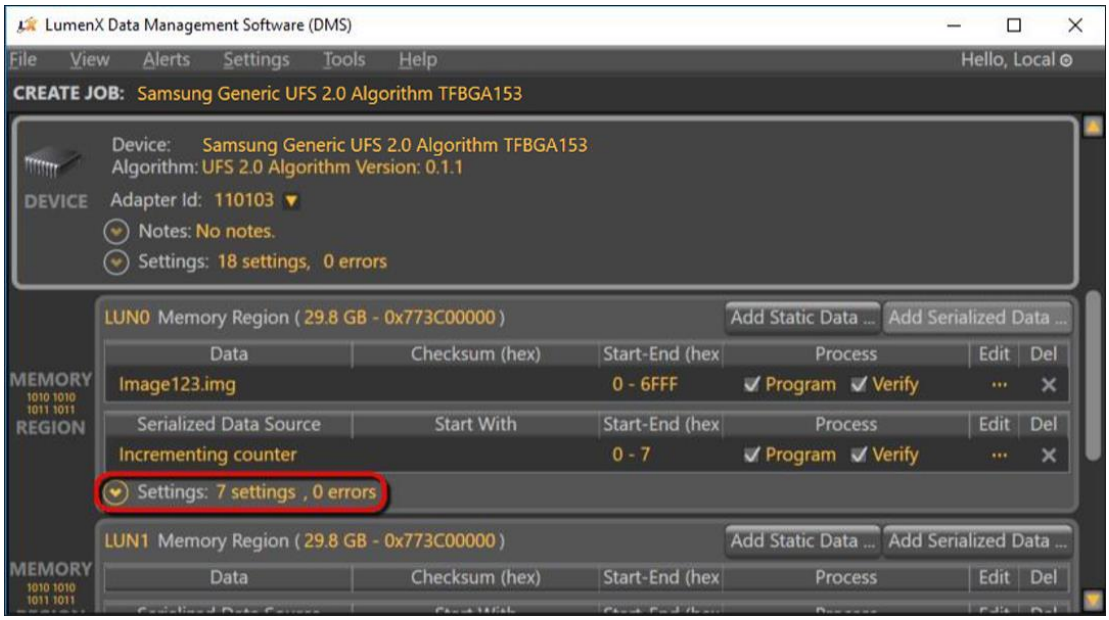
7. To include dynamic/serialized data in the programming job, click **Add Serialized Data**.



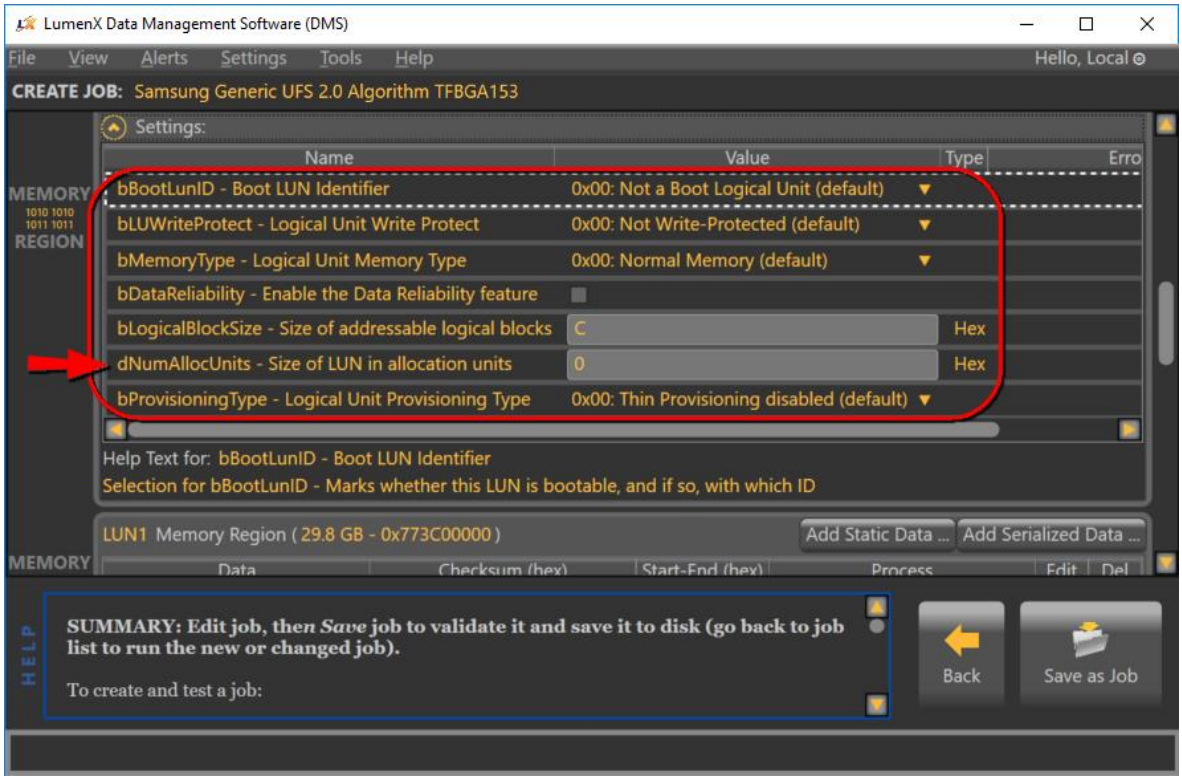
8. In the **LumenX Edit Serial Data Information** dialog box, complete the desired fields, and then click **OK**.



9. To configure LUN-specific Unit Descriptors, click **Settings** to expand the available options.



10. Configure the Unit Descriptors as desired.



LumenX supports the standard set of LUN descriptors defined by the JEDEC specification for UFS Version 2.1 (JESD220C, March 2016). For more information about these descriptors, see **Appendix D: LUN Settings, UFS Unit Descriptors**.

Calculating LUN Size (dNumAllocUnits)

The **dNumAllocUnits** setting (as highlighted by arrow in the preceding screenshot) is unique in that it is REQUIRED (you cannot save UFS jobs if **dNumAllocUnits** is blank or otherwise invalid).

dNumAllocUnits simply specifies the desired size of the LUN (similar to partitioning any storage drive), so the size you specify must be equal to or greater than the sum of all the data/image files that you intend to program into the specific LUN/memory region. Also include additional storage as a buffer if your application involves logging (allocate extra space for the log files).

The JEDEC formula for calculating **dNumAllocUnits** is:

$$\text{dNumAllocUnits (hex)} = \frac{\textbf{Desired LUN Size (bytes, decimal)} \times \text{CapacityAdjFactor}}{\text{bAllocationUnitSize (bytes, decimal)} \times \text{dSegmentSize} \times 512}$$

For the numerator, you set the **desired LUN size** while the **CapacityAdjFactor** is always 1 for Normal memory type. For Enhanced memory types, see the JEDEC specification on how to calculate the **CapacityAdjFactor**.

For the denominator, both of the variables are fixed per device specifications. So calculating **dNumAllocUnits** is relatively easy because 3 of the 4 variables are fixed and you set the 4th. For example, if 3 GB is the desired LUN size and your device has the following specifications:

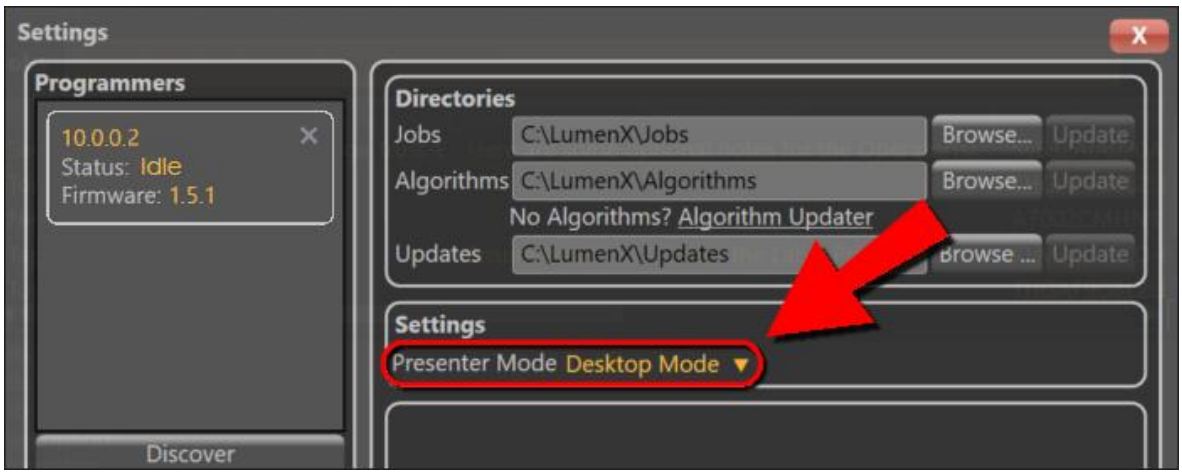
- CapacityAdjFactor = 1
- bAllocationUnitSize = 0x01 (Hex)
- dSegmentSize = 0x00002000 (Hex)

Then calculate **dNumAllocUnits** as follows:

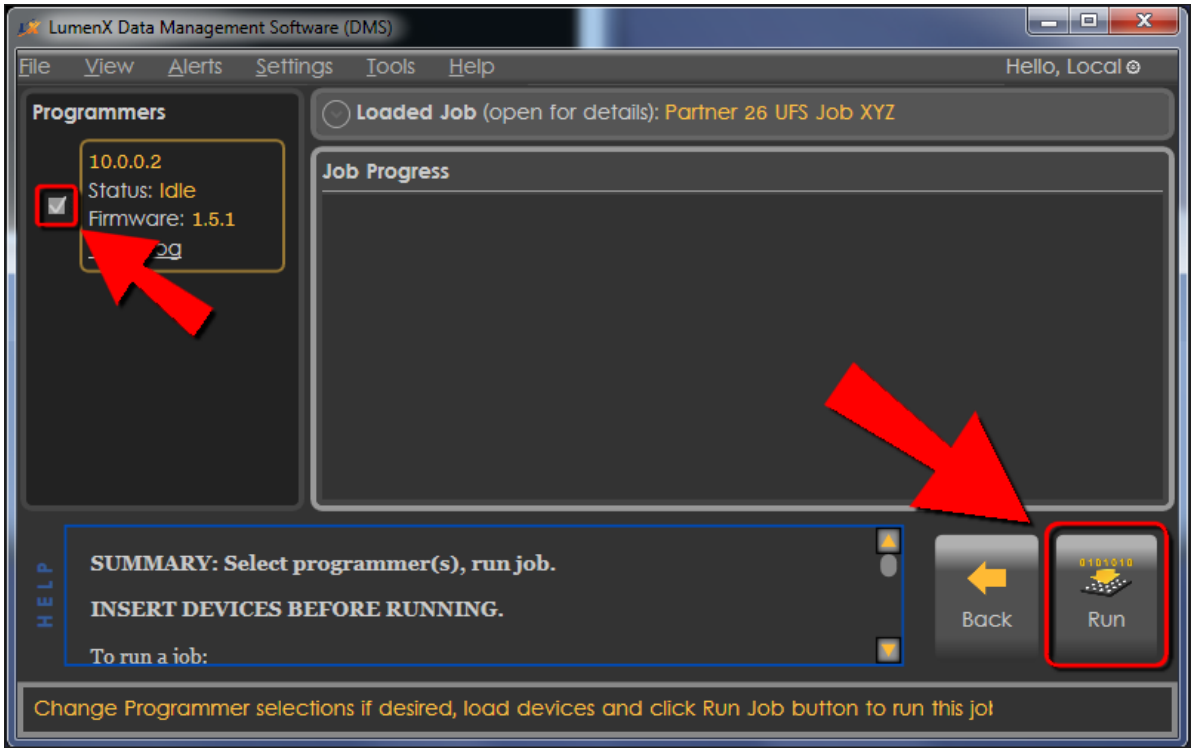
Step	Calculation
1. Determine the desired LUN size, then convert this value to bytes.	3 GB = **3,000,000,000**
2. In the specifications for your device, calculate the **CapacityAdjFactor** for your device's memory type. (The value is 1 for Normal memory type.)	Hex 0x01 = Decimal **1**
3. In your device specifications, lookup the **bAllocationUnitSize** and **dSegmentSize** values, then convert them from hexadecimal to decimal.	bAllocationUnitSize=1 dSegmentSize=8192
4. Using the formula above for calculating **dNumAllocUnits**, plug the values from the first 3 steps into the formula.	3,000,000,000 x 1 1 x 8192 x 512
5. Convert the quotient in Step 4 from decimal to hexadecimal, and enter this hex value in the **dNumAllocUnits** box.	Decimal 715 = Hex **2CC**

Starting the Job Run

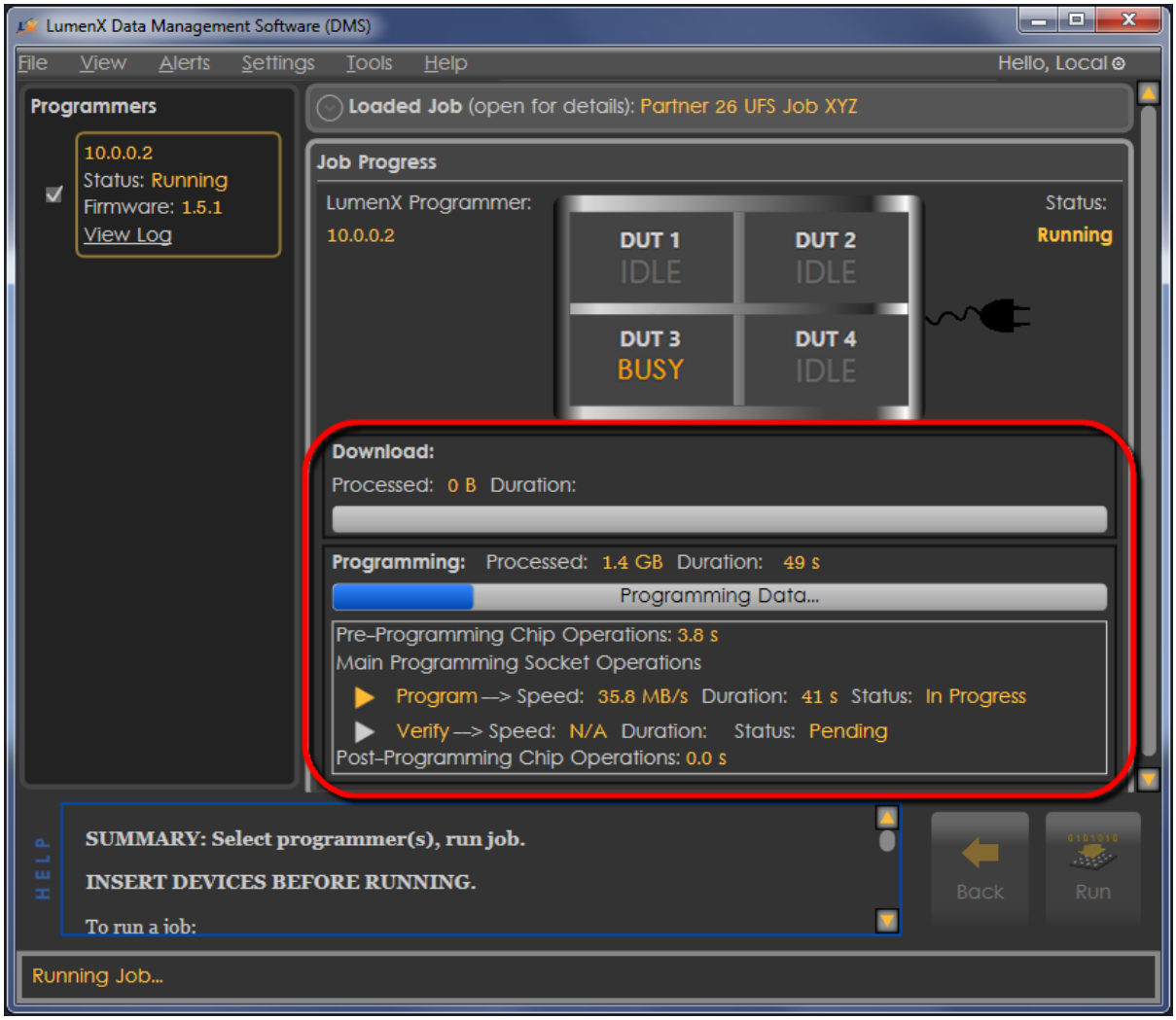
1. Gently insert and place a blank UFS device into its socket adapter (note the PIN1 location indicated on the socket adapter board).
2. Ensure the system is in the appropriate presenter mode: in the **Settings** group, from the **Presenter Mode** drop-down list, select **Desktop Mode** (vs PSV7000 or PSV5000 for automated systems).



3. In the left pane, check the box for the desired programmer(s), and then click **Run**.



4. View the **Job Progress** pane for the current status:
   - **DUT** = Device Under Test = Socket
   - **IDLE** = Job is downloading/no activity in slots
   - **BUSY** = Job is programming
   - **PASS** = Job has successfully completed
   - **FAIL** = Error occurred



When a specific job is run for the first time, there may be an apparent delay between the **Downloading** and **Programming** states because LumenX may need to update the bitstream version of the UFS Interface Board. If needed, the bitstream update takes approximately one minute (the yellow LED remains lit until the update completes).

Chapter 5: Verify Job Completion

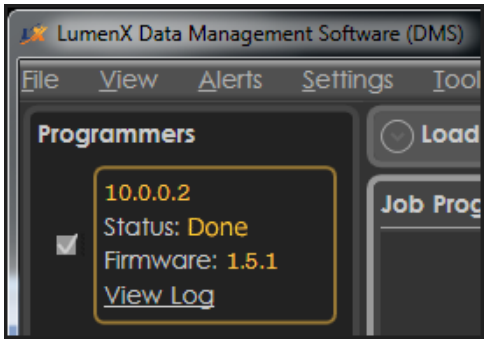
This Chapter provides instructions to verify that the job completed, specifically:

- Programmer and socket status confirmation
- Socket adapter LEDs check
- Error alert notification

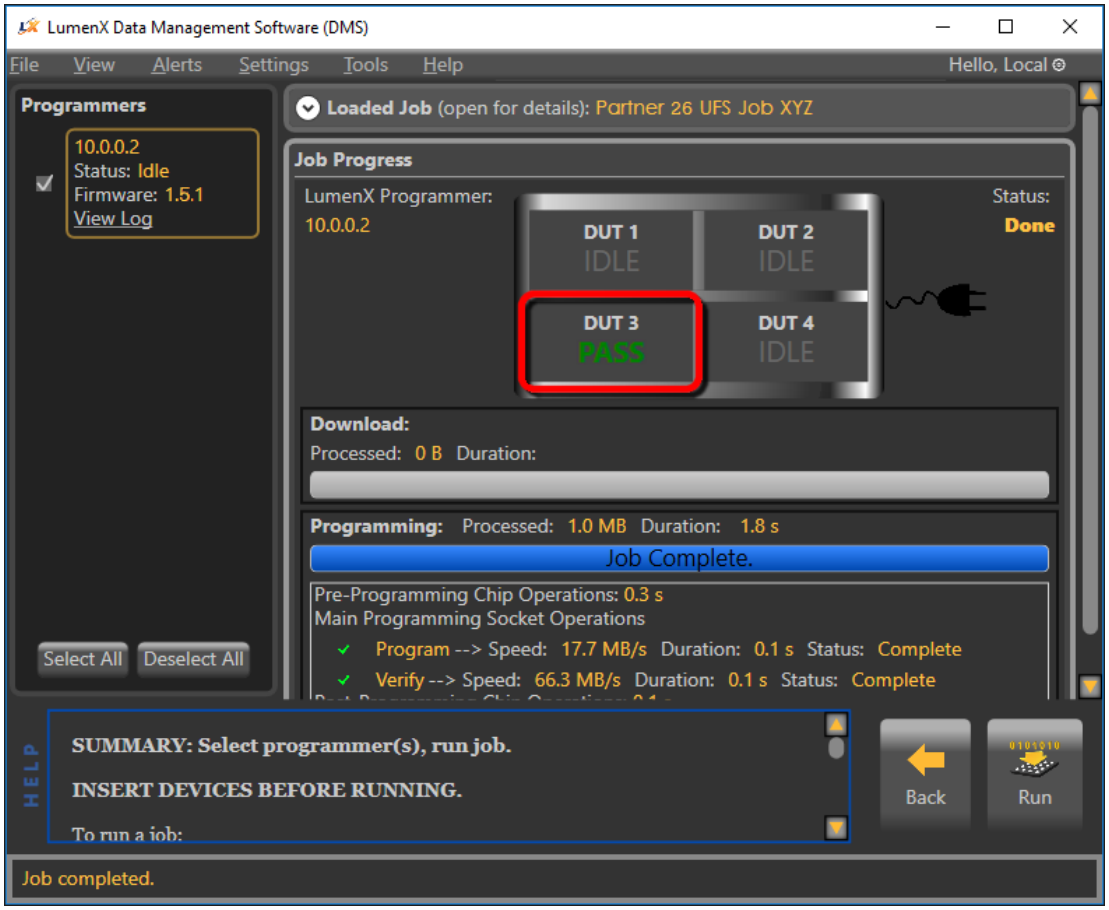
After configuring and running the programming job in the last Chapter, now verify in LumenX that the job completed properly. Ultimately, verifying that the part/device was programmed properly involves reading from it (not addressed in this document).

Confirming Status

1. In the left pane under **Programmers**, verify that the **Status** entry shows **Done**.



2. To confirm socket status, verify that the **Job Progress** pane shows **PASS** for each socket and programmer used.



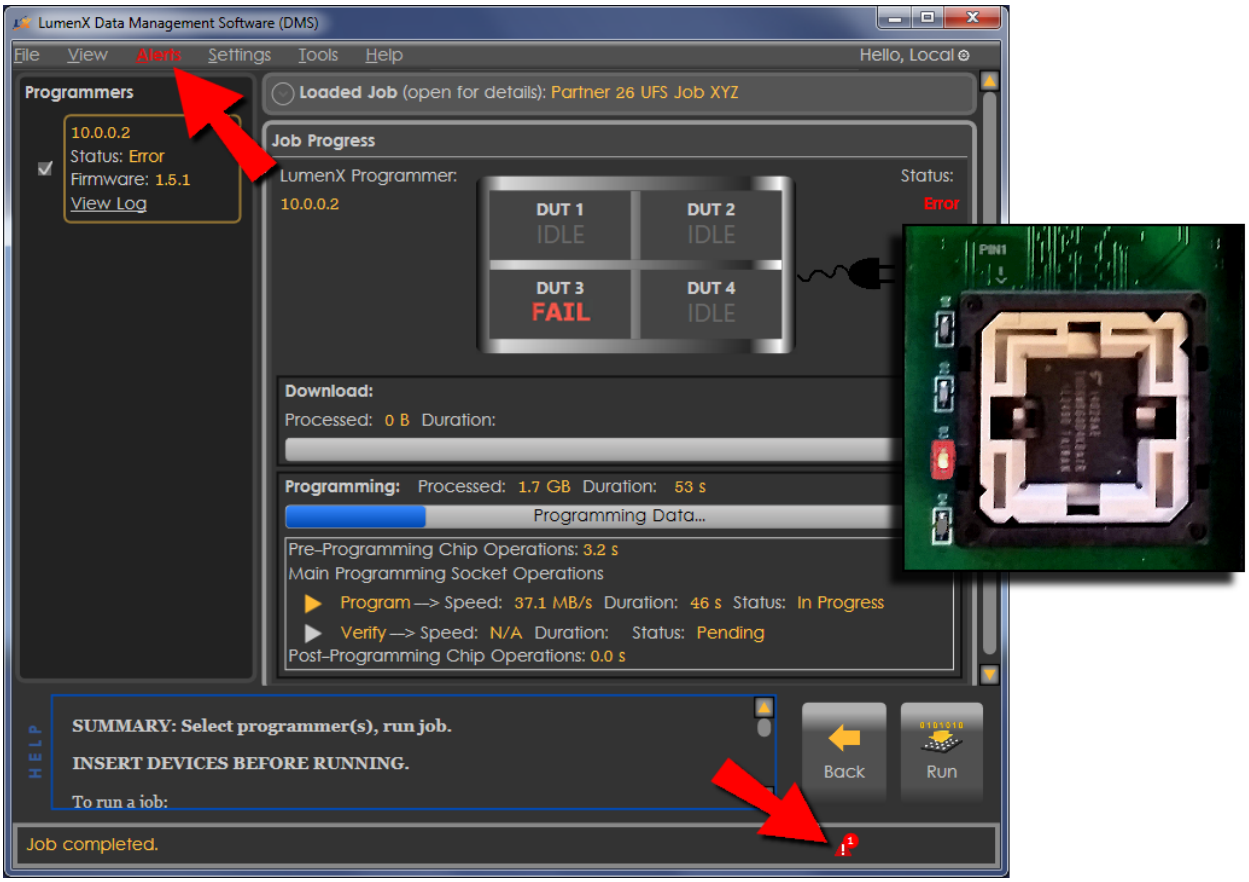
Checking Socket Adapter LEDs

All LEDs will light simultaneously at startup and go off when the startup process is complete.

- **Green** = PASS
- **Yellow** = BUSY
- **Red** = FAIL
- White = Continuity Error

Checking for Alerts

If an error occurs (red-color LED of socket stays lit or flashes on-and-off repeatedly), check for alert notifications at the top and bottom of LumenX Data Management Software (DMS).



Appendices

The following Appendices provide additional details about UFS configuration:

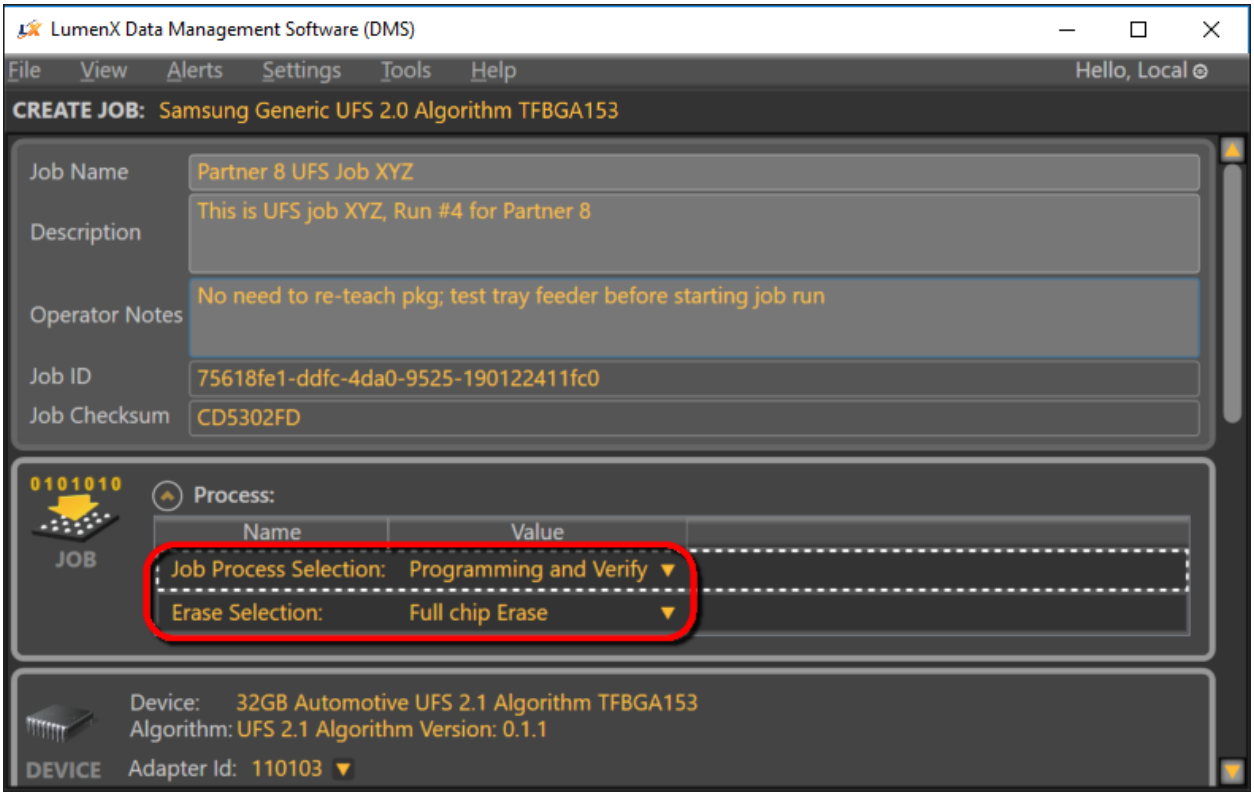
- Appendix A: Job Settings, Job Process Selection
- Appendix B: Device Settings, UFS Configuration Descriptors
- Appendix C: Device Settings, UFS Device Attributes
- Appendix D: LUN Settings, UFS Unit Descriptors
- Appendix E: Sample UFS Job with Default Settings
- Appendix F: User Interface Legend

To avoid disrupting the workflow of running the programming job, many of the UFS settings are detailed here rather than inline with the steps earlier.

Note: The settings and default values shown here are for sample purposes only; they may vary slightly from those of your specific device and algorithm.

Appendix A: Job Settings, Job Process Selection

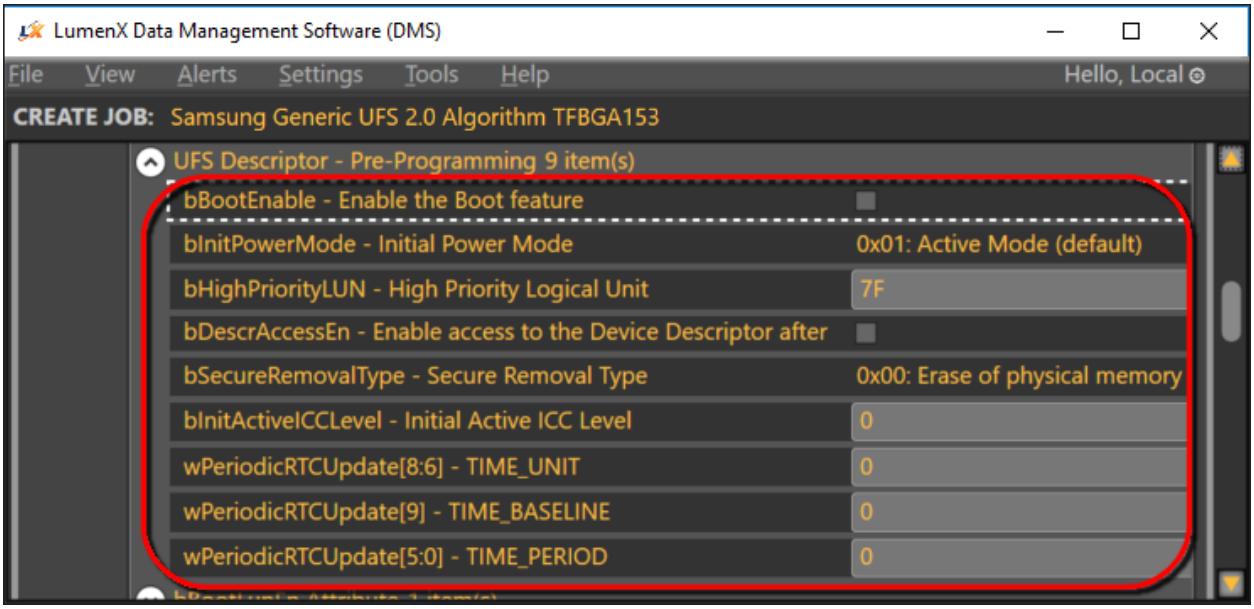
Make the desired job process selection(s) from the drop-down lists in the **Job** section.



Setting	Available Options	Description
Job Process Selection	• Program and Verify (default) • Verify Only	Specifies the programming operation(s) to perform on the device.
Erase Selection	• Disabled • Full Chip Erase (default)	Specifies if Full Chip Erase is enabled.

Appendix B: Device Settings, UFS Configuration Descriptors

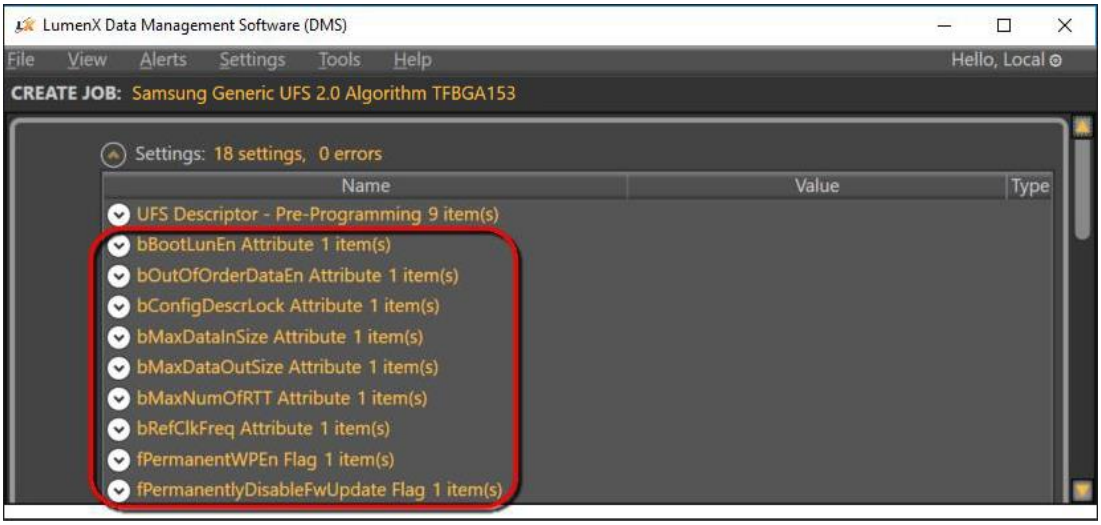
Configure the desired descriptors in the **Device** section.



Setting	Available Options	Description
bBootEnable	• 00h Disabled (default)	Specifies if the device is bootable.
bInitPowerMode	• 00h UFS-Sleep Mode • 01h Active Mode (default)	Specifies the initial power mode.
bHighPriorityLUN	• 7Fh (default) • 0 to ***n***, where ***n*** = # of LUNs specified by **bMaxNumberLU**	Specifies which LUN has the command queue with the highest priority. Default value **7F** means equal priority across all LUNs.
bDescrAccessEn	• 00h Disabled (default) • 01h Enable	Specifies if Device Descriptors are accessible after initialization.
bSecureRemovalType	• 00h Erase (default) • 01h Overwrite once, then erase • 02h Overwrite thrice, then erase • 03h Remove by vendor method	Specifies the method by which information is removed.
bInitActiveICCLevel	• 0 (default) • 00h to 0Fh	Specifies the **bActiveICCLevel** after power on or reset.
wPeriodicRTCUpdate[8:6]	• 0b Undefined (default)	Specifies the TIME_UNIT of real-time clock updates.
wPeriodicRTCUpdate[9]	• 0b Time from last update	Specifies the TIME_BASELINE of real-time clock updates.
wPeriodicRTCUpdate[5:0]	• 0b	Specifies the TIME_PERIOD of real-time clock updates.

Appendix C: Device Settings, UFS Device Attributes

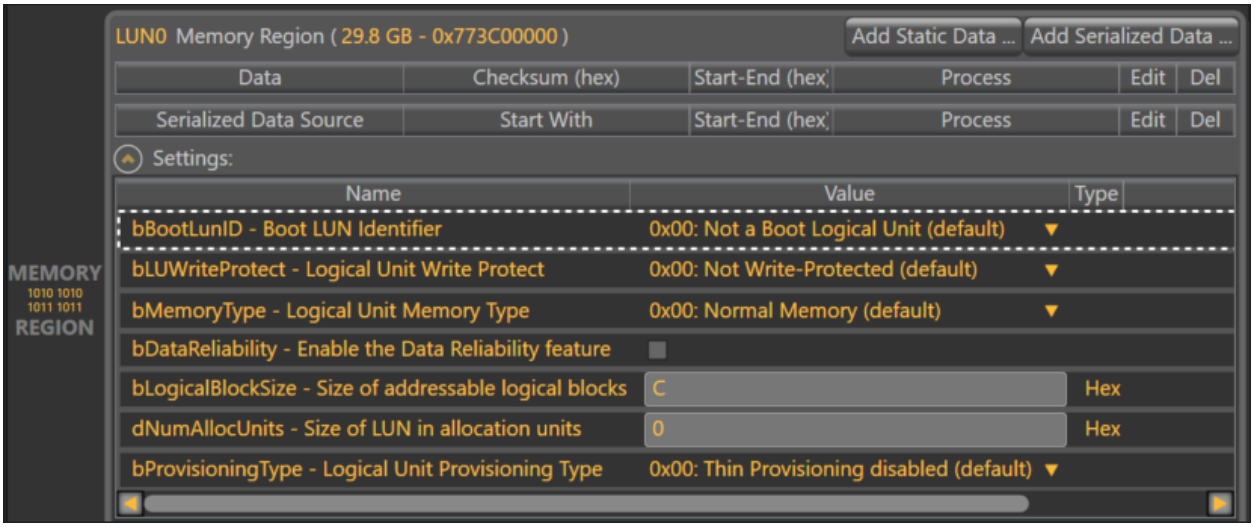
Configure the desired device attributes in the **Device** section.



Setting	Available Options	Description
bBootLunEn	• 00h Boot disabled (default)	Specifies if a particular LUN is active during boot.
bOutOfOrderDateEn	• 00h Disabled (default) • 01h Enabled	Specifies if out of order sequencing is enabled.
bConfigDescrLock	• 0h Disabled (default) • 1h Enabled	Specifies if device configuration (Configuration Descriptor) is locked.
bMaxDataInSize	• 0 to *n*, where *n* = bMaxInBufferSize	Specifies the maximum size of data in (number of 512-byte units).
bMaxDataOutSize	• 0 to *n*, where *n* = bMaxOutBufferSize	Specifies the maximum size of data out (number of 512-byte units).
bMaxNumOfRTT	• 0 to *n*, where *n* = bDeviceRTTCap	Specifies the maximum number of outstanding RTTs allowed.
bRefClkFreq	• 0x00h – 19.2 MHz • 0x01h – 26 MHz (default) • 0x02h – 38.4 MHz • 0x03h – 52 MHz • Others: Reserved	Specifies the reference clock frequency.
fPermanentWPEn	• 00h Disabled (default) • 01h Enabled	Specifies if permanent write protection is enabled.
fPermanentlyDisableFwUpdate	• 0b Disabled (default) • 1b Enabled	Specifies if firmware updates are permanently disallowed.

Appendix D: LUN Settings, UFS Unit Descriptors

Configure the desired LUN descriptors in the **Memory Region** section.



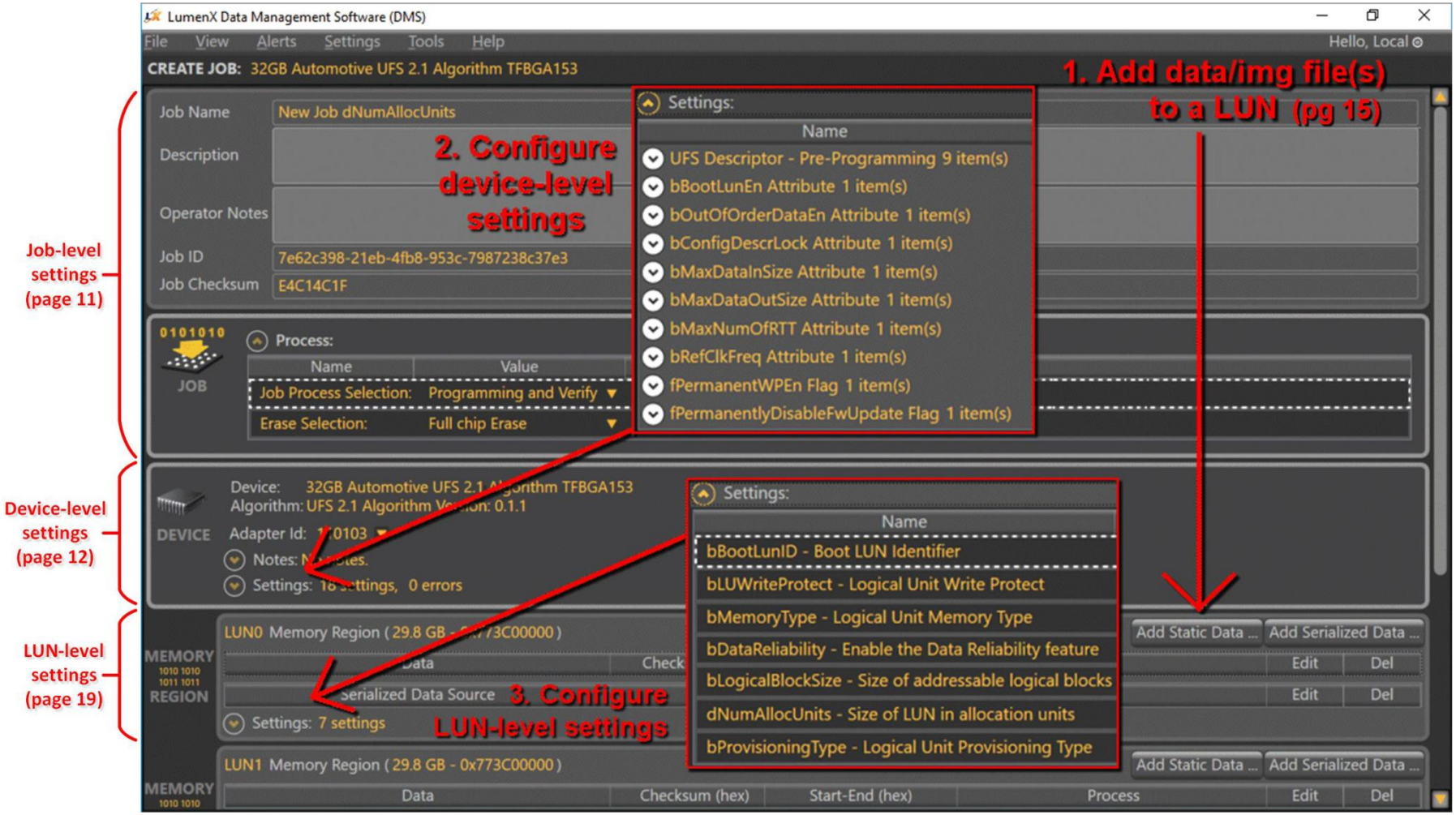
Setting	Available Options	Description
bBootLunID	• 00h Not Bootable (default) • 01h Boot LUN A • 02h Boot LUN B	Specifies if a particular LUN is bootable.
bLUWriteProtect	• 00h Not Write-Protected	Specifies if the LUN is write-protected.
bMemoryType	• 00h Normal Memory	Specifies a particular memory type (as supported by **wSupportedMemoryTypes**).
bDataReliability	• 00h Disabled (default) • 01h Enable	Specifies device behavior when a power failure occurs while writing to the LUN.
bLogicalBlockSize	• C (default)	Specifies the logical block size.
dNumAllocUnits	• 0 (default)	Specifies the size of the LUN.
bProvisioningType	• 00h Disabled (default) • 01h Enabled and TPRZ=0 • 02h Enabled and TPRZ=1	Specifies if thin provisioning is enabled.

Appendix E: Sample UFS Job with Default Settings

The following table shows the default UFS settings applied to a UFS job/device in LumenX Data Management Software (DMS). At a minimum, you only need to 1) load the intended data/image file(s) to program into the device and 2) set the LUN size/capacity with **dNumAllocUnits**.

Level	Setting	Options
Job	Job Process Selection	• Program and Verify
	Erase Selection	• Full Chip Erase
Device	Descriptor: **bBootEnable**	• 00h Disabled
	Descriptor: **bInitPowerMode**	• 01h Active Mode
	Descriptor: **bHighPriorityLUN**	• 7F (all LUNs equally prioritized)
	Descriptor: **bDescrAccessEn**	• 00h Disabled
	Descriptor: **bSecureRemovalType**	• 00h Erase
	Descriptor: **bInitActiveICCLevel**	• 0
	Descriptor: **bPeriodicRTCUpdate[8:6]** TIME_UNIT	• 0b Undefined
	Descriptor: **bPeriodicRTCUpdate[9]** TIME_BASELINE	• 0b Undefined
	Descriptor: **bPeriodicRTCUpdate[5:0]** TIME_PERIOD	• 0b Undefined
	Attribute: **bBootLunEn**	• 00h Boot disabled
	Attribute: **bOutOfOrderDataEn**	• 00h Disabled
	Attribute: **bConfigDescrLock**	• 0h Disabled
	Attribute: **bMaxDataInSize**	• 8
	Attribute: **bMaxDataOutSize**	• 8
	Attribute: **bMaxNumOfRTT**	• 2
	Attribute: **bRefClkFreq**	• 0x01h - 26 MHz
	Attribute: **bPermanentWPEn**	• 00h Disabled
	Attribute: **bPermanentlyDisableFwUpdate**	• 0b Disabled
LUN	**bBootLunID**	• 00h Not Bootable
	bLUWriteProtect	• 00h Not Write-Protected
	bMemoryType	• 00h Normal Memory
	bDataReliability	• 00h Disabled
	bLogicalBlockSize	• C
	dNumAllocUnits	• 0
	bProvisioningType	• 00h Disabled

Appendix F: User Interface Legend



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