DTC-1200

DIGITAL TRANSPORT CONTROLLER

AMPEX MM-1200 UPGRADE

Owner's Manual and User Guide

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DOC-REV-A04
02/18/2018

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1 INTRODUCTION

Thank you for purchasing your new DTC-1200 digital transport controller for Ampex MM-1200 studio recorders! All controller cards are tested individually prior to shipping. Before installing the card, please read this document thoroughly and retain it for future reference. Additional copies of this manual are available for a nominal printing fee, or may be downloaded from our website at http://www.rtzaudio.com.

All items are carefully packed to endure the rigors of shipping and handling. However, please inspect all contents and packaging immediately upon receipt. Please report any problems to us immediately. In the event of damage, retain all shipping and packaging materials for shipper damage claims inspection.

1.1 DESCRIPTION

The DTC-1200 is a digital servo loop and transport logic controller designed around the latest 32-bit advanced ARM microprocessor technology. The DTC-1200 controller uses a Tiva TM4C123AE6PM 32-bit M4 ARM processor by Texas Instruments[1] that is designed for use in advanced motion control system applications. A precision dual 12-bit DAC was also added to allow fine torque control of both reel motors under microprocessor servo loop control.

The transport controller firmware runs under Texas Instruments TI-RTOS operating system. TI-RTOS brings true multi-threaded real-time programming power to ARM embedded systems. The transport servo loop task runs at highest priority and manages all tape transport servo and user mode handling.

1.2 OVERVIEW

Several wiring and mechanical modifications are required to use the DTC-1200 transport controller in the MM-1200. Please refer to the *DTC-1200 Installation Manual* for details on all modifications required prior to using the DTC-1200 card in your machine. Failure to perform the required modifications will result in improper operation and/or possible damage to the DC-1200 card and/or your machine.

This document describes the basic setup and use of the DTC-1200 digital transport controller card. You must perform all the modifications described in the installation guide prior to using the DTC-1200 card in your machine.

[1] Texas Instruments is a legal trademark of Texas Instruments Corporation.

2 DTC-1200 HARDWARE & SETUP CONFIGURATION

The DTC-1200 digital transport controller card can be installed in the machine once the wiring changes and reel motor quadrature encoders have been installed. RTZ recommends using an extender card if available for easy access during initial system power up and installation. The extender card will allow easier access to the tension sensor gain trimmer (R85 on revision C PCB's) and power status LED's.

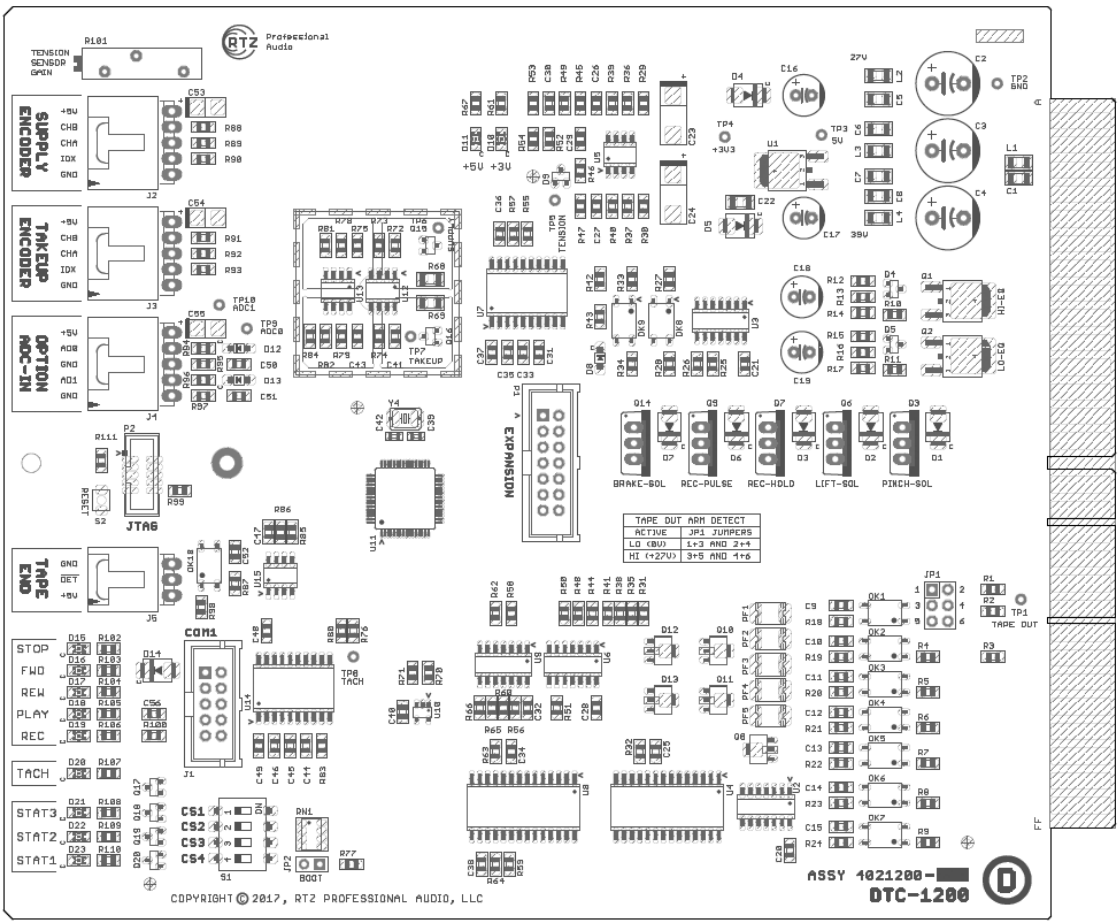
2.1 Initial 5V Power Check

First check that 5V system power is available on pins 4/D of J1 before installing the DTC-1200 into the machine. Since you've redirected the 5V power to connector J1, you must confirm that 5V power is correct and available on these pins. It is important to ensure that the 5V supply is not over 5.1V or damage may occur to chips on the controller board.

> Note that the reels motors will run at full speed when the machine is powered up with no transport controller card installed in the machine.

Remove any tapes/reels from the tape machine and power up the machine with no transport control card installed. Measure and check that 5.0V power is correct on pins 4/D of edge connector J1. If the 5.0V voltage is off, refer the Ampex MM1200 service manual for the machine's 5V regulator adjustments.

Figure 1 - DTC-1200 Controller PCB



2.2 Tape Out Detect Polarity Configuration

The tape out arm on the right-hand side of the machine actuates a micro switch inside the machine when tape is present and loaded in the tape path. Apparently, some machines have this wired as active high logic (+27V) or active low logic (ground) when the switch is activated.

The 6-pin jumper JP1 configures the tape detection for high or low logic. By default, the controller ships configured for active low logic. Refer to Figure 1 below for JP1 jumper configuration. Review the DTC-1200 schematics prior to changing these jumpers for additional information.

Table 1- Tape-Out Detect Polarity

TAPE OUT SENSE POLARITY	
ACTIVE	**JP1 JUMPER CONFIG**
HIGH (27V)	Jumper pins 3+5 and pins 4+6
LOW (GND)	Jumper Pins 1+3 and pins 2+4 (default)

Make sure to power down the machine and card before changing jumper JP1 configuration jumpers. Pay special attention to the jumper configuration and orientation as shown above and in the schematic.

2.3 DIP Switch Configuration

Currently the DIP switch allows setting the COM1 serial port baud rate. It also controls blinking of the STOP button during transport mode changes that require a transport stop (e.g. shuttle to play mode) prior to executing a new transport mode. Currently configuration switches CS3 and CS4 are not defined and are reserved for future use.

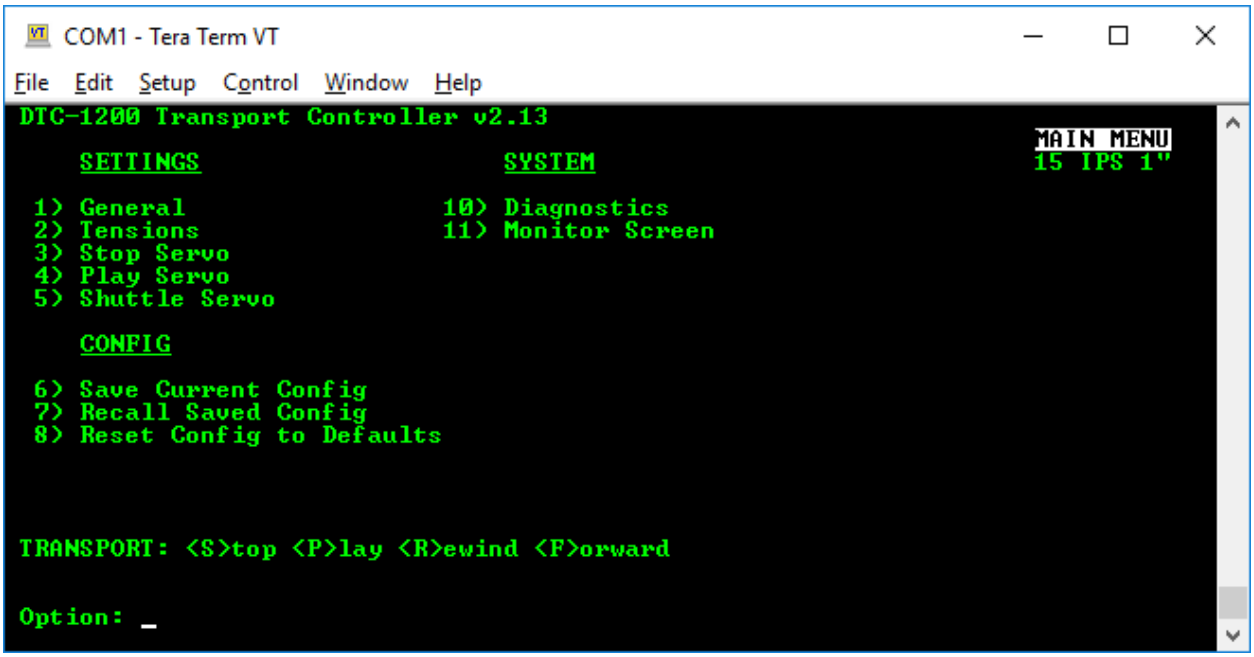
Table 2- DIP Switch Configuration

DIP SWITCH S1 SETTINGS	
SWITCH	**FUNCTION**
CS1	This switch sets the baud rate of the COM1 serial port. The serial port baud rate is 19,200 bps in the default OFF position. The baud rate is set to a slower speed at 9600 bps with this switch in the ON position. The processor requires a reset before this setting takes effect.
CS2	This switch controls the STOP mode pending button flash state. The STOP button will flash when a STOP mode is pending before executing the next command with this switch in the ON position. The STOP lamp will not flash with CS2 in the OFF position and only lights once all tape motion ceases.
CS3	(function currently undefined)
CS4	(function currently undefined)

2.4 Controller Configuration via TTY

The COM1 serial port on the DTC-1200 provides TTY terminal access for all system configuration and diagnostics information. You will need a VT-100 terminal emulator program (the freeware program **TeraTerm**) and a computer with a male DB-9 style RS-232 serial port available.

Figure 2 – Main Configuration Menu



Most modern motherboards still have a RS-232 header connector available on the motherboard that can be used by adding the appropriate break out cable to a DB-9 connector. Please consult with your computer motherboard vendor to locate or build a RS-232 breakout cable if needed. You might consider purchasing a PCI card RS-232 serial port adapter. Also, USB-to-RS232 serial port adapters are available for use with laptops and computers.

2.4.1 RS-232 Serial Port

The DTC-1200 includes a ribbon cable with DB9 connector for the RS-232 connection to a PC. The ribbon cable header end plugs into J1 (COM1) on the DTC-1200 board. The DTC-1200 serial port is configured for baud rate 19200, no parity, 8 data bits, 1 stop bit (19200/N/8/1). No handshaking signaling lines are used (DTR, CTS, etc.). The baud rate can be changed to 9600 by switching DIP switch #1 (CS1) to the ON position and resetting the CPU. RESET switch S2 is located in the center of the board along the edge, or power cycle the machine.

Connect the ribbon cable header end to J1 on the DTC-1200. Connect the DB9 connector end to a PC with serial port running **TeraTerm**. Press the enter key to refresh and the main configuration screen should appears as shown below in Figure 2 above.

A variety of USB-to-RS232 converter cables are available for use with laptops and computers. If you do not have access to a RS-232 port on your computer, a reliable UBS-to-RS232 converter is most likely the easiest way to establish communication with the DTC-1200.

2.5 Tape Tension Sensor Adjustment

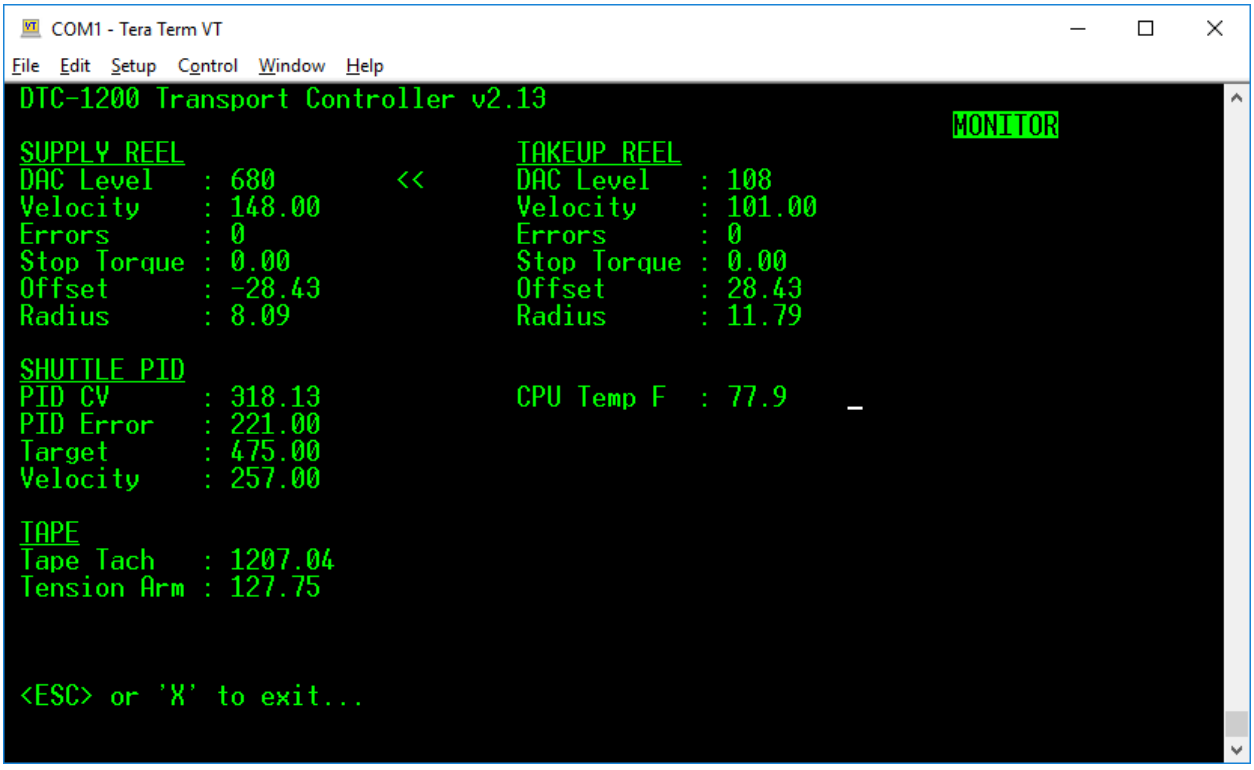
The MM-1200 tape tension sensor arm (located on the supply reel side of the machine) contains an optical sensor that uses two photo cells and a light bulb to sense tape tension. Check that the light bulb in the tension sensor arm housing is fully illuminated with the machine powered up. The light bulb and photo cells must be in working order for use with the DTC-1200. The servo control loop continuously monitors this tension sensor in real-time. If the bulb does not light, replace the bulb and ensure that it illuminates properly when the machine is powered on. The tension sensor must work properly as the controller samples this value in the real-time servo loop to correct tape tension in the servo loop logic.

TTY Monitor mode must be used to monitor the tension sensor A/D value. Navigate to the TTY main menu screen as shown in Figure 2 and select the monitor menu item 11 to enable and view the monitor mode screen. Monitor mode updates the screen every second as shown below in Figure 3 until the ESC key is pressed. Pressing the ESC key exits any menu or exits the monitor mode.

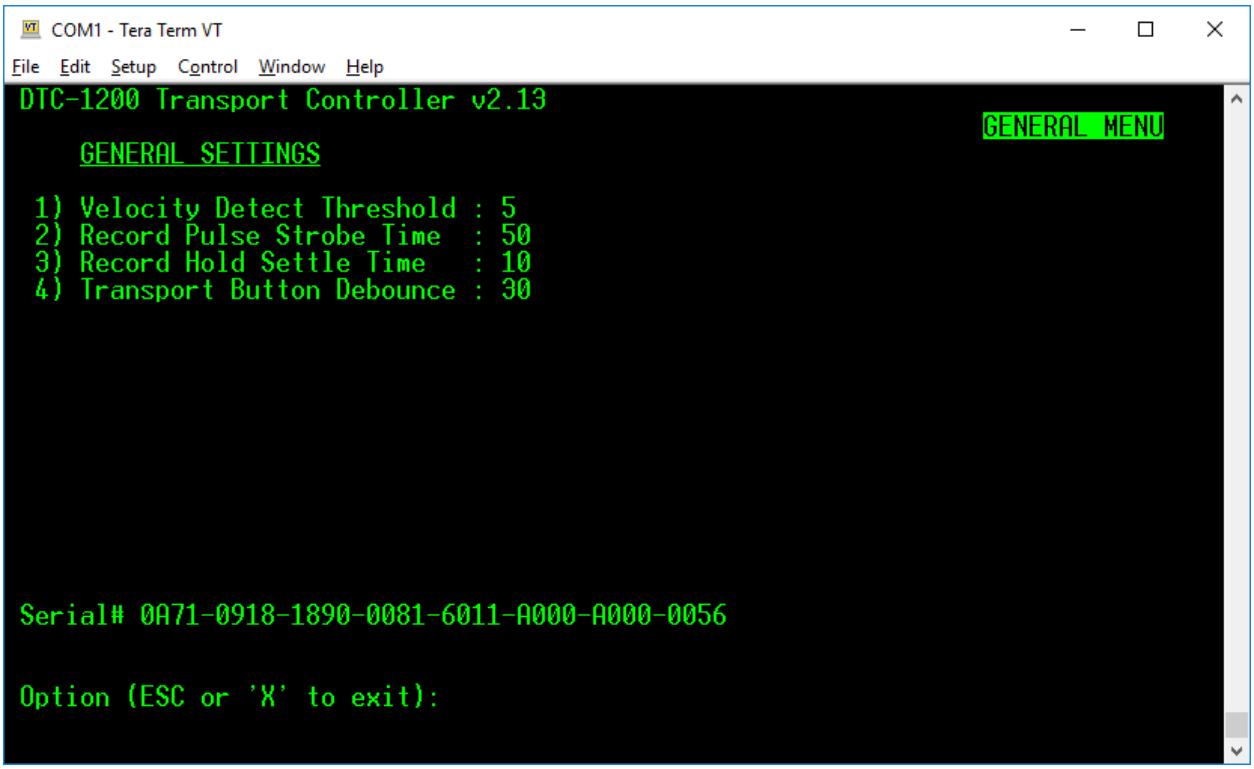
2.6 Adjusting the Tension Gain Trimmer

Move the tension sensor arm by hand and note the ***Tension Arm*** reading as shown in Figure 3 under the ***TAPE*** heading screen section. Set the transport to halt mode (disengage right hand tape arm) and remove tape from the tape tension sensor arm. Make sure nothing is touching the tape tension sensor arm and adjust R85 until the ***Tension Arm*** value reads 400 as closely as possible. Push the tape tension arm by hand all the way forward and note the tension value should reach zero at the maximum forward limit position. Likewise, the tension value should measure around 450-500 or higher when pulled back to the maximum travel limit.

Figure 3 - Monitor Mode Screen

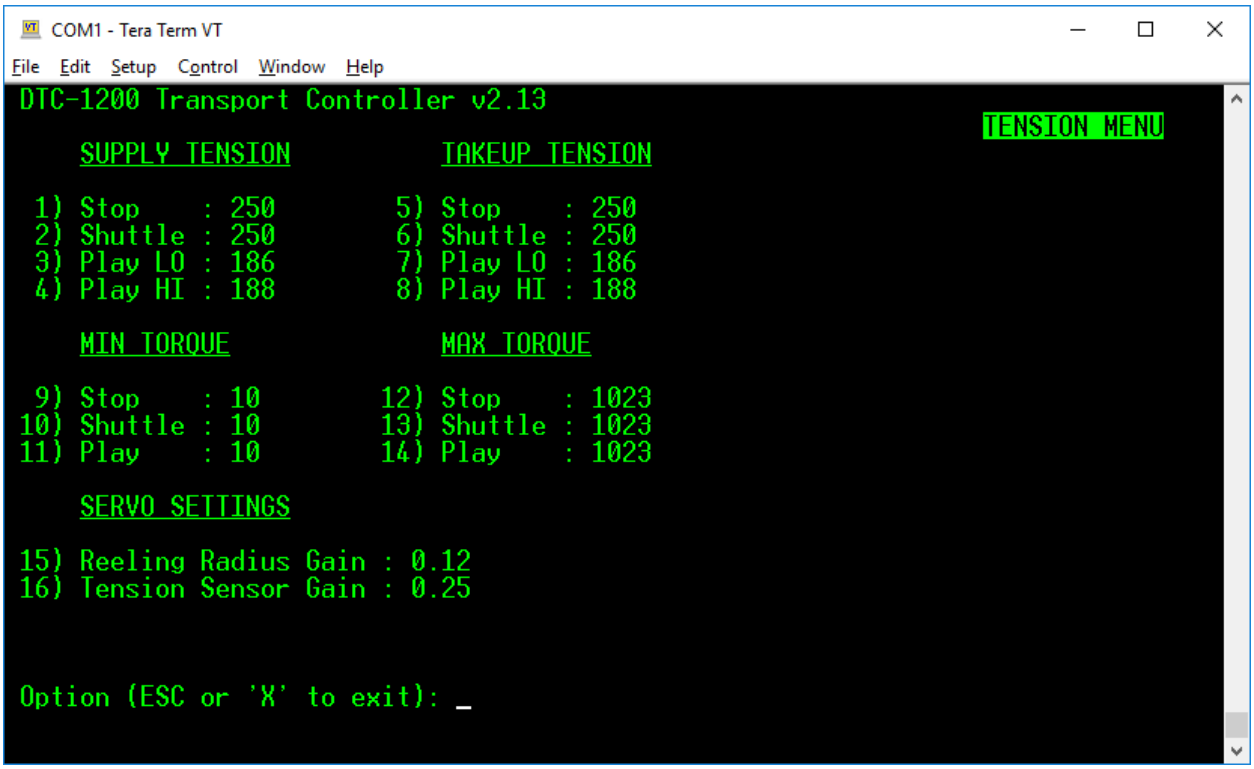


2.7 General Settings Menu



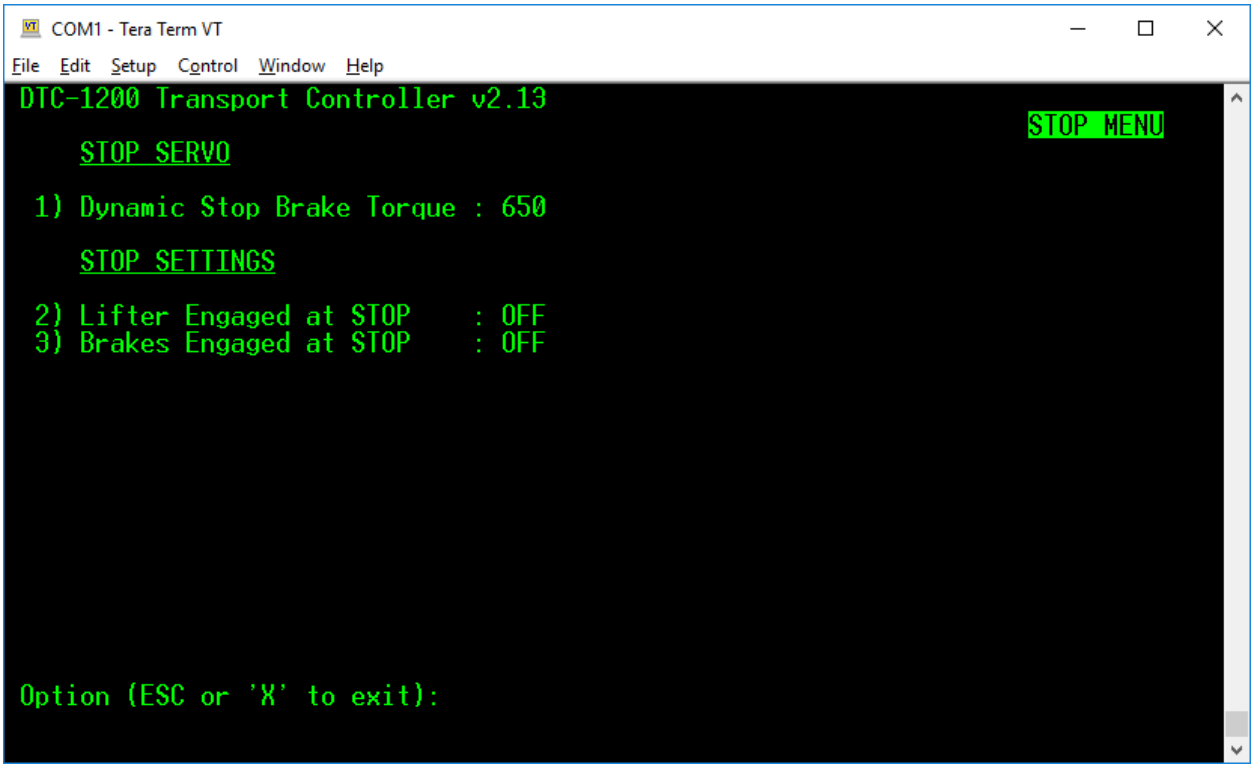
GENERAL MENU SETTINGS	
OPTION	**DESCRIPTION**
1	The velocity detect threshold sets the minimum number of tach counts from the reels to consider velocity detected. In general, this value should not require changing from the default value.
2	The record pulse strobe time determines the length of the pulse that triggers the relays on the audio cards to switch into record and hold. If channels fail to enter record, this parameter may be too small.
3	The record hold settle adds a small settling delay after the record hold latch signal prior record latch pulse signal. The record hold line keeps the record relays energized until released. The record pulse strobe signal follows, when record is enabled, which generates the pulse to energize any channels with record enabled. If channels fail to enter record, this parameter may be too small.
4	The transport button de-bounce time specifies the minimum amount of time a button must be pressed to be considered a valid button press. Button behavior will become erratic if this parameter is set too short. Button response will be sluggish if the de-bounce time is too long. In general, this parameter should not require changing from the default value.

2.8 Tension Settings Menu



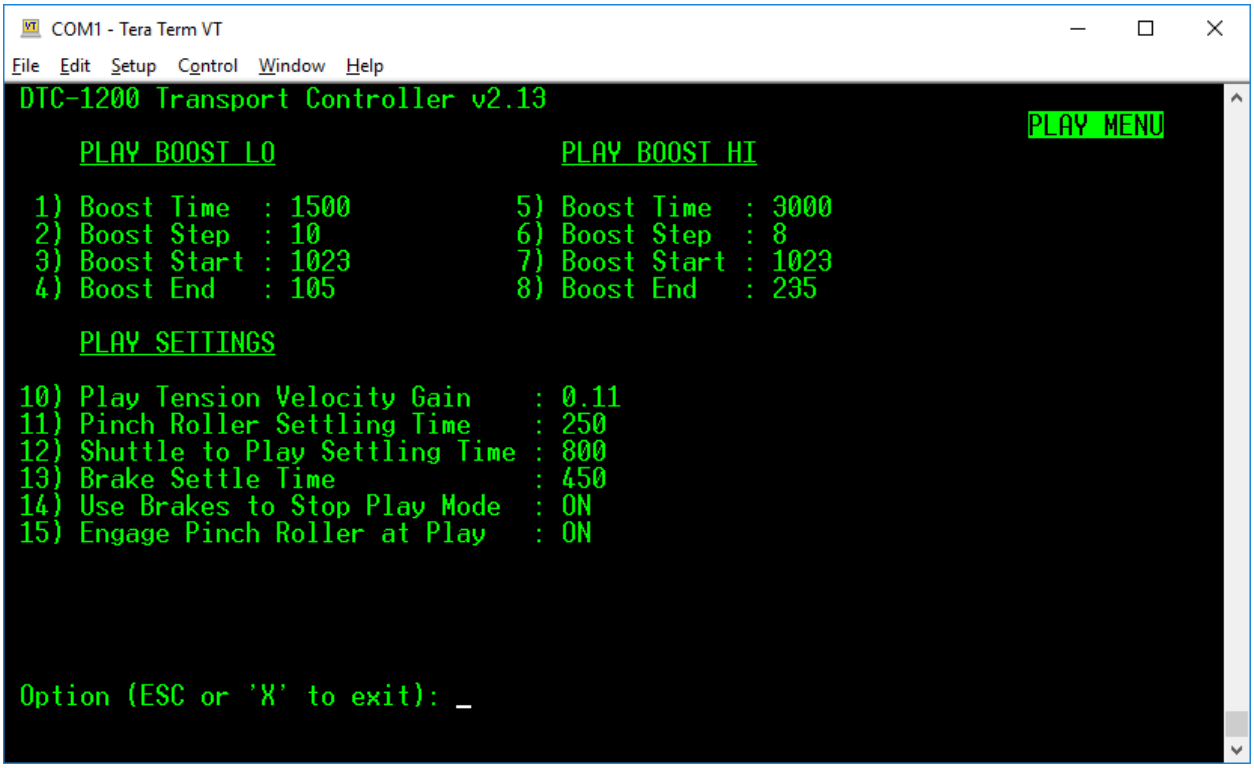
TENSION MENU SETTINGS	
OPTION	**DESCRIPTION**
1 & 5	The stop tension sets the base stop mode tension level.
2 & 6	The shuttle tension sets the base shuttle mode tension level.
3 & 7	The play tension sets the base play mode tension level.
4 & 8	The play tension sets the base play mode tension level.
9 & 12	The stop torque sets the minimum & maximum torque level in stop mode.
10&13	The shuttle torque sets the minimum & maximum torque level in shuttle mode.
11 & 14	The play torque sets the minimum & maximum torque level in play mode.
15	The reeling radius gain defines the amount torque to apply to offset the changing reel radius as the tape moves. Since the reel radius is constantly changing as the reels turn, this parameter defines how much offset (gain) torque to apply to compensate for the reel radius. If tape creeps in stop mode at either end of the reels, adjust this parameter up or down to compensate.
16	The tension sensor gain defines how much of the tensor sensor gets summed into the servo loop control. Higher values increase the amount of torque reaction in the servo loop and will cause greater changes in torque as the tension sensor arm moves.

2.9 Stop Settings Menu



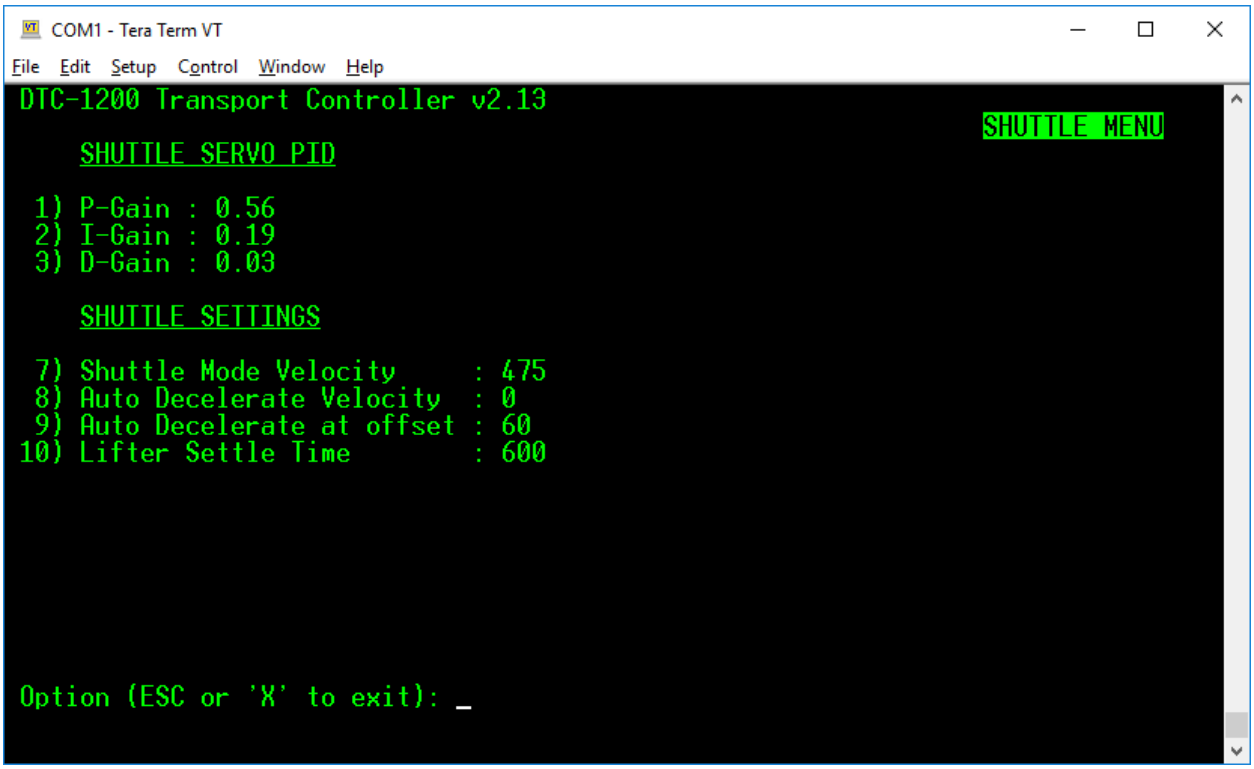
STOP MENU SETTINGS	
OPTION	**DESCRIPTION**
1	The dynamic stop brake torque parameter defines the maximum amount of torque that the controller can apply during servo loop dynamic braking mode. Dynamic braking applies opposing torque gently at first, then as the reels slow it applies greater and greater torque until all motion ceases. The initial dynamic braking force is applied at slower rate the faster the reels are turn, then the torque rises sharply as velocity decrease to halt reel motion.
2	The tape lifters normally release when the transport brings tape to a stop. This option may be used to keep the lifters engaged, even in stop mode after shuttling. Generally, this feature should be set to OFF.
3	The DTC-1200 normally releases the breaks in stop mode when exiting play mode so the reels can spin freely by hand. The servo loop control keeps tape balanced such that the brakes are not needed with tape stopped.

2.10 Play Menu Settings



PLAY MENU SETTINGS	
OPTION	**DESCRIPTION**
1 & 5	Play boost time specifies the maximum amount of time to apply play boost when entering play mode.
2 & 6	Boost step specifies the increment amount to decrease boost torque during play boost. Initially the play boost starts at full torque, then decreases rapidly as tape comes up to speed.
3 & 7	The boost start specifies the maximum amount of torque boost to apply initially when entering play mode. Generally, this parameter should be set to 1023 for maximum torque.
4 & 8	Boost end specifies the tape speed at which torque boost should cease being applied. In general, the default values should be used.
10	Play tension velocity gain defines the ratio of how much tension is applied to the tape reels during play mode.
11	Pinch roller settling time defines a time delay after the pinch roller is engaged to allow for mechanical settling before any new mode change begins.
12	Shuttle-to-play settling time specifies a time delay to wait before entering play mode anytime the machine changes from shuttle to play mode. This provides a short delay when shuttle mode stops prior to entering play mode.
13	Brake settling time specifies a small delay to apply any time the transport releases the brakes. This allows the servo loop time to stabilize upon releasing the brakes.
14	Use brakes to stop play mode enables the brakes to stop play mode quickly. The servo loop will stop play mode also, but some audio drag will be noticed during stop mode.
15	Engage pinch roller at play should normally be left on. This parameter is used for debugging or diagnostic purposes only.

2.11 Shuttle Menu Settings

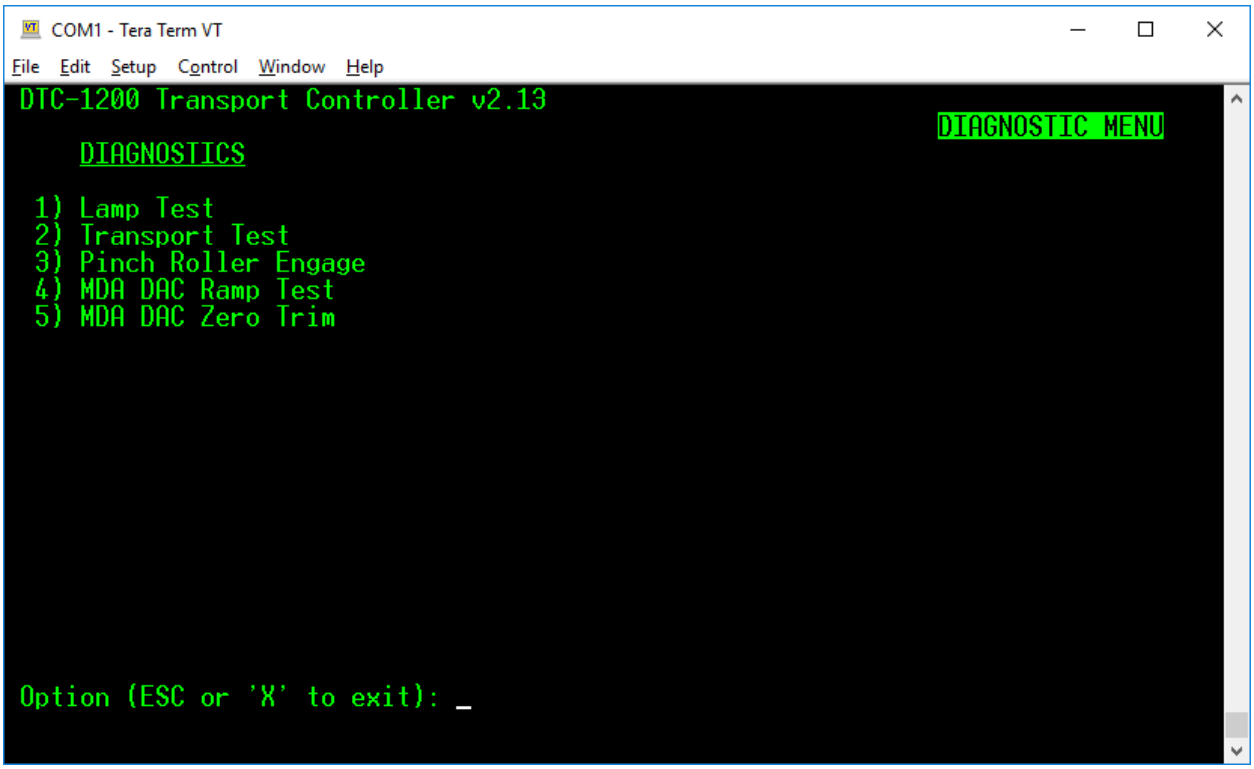


SHUTTLE MENU SETTINGS	
OPTION	**DESCRIPTION**
1	PID algorithm – proportional input gain
2	PID algorithm – integral input gain
3	PID algorithm – derivative input gain
7	Shuttle mode velocity specifies that maximum velocity for tape shuttle. Generally, the maximum shuttle speed that the transport can reach will be around 450-475. This parameter can be set lower if you prefer slower tape shuttling. Do not set this to a value higher than the transport can achieve or the PID algorithm will not work properly.
8	The auto decelerate velocity specifies the velocity the machine should slow to during shuttle mode as the tape nears the end of the reels. If set to non-zero, the machine will slow to this value once the auto decelerate at offset value is reached.
9	The auto decelerate offset specifies the reeling radius offset point at which the machine should slow velocity during shuttle mode as the tape nears the end of the reels. Once the reeling radius offset reaches this value, the machine will slow to the velocity specified in the auto decelerate velocity parameter (i.e. 50, 100, etc.).
10	The lifter settling time specifies a time delay to wait after the lifters release. This is to allow the transport tensions to settle after the lifters release.

The PID algorithm is a complex subject that we'll not cover here. You'll find a wealth information is available for further reading on the internet. The following gives a good overview and description of the PID:

https://en.wikipedia.org/wiki/PID_controller

2.12 Diagnostic Menu Settings



DIAGNOSTIC MENU SETTINGS	
OPTION	**DESCRIPTION**
1	This option enables the transport lamp test mode and sequentially lights each lamp individually to verify indication.
2	This function executes a basic transport test by sequentially toggling the solenoids for brakes, lifters and capstan to confirm operation.
3	This function engages the pinch roller solenoid with the transport stopped. This is useful when adjusting the pinch roller tension spring.
4	The MDA ramp test allows single stepping the DAC's that drive the MDA's to each motor. This is used to confirm operation and allows measuring the torque of each motor.
5	The MDA zero trim steps through a series of "zero torque" reference points for MDA offset alignment purposes. In general, torque should just start to develop on the reel motor with the DAC set at 100 level. The DAC's are 10-bit DAC's and the levels range from zero to 1023.

3 FIRMWARE UPGRADE via BOOTLOADER

All DTC-1200 controller boards ship with bootloader firmware installed in the first 4K of flash memory space at address 0x0000. In the DTC-1200 design, the first 4kB of code space is reserved exclusively for the bootloader firmware. The main transport controller firmware resides just after the 4kB bootloader area at address 0x1000 (4096).

The computer used for downloading must have a standard RS-232 port available. Most computer motherboards have a single RS-232 connector header on the board. Refer to your computer motherboard documentation for RS-232 port information. You may also use a RS-232-to-USB serial converter if your PC or laptop does not have a RS-232 port available.

The processor always begins execution with the bootloader anytime a system reset is issued or at power up. The bootloader checks for presence of the transport controller firmware by doing a blank check of the application code space. If no code is found, it then enters in bootloader download state waiting for data packets and commands via the COM1 serial port on the DTC-1200 board.

3.1 Enabling the bootloader

BOOT jumper JP2 on the DTC board is used to manually enable the bootloader at system reset time. The jumper should only be installed to activate the boot loader, otherwise is should remain in the un-jumped position.

Figure 4 - Bootloader Jumper

Install jumper JP2 and press the RESET button S2 located next to the TAPE END connector J5. You can also power down the machine and re-power the machine to enter bootloader mode.

The bootloader indicates ready state by turning on all three of the status LED's as shown in Figure 4 above. The transport status LED's should all be off and the DTC-1200 board is now ready to accept downloading via the COM1 serial port at 19,200 BAUD.

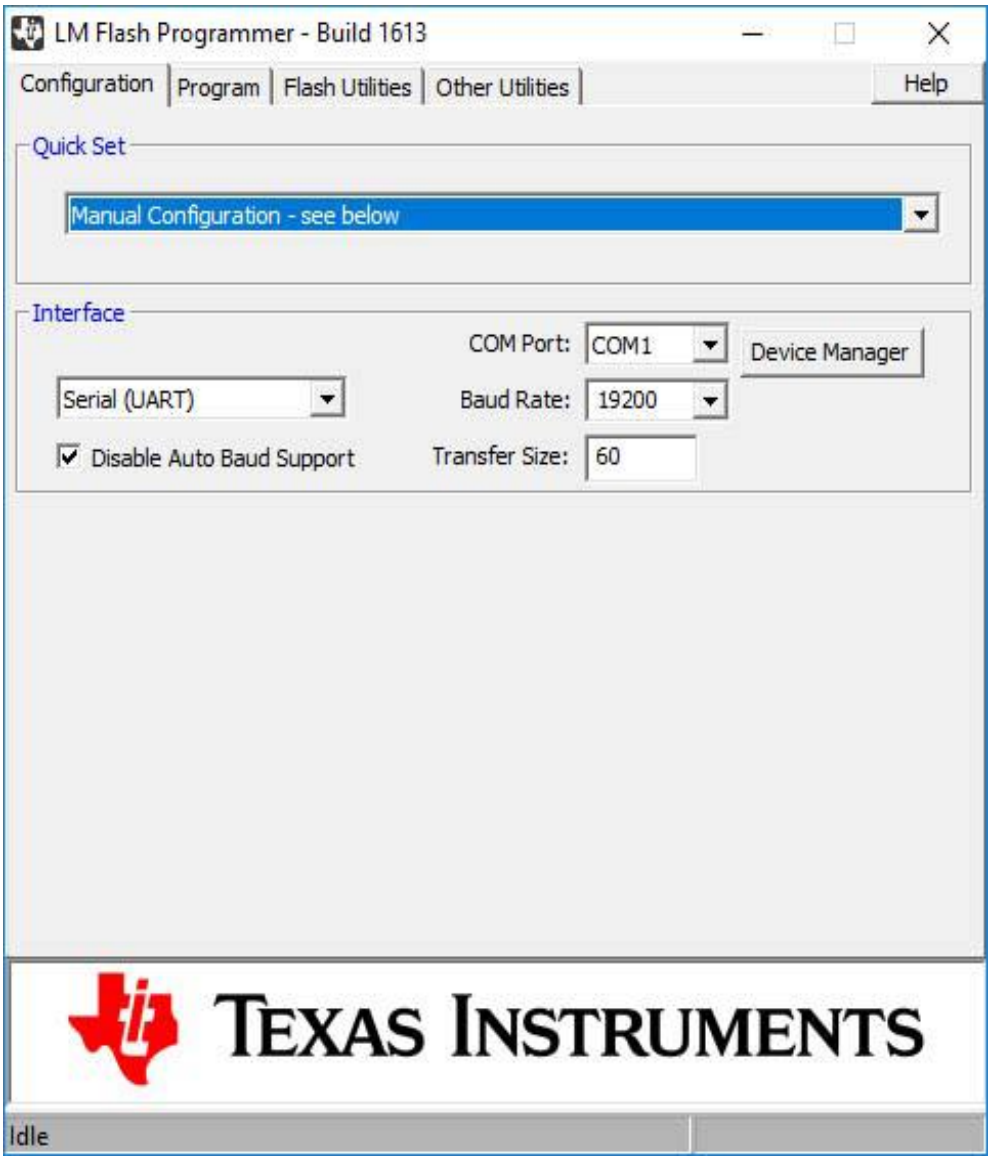
3.2 LMFLASH Installation and Serial Port Configuration

LMFLASH is a free application from Texas Instruments that allows downloading firmware updates to the DTC-1200 via the COM1 RS-232 serial port on the DTC-1200. You must create an account at ti.com to download this utility. The LMFLASH available on the RTZ Audio website at http://rtzaudio.com/pages/MM1200.html.

Make sure no other applications are using the serial port (usually COM1) prior starting LMFLASH. You must close any instances of TeraTerm prior to using LMFLASH or the COM1 serial port will be locked.

Start the LMFLASH application and set the serial port settings as shown below on the configuration tab. The serial port must be configured for 19,200 BAUD (e.g. 19200,N,8,1). Be sure to disable the **Auto Baud Support** option as shown below in Figure 5.

Figure 5 - LMFLASH Serial Port Settings

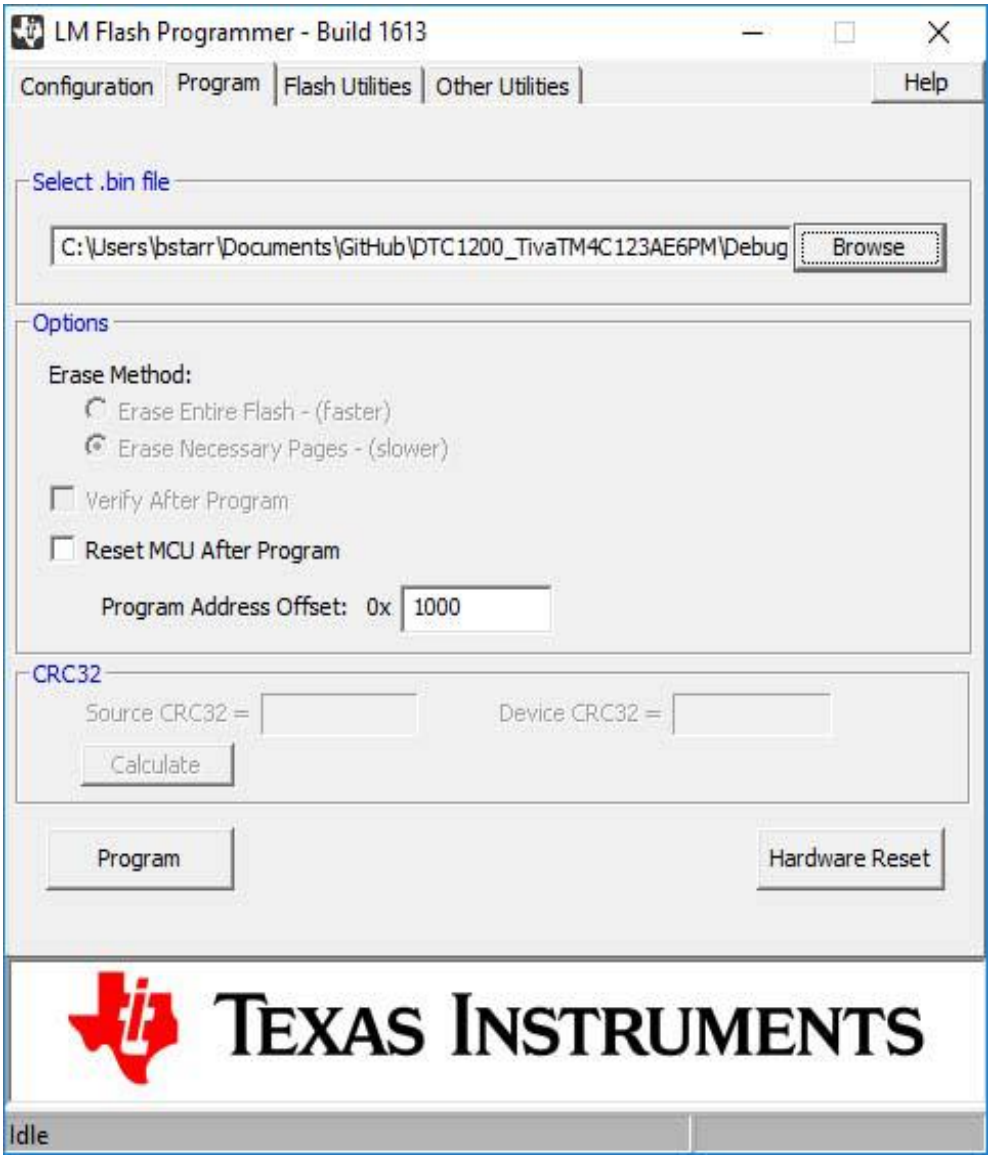


3.3 Select Binary Image and Program Address

Next select the new DTC-1200 binary firmware image to be flashed on the board. The latest binary firmware images are available at our rtzaudio.com website. The DTC-1200 binary image will generally be named DTC1200_TivaTM4C123AE6PM.bin and should be placed on your computer. You may want to make a backup of this file in the event it's needed in the future for some reason.

Warning, you must set "Program Address Offset" to 1000 as shown below. Failure to set the program address to 1000 may overwrite the bootloader. In this case, a JTAG programmer must be used to re-flash the bootloader into the processor.

Figure 6 - Binary File Image Selection



3.4 Downloading the Binary Image

Once the binary image and program address is set to 1000, the LMFLASH is ready to begin downloading. First, check that the DTC-1200 BOOT jumper is set, reset the DTC and make sure that the STAT1, STAT2 and STAT3 are on solid indicating the bootloader is ready to receive. Then, click the Program button to begin downloading the firmware.

Once programming begins, the STAT1 and STAT3 will turn off and the STAT2 will blink as each package of data is received and written to flash. The status bar of the LMFLASH application shows the progress of the download/flash operation. Once the process completes, remove the BOOT jumper on the DTC card and restart the card via the RESET button or power cycle to begin executing the new firmware.

If the download fails to start, check that the serial port is connected and set correctly. The LMFLASH application serial port baud rate must be set to 19,200 baud in order to work with the bootloader.

Figure 7 - Downloading Binary Image