DTC-1200

DIGITAL TRANSPORT CONTROLLER

AMPEX MM-1200 UPGRADE

Owner's Manual and User Guide

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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.

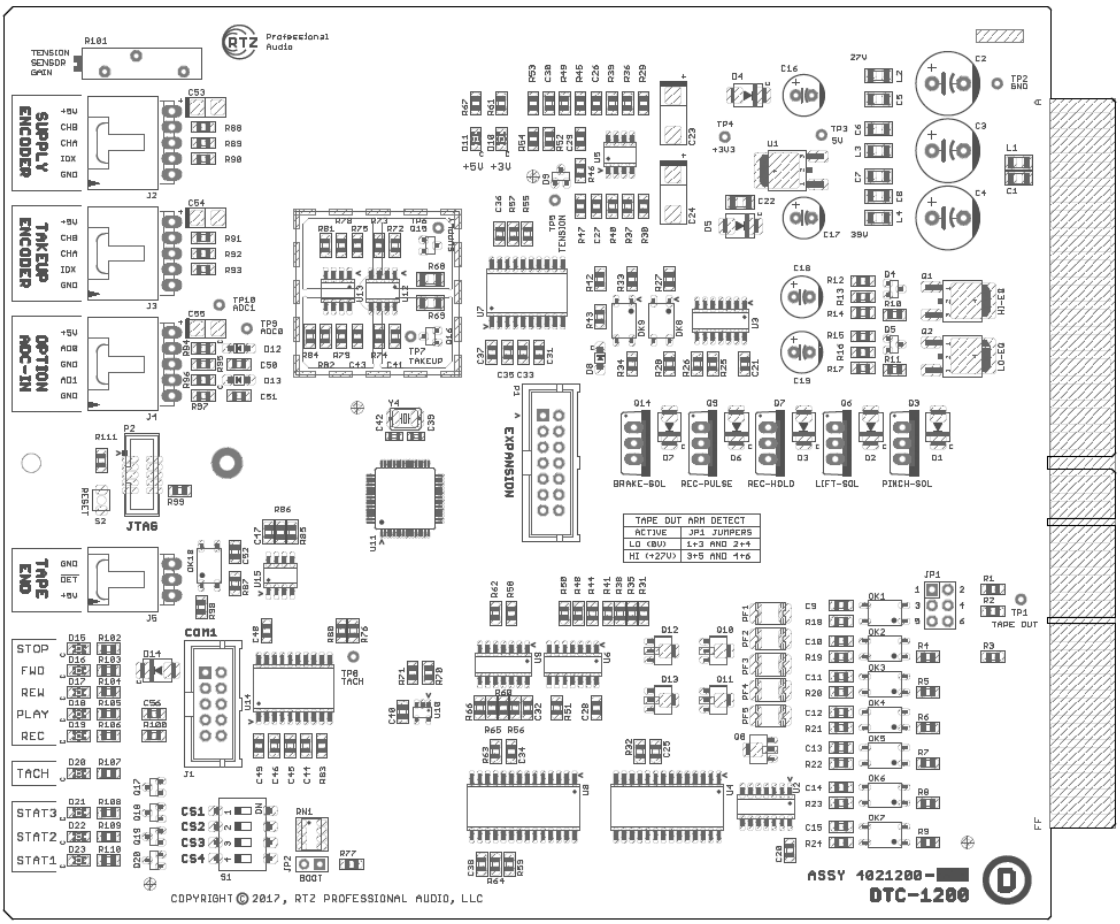
2.1 Initial 5V Power Check

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.

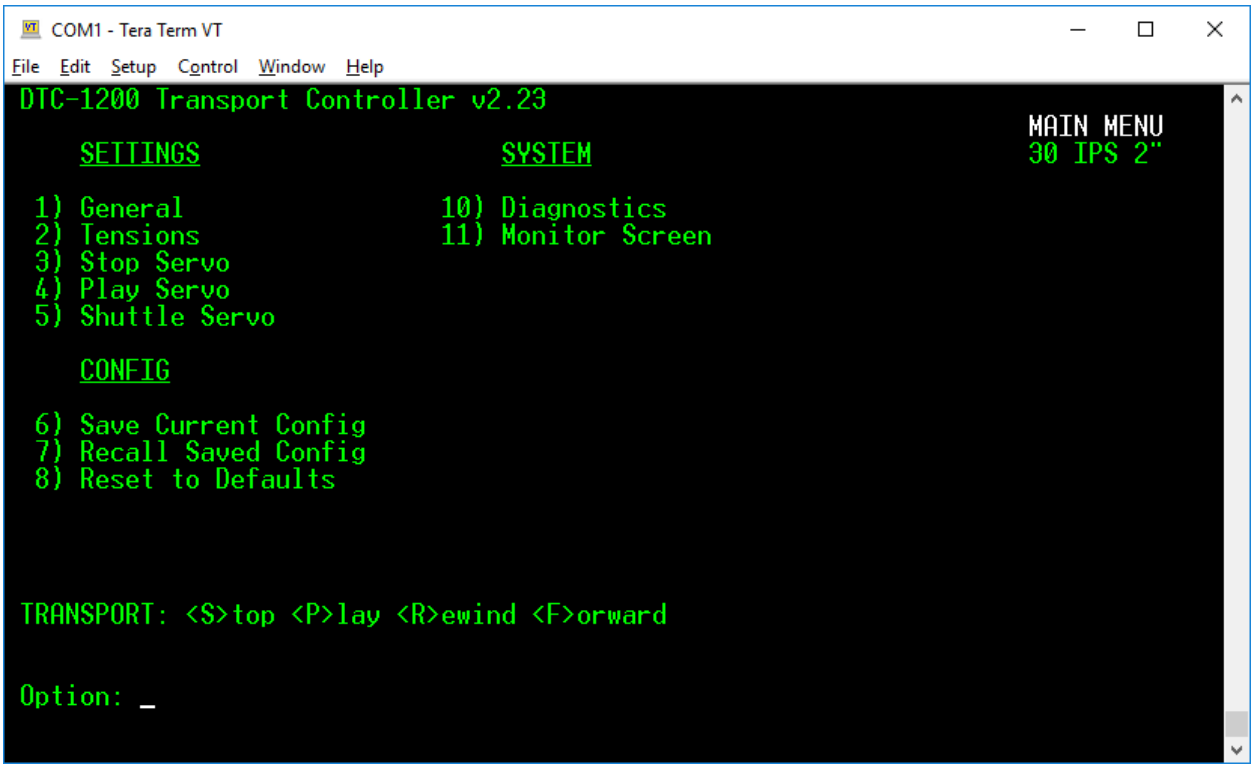
Table 2- DIP Switch Configuration

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 baud in the default OFF position. The baud rate is set to high speed mode at 15,200 baud 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 FWD/REW button will flash when a STOP mode is pending before executing the next command. The buttons will not flash with CS2 in the ON position.
CS3	(function currently undefined - reserved)
CS4	(function currently undefined - reserved)

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

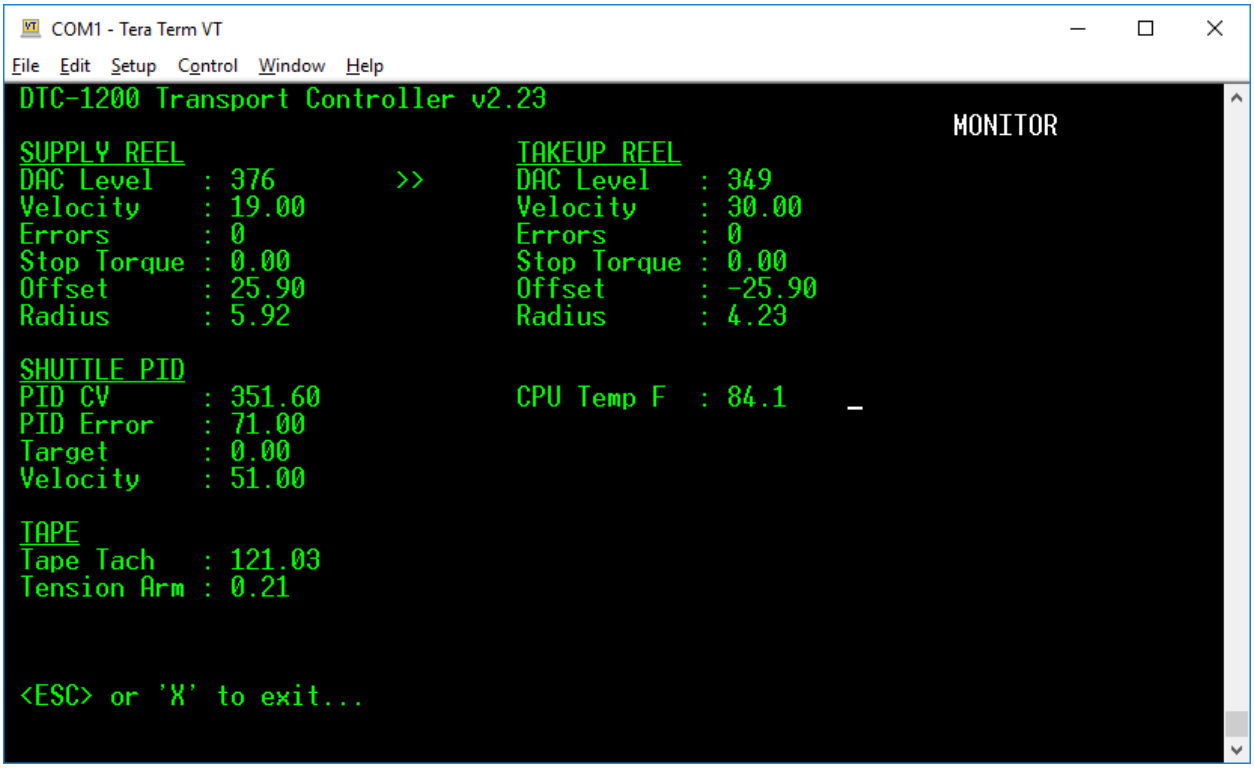
The MM-1200 tape tension sensor arm (located on the supply reel side of the machine) contains an optical sensor that uses two photo cells and a light bulb to sense tape tension. Check that the light bulb in the tension sensor arm housing is fully illuminated with the machine powered up. The light bulb 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.

2.6 Adjusting the Tension Sensor Gain Trimmer

Trimmer R85, located on the top right-hand edge of the DTC board, is a 15-turn type that adjusts the tension sensor amplifier gain. The tension sensor gain must be calibrated with 9 ounces of pull back force such that the tension sensor arm aligns with the calibration mark on the deck. We recommend using a Wagner Instruments model FDK16 pull force gauge and a piece of string looped around the arm. You might also use a small block or other object to hold the tension arm so it is aligned on the 9 oz tension mark on the transport deck if you don't have access to a force dial gauge.

Remove tape from the tape path, power up the machine, enter the TeraTerm TTY terminal configuration screen and select the **MONITOR** screen from the **MAIN** menu to view the DTC real time system data. Note the ***Tension Arm*** reading as shown in Figure 3 below. Adjust trimmer R85 until the reading is close to zero as possible with the tension arm held at the 9 oz calibration mark. The readings will always be changing due to the analog nature of the circuit and optical components, but the goal is to keep it closely centered around zero at the calibration mark. The sensor should read around zero at the 9 oz calibration mark and approximately +/-200 units when pushed or pulled to either extreme.

Figure 3 - Monitor Mode Screen



2.7 Setting the Tape Tension Levels

The following steps describe how to set the tension levels on the machine for various modes of operation. Please refer the various configuration parameter descriptions in the TENSIONS MENU for additional information on these parameters.

Make sure the tape tension sensor is calibrated properly as described in the previous section before setting the tape takeup and supply tension levels. The tape tensions levels and tension sensor gain settings form a feedback loop and creates a balancing act between the tension sensor and reel motor tape tension levels.

1. Spool a full roll of tape to mid position on the transport with equal pack on each reel. You can also observe the takeup and supply reel “offset” values shown on the monitor screen are both zero when tape pack is equal on both reels.

2. Measure the tape tension levels on the takeup and supply reel using a Tentelometer to measure the stop mode tension with equal pack on both reels. Select the TENSIONS MENU from the configuration screen and adjust the stop mode tension levels on each side to read 6.5 to 7 ounces of force on each side.

3. Repeat adjustment of the tension sensor gain trimmer once base tension levels have been established. It’s important to note that the tension sensor calibration and overall tape tension values interact with each other and balances tensions between tension sensor arm and reel motors when adjusted properly.

4. Once the tension sensor gain and stop mode tape tension levels are set and properly balanced, change the shuttle and play mode tension levels to match the stop mode values. The shuttle and stop mode tension levels are specified separately from stop mode and may be tweaked later as necessary to achieve the best tension performance in the various modes of operation.

5. Spool to the start of the tape and check that tension levels are still within 0.5oz on both reels with the tape stopped. If not the “Reeling Radius Offset” value on the Tensions Menu may require adjusting. This value determines how much “correction” is applied to offset the varying tape pack diameter as the tape position changes with tape moving.

6. Enter PLAY mode and check that the takeup and supply tensions are within 0.5 oz also. If not, adjust the play mode tensions either up or down to achieve correct play mode tensions.

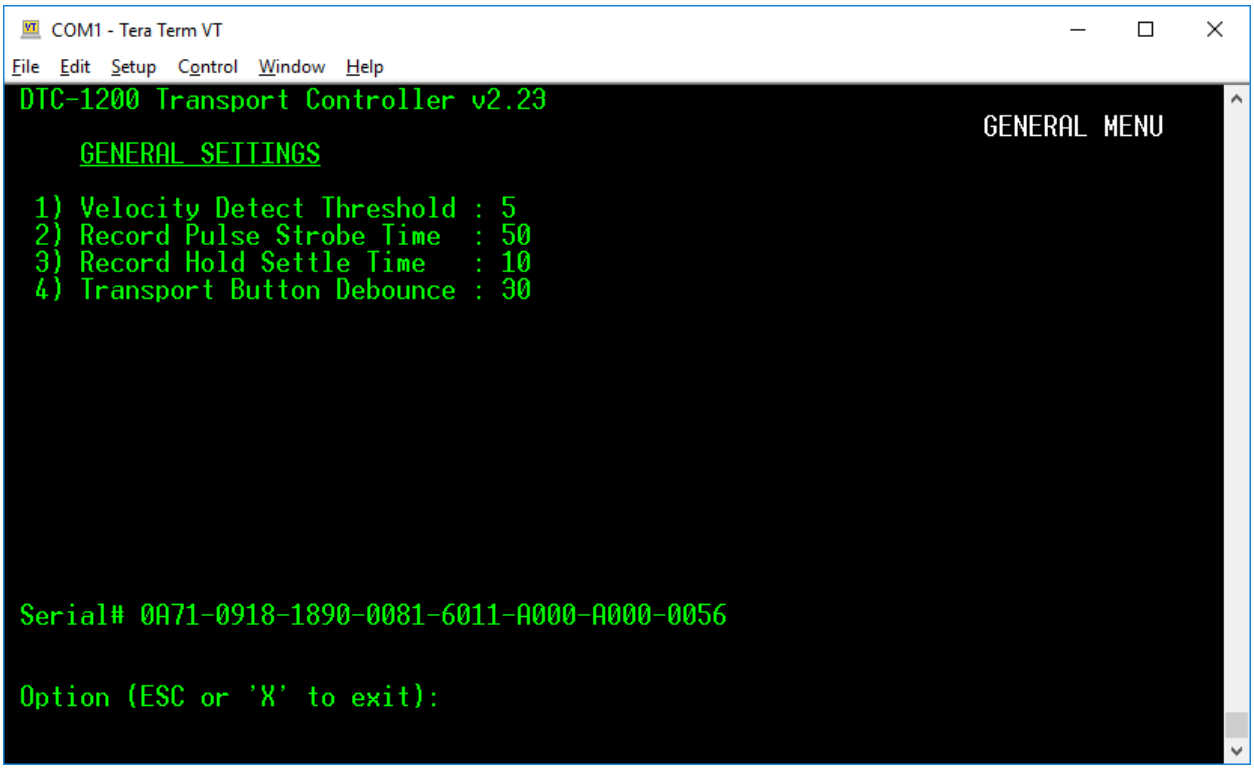
Once all tape tensions are set, the machine should be ready for use and no general regular adjustments should be required.

2.8 Verify Tape Roller Tachometer Operation

The tape roller should send a stream of pulses to the DTC when the tape counter roller moves. Note the TACH LED on the DTC gives visual indication of the tachometer pulses. The tachometer signal is routed from the timer/counter card to the DTC card as part of the required upgrade modifications and is required for proper PLAY mode operation. The tachometer signal allows the DTC to measure the tape path speed during operation and is also used during PLAY boost to calculate tape speed for torque ramping.

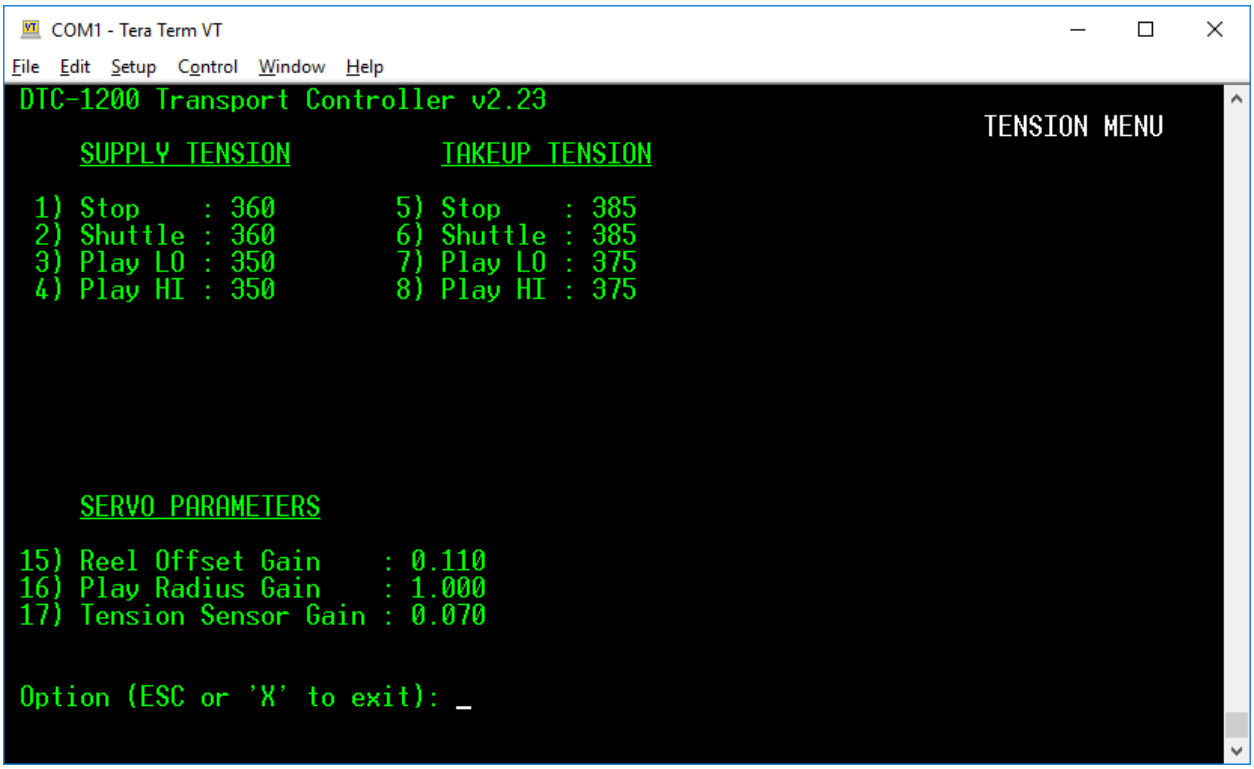
Confirm the DTC is measuring the tachometer pulses correctly by viewing the Tape Tach level on the Monitor screen. Slowly move the tape roller by hand and observe that the TACH LED on the DTC card is blinking. The tape tachometer should read around 120 in play mode at 30 IPS. You may also connect an oscilloscope to the TACH test point TP8 on the DTC card to monitor the tach pulses. If tach pulses are not present, check the tachometer wiring modifications as described in the DTC-1200 Installation Manual.

2.9 General Settings Menu



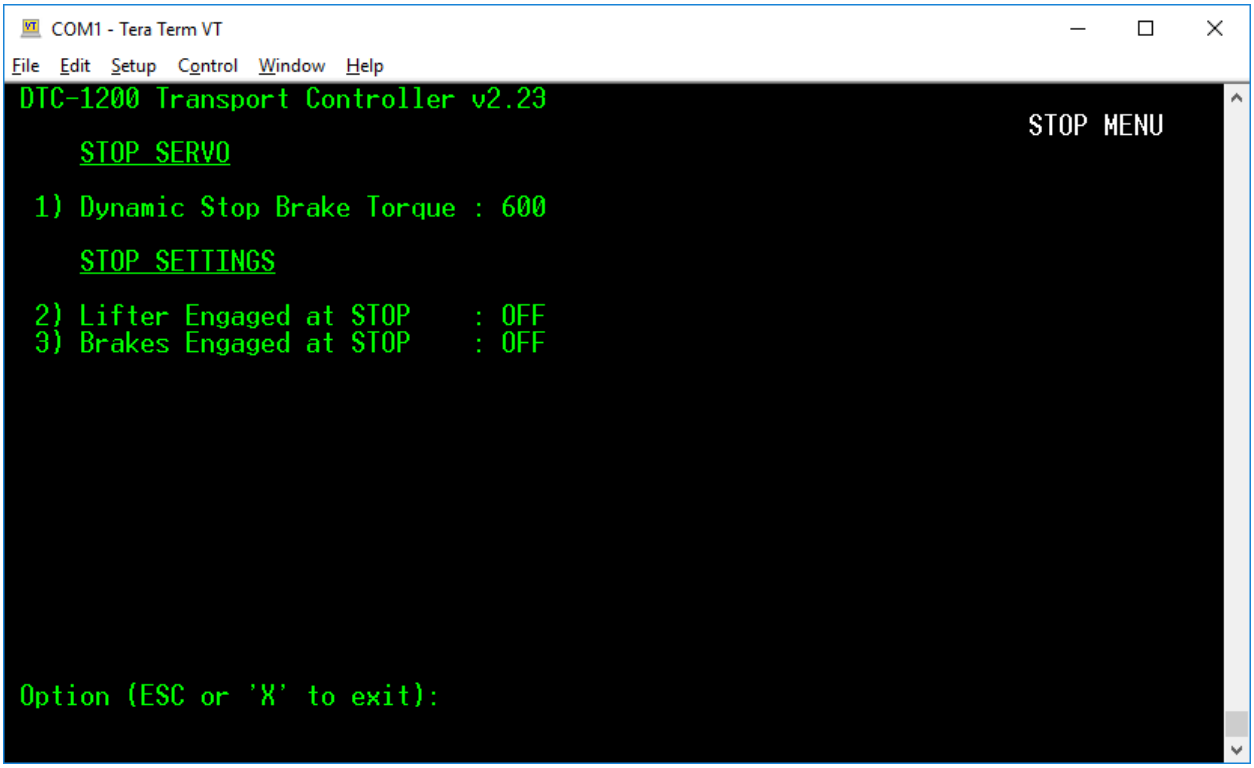
GENERAL MENU SETTINGS	
OPTION	**DESCRIPTION**
1	*Velocity Detect Threshold* sets the minimum number of tach counts from the reels to consider velocity detected. In general, this value should not require changing from the default value.
2	*Record Pulse Strobe Time* defines the length of the pulse that triggers the relays on the audio cards to switch into record and hold. If channels fail to enter record, this parameter may need to be increased. Machines with faster relays maybe able to reduce this value down to 25 or so to speed up the record enable strobe.
3	*Record Hold Settle Time* adds a small settling delay after the record hold latch signal is engaged, 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	*Transport Button Debounce* 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.

2.10 Tension Settings Menu



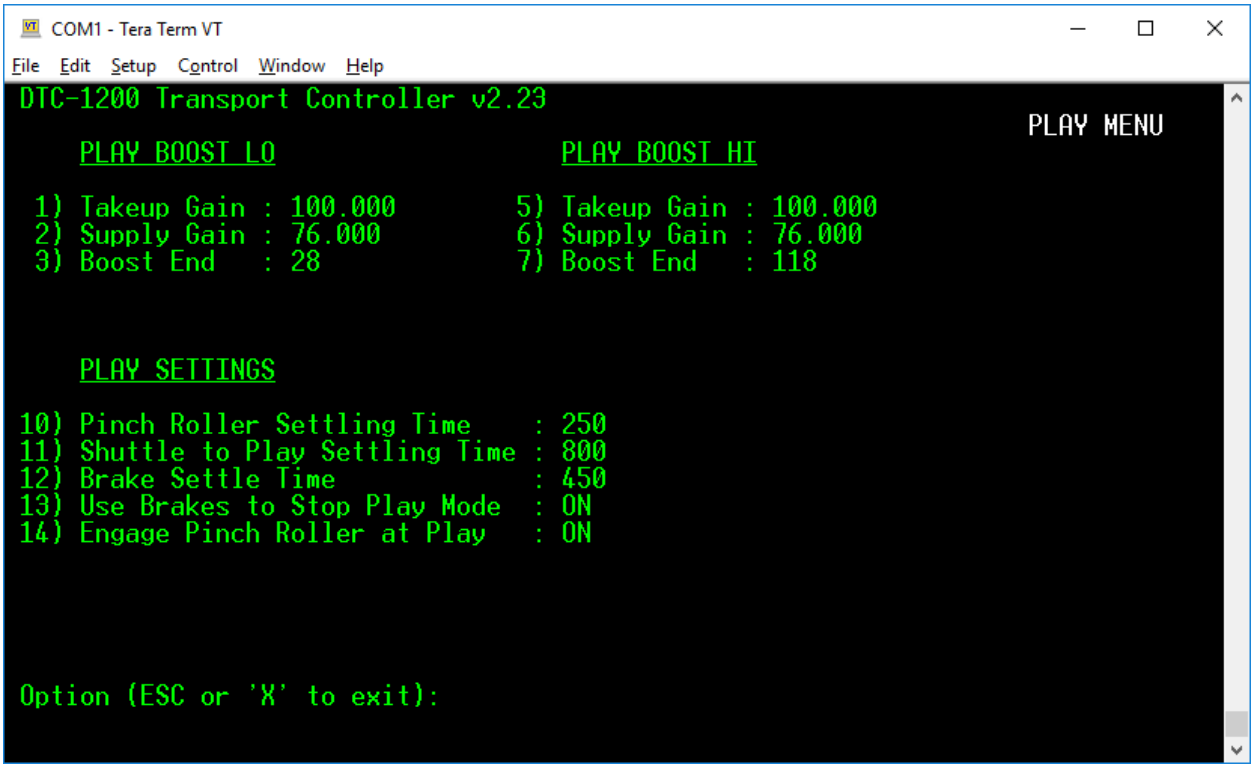
TENSION MENU SETTINGS	
OPTION	**DESCRIPTION**
1 & 5	*Stop* tension sets the base stop mode tension level.
2 & 6	*Shuttle* tension sets the base shuttle mode tension level.
3 & 7	*Play LO* sets the base play mode tension level for low tape speed.
4 & 8	*Play HI* sets the base play mode tension level for high tape speed.
15	*Reel Offset Gain* defines the amount torque needed 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 changing reel radius. If tape creeps in stop mode at either end of the reels, adjust this parameter up or down in small increments to compensate.
16	*Play Radius Gain* is used for play mode only. Currently this should be left at 1 unless directed by RTZ support to change otherwise.
17	*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.

2.11 Stop Servo Menu



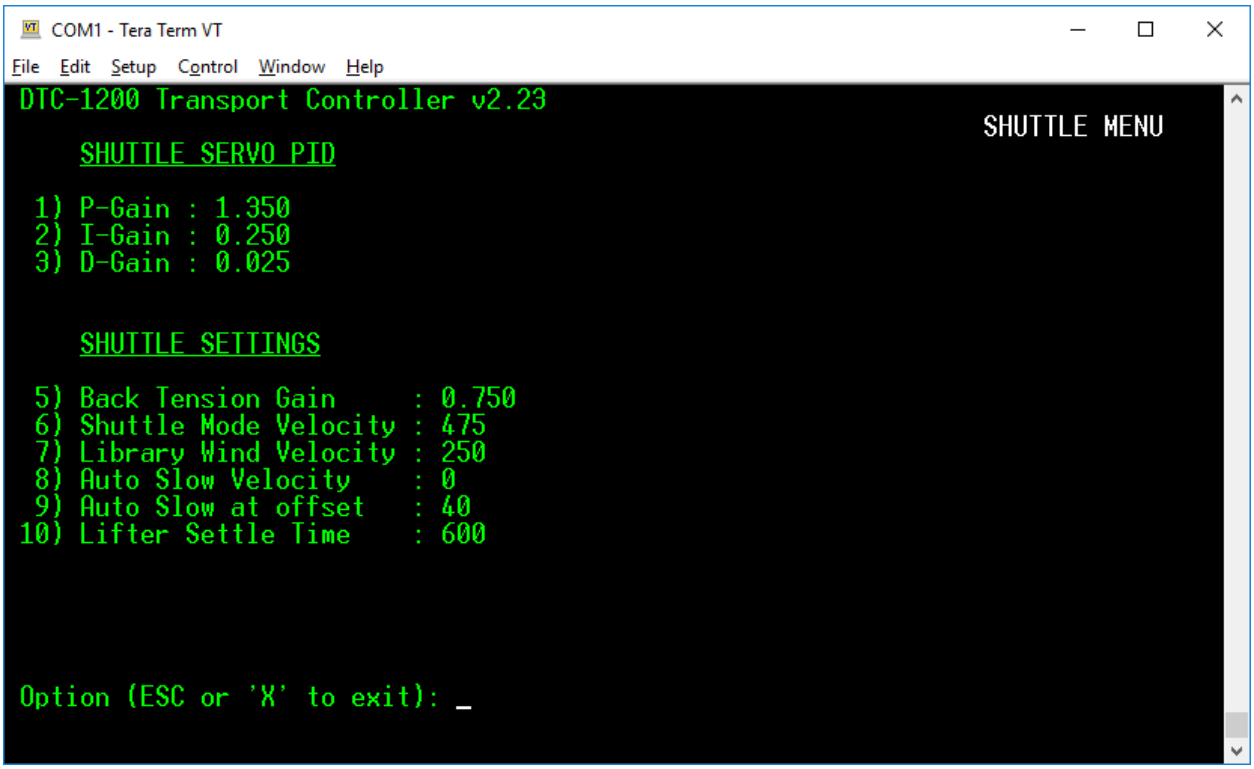
STOP MENU SETTINGS	
OPTION	**DESCRIPTION**
1	*Dynamic Stop Brake Torque* defines the maximum amount of torque that the controller can apply during servo loop dynamic braking mode. Dynamic braking applies opposing torque gently at first, then as the reels slow it applies greater and greater torque until all motion ceases. The initial dynamic braking force is applied at slower rate the faster the reels are turning, then the torque rises sharply as velocity decrease to halt reel motion quickly as possible while maintaining smooth tape tension.
2	*Lifter Engaged at STOP* defines the stop mode lifter behavior. 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	*Brakes Engaged at STOP* defines the stop mode brake behavior. The controller 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.

2.12 Play Menu Settings



PLAY MENU SETTINGS	
OPTION	**DESCRIPTION**
1 & 5	*Takeup Gain* specifies a constant factor used to calculate the torque during play boost phase. A higher value here will apply more takeup boost torque during play boost phase.
2 & 6	*Supply Gain* specifies a constant factor used to calculate the torque during play boost phase. A higher value here will apply more back tension torque during play boost.
3 & 7	*Boost End* specifies the tape tachometer speed at which torque boost phase should end. Note that the STAT3 LED is illuminated during play boost phase. Once the tape reaches the tape speed value specified by *Boost End*, the controller exits play boost mode. The STAT3 LED will remain lit to indicate play boost error if the controller is unable to reach the tape speed specified by *Boost End*.
10	*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.
11	*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.
12	*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.
13	*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.
14	*Engage Pinch Roller at Play* should normally be left on. This parameter is used for debugging or diagnostic purposes only.

2.13 Shuttle Menu Settings

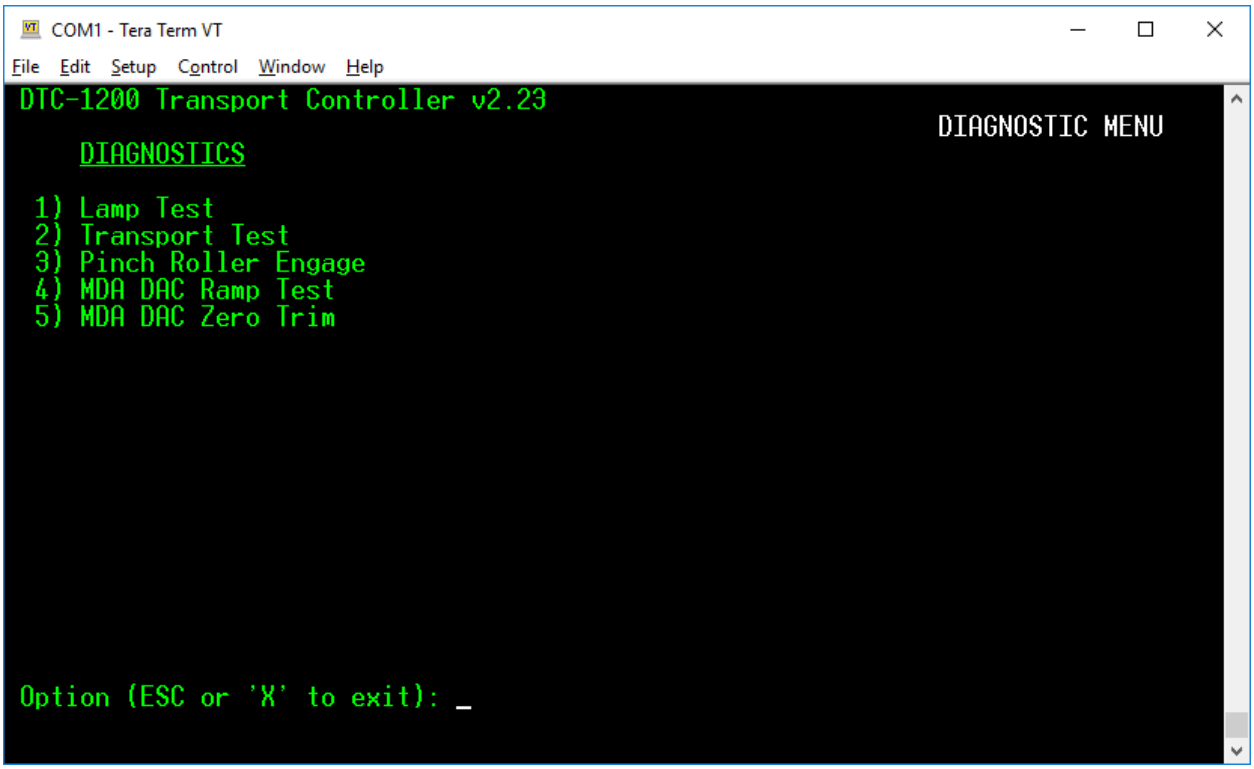


SHUTTLE MENU SETTINGS	
OPTION	**DESCRIPTION**
1	*P-Gain* defines the Proportional input gain for the shuttle velocity PID controller.
2	*I-Gain* defines the Integral input gain for the shuttle velocity PID controller.
3	*D-Gain* defines the Derivative input gain for the shuttle mode velocity control.
5	*Back Tension Gain* defines an additional compensation factor when shuttling at high speeds. If tension droops as speed increases, decrease this in small amounts.
6	*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.
7	*Library Wind Velocity* specifies the shuttle velocity to use in library wind mode. Library wind mode is enabled by holding the REC button and pressing FWD or the REW button.
8	*Auto Slow 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	*Auto Slow at 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	*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 not covered here. The following link gives a good overview and description of the PID:

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

2.14 Diagnostic Menu Settings



DIAGNOSTIC MENU SETTINGS	
OPTION	**DESCRIPTION**
1	*Lamp Test* executes the transport lamp test mode and sequentially lights each lamp individually to verify indication.
2	*Transport Test* executes a basic transport test by sequentially toggling the solenoids for brakes, lifters and capstan to confirm operation.
3	*Pinch Roller Engage* allows engaging the pinch roller solenoid with the transport in stop mode. This is useful when adjusting the pinch roller tension spring.
4	*MDA DAC 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	*MDA DAC 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.

NOTE

The RTZ Motor Drive Amplifier (MDA) is required for proper tension calibration and operation with the DTC-1200. Refer to the MDA Owner's Manual for complete instructions on balancing the MDA torque levels using the DTC Diagnostics and MDA calibration procedures.

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.

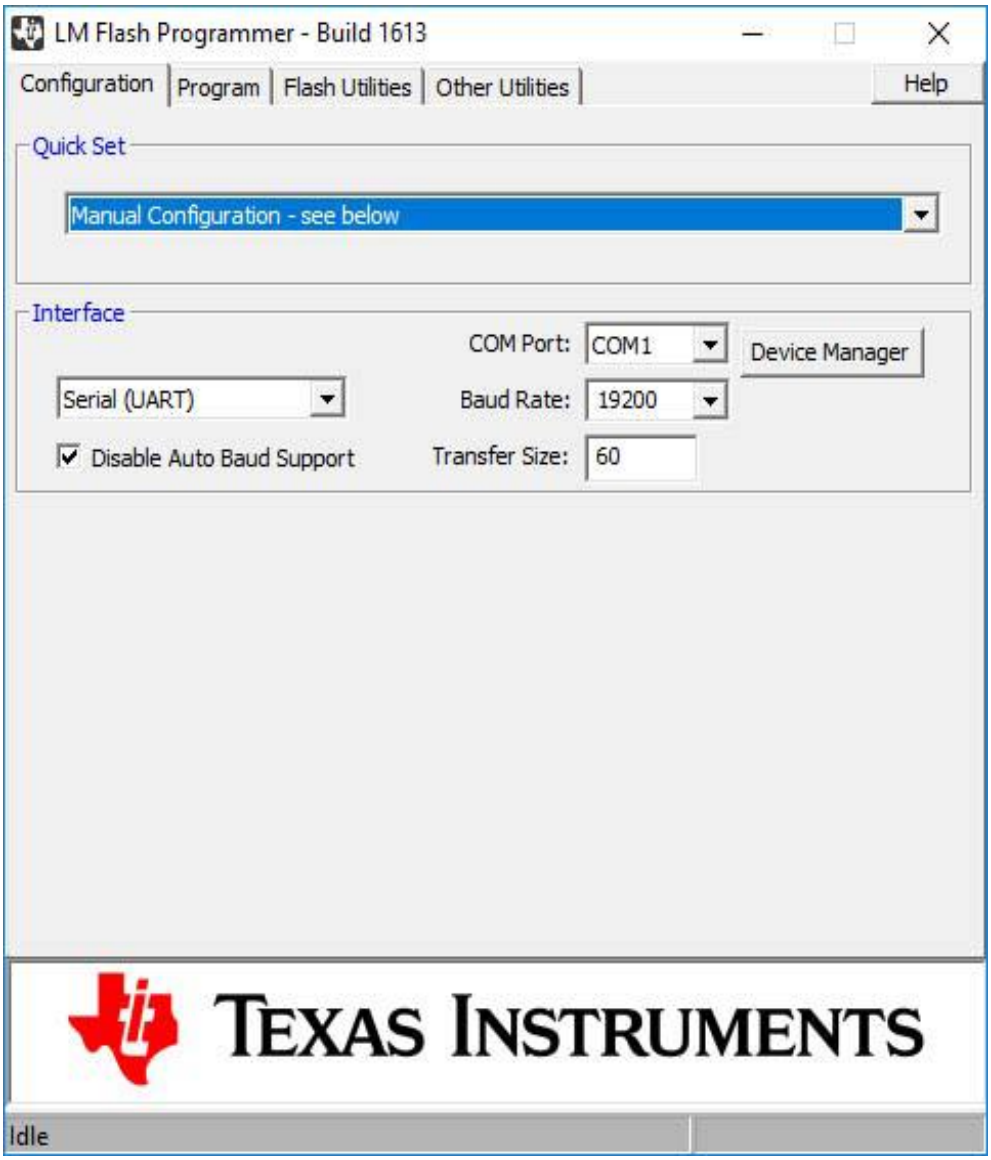
3.2 LMFLASH Installation and Serial Port Configuration

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

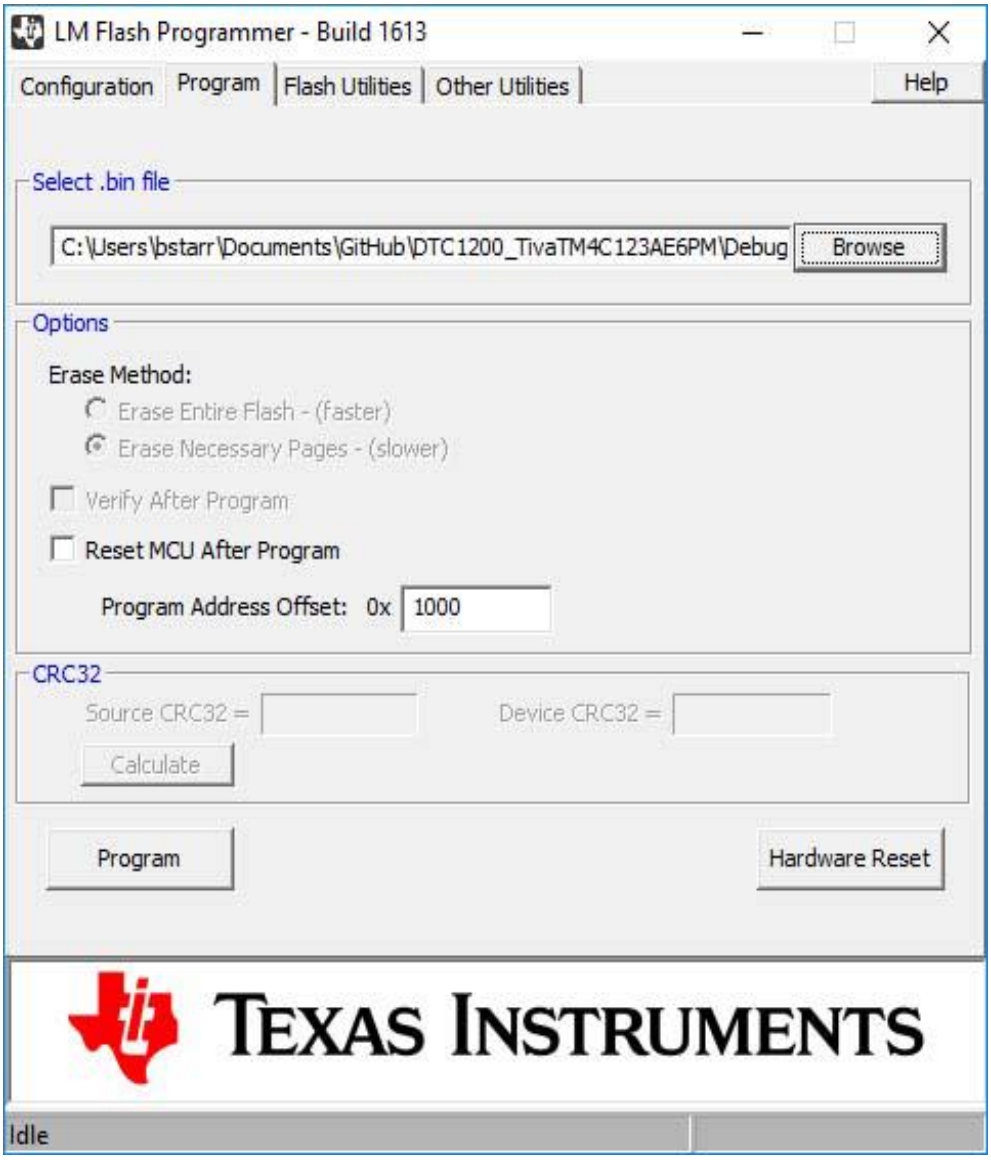


3.3 Select Binary Image and Program Address

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