Computer Sports Medicine, Inc., (CSMi)

HUMAC2015®/E-STIM
APPLICATION PROGRAM
User's Guide

Disclaimer:

CSMi makes no representation or warranties regarding the contents of this manual. We reserve the right to revise this document at any time or to make changes to the product described within it without notice or obligation to notify any person of such revisions or changes.

Printed in the United States of America
Part No.: 301002 Rev: B

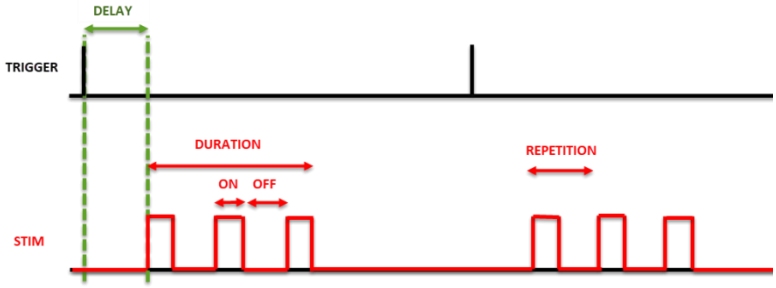
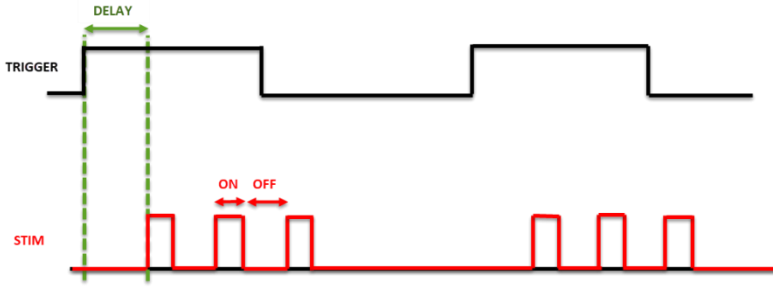
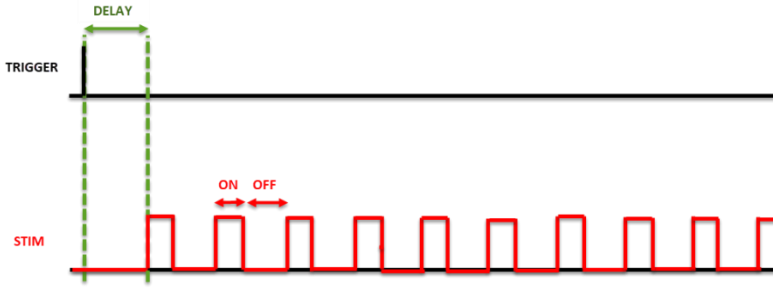
TABLE OF CONTENTS

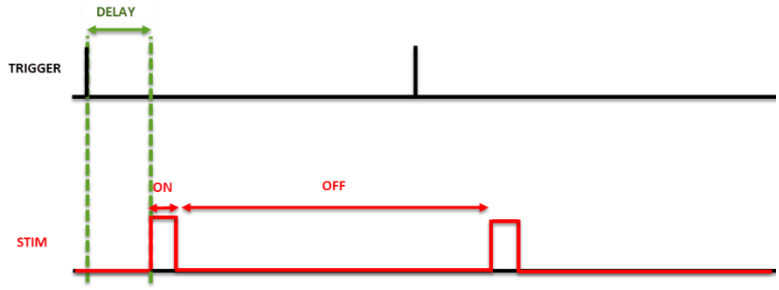
LIST OF FIGURES

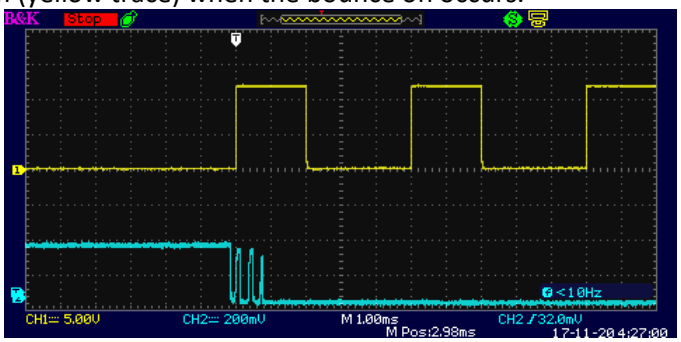
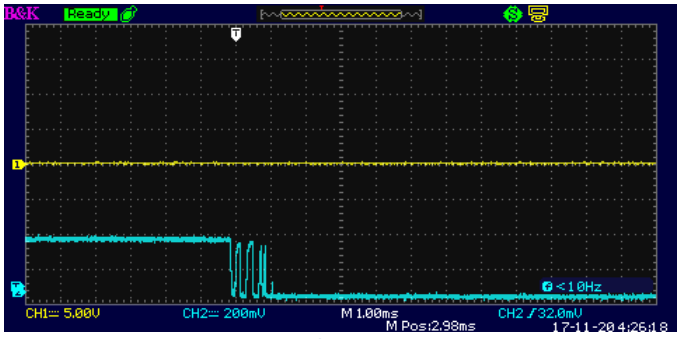
SECTION 1.INTRODUCTION

This document describes the HUMAC/E-Stim option. The HUMAC/E-Stim is compatible with the Digitimer and Grass E-Stim systems.

SECTION 2.DEFINITIONS

COMMAND	PARAM	DEFINITION
MODE	Mode	**TRAIN**: After a **TRIGGER** is active, wait **DELAY** then generate a pulse train of **PULSE ON/OFF** for **DURATION**.  **GATED**: After a **TRIGGER** is active, wait **DELAY**, then generate a pulse train of **PULSE ON/OFF** until **TRIGGER** is inactive.  **FREERUN**: After a **TRIGGER** is active, wait **DELAY**, then generate a continuous pulse train of **PULSE ON/OFF** until a **STOP** command is received.  **SINGLE**: After a **TRIGGER** is received, wait **DELAY**, then generate a single **PULSE ON/OFF**.

COMMAND	PARAM	DEFINITION
		
PULSE WIDTH ON	TIME	0 usec to 2,147 sec in 100usec steps.
PULSE WIDTH OFF	TIME	0 usec to 2,147 sec in 100usec steps.
TRAIN DURATION	TIME	0 usec to 2,147 sec in 100usec steps. The amount of time the PUSLES pulses are delivered in **TRAIN** mode.
DELAY	TIME	0 usec to 2,147 sec in 100usec steps. The delay between the TRIGGER and the first pulse delivery.
REPETITION	SINGLE, CONTINUOUS	• **SINGLE:** Generate a single sequence based on the **MODE** when the **TRIGGER** is received. ***Example:*** *You are doing 20 second isometric contractions and want to send a 3 second* ***PULSE TRAIN*** *the first time the patient exceeds the* ***TORQUE TRIGGER*** *during the 20 second contraction.* • **CONTINUOUS:** Generate a sequence based on the **MODE** each time the **TRIGGER** is received. ***Example:*** *You are doing 20 second isometric contractions and want to send a 3 second* ***PULSE TRAIN*** *each time the patient exceeds the* ***TORQUE TRIGGER*** *during the 20 second contraction.* • **TIMER:** The timer mode is used with the TRAIN setting to periodically generate pulse trains for a set duration. Example: With a **TRAIN DURATION** of 1 second, a **TIMER PERIOD** of 2 seconds, and a **TIMER DURATION** of 12 seconds, the HUMAC will generate a 1 second pulse train. The pulse train will be repeated every 2 seconds. The sequence will continue for 12 seconds.
TRIGGER	MODE, THRESHOLD	**Mode** • Start Now. • Start when Torque exceeds the Threshold. • Start when Aux Digital Input = 1.
DEBOUNCE	TIME	0 usec to 2,147 sec in 100usec steps. The amount of time the TRIGGER must be asserted (True) for the HUMAC to respond to the TRIGGER. **TORQUE TRIGGER:** The amount of time the patient must maintain torque above the TRIGGER for the HUMAC to consider the TRIGGER active.

COMMAND	PARAM	DEFINITION
		AUX INPUT TRIGGER: The amount of time the input must be TRUE (typically a switch is pressed and held) for the HUMAC to consider the TRIGGER active. This is typically used to eliminated repeated triggering due to switch bounce as a button is pressed and released. In Figure 1 when DEBOUNCE = 0 and the switch is released (blue trace) it bounces on and off causing the HUMAC to trigger the E-Stim (yellow trace) when the bounce on occurs.  Figure 1 Debounce = 0 In Figure 2 when DEBOUNCE = 1 msec and the switch is released the HUMAC does not re-trigger the E-Stim because each small bounce is less than 1 msec..  Figure 2 Debounce = 1msec ***NOTE:*** *The de-bounce is only applied to detecting a trigger. In GATED mode, the HUMAC discontinues the E-Stim as soon as the GATE is removed.*

SECTION 3.WAVEFORMS

This section shows plots of waveforms for various HUMAC E-Stim settings in the HUMAC.

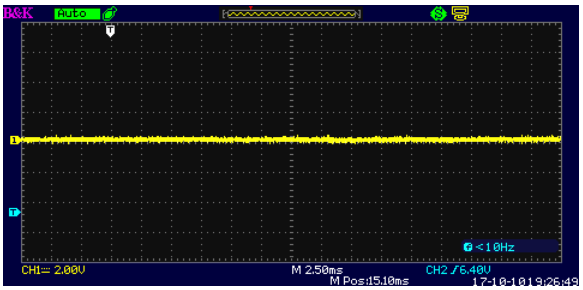
COLOR	DATA
YELLOW	E-Stim output
GREEN	NORM Torque
BLUE	SYNC pulse or button press input to HUMAC.

Mode: OFF

SETTINGS	RESULTS

OPTION	VALUE
Mode	OFF, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

Turn the E-Stim Off.

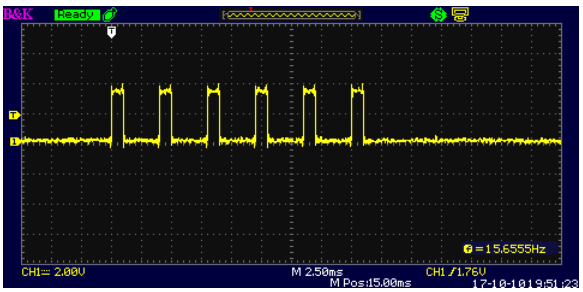


Mode: TRAIN

SETTINGS	RESULTS

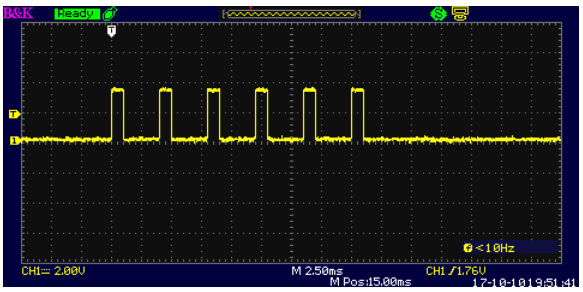
OPTION	VALUE
Mode	TRAIN, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

When you click the **SEND** button the HUMAC sends one set of pulses You must re-issue the **MODE** command to send the next set of pulses.

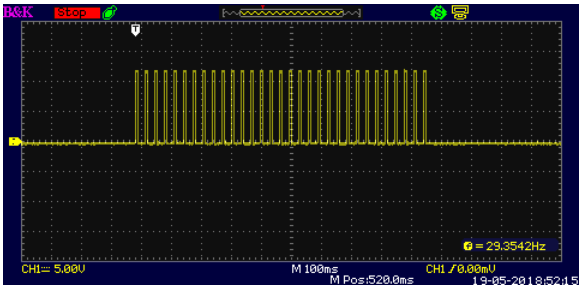


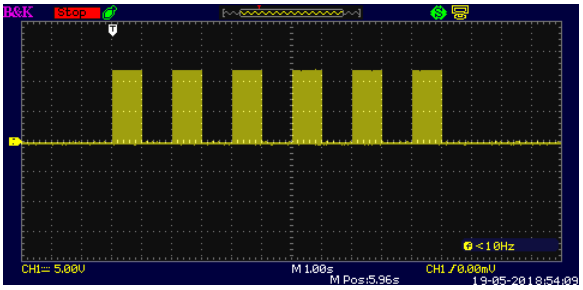
OPTION	VALUE
Mode	TRIGGER, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

Each time you click the **SEND** button the HUMAC sends a set of pulses.



OPTION	VALUE
Mode	TRIGGER, TIMER
Pulse On	10
Pulse Off	23
Duration	1000
Delay	0
Trigger	IMMEDIATE
Timer Period	2000
Timer Duration	12000

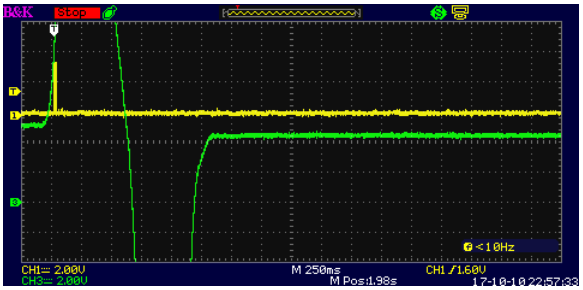


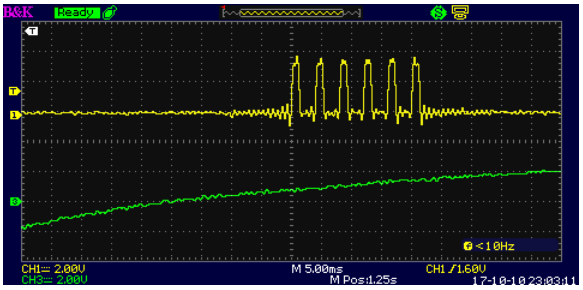


SETTINGS	RESULTS

OPTION	VALUE
Mode	TRIGGER, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

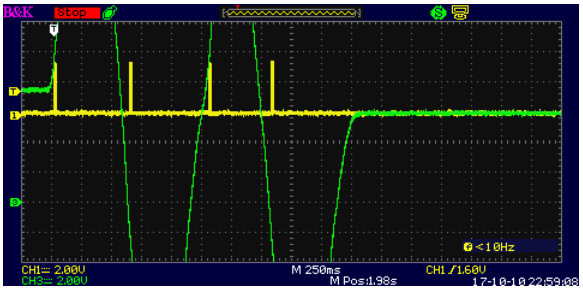
Send one set of pulses when the **TORQUE** exceeds the **TRIGGER** value.





OPTION	VALUE
Mode	TRIGGER, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

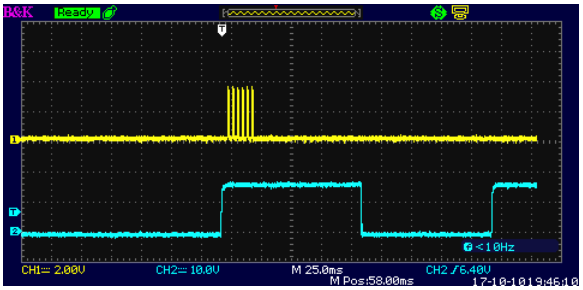
Send one set of pulses each time the **TORQUE** exceeds the **TRIGGER** value.

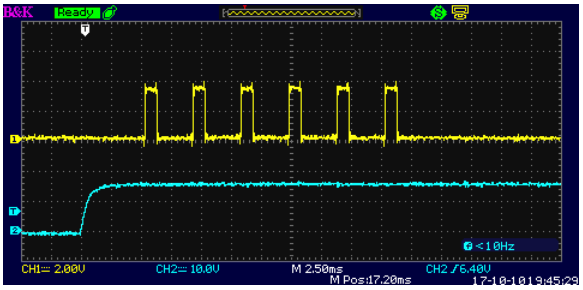


OPTION	VALUE
Mode	TRIGGER, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send one set of pulses when the **EXTERNAL TRIGGER**, (e.g. button press) is received.

The second plot shows the 5 msec **DELAY**.

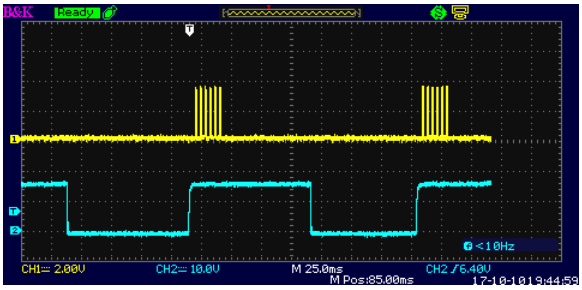




SETTINGS	RESULTS

OPTION	VALUE
Mode	TRIGGER, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a set of pulses each time the **EXTERNAL TRIGGER**, is received.



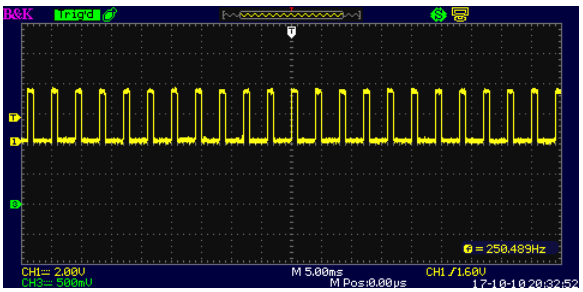
MODE: GATED

SETTINGS	RESULTS

OPTION	VALUE
Mode	GATED, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

When you click the **SEND** button the HUMAC sends a set of pulses. You must re-issue the **MODE** command to send the next set of pulses.

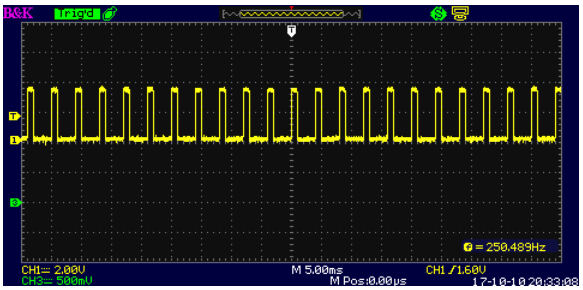
Note: *This example is equivalent to* ***FREE RUN*** *and would not typically be used.*



OPTION	VALUE
Mode	GATED, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

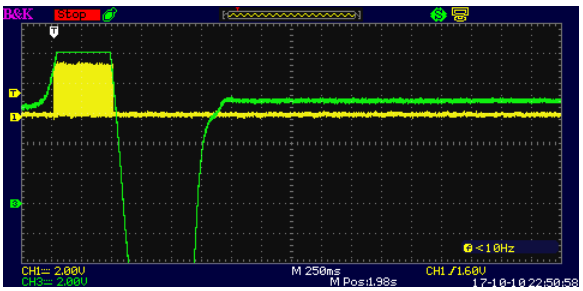
Each time you click the **SEND** button the HUMAC sends a set of pulses.

Note: *This example is equivalent to* ***FREE RUN*** *and would not typically be used.*



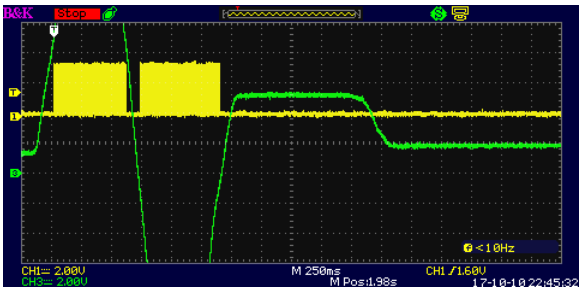
OPTION	VALUE
Mode	GATED, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

Send one set of pulses as long as the **TORQUE** exceeds the **TRIGGER** value.



Option	Value
Mode	GATED, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

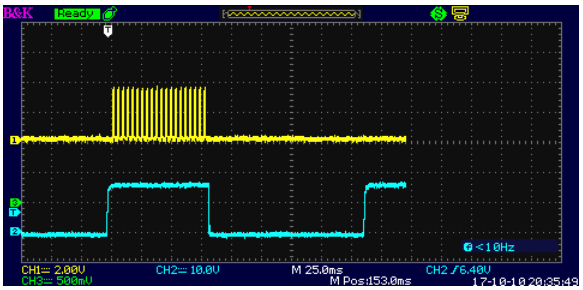
Send pulses as long as the **TORQUE** exceeds the **TRIGGER** value.

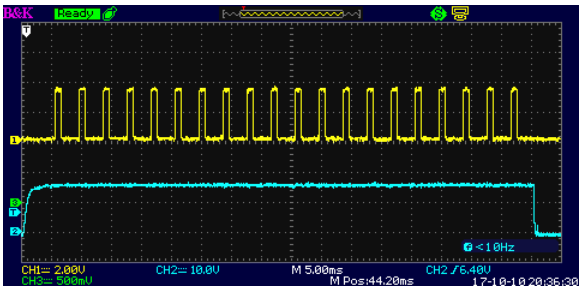


SETTINGS	RESULTS
Note: *In this example, there is both an Extension and a Flexion TRIGGER. In practice you would select one or the other.*	

Option	Value
Mode	GATED, Single
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

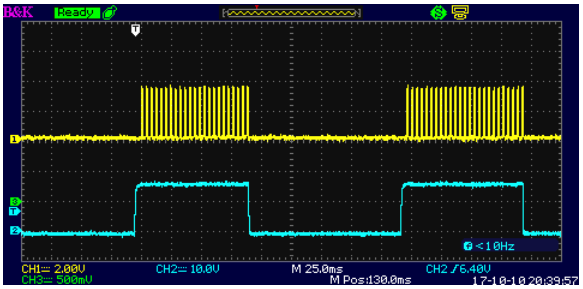
Send one set of pulses as long as the SYNC is active.





Option	Value
Mode	GATED, Continuous
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a set of pulses each time the **SYNC** is active.



MODE: FREE RUN

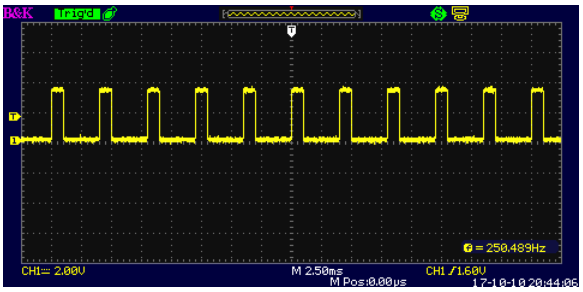
Note:

1. *In **FREE RUN** mode, **SINGLE** and **CONTINUOUS** provide the same pulse trains.*
2. *The pulse train continues until the **MODE OFF** command is received.*

SETTINGS	RESULTS

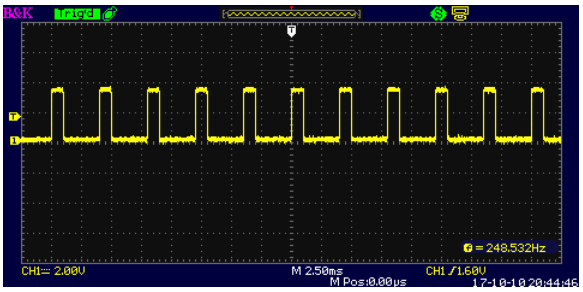
OPTION	VALUE
Mode	FREE RUN, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

When you click the **SEND** button the HUMAC sends a continuous set of pulses. You must re-issue the **MODE** command to send the next set of pulses.



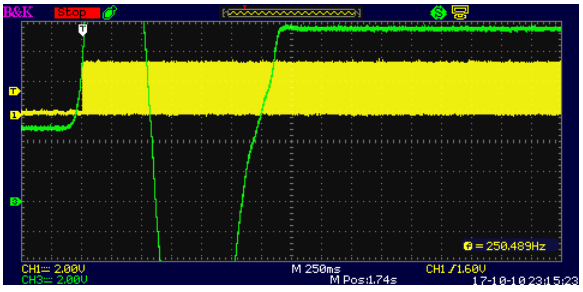
OPTION	VALUE
Mode	FREE RUN, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

Send a continuous set of pulses each time you click the **SEND** button.

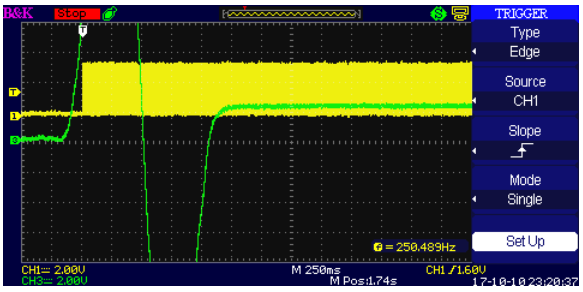


OPTION	VALUE
Mode	FREE RUN, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

Send a stream of continuous pulses when the **TORQUE** exceeds the **TRIGGER** value.



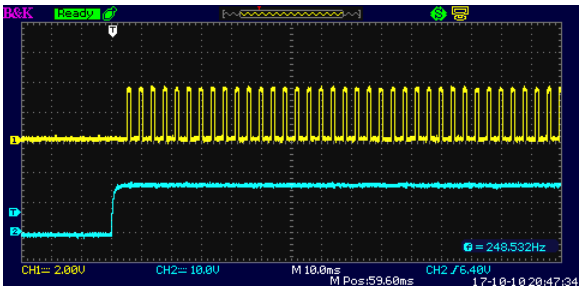
OPTION	VALUE
Mode	FREE RUN, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE



SETTINGS	RESULTS
Send a stream of continuous pulses each time the **TORQUE** exceeds the **TRIGGER** value.	

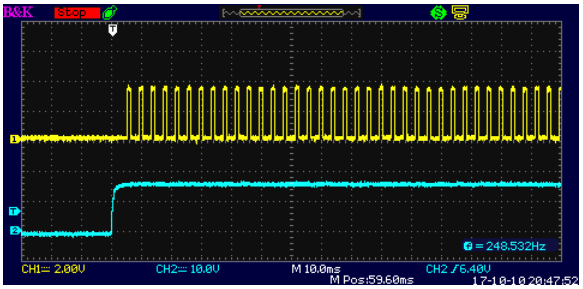
OPTION	VALUE
Mode	FREE RUN, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a stream of continuous pulses when the **SYNC** becomes active.



OPTION	VALUE
Mode	FREE RUN, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a stream of continuous pulses each time the **SYNC** becomes active.

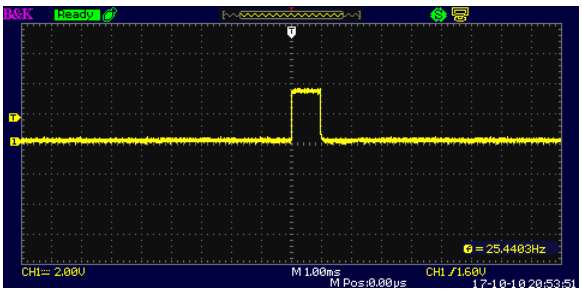


MODE: SINGLE

SETTINGS	RESULTS

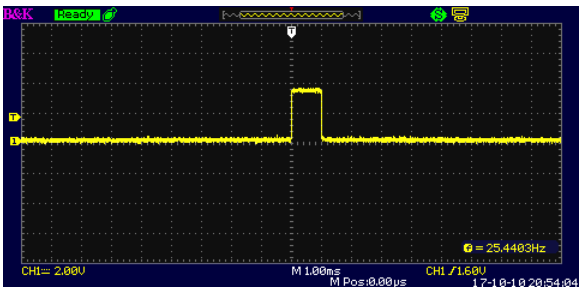
OPTION	VALUE
Mode	SINGLE, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

Send a single plus each time the **MODE** command is sent.



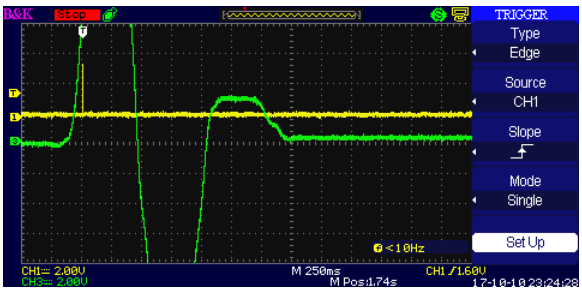
OPTION	VALUE
Mode	SINGLE, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	IMMEDIATE

Send a single plus each time the **MODE** command is sent.



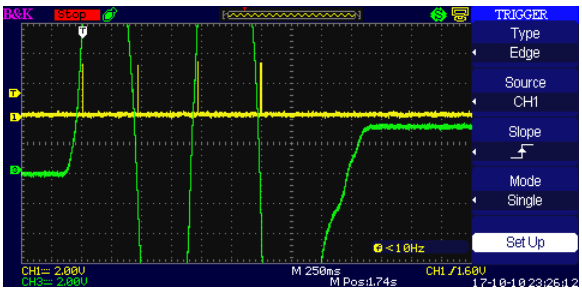
OPTION	VALUE
Mode	SINGLE, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

Send a single pulse when the **TORQUE** exceeds the **TRIGGER** value. The **SINGLE** command must be re-sent to send another pulse.



OPTION	VALUE
Mode	SINGLE, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	0
Trigger	TORQUE

Send a single pulse each time the **TORQUE** exceeds the **TRIGGER** value.

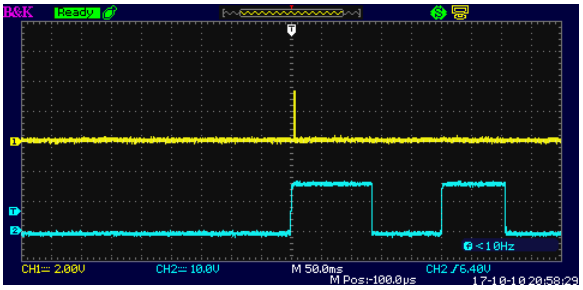


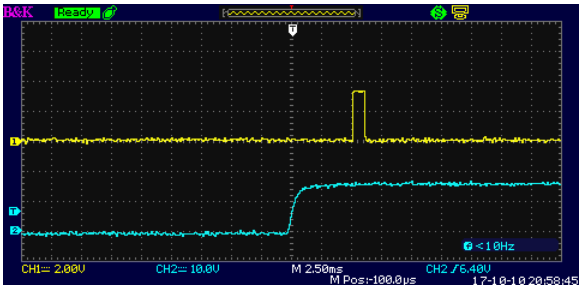
SETTINGS	RESULTS

OPTION	VALUE
Mode	SINGLE, SINGLE
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a single pulse when the **SYNC** is active. The **SINGLE** command must be re-sent to send another pulse.

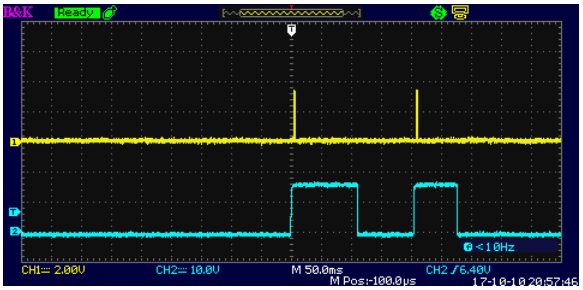
The second plot show the **DELAY**.





OPTION	VALUE
Mode	SINGLE, CONTINUOUS
Pulse On	1
Pulse Off	3
Duration	25
Delay	5
Trigger	SYNC

Send a single pulse each time the **SYNC** becomes active.



SECTION 4.HUMAC SCREENS

1. The E-Stim setup is reached from the Protocols screen.

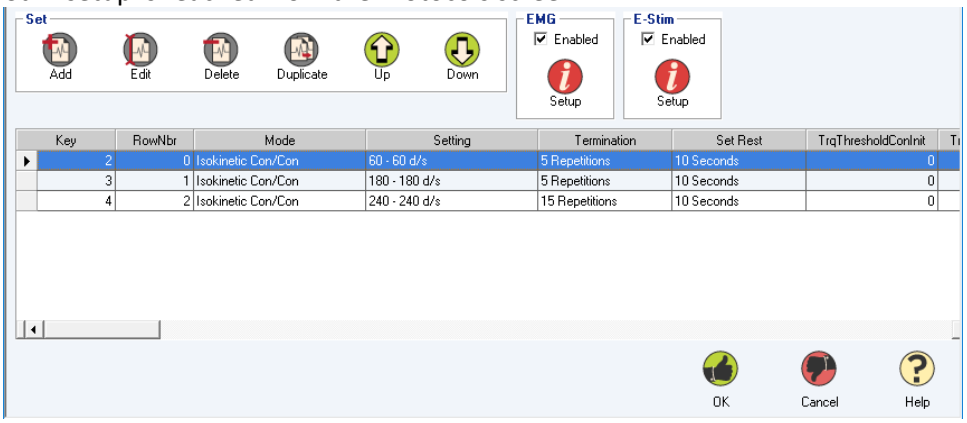


Figure 3 HUMAC Test Protocol with E-Stim Option

2. The E-Stim page allows the following settings.

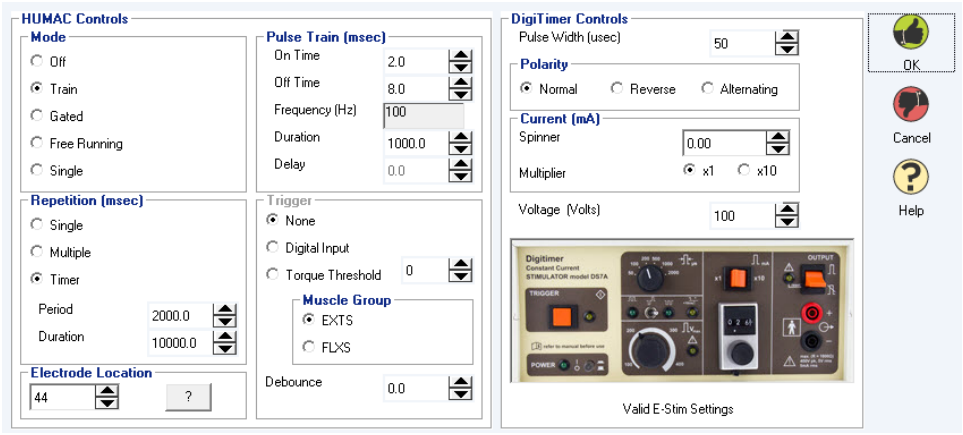


Figure 4 Stim Setup Page

When used with the Digitimer DS7A and DS7AH, the HUMAC checks the settings against the recommended maximums for the Digitimer and displays a confirmation of valid settings or an error indicating invalid settings. Invalid settings must be corrected before continuing. ***IMPORANT:*** *The HUMAC program checks the settings against the manufacturer's recommendations at the time the specific E-Stim unit was added to the HUMAC Program. Always refer to the User Manual for your specific unit as manufacturers may change their recommended settings.*

SECTION 5.REPORTS

Sample isometric report showing change in torque when E-Stim triggered at 10 ft-lbs of torque.

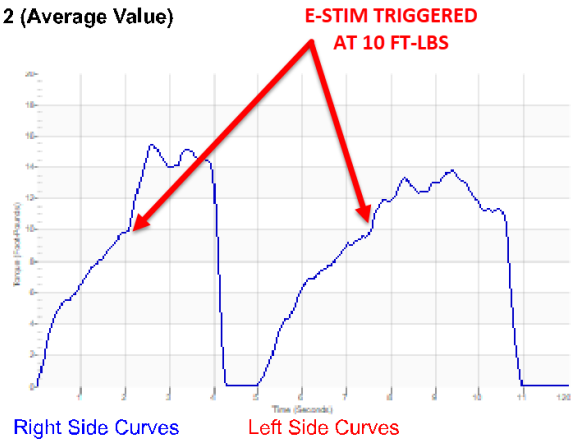
HUMAC2015 Computer Sports Medicine, Inc.

Isometric - Knee Extension/Flexion

Name:	Potash, Robert L	**ID:**	12345	**Right/Left:**	11/7/2017 11/7/2017
Birth date:	1/1/1970	**Involved Side:**	Right & Left	**Group 1:**	
Height:	65 Inches	**Preferred Side:**	Right & Left	**Group 2:**	
Weight:	165 Pounds	**Doctor:**			
Gender:	Male	**Tester:**	CSMi Tech		
Diagnosis:					
Surgery:					

Isometric Extensors (Con) Angle 45 Time 12 Repetition 2 (Average Value)

	Value	Cof Var	%BW
Peak Torque (Foot-Pounds)			
Right	8	1.41	5
Left	0	0.00	0
Deficit	0		
Average Torque (Foot-Pounds)			
Right	4	1.31	2
Left	0	0.00	0
Deficit	0		
Peak Torque Slope (Foot-Pounds/Seconds)			
Right	3	1.41	2
Left	0	0.00	0
Deficit	0		
Time to Half Peak Torque (Seconds)			
Right	0.64	1.41	
Left	0.00	0.00	
Time to Peak Torque (Seconds)			
Right	1.29	1.41	
Left	0.00	0.00	



HUMAC2015® Version: 15.000.0186 © Computer Sports Medicine, Inc. www.csmisolutions.com

Figure 5 Isometric Report

SECTION 6.DATA ANALYSIS

The HUMAC real-time data includes markers for:

1. External trigger input to the HUMAC.
2. E-Stim activation.

These markers allow researchers to measure the time between the E-Stim activation and changes in the muscle output.

SECTION 7.SAMPLE PLOTS

Sample plots from the HUMAC exported data are shown below.

Settings

Option	Value
Mode	Train mode, 5 Seconds, Continuous (Each time the Threshold criteria are met, enable the E-Stim for 5 seconds.
Trigger	32 ft-lbs of torque (red line).
Delay	Tested with 0 sec and 2 sec. The time between when the Trigger criteria are met and the E-Stim is enabled.
De-bounce	Tested with 0 sec and 2 sec. The amount of time the Torque must be above the Threshold to be considered a valid Trigger.

Plots

Trace	Data
Blue	Torque Curve
Green	E-Stim Active

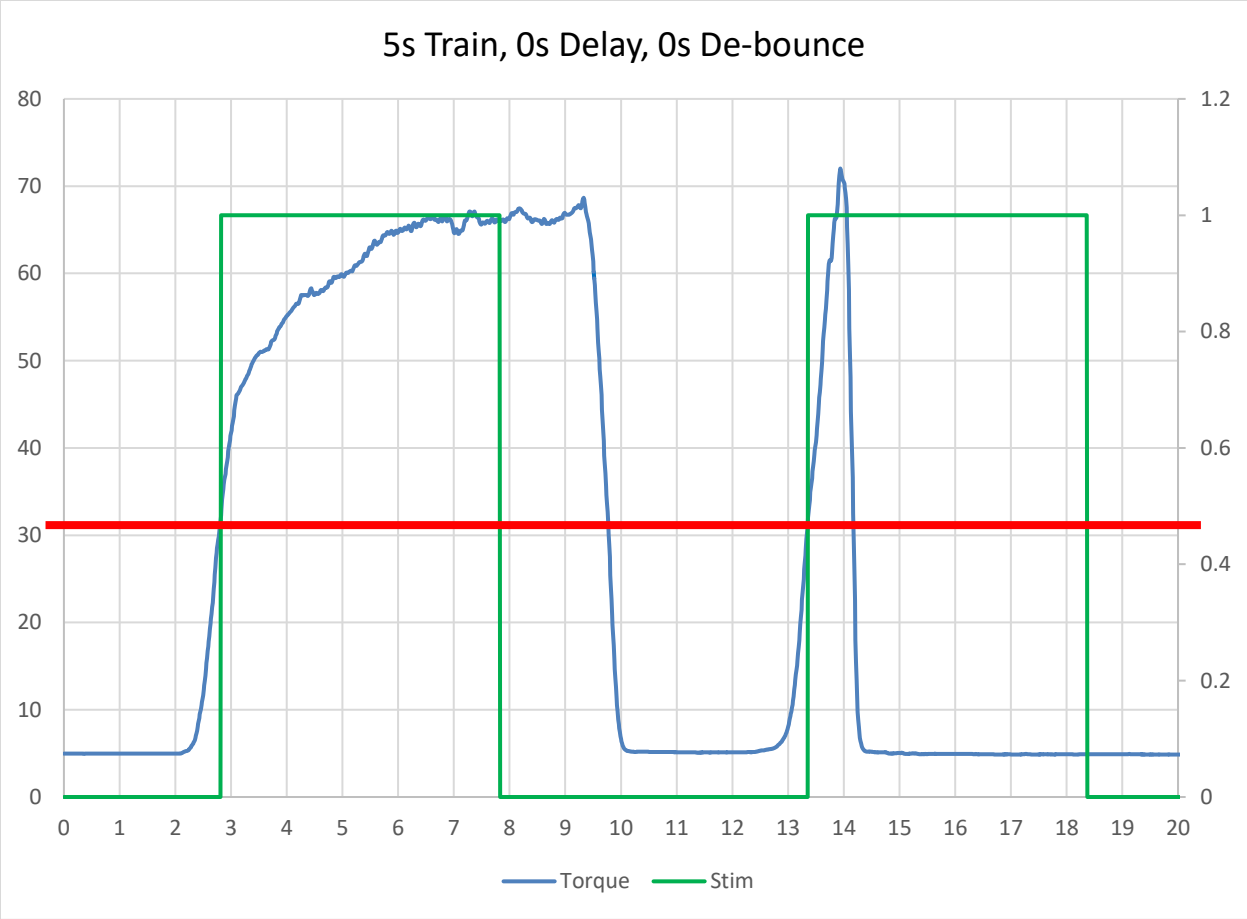


Figure 6 5s Train, 0s Delay, 0s De-bounce

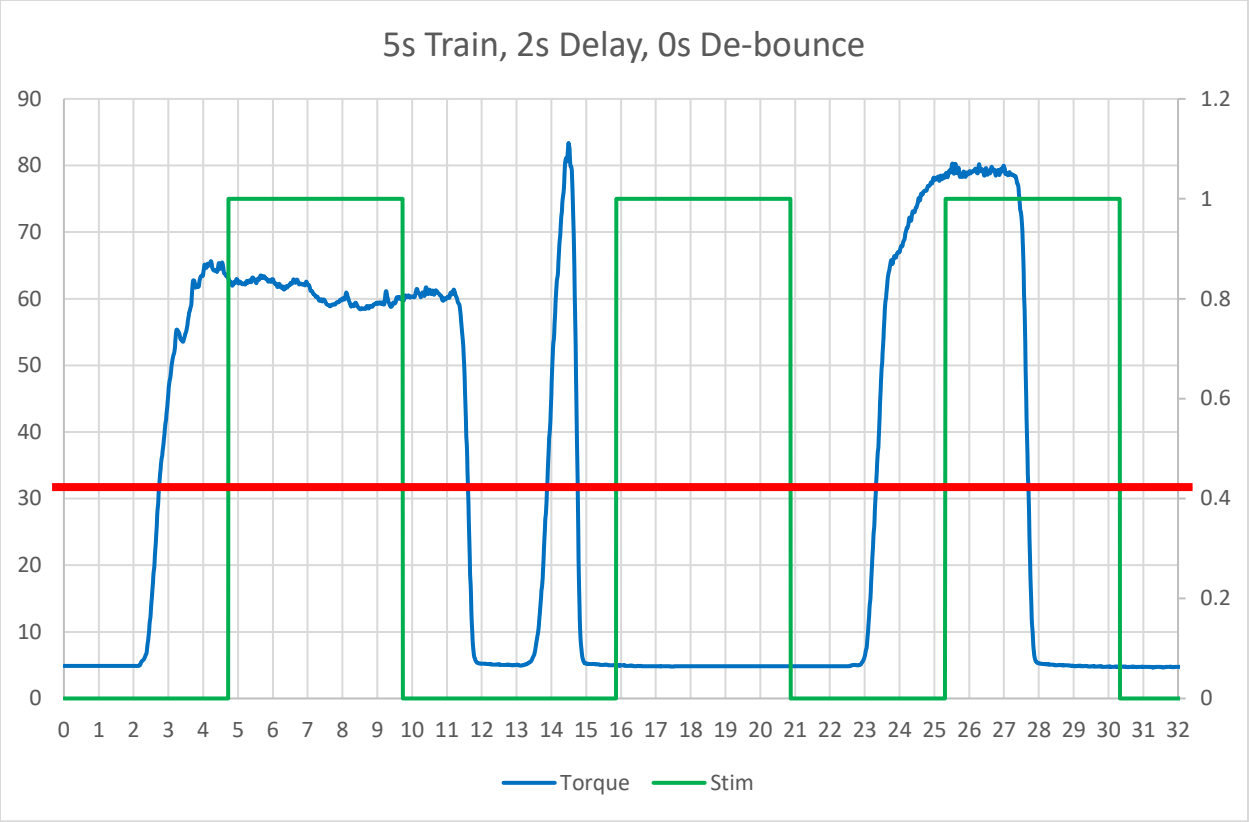


Figure 7 5s Train, 2s Delay, 0s De-bounce

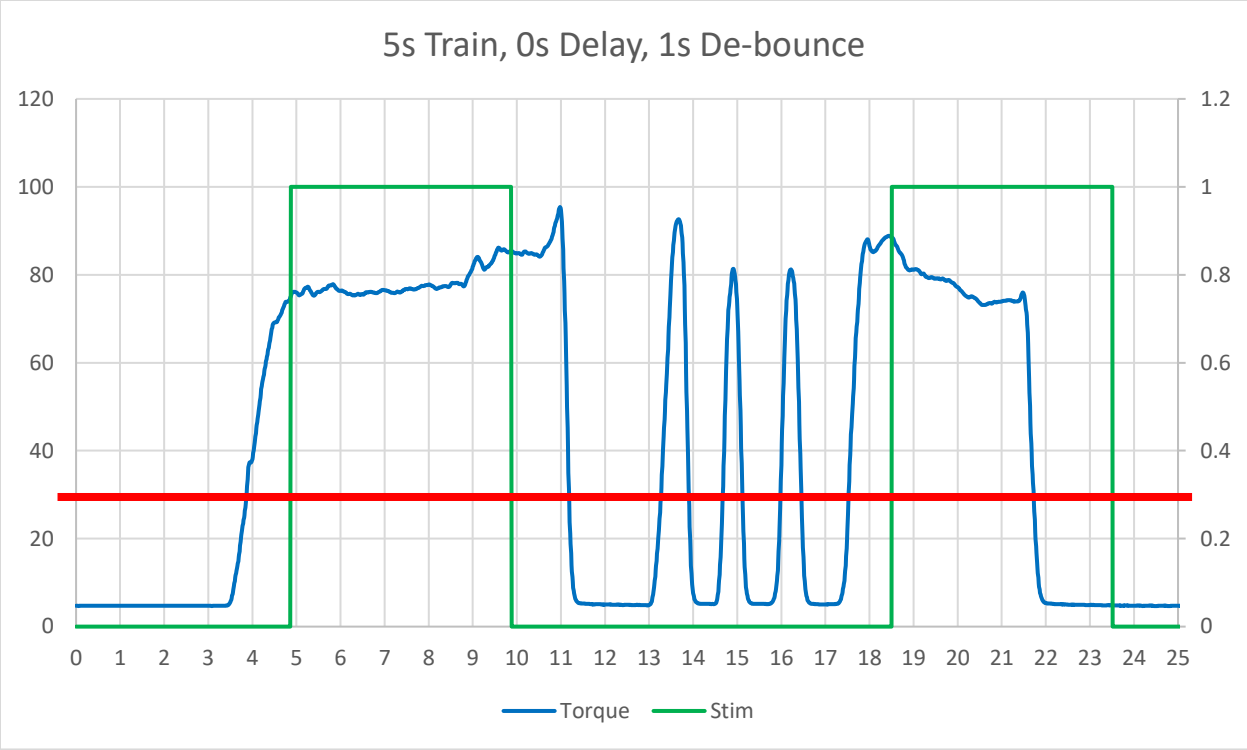


Figure 8 5s Train, 0s Delay, 1s De-bounce

You can see in Figure 8, the E-Stim did not fire between times 10s and 16s because the patient did not maintain the Threshold for the required 1s de-bounce time.

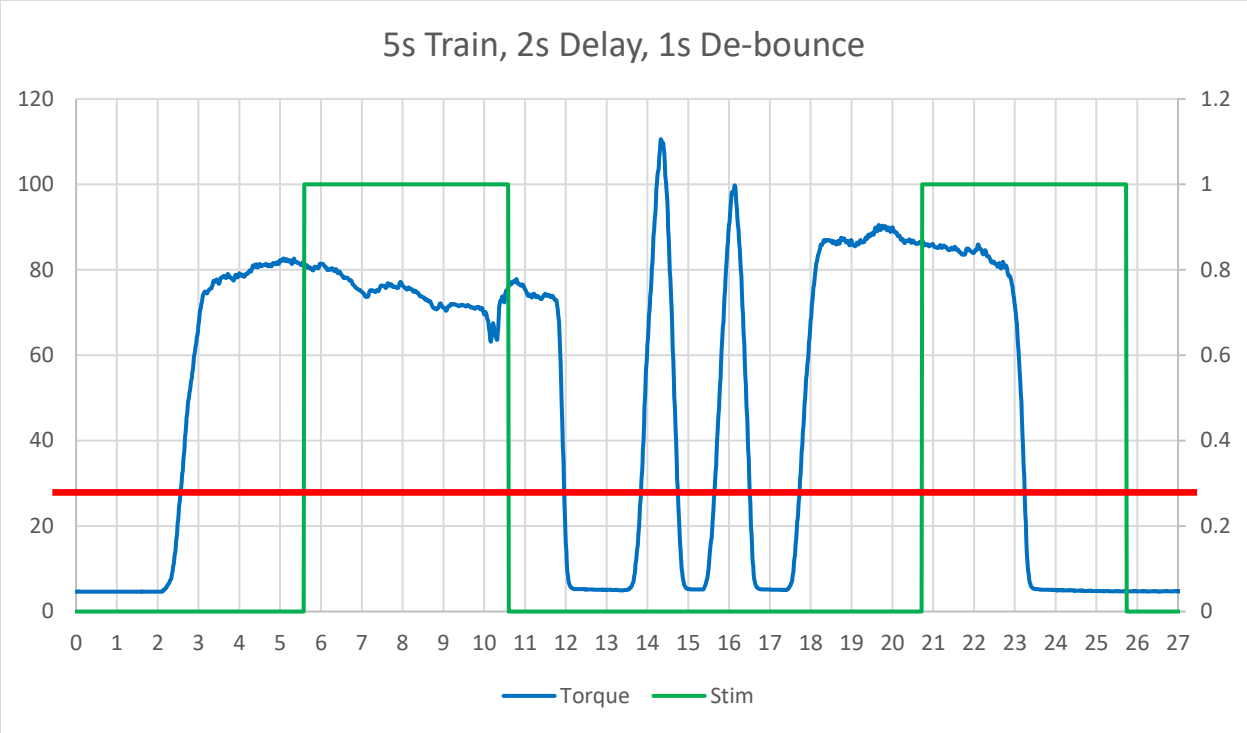


Figure 9 5s Train, 2s Delay, 1s De-bounce