Computer Sports Medicine, Inc., (CSMi)

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

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

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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 .
		TRIGGER
		STIM
		GATED: After a TRIGGER is active, wait DELAY, then generate a
		pulse train of PULSE ON/OFF until TRIGGER is inactive.
		DELAY
		TRIGGER
		STIM
		FREERUN : After a TRIGGER is active, wait DELAY , then generate
		a continuous pulse train of PULSE ON/OFF until a STOP
		command is received.
		TRIGGER
		ON OFF
		STIM
		SINGLE: After a TRIGGER is received, wait DELAY, then generate
		a single PULSE ON/OFF.

WAVEFORMS

COMMAND	PARAM	DEFINITION		
		DELAY		
		TRIGGER		
		ON OFF		
		STIM		
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,	• SINGLE: Generate a single sequence based on the MODE		
	CONTINUOUS	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 IRIGGER is received. Example: You are doing		
		PULSE TRAIN each time the national exceeds the TOROLLE		
		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,	Mode		
	THRESHOLD	• 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.		
		TOROLIE TRIGGER. The amount of time the nationt must		
		maintain torque above the TRIGGER for the $HIIM\Delta C$ to consider		
		the TRIGGER active.		

WAVEFORMS

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.
		CHI= 5,000 CH2= 200mU M 100ms CHI= 5,000 CH2= 200mU M 100ms 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
		Rek Rescurve Rescurve </th
		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	R&K (************************************
Mode	OFF, SINGLE	
Pulse On	1	
Pulse Off	3	Description of the second s
Duration	25	
Delay	5	
Trigger	IMMEDIATE	G < 1 0Hz
Turn the E-Stin	n Off.	CHI= 2,000 M 2.56ms CH2 /6,400 M Pos:(15.18ms 17-10-1019;26;49)

Mode: TRAIN

SETTINGS		RESULTS
OPTION	VALUE	N&K (#355/) 💣 (***********************************
Mode	TRAIN, SINGLE	
Pulse On	1	
Pulse Off	3	Dimanie energianani , banneni , borreigi , borreigi , berreigi , bereining sandalaren izerreigiatura
Duration	25	
Delay	5	
Trigger	IMMEDIATE	G = 15.6555Hz
A/h an way alia	ale the CEND button the LULINAAC conde	CH1== 2,00V M 2.50ms CH1 / 1.76V M Post15 00ms 1.7-16-16 1 9:51 /

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	12000
Duration	







WAVEFORMS

SETTINGS		RESULTS
OPTION Mode Pulse On Pulse Off Duration Delay Trigger Send one set o the TRIGGER va	VALUE TRIGGER, SINGLE 1 3 25 0 TORQUE f pulses when the TORQUE exceeds alue.	
OPTION Mode Pulse On Pulse Off Duration Delay Trigger Send one set	VALUE TRIGGER, CONTINUOUS 1 3 25 0 TORQUE of pulses each time the TORQUE	Rikk term ((() () () () () () () () (
OPTION Mode Pulse On Pulse Off Duration Delay Trigger Send one set TRIGGER, (e.g. The second plo	VALUE TRIGGER, SINGLE 1 3 25 5 SYNC of pulses when the EXTERNAL button press) is received. t shows the 5 msec DELAY.	NK LCDSS/I Image: Character of the state of the stat

SETTINGS		RESULTS	
OPTION	VALUE	B&K [1055]	
Mode	TRIGGER, CONTINUOUS		
Pulse On	1		
Pulse Off	3		
Duration	25		-
Delay	5		
Trigger	SYNC		<10Hz
Send a set or TRIGGER , is rea	f pulses each time the EXTERNAL ceived.	CH2=2.000 CH2=10.00 M 25.0ns CH2 / 6.40 M Posi85.00ms 1	10 7-10-1019:44:59

MODE: GATED

SETTINGS		RESULTS
OPTION	VALUE	
Mode	GATED, SINGLE	
Pulse On	1	
Pulse Off	3	المعارجها لبغاراتها البعار المعارجين المعارجين البغار المعارجين المعارجين البغار البعارجين المعارجين المعار
Duration	25	
Delay	5	
Trigger	IMMEDIATE	C = 258,499Hz

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 se	t of pulses as long as the TOROU

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 lon	g as the TORQUE exceeds the
TRIGGER value.	



CH1 / 1.6



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 eac	h 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

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	B&K kasay ø (∼~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Mode	SINGLE, SINGLE	
Pulse On	1	
Pulse Off	3	
Duration	25	
Delay	5	
Trigger	IMMEDIATE	G = 25,440
		CH1== 2,000 M 1.00ms CH1 /1.600

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 resent 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.



G = 25,440 M 1.00ms CH1 / 1.600





WAVEFORMS

SETTINGS		RESULTS
OPTION	VALUE	
Mode	SINGLE, SINGLE	
Pulse On	1	
Pulse Off	3	B and a state of the second
Duration	25	jaunin
Delay	5	
Trigger	SYNC	
Send a single p	oulse when the SYNC is active. The	CHI 2.000 CH2 10.00 W Souths CH2 76.400 M Pos:-100.0µs 17-10-10.20:58:29
SINGLE comma	nd must be re-sent to send another	R&K Heady @ (***********************************
pulse.		Ÿ.
The second plo	t show the DELAY .	
		a second and a second a second a
		B
		CHI= 2.00U CH2= 10.0U M 2.50ms CH2/5.40U M Pos:-100.0U 12:50.5045
OPTION	VALUE	
Mode	SINGLE, CONTINUOUS	
Pulse On	1	
Pulse Off	3	Dennis and an and and
Duration	25	
Delay	5	
Trigger	SYNC	¹²)
Send a single p	oulse each time the SYNC becomes	UH1== 2/890 CH2== 10,90 M 50.8ms CH2 / 6.490 M Pos:-100.8µs 17-1.0-10.20;57:46
active.		

SECTION 4.HUMAC SCREENS

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

Set Add	Edit	Delete D	uplicate	Ûp Up	Down	MG Enabled Setup	E-Stim Enabled Enabled Setup	i		
Key	RowNbr	Mod	le	Se	etting	Terminati	on	Set Rest	TrqThreshold	ConInit T
•	2 (] Isokinetic Con/C	on I	60 - 60 d/s		5 Repetitions	10 Se	econds		0
	3 .	I Isokinetic Con/C	on '	180 - 180 d/s		5 Repetitions	10 Se	econds		0
	4 2	2 Isokinetic Con/Ci	on i	240 · 240 d/s		15 Repetitions	10 Se	econds		0
								бк	(P) Cancel	? Help

Figure 3 HUMAC Test Protocol with E-Stim Option

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

HUMAC Controls			DigiTimer Controls	
Mode	⊢Pulse Train (mse	c)	Pulse Width (usec) 50	
C Off	On Time	2.0	Polarity	ок
Train	Off Time	8.0 🖨	Normal C Reverse C Alternating	
C Gated	Frequency (Hz)	100	Current (mA)	
C Free Running	Duration	1000.0 🚔	Spinner 0.00	Cancel
C Single	Delay	0.0	Multiplier	?
Repetition (msec)	- Trigger		Voltage (Volta)	
C Single	None			пер
C Multiple	C Digital Input		Digitimer	
• Timer	C Torque Threshol	ld 0 🖶	Constant Current STIMULATOR model DS7A	
Period 2000.0		oup		
Duration 10000.0	O FLXS			
Electrode Location	Debounce	0.0		
44 ?		0.0	Valid E-Stim 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.



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Figure 5 Isometric Report

5-1

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.

SAMPLE PLOTS



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