Controls Specifications (CS)

T350

Controls Group

Revision Number: C

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Revision History

Change #	Description of Change	Source of Change	Date	Author
A	• Initial starting document		8/31/2016	CS
C	• Added charger profile table for battery options	Abdi provided info	5/2/2017	TL

Table of Contents

Table of Tables

OVERVIEW

This section lays out many of the design specifics required to be compatible with the existing design. Many design parameters have been chosen and put in place with third party groups that require this design to follow these constraints.

The tables represent the default factory configuration. There may be special circumstances in which a specific machine may be configured to deviate from this specification.

POWER

This section covers the software conditions relating to the machine power.

BATTERY CAPACITY

Each battery type has a specific curve for calculating battery capacity remaining from the battery voltage. The following table describes the set points. A capacity between these set points is interpolated linearly between the high and low.

Table 1: Battery Capacity Calculation

	Battery Capacity Remaining							
Battery Type	**0%**	**20%**	**40%**	**60%**	**80%**	**100%**	**Reset**	**Units**
Unknown	21.33	22.00	22.67	23.33	24.00	24.67	25.0	Volts
Lead Acid	21.30	21.90	22.60	23.20	23.77	24.17		Volts
AGM	22.45	22.80	23.15	23.60	24.05	24.50		Volts
Gel	22.20	22.60	23.00	23.50	24.00	24.50		Volts
TPPL	22.80	23.10	23.50	23.80	24.20	24.60		Volts

BATTERY GAUGE

The following data is default for the operation of the battery gauge. Other percent's not specifically detailed in the capacity table are interpolated.

Table 2: Battery Gauge Operation

Category	Symbol	Description	Min	Typ	Max	Units
Capacity Gauge		5/5 LED's	60	-	100	%
		4/5 LED's	50	-	60	%
		3/5 LED's	40	-	50	%
		2/5 LED's	30	-	40	%
		1/5 LED's	20	-	30	%
		Blinking 1 LED	-	-	20	%

BATTERY MONITORING

As the battery capacity drops, certain machine functions become disabled.

Table 3: Battery Cutoff Capacity

Category	Symbol	Description	Min	Typ	Max	Units
General		Scrub Turn-off Threshold	-	20	60	%
		Vac Disable Threshold	5	10	-	%
		Propel Disable Threshold	-	~0	-	%

BATTERY CHARGING

The following battery options and charger profiles are available on the machine.

Table 4: Battery Charger Profiles

Model	SAP Code Description	Comments	Charger Profile # SPE	Profile # Delta-Q
T605	Wet 210AH C/20	Standard option	002	001/003
T125	Wet 240AH C/20	Long run-time option	002	001/003
EVGC6A-A	Sealed/MF AGM 220AH C/20	Sealed option	031	043
GF6180 V	Sealed/MF GEL 180AH C/5	EMEA sealed option	061	051
6TP180	Wet 180AH C/5	EMEA standard option	011	021
6TP210	Wet 210AH C/5	EMEA long Run-time option	011	021

INPUT PERIPHERALS: E-STOP, OPERATOR PRESENCE, & PROPEL

These inputs are handled differently based on the machine type. The Design Parameters for the Peripherals module are shown in the three tables below:

Table 5: E-Stop Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	t_{ESTOP}	Debounce Time	-	100	-	msec
	$t_{ESTOPTSK}$	Task Rate	-	10	-	msec

Table 6: Operator Presence Switch Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	t_{OP}	Debounce Time	-	100	-	msec
	t_{OP}	Task Rate	-	10	-	msec

Table 7: Propel Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	t_{PROP}	Propel Bail Switch Debounce Time	-	100	-	msec
	t_{CB}	Circuit Breaker Debounce Time	-	100	-	msec
	t_{REV}	Reverse Switch Debounce Time	-	40	-	msec

HOUR METERS

The machine contains a mechanical hour meter for tracking ***Scrub*** hours. In addition, the following table of hour meters are also tracked internally through software. Meters tied to variant configuration options only work if machine contains the option.

Table 8: Firmware Hour Meters

	Symbol	Description	Min	Typ	Max	Units
Meters	$t_{MACHINE}$	Machine Usage Time[1]	0	-	2^{32}	sec
	t_{SCRUB}	Scrub Time[2]	0	-	2^{32}	sec
	t_{VAC}	Vac Time	0	-	2^{32}	sec
	t_{PROPEL}	Propel Time	0	-	2^{32}	sec
	t_{SCRUB}	ECH2O Time	0	-	2^{32}	sec
	t_{VAC}	Quiet Mode Time	0	-	2^{32}	sec
	$t_{DETERGENT}$	S.E. Time	0	-	2^{32}	sec

1. Current draw greater than key on idle.
2. This value should be really close to the mechanical machine hour meter.

DOWN PRESSURE

ACTUATOR CONTROL

The Design Parameters for the Actuator Control module are shown in the table below:

Table 9: Actuator Control Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	P_{SPD}	Speed[1]	-	80.0	-	%
	P_{HSPD}	Hysteresis Speed	-	30.0	-	%
	t_{TSK}	Task Rate	-	50	-	msec

1. The speed is a percent of the actuator operating voltage or battery voltage.

ACTUATOR

The Design Parameters for the Actuator module are shown in the two tables below:

Table 10: Actuator Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	A_{OFFSET}	Current Offset	-	-	2.5	A
	D_{ACT}	Duty Cycle	0	-	95	%
	t_{IDLE}	Idle time	-	250	-	msec
	t_{TSK}	Task rate	-	50	-	msec
	V_{BATT}	Battery Voltage	-	24	-	V
		Operating Target Voltage X: Operating Voltage 0: Disabled (Battery Voltage)		21	0.95 x V_{BATT}	V

Table 11: Actuator Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	$t_{TIMEOUT}$	Timeout warning time	-	-	20	sec
Open Fault	A_{OPEN}	Open warning current threshold	-	100	-	mA
	t_{OPEN}	Open warning test time	-	200	-	msec
FET Fault	A_{HW}	FET fault current threshold	-	500	-	mA
	t_{HW}	FET fault duration	-	800	-	msec
Stall Fault	A_{STALL}	Stall fault current threshold	-	3.25	5	A
	$A_{STALLRES}$	Stall fault current resolution	-	10	-	mA
	n_{STALL}	Number of clipped pulses per task rate before stall	-	50	-	-
	t_{STALL}	Stall fault duration	-	500	-	msec

PRESSURE ADJUST

The head down pressure is controlled via two actuator positions. There is a control scheme that allows the machine to automatically drop down pressure level based on motor over current conditions. Stages and timings are dependent on the original user down pressure setting. The x refers to software over current 1 or 2 of the motor module.

Table 12: Over Current Motor Protection

<table>
<tr><th colspan="3" rowspan="2"></th><th colspan="2">User Set Point</th></tr>
<tr><th>Low</th><th>High</th></tr>
<tr><td rowspan="2">Stage 1</td><td rowspan="2">Over Current x</td><td>Threshold (A)</td><td rowspan="2"></td><td rowspan="2">See Motor Over Current x</td></tr>
<tr><td>Time (s)</td></tr>
<tr><td colspan="3"></td><td></td><td>⇩</td></tr>
<tr><td rowspan="2">Stage 2</td><td rowspan="2">Over Current x</td><td>Threshold (A)</td><td rowspan="2">See Motor Over Current x</td><td>Over Current x</td></tr>
<tr><td>Time (s)</td><td>10</td></tr>
<tr><td colspan="3"></td><td>⇩</td><td>⇩</td></tr>
<tr><td colspan="3">Machine Fault</td><td>Fault</td><td>Fault</td></tr>
</table>

SCRUB

MOTOR

The Design Parameters for the Motor module are shown in the two tables below:

Table 13: Motor Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	A_{OFFSET}	Current Offset	-	-	12	A
	D_{MTR}	Duty Cycle	5	-	95	%
	$D_{RESTART}$	Restart Duty Cycle	-	80	-	%
	D_{START}	Start Duty Cycle	-	30	-	%
	n_{AVG}	Number of Current Samples	-	100	-	-
	t_{COAST}	Coast Time	-	1	-	sec
	t_{TSK}	Task rate	-	30	-	msec
	t_{VLOSS}	Motor Voltage Loss Threshold Time	-	10	-	msec
	V_{BAT}	Battery Voltage	-	24	-	V
	V_{MTR}	Operating Voltage	15	-	50	V
	V_{VLOSS}	Voltage Loss Threshold	-	10	-	V
Soft Start	D_{STEP}	PWM Step Size	-	10	-	%
	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	0.42	30	sec
	t_{STEP}	PWM Step Time	-	60	-	msec

Table 14: Motor Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Overcurrent Fault	P_{FAULT}	Clipping Percent Threshold per task rate	-	5	-	%
	A_{CL}	Current Limit Fault Threshold	-	60	80	A
	t_{CL}	Time	0	5	30	sec
FET Fault	A_{HW}	Threshold	-	2.2	-	A
	t_{HW}	Time	-	1200	-	msec
Open Fault	A_{OPEN}	Threshold	-	1.0	5.0	A
	$A_{OPENRES}$	Threshold Resolution	-	100	-	mA
	t_{OPEN}	Time	-	1000	-	msec
Shorted Load	P_{SHORT}	Clipping Percent Threshold per task rate	-	80	-	%
	A_{CL}	Current Limit Fault Threshold	-	60	80	A
	t_{SHORT}	Time	-	3	10	sec
Over Current 1*	A_{OC1}	Threshold 0: Disabled	-	40	-	A
	t_{OC1}	Time	-	30	-	sec
Over Current 2*	A_{OC2}	Threshold 0: Disabled	-	50	-	A
	t_{OC2}	Time	-	5	-	sec

* This fault may not be declared immediately depending on down pressure. See Down Pressure section for more information.

CONVENTIONAL SOLUTION FLOW

The Design Parameters for the Solution Flow module are shown in the table below:

Table 15: Solution Flow Module Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	t_{PERIOD}	Period	-	2.5	-	sec
	t_{TSK}	Task Rate	-	50	-	msec
Conventional Solution Flow Rates	FR_{OFF}	Off	-	13.5	-	%
	FR_{LOW}	Low Flow Rate	-	31.0	-	%
	FR_{MED}	Medium Flow Rate	-	50.0	-	%
	FR_{HIGH}	High Flow Rate	-	67.5	-	%

VALVE

The Design Parameters for the Valve module on T300 are shown in the two tables below:

Table 16: Valve Module Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	A_{OFFSET}	Current Offset	-	-	0.12	A
	t_{TSK}	Task Rate	-	50	-	msec

Table 17: Valve Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Fault	A_{HW}	Threshold	-	200	-	mA
	t_{HW}	Time	-	1000	-	msec
Open Fault	A_{OPEN}	Threshold	-	20	-	mA
	t_{OPEN}	Time	-	1000	-	msec

EC-H2O SOLUTION

The Design Parameters for the ec-H2O NanoClean module are shown in the two tables below:

Table 18: ecH2O Module Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	A_{CELL}	Cell Current	3.00	-	5.00	A
	V_{PUMP}	Pump Voltage	0	-	24	V
		WCM Cartridge Expiration		25K		Gal
Flow Rates	FR_{LOW}	Low Flow Rate	-	0.120	-	gpm
	FR_{MED}	Medium Flow Rate	-	0.250	-	gpm
	FR_{HIGH}	High Flow Rate	-	0.350	-	gpm

WATER PICK-UP

VACUUM OPERATION

The following table describes the application control of the vacuum operation.

Table 19: Vacuum Operation

	Symbol	Description	Min	Typ	Max	Units
Normal Mode	V_{NORMAL}	Run Target	-	19.00	-	V
	V_{OFF_NORMAL}	Turn Off Target	-	24.00	-	V
	t_{OFF_NORMAL}	Turn Off Delay	-	15.0	-	s
Quiet Mode	V_{QUIET}	Run Target	-	15.00	-	V
	V_{OFF_QUIET}	Turn Off Target	-	15.00	-	V
	T_{OFF_QUIET}	Turn Off Delay (1 x t_{OFF_NORMAL})	-	15.0	-	s

VACUUM CONTROL MODULE

The Design Parameters for the Vacuum module are shown in the two tables below:

Table 20: Vacuum Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	A_{OFFSET}	Current Offset	-	0	12	A
	D_{MTR}	Duty Cycle	7.5	-	99	%
	D_{START}	Start Duty Cycle	-	30	-	%
	n_{AVG}	Number of Current Samples	-	100	-	-
	t_{TSK}	Task Rate	-	50	-	msec
	$t_{TURNOFF}$	Max Turn Off Delay	-	20	-	sec
	V_{BAT}	Battery Voltage	-	24	-	V
	V_{MTR}	Operating Voltage	5	-	50	V
	V_{VLOSS}	Voltage Loss Threshold	-	10	-	V
Soft Start	D_{STEP}	PWM Step Size	-	5	-	%
	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	0.6	30	sec
	t_{STEP}	Soft Start PWM Step Time	-	50	-	msec

Table 21: Vacuum Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Overcurrent Fault	P_{FAULT}	Clipping Percent Threshold per task rate	-	5	-	%
	A_{CL}	Threshold	-	30	30	A
	t_{CL}	Time	0	10	30	sec
FET Fault	A_{HW}	Threshold	-	2.2	-	A
	t_{HW}	Time	-	800	-	msec
Open Fault	A_{OPEN}	Threshold	-	1.0	2.5	A
	$A_{OPENRES}$	Threshold Resolution	-	10	-	mA
	t_{NC}	Time	-	1000	-	msec
Shorted Load	P_{SHORT}	Clipping Percent Threshold per task rate	-	80	-	%
	A_{CL}	Threshold	-	30	30	A
	t_{SHORT}	Time	0	2	4	sec
Over Current 1	A_{OC1}	Threshold 0: Disabled	-	29	-	A
	t_{OC1}	Time	-	3	30	sec
Over Current 2	A_{OC2}	Threshold 0: Disabled	-	28	-	A
	t_{OC2}	Time	-	30	30	sec

SEVERE ENVIRONMENT

The Design Parameters for the Detergent Pump module are shown in the two tables below:

DETERGENT PUMP

Table 22: Detergent Pump Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	A_{OFFSET}	Current Offset	-	0	0.24	A
	D_{MTR}	Duty Cycle	4	-	95	%
	$D_{RESTART}$	Restart Duty Cycle	-	30	-	%
	D_{START}	Start Duty Cycle	-	30	-	%
	n_{AVG}	Number of Current Samples	-	100	-	-
	t_{COAST}	Coast Time	-	10	-	sec
	t_{TSK}	Task rate	-	50	-	msec
	t_{VLOSS}	Voltage Loss Time	-	10	-	msec
	V_{BAT}	Battery Voltage	-	24	-	V
	V_{MTR}	Operating Voltage	1.5	-	26	V
	V_{VLOSS}	Voltage Loss Threshold	-	10	-	V
Soft Start	D_{STEP}	PWM Step Size	-	3	-	%
	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	-	5	sec
	t_{STEP}	PWM Step Time	-	50	-	msec

Table 23: Detergent Pump Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Overcurrent Fault	P_{FAULT}	Clipping Percent Threshold per task rate	-	50	-	%
	A_{CL}	Threshold	-	2	2	A
	t_{CL}	Time	0	10	30	sec
FET Fault	A_{HW}	Threshold	-	50	-	mA
	t_{HW}	Time	-	800	-	msec
Open Fault	A_{OPEN}	Threshold	-	0.1	0.5	A
	$A_{OPENRES}$	Threshold Resolution	-	10	-	mA
	t_{OPEN}	Time	-	1000	-	msec
Shorted Load	P_{SHORT}	Clipping Percent Threshold per task rate	-	90	-	%
	A_{CL}	Threshold	-	2	2	A
	t_{SHORT}	Time	-	4	5	sec
Over Current 1	A_{OC1}	Threshold 0: Disabled	-	1900	-	mA
	t_{OC1}	Time	-	5	30	sec
Over Current 2	A_{OC2}	Threshold 0: Disabled	-	1700	-	mA
	t_{OC2}	Time	-	30	30	sec

DETERGENT TANK

Table 24: Detergent Tank Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	t_{TSK}	Task rate	-	100	-	msec
	$t_{DEBOUNCE}$	Debounce Time	-	3000	-	msec

PROPEL

I-DRIVE

The Design Parameters for the iDrive module are shown in the table below:

Table 25: iDrive Module Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	V_1	Propel Speed 1	-	40	-	ft/min
	V_2	Propel Speed 2	-	80	-	ft/min
	V_3	Propel Speed 3	-	120	-	ft/min
	V_4	Propel Speed 4	-	160	-	ft/min
	V_5	Propel Speed 5	-	200	-	ft/min

APPENDIX A – GLOSSARY

The following glossary provides a brief explanation of some of the terms used in this document.

Battery Capacity – The approximate amount of energy remaining in the battery charge.

Coast Time – The amount of time after a motor turn off command is issued. If a turn on command is issued within this time, the PWM duty cycle is restarted at a higher level than the typical starting duty cycle.

Clipping Percent – The percent number of pulses that were not allowed to fully complete within a task cycle. Clipped pulses occur when current is above the hardware design limit.

Current Offset – A fixed amount of current allowed when zeroing out current reads at board power-up.

Debounce Time – The time allowed for a signal to settle to a constant value before a state change.

Duty Cycle – The percent of time the PWM signal is at high (battery) level. Remainder of time it is off.

Duty Cycle (Start) – The percent signal to begin a motor when starting from an off state. This provides a soft start function.

Duty Cycle (Restart) – If within the coast time, the motor will start at this higher level duty cycle as it is likely to still be spinning. Starting a motor at a lower duty cycle may "brake" a motor from current speed.

Hysteresis – The over shoot of a target that may occur due to hardware behavior.

Period – The total time for a cycle of operation to occur.

PWM – Pulse Width Modulation or the process of reducing the average target voltage by switching at high frequency a fixed voltage on and off.

Samples – The number of data points collected of a value.

Soft Start – The act of gently starting a motor at a low value and ramping up to the target value.

Speed – A percent mapping to a voltage to drive a motor at a portion of its capabilities.

Target – Any value the machine may command for operation.

Task Rate – The time it takes for the software to make changes in operation to or monitor behavior of the controlled device.

Threshold – A measured value in which a limit of operation is expected. This may be a high or low limit.

Turn Off Delay – The amount of time the motor may run after the command to turn off is issued. This may include operating at a different voltage during the delay time.