Controls Specifications (CS)

M17

Controls Group

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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.

INPUT PERIPHERALS

Table 1: Hopper Input Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hopper Lift	t_{HLIFT}	Debounce Time	-	50	-	msec
Hopper Lower	t_{HLOWER}	Debounce Time	-	50	-	msec
Hopper Roll Out	t_{HROUT}	Debounce Time	-	50	-	msec
Hopper Roll In	t_{HRIN}	Debounce Time	-	50	-	msec
Hopper Home	t_{HOME}	Debounce Time	-	2000	-	msec
Filter Shaker	$t_{FLTSHKR}$	Debounce Time	-	50	-	msec
Filter Clogged	$t_{FLTCLGD}$	Debounce Time	-	50	-	msec

Table 2: Solution Input Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
SE Long	t_{SELONG}	Debounce Time	-	0	-	msec
SE Short	$t_{SESHORT}$	Debounce Time	-	0	-	msec
Recovery Tank Full	t_{RTFULL}	Debounce Time	-	5000	-	msec
Recovery Tank Half	t_{RTHALF}	Debounce Time	-	5000	-	msec
Sol Tank Empty	$t_{SOLEMPTY}$	Debounce Time	-	5000	-	msec

DOWN PRESSURE

SCRUB ACTUATOR CONTROL

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

Table 3: Scrub Actuator Control Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	A_{BAND}	Current Band Size	-	2	-	A
	A_{FLAT}	Flat Current Threshold	-	200	-	mA
	n_{SMPL}	Number of Current Samples	-	5	-	#
	t_{FLATUP}	Flat Step Size Up	-	-50	-	msec
	t_{FLATDN}	Flat Step Size Down	-	50	-	msec
	t_{UP}	Step Size Up	-	-25	1000	msec
	t_{DN}	Step Size Down	-	25	1000	msec

SCRUB

MAIN SCRUB MOTORS

The Design Parameters for the Main Scrub Motor modules are shown in the two tables below:

Table 4: Main Scrub Motor Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	s_{CTRGT}	Cylindrical Target Speed	-	1750	-	RPM
	s_{DTRGT}	Disk Target Speed	-	2520	-	RPM
	t_{TSK}	Task rate	-	50	-	msec
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	1	30	sec

Table 5: Main Scrub Motor Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Open Fault Threshold	-	1	-	A
	t_{OPEN}	Open Fault Time	-	5	-	sec
Hardware Fault	t_{HW}	Open Fault Time	0	5	30	sec
Overtemp Fault	t_{OPEN}	Open Fault Time	-	3	-	msec
Over Voltage Fault	t_{SHORT}	Open Fault Time	-	5	-	sec
Motor Fault	A_{MTR}	Motor Fault Over Current Threshold	-	42	-	A
	s_{MTR}	Motor Fault Speed Threshold	-	500	-	RPM
	t_{MTR}	Motor Fault Time	-	15	-	sec

MAIN SCRUB ACTUATOR

The Design Parameters for the Main Scrub Actuator module are shown in the three tables below:

Table 6: Main Scrub Actuator Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{FAST}	Fast Speed Duty Cycle	-	95	-	%
	D_{NRML}	Normal Speed Duty Cycle	-	75	-	%
	D_{SLOW}	Slow Speed Duty Cycle	-	50	-	%
	D_{HUNT}	Hunt Speed Duty Cycle	-	30	-	%
	t_{TSK}	Task rate	-	25	-	msec
	V_{BATT}	No Battery Voltage Compensation	-	-	-	V

Table 7: Main Scrub Actuator Timeout Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	$t_{TIMEOUT}$	Default Timeout	-	16	-	sec
	t_{DPRF} (Disk)	Parked to Ready Fast Timeout	-	5	-	sec
	t_{DHNT} (Disk)	Hunt Time	0.5	60	-	sec
	t_{DLLT} (Disk)	Lower from Lost Timeout	-	30	-	sec
	t_{DLPF} (Disk)	Lowered to Parked Fast Timeout	-	1	-	sec
	t_{DLPN} (Disk)	Lowered to Parked Normal Timeout	-	1	-	sec
	t_{DLPS} (Disk)	Lowered to Parked Slow Timeout	-	8	-	sec
	t_{DRPF} (Disk)	Ready to Parked Fast Timeout	-	0.1	-	sec
	t_{DRPN} (Disk)	Ready to Parked Normal Timeout	-	0.2	-	sec
	t_{DRPS} (Disk)	Ready to Parked Slow Timeout	-	8	-	sec
	t_{DLTPS} (Disk)	Lost to Parked Slow Timeout	-	12	-	sec
	t_{DLR} (Disk)	Lowered to Ready Timeout	0.1	-	7	sec
	t_{DPRF} (Cyl)	Parked to Ready Fast Timeout	-	4.1	-	sec
	t_{DHNT} (Cyl)	Hunt Time	2.5	60	-	sec
	t_{DLLT} (Cyl)	Lower from Lost Timeout	-	0.1	-	sec
	t_{DLPF} (Cyl)	Lowered to Parked Fast Timeout	-	1	-	sec
	t_{DLPN} (Cyl)	Lowered to Parked Normal Timeout	-	2	-	sec
	t_{DLPS} (Cyl)	Lowered to Parked Slow Timeout	-	8	-	sec
	t_{DRPF} (Cyl)	Ready to Parked Fast Timeout	-	0.4	-	sec
	t_{DRPN} (Cyl)	Ready to Parked Normal Timeout	-	0.4	-	sec
	t_{DRPS} (Cyl)	Ready to Parked Slow Timeout	-	8	-	sec
	t_{DLTPS} (Cyl)	Lost to Parked Slow Timeout	-	12	-	sec
	t_{DLR} (Cyl)	Lowered to Ready Timeout	0.1	-	7.25	sec
	t_{MAN}	Manual Timeout	-	30	-	sec

Table 8: Main Scrub Actuator Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Stall Fault	$A_{DSTALLF}$	Disk Fast Stall Fault Threshold	-	8	-	A
	$A_{DSTALLN}$	Disk Normal Stall Fault Threshold	-	8	-	A
	$A_{DSTALLS}$	Disk Slow Stall Fault Threshold	-	8	-	A
	$A_{DSTALLH}$	Disk Hunt Stall Fault Threshold	-	8	-	A
	$A_{CSTALLF}$	Cyl Fast Stall Fault Threshold	-	10	-	A
	$A_{CSTALLN}$	Cyl Normal Stall Fault Threshold	-	10	-	A
	$A_{CSTALLS}$	Cyl Slow Stall Fault Threshold	-	10	-	A
	$A_{CSTALLH}$	Cyl Hunt Stall Fault Threshold	-	10	-	A
	t_{STALLF}	Fast Stall Fault Time	-	0.5	-	sec
	t_{STALLN}	Normal Stall Fault Time	-	0.5	-	sec
	t_{STALLS}	Slow Stall Fault Time	-	0.5	-	sec
	t_{STALLH}	Hunt Stall Fault Time	-	0.5	-	sec

SIDE SCRUB MOTOR

The Design Parameters for the Side Scrub Motor modules are shown in the two tables below:

Table 9: Side Scrub Motor Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	s_{TRGT}	Target Speed	-	2320	-	RPM
	t_{TSK}	Task rate	-	50	-	msec
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	0	30	sec

Table 10: Side Scrub Motor Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Open Fault Threshold	-	1	-	A
	t_{OPEN}	Open Fault Time	-	5	-	sec
Hardware Fault	t_{HW}	Open Fault Time	0	5	30	sec
Overtemp Fault	t_{OPEN}	Open Fault Time	-	3	-	msec
Over Voltage Fault	t_{SHORT}	Open Fault Time	-	5	-	sec
Motor Fault	A_{MTR}	Motor Fault Over Current Threshold	-	42	-	A
	s_{MTR}	Motor Fault Speed Threshold	-	500	-	RPM
	t_{MTR}	Motor Fault Time	-	15	-	sec

WATER PICK-UP

WATER PICK-UP CONTROL

The Design Parameters for the Water Pick-Up Control module are shown in the two tables below:

Table 11: Sweep Control Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	$t_{SQGPICKUP}$	Squeegee Pick Up Delay	-	1	-	sec
	$t_{SQGSCRUB}$	Squeegee Scrub Delay	-	7	-	sec
	$t_{VACSHORT}$	Pickup Vac Short Turn Off Delay	-	8	-	sec
	$t_{VACSCRUB}$	Pickup Vac Scrub Turn Off Delay	-	14	-	sec
	$t_{VACSIDE}$	Pikcup Vac Side Turn Off Delay	-	21	-	sec

WATER PICK-UP VACUUM

The Design Parameters for the Water Pick-Up Vacuum module are shown in the two tables below:

Table 12: Water Pick-Up Vacuum Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Running Duty Cycle	-	99	-	%
	D_{START}	Starting Duty Cycle	-	25	-	%
	D_{STEP}	Duty Cycle Step	-	5	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	25	-	50	V
	V_{ECON}	Economy Mode Operating Voltage	-	28.75	-	V
	V_{TRGT}	Normal Mode Operating Voltage	-	31.5	-	V

Table 13: Water Pick-Up Vacuum Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Open Fault Threshold	-	1.1	-	A
	t_{OPEN}	Open Fault Time	-	5	-	sec

SQUEEGEE ACTUATOR

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

Table 14: Squeegee Actuator Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{LOWER}	Lowering Duty Cycle	-	66	-	%
	D_{RAISE}	Raising Duty Cycle	-	95	-	%
	t_{TSK}	Task rate	-	50	-	msec

Table 15: Squeegee Actuator Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	t_{LOWER}	Lowering Timeout Time	-	10	-	sec
	t_{RAISE}	Raising Timeout Time	-	7.5	-	sec
Stall Fault	A_{LSTALL}	Lowering Stall Fault Threshold	-	15	-	A
	A_{RSTALL}	Raising Stall Fault Threshold	-	15	-	A

SOLUTION CONTROL

This section includes Design Parameters related to the operation of devices related to Solution Control. The Flow Rate Design Parameters are included in the M17 Flow Rate Specification document.

MAIN WATER VALVE

The Design Parameters for the Main Water Valve module are shown in the table below:

Table 16: Main Water Valve Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Fault	A_{HW}	Threshold	-	80	-	mA
	t_{HW}	Time	-	1	-	sec
Open Fault	A_{OPEN}	Threshold	-	80	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of retries	-	3	-	#

DETERGENT PUMP

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

Table 17: Detergent Pump Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Max Duty Cycle	-	95	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	-	-	36	V

Table 18: Detergent Pump Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Threshold	-	150	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of clipped pulses	-	20	-	#
	t_{SHORT}	Time	-	1	-	sec

SIDE VALVE

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

Table 19: Side Valve Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Fault	A_{HW}	Threshold	-	60	-	mA
	t_{HW}	Time	-	1	-	sec
Open Fault	A_{OPEN}	Threshold	-	60	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of retries	-	3	-	#

SIDE PUMP

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

Table 20: Side Pump Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Max Duty Cycle	-	95	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	-	-	36	V

Table 21: Side Pump Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Threshold	-	150	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of clipped pulses	-	20	-	#
	t_{SHORT}	Time	-	1	-	sec

EXTENDED SCRUB PUMP

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

Table 22: Extended Scrub Pump Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Max Duty Cycle	-	95	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	-	-	36	V

Table 23: Extended Scrub Pump Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Open Fault	A_{OPEN}	Threshold	-	30	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of clipped pulses	-	20	-	#
	t_{SHORT}	Time	-	1	-	sec

RECOVERY AUTOFILL VALVE

The Design Parameters for the Recovery AutoFill Valve module are shown in the table below:

Table 24: Recovery AutoFill Valve Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Fault	A_{HW}	Threshold	-	150	-	mA
	t_{HW}	Time	-	1	-	sec
Open Fault	A_{OPEN}	Threshold	-	150	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of retries	-	3	-	#

SOLUTION AUTOFILL VALVE

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

Table 25: Solution AutoFill Valve Module Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Hardware Fault	A_{HW}	Threshold	-	150	-	mA
	t_{HW}	Time	-	1	-	sec
Open Fault	A_{OPEN}	Threshold	-	150	-	mA
	t_{OPEN}	Time	-	1	-	sec
Shorted Load	n_{SHORT}	Number of retries	-	3	-	#

ECH2O

The Design Parameters for the EcH2O module are contained in the design documentation related to EcH2O. The flow rates used when running EcH2O are captured in the M17 Flow Rate Specification document.

SWEEP

SWEEP CONTROL

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

Table 26: Sweep Control Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{SLOW}	Slow Speed Duty Cycle	-	50	-	%
	$D_{DEFAULT}$	Default Speed Duty Cycle	-	95	-	%
	t_{DVAC}	Dust Vac Turn Off Delay	-	1	-	sec
	t_{MSWP}	Main Sweep Actuator Delay before switching to slow speed when retracting	-	9	-	sec
	t_{TSK}	Task rate	-	50	-	msec
Filter Shaker	$S_{FLTSHKR}$	Filter Shaker Auto Enable Speed	-	2	-	mph
	$t_{FLTSHKR}$	Filter Shaker Auto Enable Time	-	10	-	sec
	t_{ON}	Filter Shaker On Time	-	30	-	sec

MAIN SWEEP HEAD BRUSH MOTORS

The Design Parameters for the Main Sweep Head Brush Motors module are shown in the two tables below:

Table 27: Main Sweep Head Brush Motors Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Max Duty Cycle	0	99	99	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	1	30	36	V
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	10	10	sec

Table 28: Main Sweep Head Brush Motors Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Current Limit Fault	A_{LIMIT}	Current Limit	-	40	-	A
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.2	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	1	15	sec
Shorted Load	n_{SHRT}	Short Fault Threshold (Pulses)	-	20	-	#
	t_{SHRT}	Short Fault Time	0	5	15	sec

MAIN SWEEP ACTUATOR

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

Table 29: Main Sweep Actuator Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{ACT}	Duty Cycle	0	-	95	%
	D_{SPD}	Default Speed Duty Cycle	-	95	-	%
	D_{SSPD}	Slow Speed Duty Cycle	-	50	-	%
	D_{STEP}	Duty Cycle Step Size	-	1	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BATT}	No Battery Voltage Compensation	-	-	-	V
Soft Start	$t_{SFTSTART}$	Soft Start Time	-	0	-	msec

Table 30: Main Sweep Actuator Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	$t_{RTIMEOUT}$	Retract Timeout Time	0	16	30	sec
	$t_{ETIMEOUT}$	Extend Timeout Time	0	6	30	sec
Stall Fault	A_{STALL}	Current Limit	-	10	-	A
	t_{STALL}	Stall Fault Time	0	0.8	15	sec
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.5	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	0.2	15	sec

SIDE SWEEP HEAD BRUSH MOTORS

The Design Parameters for the Side Sweep Head Brush Motors module are shown in the two tables below:

Table 31: Side Sweep Head Brush Motors Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Duty Cycle	0	99	99	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	1	30	36	V
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	5	10	sec

Table 32: Side Sweep Head Brush Motors Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Current Limit Fault	A_{LIMIT}	Current Limit	-	5	-	A
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.2	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	1	15	sec
Shorted Load	n_{SHRT}	Short Fault Threshold (Pulses)	-	20	-	#
	t_{SHRT}	Short Fault Time	0	0.3	15	sec

SIDE SWEEP ACTUATORS

The Design Parameters for the Side Sweep Actuators module are shown in the two tables below:

Table 33: Side Sweep Actuators Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{ACT}	Duty Cycle	0	95	95	%
	t_{TSK}	Task rate	-	50	-	msec
	t_{EXT1}	Timed Position 1	-	2500	-	msec
	t_{EXT2}	Timed Position 2	-	2750	-	msec
	t_{EXT3}	Timed Position 3	-	3000	-	msec
	t_{EXT4}	Timed Position 4	-	3250	-	msec
	t_{EXT5}	Timed Position 5	-	3500	-	msec
	t_{EXT6}	Timed Position 6	-	3750	-	msec
	t_{EXT7}	Timed Position 7	-	4000	-	msec
	t_{EXT8}	Timed Position 8	-	4250	-	msec
	V_{BATT}	Battery Voltage	-	36	-	V
	V_{TARGET}	Target Voltage (when driven at full speed)	-	31.0	-	V

Table 34: Side Sweep Actuators Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	A_{LIMIT}	Current Limit	-	10	-	A
	$t_{TIMEOUT}$	Timeout Time	0	16	30	sec
Stall Fault	n_{STALL}	Stall Fault Clipped Pulses Threshold	-	3	-	#
	t_{STALL}	Stall Fault Time	0	0.8	15	sec
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.2	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.1	0.1	10	A
	t_{OPEN}	Open Fault Time	0	1	15	sec

DUST VAC MOTORS

The Design Parameters for the Dust Vac Motors module are shown in the two tables below:

Table 35: Dust Vac Motors Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Single Dust Vac Duty Cycle	0	???	95	%
	D_{MTR}	Dual Dust Vac Duty Cycle	0	???	95	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	No Battery Voltage Compensation	-	-	-	V

Table 36: Dust Vac Motors Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Underspeed Fault	s_{SPD}	Underspeed Fault Threshold	10	2000	20000	RPM
	t_{SPD}	Underspeed Fault Time	0	5	15	sec

FILTER SHAKER MOTOR

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

Table 37: Filter Shaker Motor Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Duty Cycle	0	95	99	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	1	31.5	36	V
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	0	0.5	10	sec

Table 38: Filter Shaker Motor Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Current Limit Fault	A_{LIMIT}	Current Limit	-	5	-	A
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.2	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	1	15	sec
Shorted Load	n_{SHRT}	Short Fault Threshold (Pulses)	-	20	-	#
	t_{SHRT}	Short Fault Time	0	0.3	15	sec

HOPPER CONTROL

HOPPER CONTROL

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

Table 39: Hopper Control Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	t_{MAXHT}	Max Lift Height	-	15	-	sec
	$t_{ROLLOUT}$	Hopper roll out lift height	7	-	7.5	sec
	V_{UNDER}	Hopper Roll Angle under roll out lift height relative to home position	70	-	100	mV
	V_{ABOVE}	Hopper Roll Angle above roll out lift height relative to home position	0	-	800	mV

HOPPER LIFT PUMP

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

Table 40: Hopper Lift Pump Motor Module Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{MTR}	Max Duty Cycle	0	-	95	%
	D_{HIGH}	High Speed	-	95	-	%
	D_{LOW}	Low Speed	-	40	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BAT}	Battery Voltage	-	36	-	V
	V_{MTR}	Operating Voltage	-	31.5	-	V
Soft Start	$t_{SFTSTART}$	Time Interval Configurable in 0.1s increments 0: Disabled	-	250	-	sec

Table 41: Hopper Lift Pump Motor Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
Current Limit Fault	A_{LIMIT}	Current Limit	-	40	-	A
	$t_{TIMEOUT}$	Timeout Time	0	25	30	sec
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.5	10	A
	t_{HW}	Hardware Fault Time	0	0.8	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	0.2	15	sec
Stall Fault	n_{SHRT}	Short Fault Threshold (Pulses)	-	3	-	#
	t_{SHRT}	Short Fault Time	0	3	15	sec

HOPPER ROLL ACTUATOR

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

Table 42: Hopper Roll Actuator Operation Design Parameters

	Symbol	Description	Min	Typ	Max	Units
General	D_{ACT}	Duty Cycle	0	-	95	%
	D_{HIGH}	High Roll Speed Duty Cycle	-	95	-	%
	D_{LOW}	Low Roll Speed Duty Cycle	-	95	-	%
	t_{TSK}	Task rate	-	50	-	msec
	V_{BATT}	No Battery Voltage Compensation	-	-	-	V
Soft Start	$t_{SFTSTART}$	Soft Start Time	-	250	-	msec

Table 43: Hopper Roll Actuator Fault Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	$t_{RTIMEOUT}$	Retract Timeout Time	0	16	30	sec
Stall Fault	$A_{SEALING}$	Sealing Current Limit	-	3.5	-	A
	A_{NORMAL}	Normal Current Limit	-	6.5	-	A
	$A_{ROLLOUT}$	Roll Out Current Limit	-	5.5	-	A
	t_{STALL}	Stall Fault Time	0	0.25	15	sec
Hardware Fault	A_{HW}	Hardware Fault Threshold	0.2	0.2	10	A
	t_{HW}	Hardware Fault Time	0	5	15	sec
Open Fault	A_{OPEN}	Open Fault Threshold	0.2	0.2	10	A
	t_{OPEN}	Open Fault Time	0	0.2	15	sec

PROPEL

CURTIS

The Design Parameters for the Curtis propel controller module are shown in the table below:

Table 44: iDrive Module Operation Design Parameters

Category	Symbol	Description	Min	Typ	Max	Units
General	V_{HPPR}	Hopper Raised Propel Speed	-	2	-	mph
	V_{SSA}	Side Sweep Adjust Propel Speed	-	2	-	mph
	V_{SCRUB}	Scrub Propel Speed	-	4	-	mph
	$V_{TRANSPORT}$	Transport Propel Speed	-	5.5	-	mph

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.