NOTES:

1. Unless otherwise stated:
   Resistors are 250 mW, 1% tolerance.
   Capacitors are 50V, 10% tolerance.
2. Port and Net Name scopes for this project are:
   Port — NOT Global (connected via Sheet Symbols)
   Net Name — Local (connected on same page only)
3. Do not install (DNI).
4. Tailored value. Nominal value shown.

REVISION BLOCK			
REV	DESCRIPTION	DATE	INCORP. BY

Sheet_Symbol_HA_Tach
SB_PG5.SCHDOC

East_Tach+ East_Vel_Out
East_Tach- West_Vel_Out
West_Tach+ East_Tach_Out
West_Tach- West_Tach_Out
East_Vel_In HA_Lab_Select
West_Vel_In HA_Vel_Feedback

South_Tach+ South_Vel_Out
South_Tach- North_Vel_Out
North_Tach+ South_Tach_Out
North_Tach- North_Tach_Out
South_Vel_In Dec_Lab_Select
North_Vel_In Dec_Vel_Feedback

Sheet_Symbol_Dec_Tach
SB_PG4.SCHDOC

Sheet_Symbol_Overspeed
SB_PG13.SCHDOC

HA_Vel_Feedback
Dec_Vel_Feedback
HA_Overspeed_N
Dec_Overspeed_N

Sheet_Symbol_CPLD
SB_PG6.SCHDOC

Tel_Amp_Enable_&_Therm_Stat
Tel_Brake_Release_&_Amp_Enable_N
Red_Tel_Brake_Release_&_Amp_Enable
HA_Overspeed_N Dome_Amp_Enable_&_Therm_Stat
Dec_Overspeed_N Dome_Amp_Enable_N
Lab_Select

HA_Overspeed_Latch
Dec_Overspeed_Latch
West_Overcurrent_Latch
East_Overcurrent_Latch
North_Overcurrent_Latch
South_Overcurrent_Latch
Dome1_Overcurrent_Latch
Dome2_Overcurrent_Latch
Dome3_Overcurrent_Latch
Emerg_Stop_Latch
HP_Stop_Latch
Mtr_Cntr_Err_Latch
TCS_Lockout_Latch
HA_Stop_W_Latch
HA_Stop_E_Latch
HA_Emerg_W_Latch
HA_Emerg_E_Latch
Dec_Stop_N_Latch
Dec_Stop_S_Latch
Dec_Emerg_N_Latch
Dec_Emerg_S_Latch
Horizon_Stop_Latch
Watchdog_Timer_Latch
SB_Clock_WD_Err_Latch
Dome_Amp_Enable_&_Therm_Stat_Latch
Tel_Amp_Enable_&_Therm_Stat_Latch
Lab_Select_Latch
Spare1_Latch

CPLD_Clk TOP_Dome_Cntl_Handpaddle_BUF
SB_Clock_WD_Err_N TOP_TCS_Enable
Watchdog_Timer_Error_N TOP_Brake_Enable_Out

Sheet_Symbol_Relays
SB_PG8.SCHDOC

Tel_Amp_Enable_&_Therm_Stat
Tel_Brake_Release_&_Amp_Enable_N
Red_Tel_Brake_Release_&_Amp_Enable
Emerg_Stop_N
Dome_Amp_Enable_&_Therm_Stat
Dome_Amp_Enable_N
24V
Brake_Release_Relay
Tel_Amp_En_N
Tel_Amp_Rtn
Dome_Amp_En_N
Dome_Amp_Rtn

J1

1	East Drive+	26	North Current
2	East Drive-	27	South Current
3		28	Dome1 Current
4	West Drive+	29	Dome2 Current
5	West Drive-	30	Dome3 Current
6		31	Horizon Stop
7	South Drive+	32	HA Stop W
8	South Drive-	33	HA Stop E
9		34	HA Emerg W
10	North Drive+	35	HA Emerg E
11	North Drive-	36	Dec Stop N
12		37	Dec Stop S
13	East Vel In	38	Dec Emerg N
14	West Vel In	39	Dec Emerg S
15	South Vel In	40	Emerg Stop
16	North Vel In	41	TOP DomeCntl Software
17	HA Vel Feedback	42	TOP Tel Enable Switch
18	Dec Vel Feedback	43	TOP Lm Override Switch
19	Mtr Cntr Err	44	HP Stop
20	TCS Lockout	45	Spare In 1
21	Brake En In	46	Spare In 2
22	Watchdog In	47	
23	Reset	48	
24	West Current	49	
25	East Current	50	

AGND
1-5499923-0

Sheet_Symbol_Overcurrent
SB_PG11.SCHDOC; SB_PG12.SCHDOC; SB_PG14.SCHDOC; SB_PG15.SCHDOC

West_Current West_Overcurrent_N
East_Current East_Overcurrent_N
North_Current North_Overcurrent_N
South_Current South_Overcurrent_N
Dome1_Current Dome1_Overcurrent_N
Dome2_Current Dome2_Overcurrent_N
Dome3_Current Dome3_Overcurrent_N

Sheet_Symbol_Input_Buffer
SB_PG9.SCHDOC;SB_PG10.SCHDOC

Mtr_Cntr_Err_N Mtr_Cntr_Err_BUF_N
TCS_Lockout_N TCS_Lockout_BUF_N
Brake_En_In Brake_En_In_BUF
Watchdog_In
Reset_N Reset_BUF_N
Horizon_Stop_N Horizon_Stop_BUF_N
HA_Stop_West_N HA_Stop_West_BUF_N
HA_Stop_East_N HA_Stop_East_BUF_N
HA_Emerg_West_N HA_Emerg_West_BUF_N
HA_Emerg_East_N HA_Emerg_East_BUF_N
Dec_Stop_North_N Dec_Stop_North_BUF_N
Dec_Stop_South_N Dec_Stop_South_BUF_N
Dec_Emerg_North_N Dec_Emerg_North_BUF_N
Dec_Emerg_South_N Dec_Emerg_South_BUF_N
Emerg_Stop_N Emerg_Stop_BUF_N
TOP_Dome_Cntl_Software TOP_Dome_Cntl_Software_BUF
TOP_Tel_Enable_Switch TOP_Tel_Enable_Switch_BUF
TOP_Lm_Override_Switch TOP_Lm_Override_Switch_BUF
HP_Stop_N HP_Stop_BUF_N
SPARE1 SPARE1_BUF
SPARE2 SPARE2_BUF
TOP_Dome_Cntl_Handpaddle TOP_Dome_Cntl_Handpaddle_BUF
Watchdog_In_BUF

Sheet_Symbol_WD
SB_PG7.SCHDOC

Watchdog_In_BUF
CPLD_Clk
SB_Clock_WD_Err_N
Watchdog_Timer_Error_N

Sheet_Symbol_Power_Filter
SB_PG2.SCHDOC

+5V_SE_Raw
+5V_SE_Rtn
+5V_WD_Raw
+5V_WD_Rtn
+5V_DIG_Raw
+5V_DIG_Rtn
15V_Rtn
+15V_Raw
-15V_Raw

J3 5499922-2

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

J5 22-23-2051

Sheet_Symbol_Encoder
SB_PG3.SCHDOC

West_Encoder_BUF
West_Encoder_In
East_Encoder_BUF
West_Encoder_Rtn
North_Encoder_BUF
East_Encoder_In
South_Encoder_BUF
East_Encoder_Rtn
North_Encoder_In
North_Encoder_Rtn
South_Encoder_In
South_Encoder_Rtn

J4

1	
2	
3	
4	
5	
6	
7	
8	
9	NC
10	
11	
12	
13	NC
14	
15	
16	

5499922-3
AGND

Sheet_Symbol_Spares
SB_PG16.SCHDOC

(Contains spare / unused components)

J2

1	24V	26	Mtr Cntr Err Latch
2	Brake Enable Re	27	TCS Lockout Latch
3	East Tach Out	28	HA Stop W Latch
4	Tel Amp	29	HA Stop E Latch
5	Tel Amp Ret	30	HA Emerg W Latch
6	Dome Amp	31	HA Emerg E Latch
7	Dome Amp Ret	32	Dec Stop N Latch
8	West Tach Out	33	Dec Stop S Latch
9	South Tach O	34	Dec Emerg N Latch
10	East Vel Out	35	Dec Emerg S Latch
11		36	Horizon Stop Latch
12	West Vel Out	37	Watchdog Timer Latch
13		38	Clocking Error Latch
14	South Vel Out	39	Dome_Amp_Enable_&_Therm_Stat_Latch
15		40	Tel_Amp_Enable_&_Therm_Stat_Latch
16	North Vel Out	41	Lab_Select_Latch
17		42	Spare Latch Out 1
18	HA OS Latch	43	OPTO_22_rtn_currents
19	Dec OS Latch	44	North Tach Out
20	West OS Latch	45	TOP DomeCntl Handpaddle
21	East OS Latch	46	TOP TCS Enable
22	North OS Latch	47	TOP Brake Enable Out
23	South OS Latch	48	
24	Dome1 OS Latch	49	
25	Dome2 OS Latch	50	

1-5499923-0
DGND

AGND

University of Hawaii
Institute for Astronomy

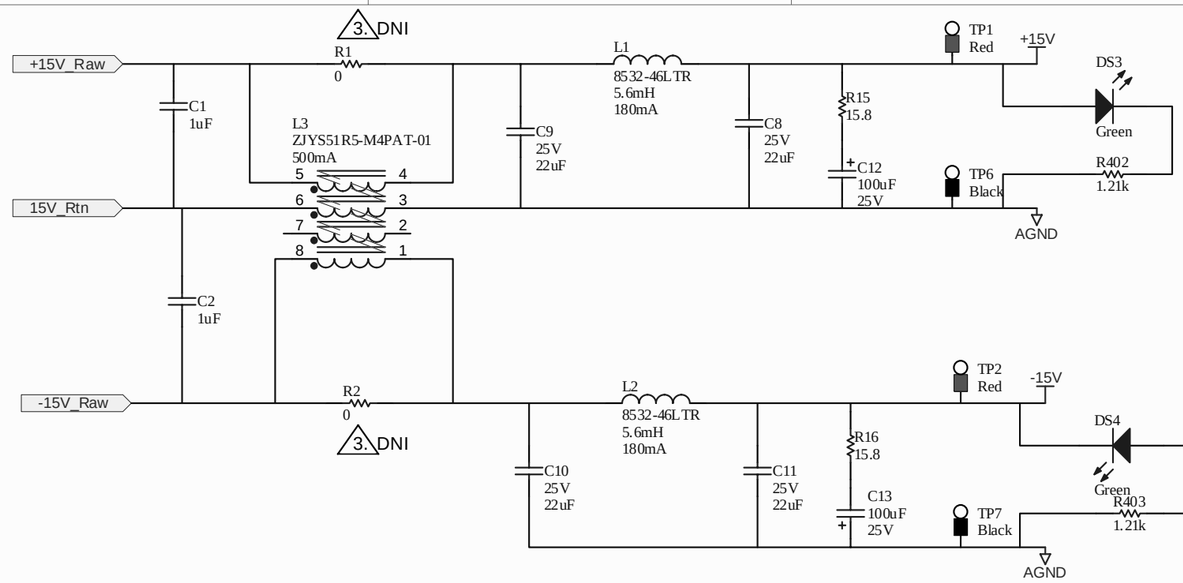
DWG #	REV	TITLE
TCS3-2070	-	TCS3 Safety Board

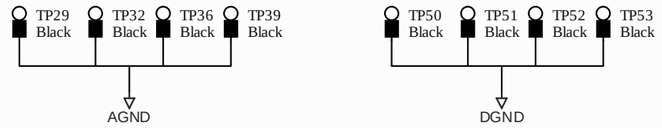
ENGINEER	LAST EDIT	SIZE	SHEET
E. Warmbier	1/21/2009 11:14:53 PM	B	1 of 16

FILE: Z:\TCS\Safety Board Schematics,PL,CCA\Safety Board Protel\Safety Board Rev D\SB_PG1.SCHDOC

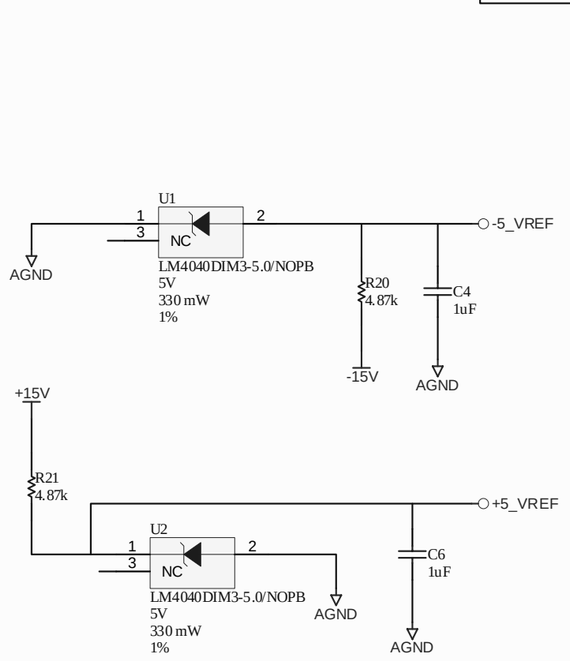
DWG # TCS3-2070 REV -

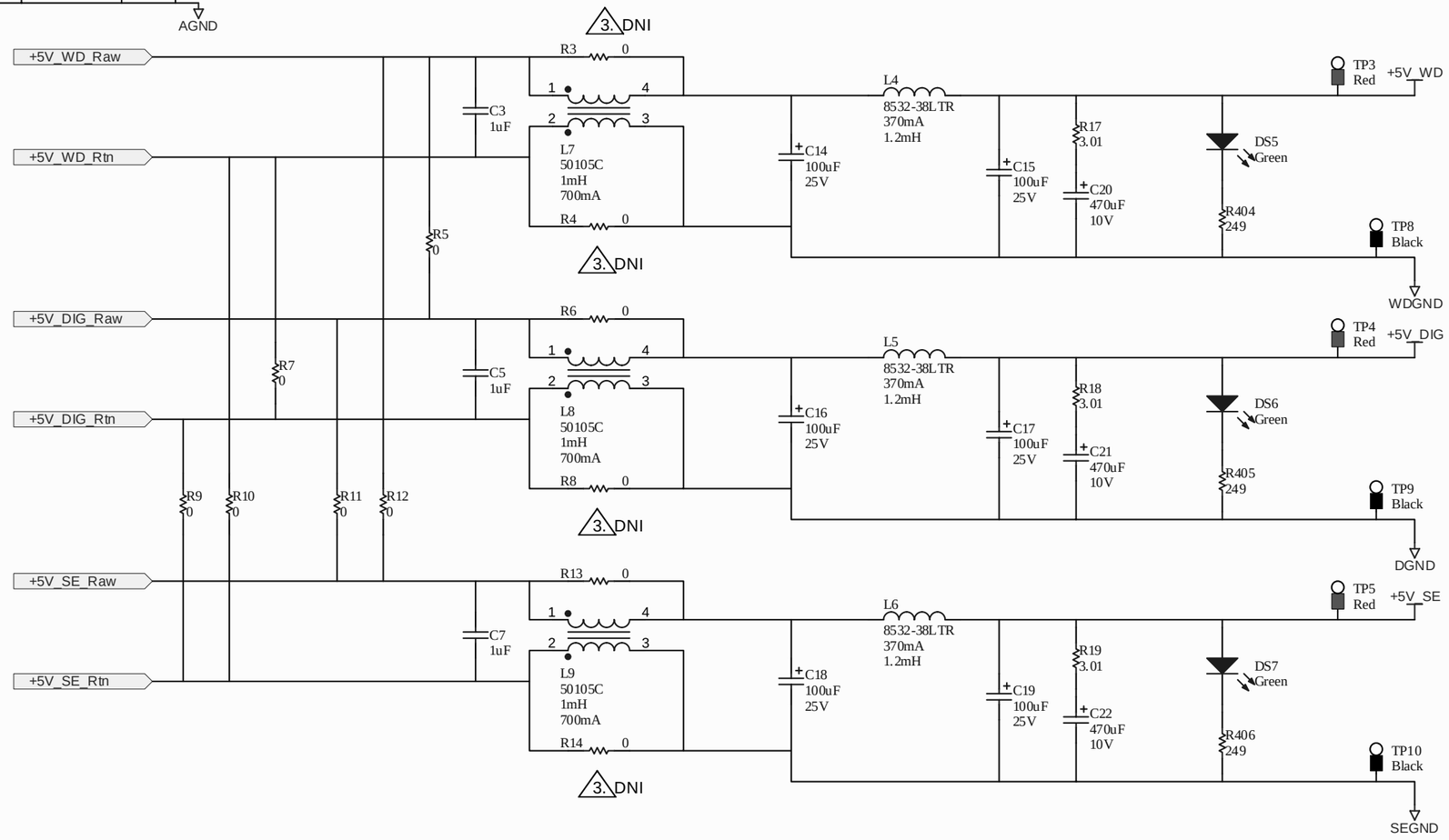
REVISION BLOCK
SEE SHEET 1





Note: DO NOT overlap input and output planes of filter in layout.
This defeats the whole purpose by creating a bypass capacitance.





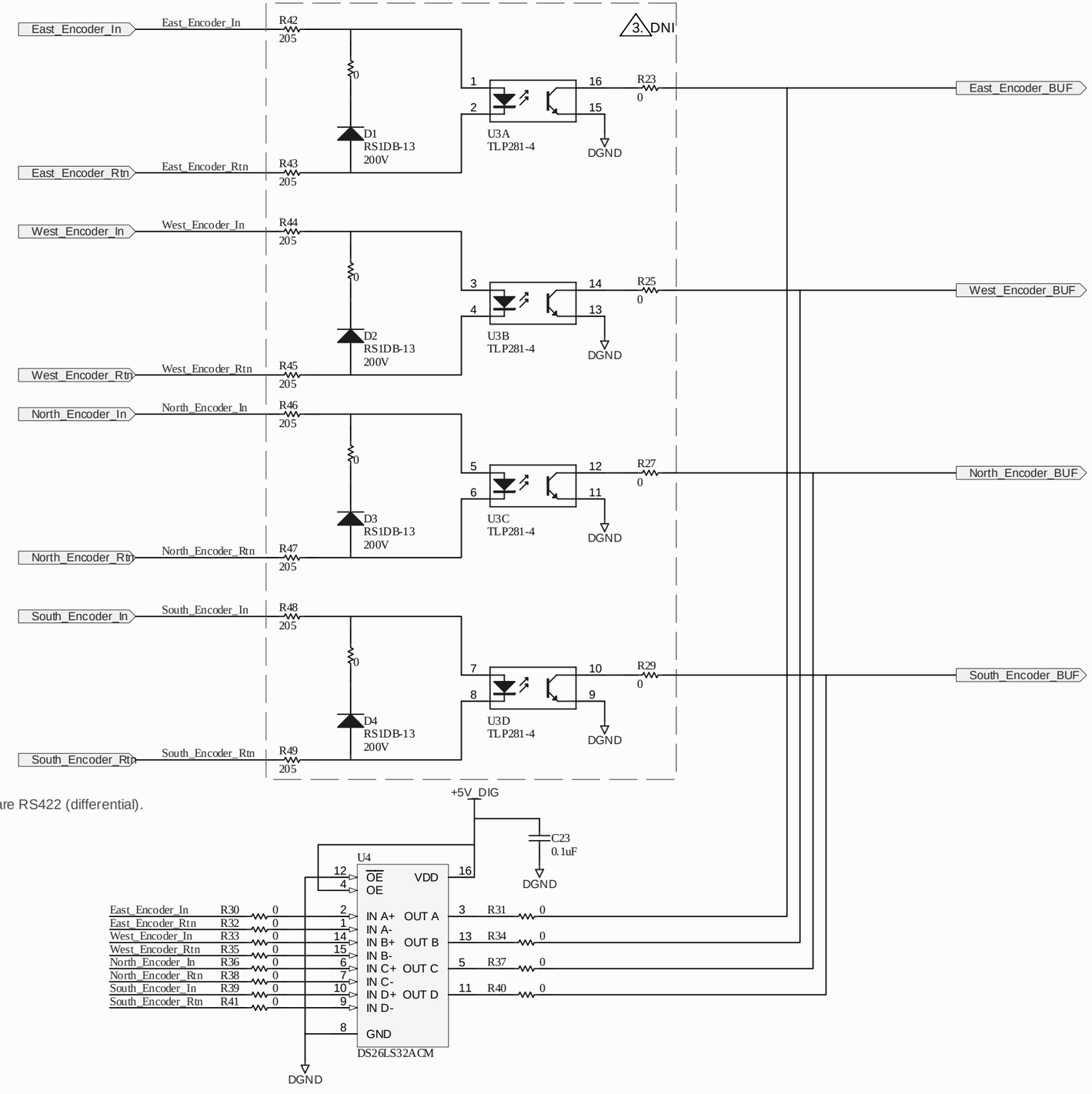
REV -

DWG # TCS3-2070

Power Filtering & References

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	2 of 16

REVISION BLOCK
SEE SHEET 1



Note: US Digital Corp EQUAD accepts TTL logic or open collector. It has 5k pullup to +5V. Configurable via switch for rising/falling edge.

Note: Input signals are RS422 (differential).

Axis Incremental Encoder Converters

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	3 of 16

DWG # TCS3-2070 REV -

REVISION BLOCK

SEE SHEET 1

Dec Tachometer & Servo Command

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	4 of 16

DWG # TCS3-2070 REV -

Note: silkscreen "North Tach"

Note: Nominally 8.78 mV/(arcsec/s)
114 (arcsec/s)/V

Note: silkscreen labels.
"SUMMIT"

Note: silkscreen "Dec Vel"

Note: 1.7mV/(arcsec/s)
588 (arcsec/s)/V

Note: silkscreen "South Tach"

Note: Nominally 8.78 mV/(arcsec/s)
114 (arcsec/s)/V

REVISION BLOCK

SEE SHEET 1

HA Tachometer & Servo Command

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	5 of 16

DWG # TCS3-2070

REV -

Note: silkscreen "West Tach"

Note: Nominally 8.78 mV/(arcsec/s)
114 (arcsec/s)/V

Note: silkscreen labels.
"SUMMIT"

Note: silkscreen "HA Vel"

Note: 1.7mV/(arcsec/s)
588 (arcsec/s)/V

Note: silkscreen "East Tach"

Note: Nominally 8.78 mV/(arcsec/s)
114 (arcsec/s)/V

REVISION BLOCK

SEE SHEET 1

J6
87831-1420
+5V_DIG
TMS
TCK
TDO
TDI
NC
NC
DGND

TCS_Lockout_BUF_N
HA_Stop_W_Latch
HA_Emerg_East_BUF_N
TOP_Dome_Cntl_Software_BUF
HA_Stop_E_Latch
Tel_Amp_Enable_&_Therm_Stat
North_Overcurrent_NC
Red_Tel_Brake_Release_&_Amp_Enable
Reset_BUF_N

VCC

U10
XC9572-15PC84C

I/O/MC1-1 4 Dec_Stop_N_Latch
I/O/MC1-2 1 SPARE1_BUF
I/O/MC1-3 6 Dec_Emerg_S_Latch
I/O/MC1-4 7 TOP_TCS_Enable
I/O/MC1-5 2 Dome1_Overcurrent_Latch
I/O/MC1-6 3 Dec_Stop_North_BUF_N
I/O/MC1-7 11 Dome2_Overcurrent_Latch
I/O/MC1-8 5 HA_Overspeed_N
I/O/GCK1/MC1-9 9 Dome3_Overcurrent_Latch
I/O/MC1-10 13 Mtr_Cntr_Err_BUF
I/O/GCK2/MC1-11 10 Dome1_Overcurrent_N
I/O/MC1-12 18 East_Overcurrent_Latch
I/O/MC1-13 20 SB_Clock_WD_Err_N
I/O/GCK3/MC1-14 12 TOP_Lm_Override_Switch_BUF
I/O/MC1-15 14 Emerg_Stop_Latch
I/O/MC1-16 23
I/O/MC1-17 15 West_Overcurrent_N
I/O/MC1-18 24 TOP_Brake_Enable_Out
I/O/MC4-1 46 East_Overcurrent_N
I/O/MC4-2 44 Dec_Emerg_N_Latch
I/O/MC4-3 51 SPARE2_BUF
I/O/MC4-4 53 Dec_Stop_S_Latch
I/O/MC4-5 47 Horizon_Stop_BUF_N
I/O/MC4-6 54 Dec_Overspeed_Latch
I/O/MC4-7 55 Brake_En_In_BUF
I/O/MC4-8 48 Horizon_Stop_Latch

I/O/MC2-8 72 HA_Overspeed_Latch
I/O/GTS1/MC2-7 76 South_Overcurrent_N
I/O/MC2-6 71 Watchdog_Timer_Error_N
I/O/MC2-5 70 HA_Stop_East_BUF_N
I/O/MC2-4 68 HA_Emerg_W_Latch
I/O/MC2-3 67 Dec_Stop_South_BUF_N
I/O/MC2-2 69 TOP_Tel_Enable_Switch_BUF
I/O/MC2-1 63 HA_Emerg_E_Latch
I/O/MC3-17 39 Tel_Amp_Enable_&_Therm_Stat_Latch
I/O/MC3-16 45 Dome_Amp_Enable_&_Therm_Stat_Latch
I/O/MC3-15 37 HA_Stop_West_BUF_N
I/O/MC3-14 36 Lab_Select_Latch
I/O/MC3-13 43 Dome2_Overcurrent_N
I/O/MC3-12 41 Spare1_Latch
I/O/MC3-11 33 Dec_Emerg_North_BUF_N
I/O/MC3-10 40
I/O/MC3-9 26 Dec_Emerg_South_BUF_N

VCC
R374
10k
LAB_Select

GND GND GND GND GND GND
DGND

I/O/MC4-9 50 TOP_Dome_Cntl_Handpaddle_BUF
I/O/MC4-10 57 HP_Stop_Latch
I/O/MC4-11 53 HA_Emerg_West_BUF_N
I/O/MC4-12 59 TCS_Lockout_Latch
I/O/MC4-13 61 Tel_Brake_Release_&_Amp_Enable_N
I/O/MC4-14 56 Watchdog_Timer_Latch
I/O/MC4-15 65 Dec_Overspeed_N
I/O/MC4-16 62 West_Overcurrent_Latch
I/O/MC4-17 66 Dome_Amp_Enable_N
I/O/MC3-1 25 Dome_Amp_Enable_&_Therm_Stat
I/O/MC3-2 17 Mtr_Cntr_Err_Latch
I/O/MC3-3 31 Dome3_Overcurrent_N
I/O/MC3-4 32 North_Overcurrent_Latch
I/O/MC3-5 19 HP_Stop_BUF_N
I/O/MC3-6 34 South_Overcurrent_Latch
I/O/MC3-7 35 Emerg_Stop_BUF_N
I/O/MC3-8 21 SB_Clock_WD_Err_Latch

+5V_DIG
C83 0.01uF
DGND
U9
TS555IDT
CVOLT VCC
RST
DISC OUT
THR
TRIG GND
+5V_DIG
C77 0.1uF
DGND
R125 4.75k
R126 4.75k
R127 100k
CPLD_Clk
C84 10uF 25V
DGND

Note: Clock is about 10 Hz.

Note: Distribute caps evenly among VCCINT and VCCIO pins.

+5V_DIG
C72 1uF
C73 1uF
C74 1uF
C75 1uF
C76 1uF
DGND
+5V_DIG
C78 0.1uF
C79 0.1uF
C80 0.1uF
C81 0.1uF
C82 0.1uF
DGND

U43
74AC541MTR
+5V_DIG
C30 0.1uF
DGND
OE1 VCC
OE2
GND
HA_Overspeed_Latch 2 A1 Y1 18 HA_Overspeed_Latch
HA_Emerg_W_Latch 3 A2 Y2 17 HA_Emerg_W_Latch
HA_Emerg_E_Latch 4 A3 Y3 16 HA_Emerg_E_Latch
Tel_Amp_Enable_&_Therm_Stat_Latch 5 A4 Y4 15 Tel_Amp_Enable_&_Therm_Stat_Latch
Dome_Amp_Enable_&_Therm_Stat_Latch 6 A5 Y5 14 Dome_Amp_Enable_&_Therm_Stat_Latch
Lab_Select_Latch 7 A6 Y6 13 Lab_Select_Latch
Spare1_Latch 8 A7 Y7 12 Spare1_Latch
SB_Clock_WD_Err_Latch 9 A8 Y8 11 SB_Clock_WD_Err_Latch

U44
74AC541MTR
+5V_DIG
C31 0.1uF
DGND
OE1 VCC
OE2
GND
South_Overcurrent_Latch 2 A1 Y1 18 South_Overcurrent_Latch
North_Overcurrent_Latch 3 A2 Y2 17 North_Overcurrent_Latch
Mtr_Cntr_Err_Latch 4 A3 Y3 16 Mtr_Cntr_Err_Latch
West_Overcurrent_Latch 5 A4 Y4 15 West_Overcurrent_Latch
Watchdog_Timer_Latch 6 A5 Y5 14 Watchdog_Timer_Latch
TCS_Lockout_Latch 7 A6 Y6 13 TCS_Lockout_Latch
HP_Stop_Latch 8 A7 Y7 12 HP_Stop_Latch
R416 0 9 A8 Y8 11
DGND DGND 10 GND

U45
74AC541MTR
+5V_DIG
C54 0.1uF
DGND
OE1 VCC
OE2
GND
Horizon_Stop_Latch 2 A1 Y1 18 Horizon_Stop_Latch
Dec_Overspeed_Latch 3 A2 Y2 17 Dec_Overspeed_Latch
Dec_Stop_S_Latch 4 A3 Y3 16 Dec_Stop_S_Latch
Dec_Emerg_N_Latch 5 A4 Y4 15 Dec_Emerg_N_Latch
TOP_Brake_Enable_Out 6 A5 Y5 14 TOP_Brake_Enable_Out
Emerg_Stop_Latch 7 A6 Y6 13 Emerg_Stop_Latch
East_Overcurrent_Latch 8 A7 Y7 12 East_Overcurrent_Latch
Dome3_Overcurrent_Latch 9 A8 Y8 11 Dome3_Overcurrent_Latch

U46
74AC541MTR
+5V_DIG
C55 0.1uF
DGND
OE1 VCC
OE2
GND
Dome2_Overcurrent_Latch 2 A1 Y1 18 Dome2_Overcurrent_Latch
Dome1_Overcurrent_Latch 3 A2 Y2 17 Dome1_Overcurrent_Latch
TOP_TCS_Enable 4 A3 Y3 16 TOP_TCS_Enable
Dec_Emerg_S_Latch 5 A4 Y4 15 Dec_Emerg_S_Latch
Dec_Stop_N_Latch 6 A5 Y5 14 Dec_Stop_N_Latch
HA_Stop_W_Latch 7 A6 Y6 13 HA_Stop_W_Latch
HA_Stop_E_Latch 8 A7 Y7 12 HA_Stop_E_Latch
R415 0 9 A8 Y8 11
DGND DGND 10 GND

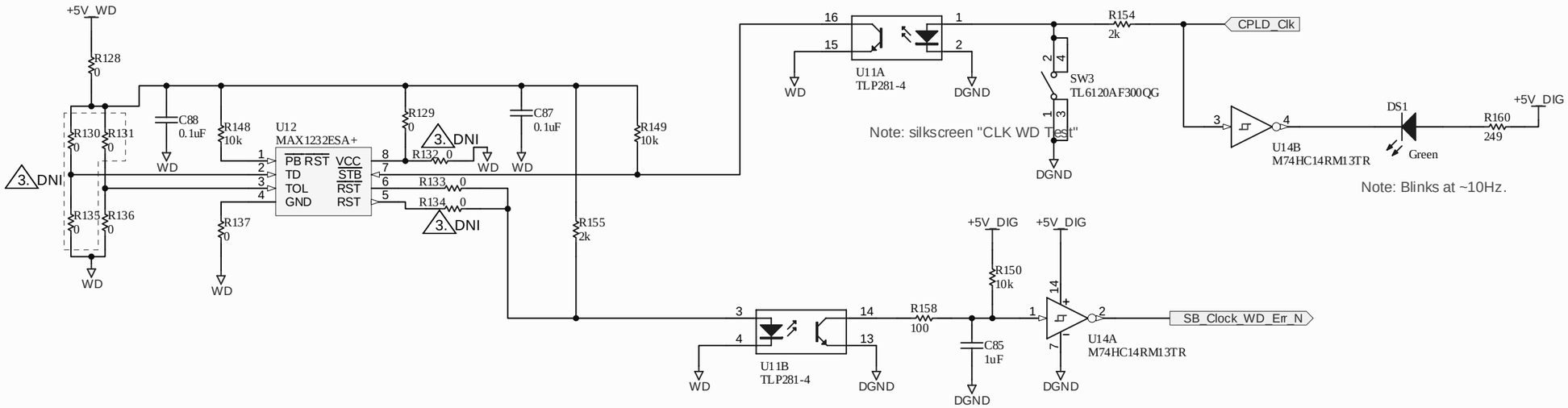
Note: Output buffers used for off board output signals.

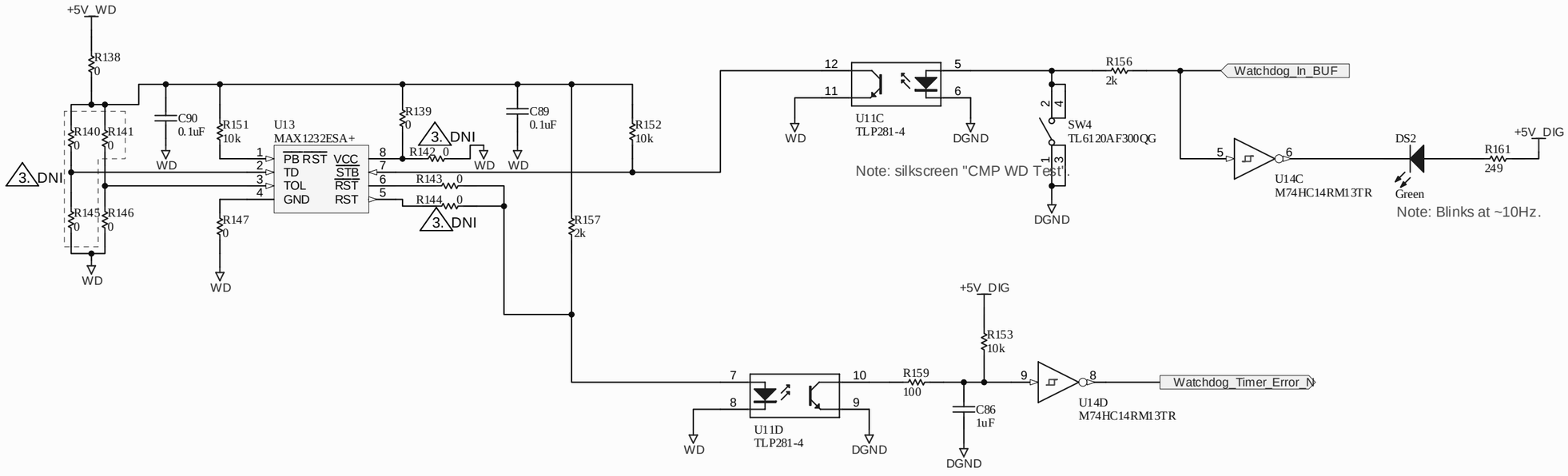
CPLD & Watchdog Circuits

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	6 of 16

DWG# TCS3-2070 REV -

REVISION BLOCK
SEE SHEET 1





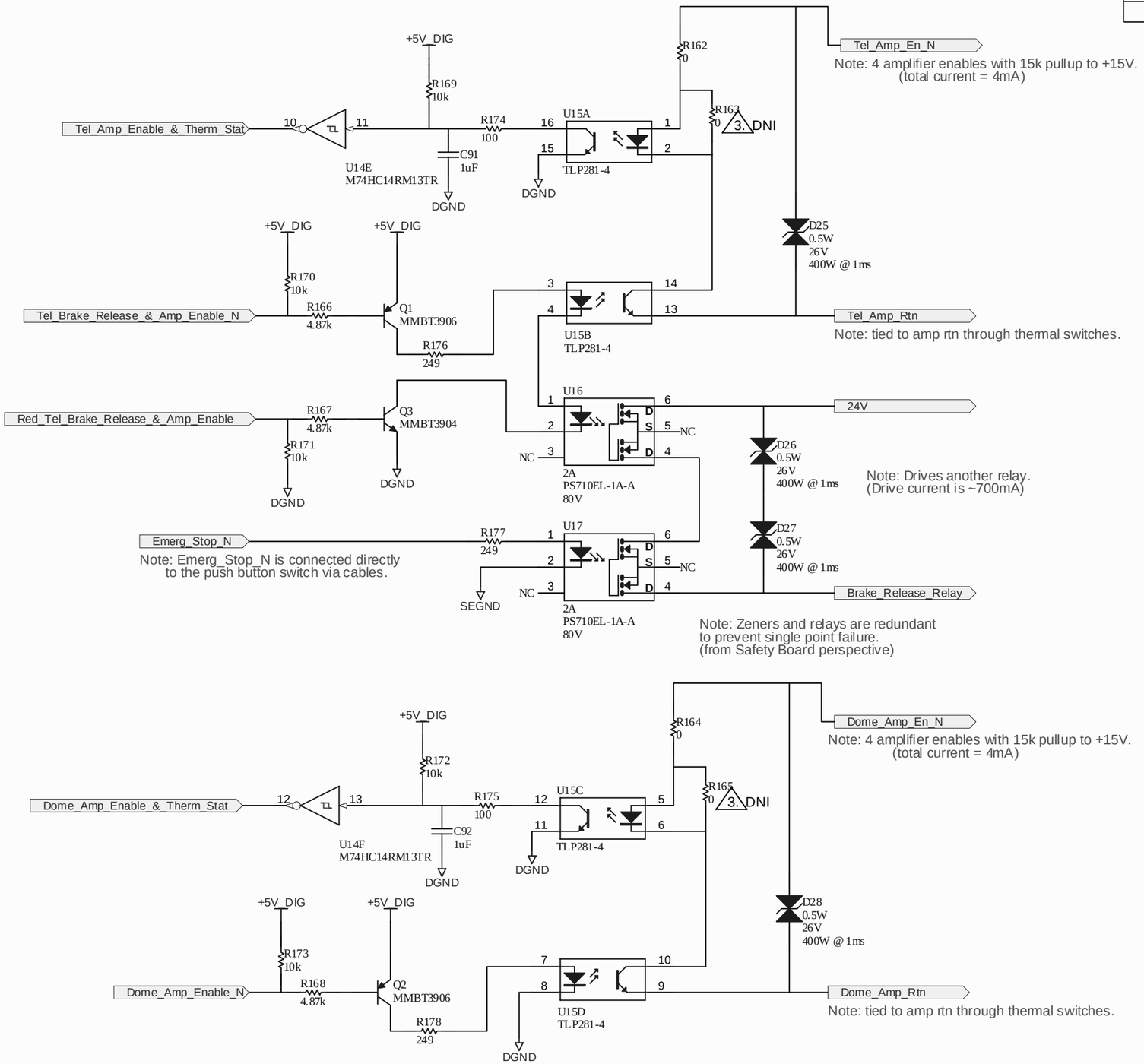
Note: The 0 ohm jumpers make it possible to use another watchdog IC. For example, a PIC 16F629 microcontroller could be programmed as a watchdog IC.

Watchdog Circuits

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	7 of 16

DWG # TCS3-2070 REV -

REVISION BLOCK
SEE SHEET 1

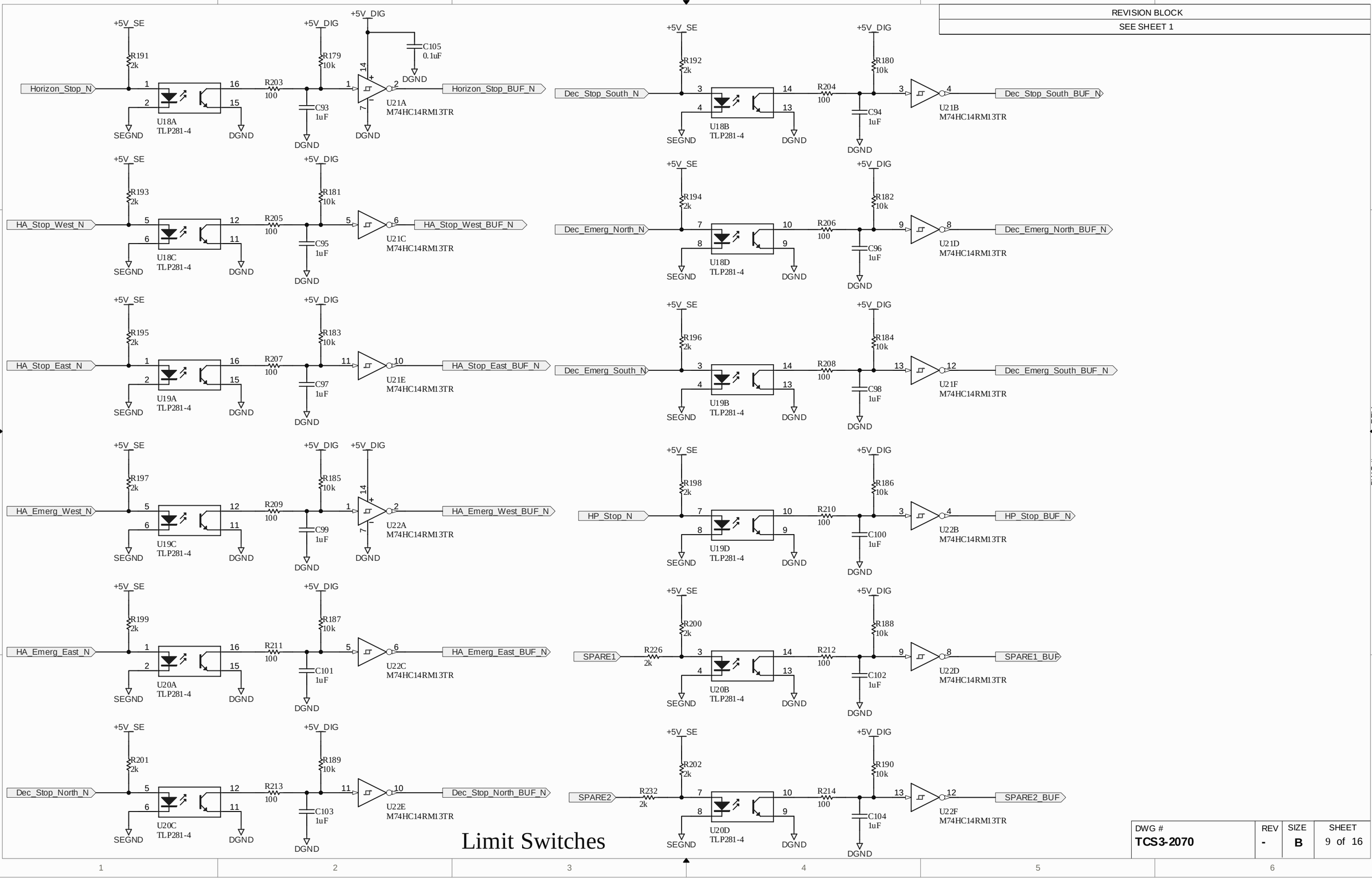


Relays - Brake, Telescope Amp, Dome Amps

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	8 of 16

REV -

DWG # TCS3-2070



Limit Switches

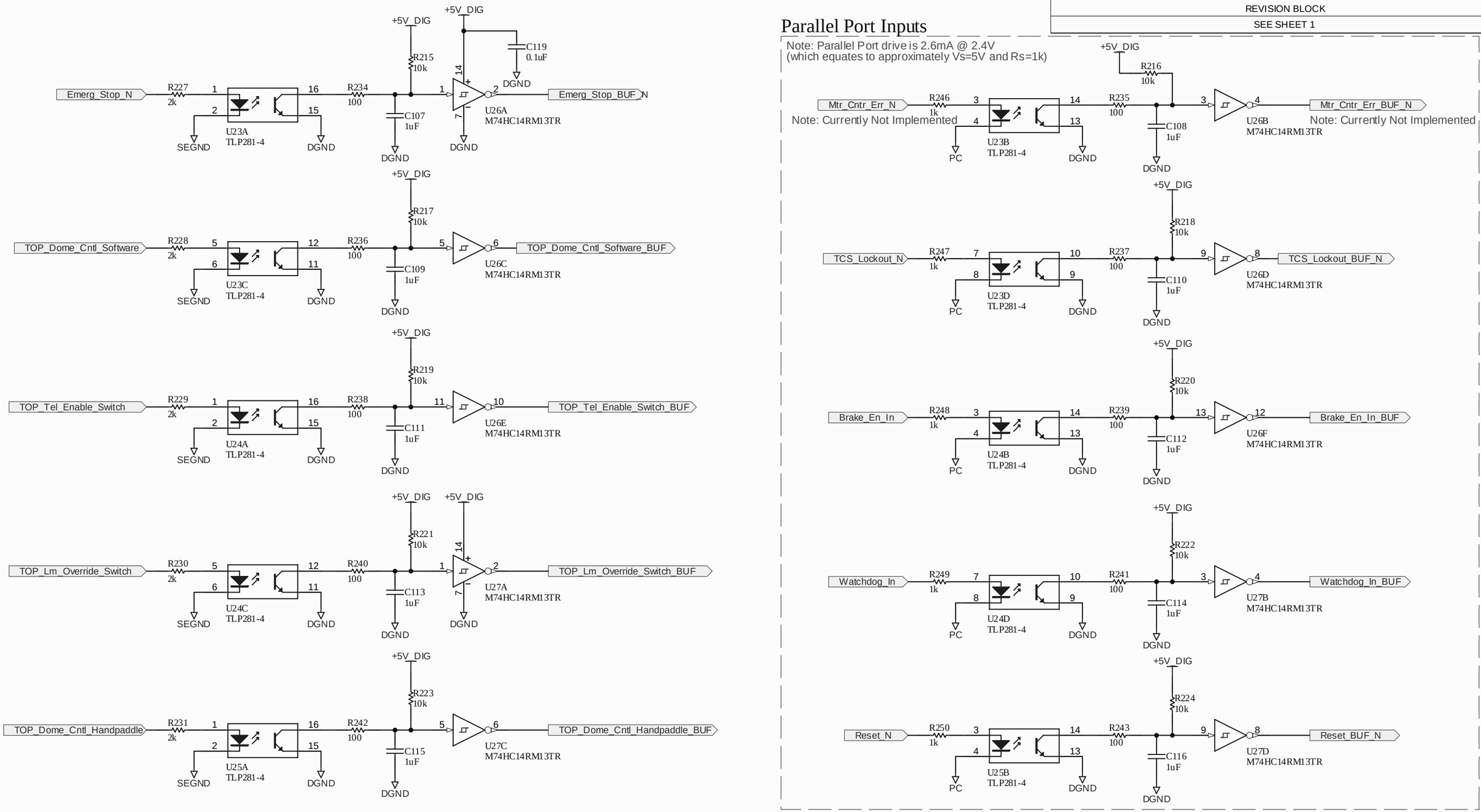
DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	9 of 16

DWG # TCS3-2070 REV -

REVISION BLOCK
SEE SHEET 1

Parallel Port Inputs

Note: Parallel Port drive is 2.6mA @ 2.4V
(which equates to approximately Vs=5V and Rs=1k)

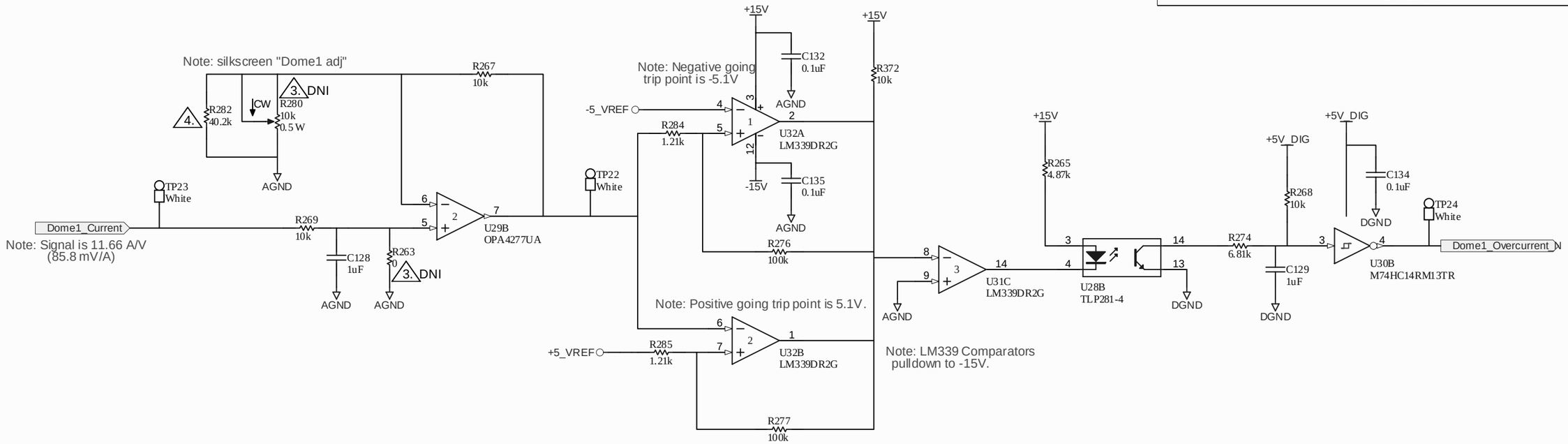


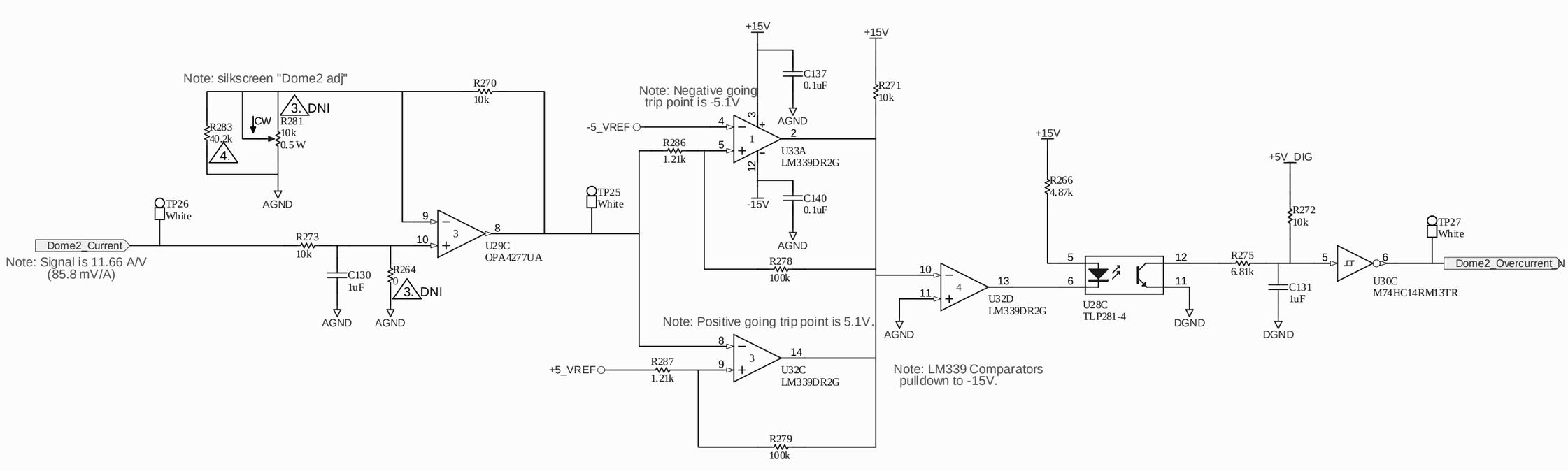
Limit Switches & Parallel Port

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	10 of 16

DWG # TCS3-2070 REV -

REVISION BLOCK
SEE SHEET 1





Dome Overcurrent

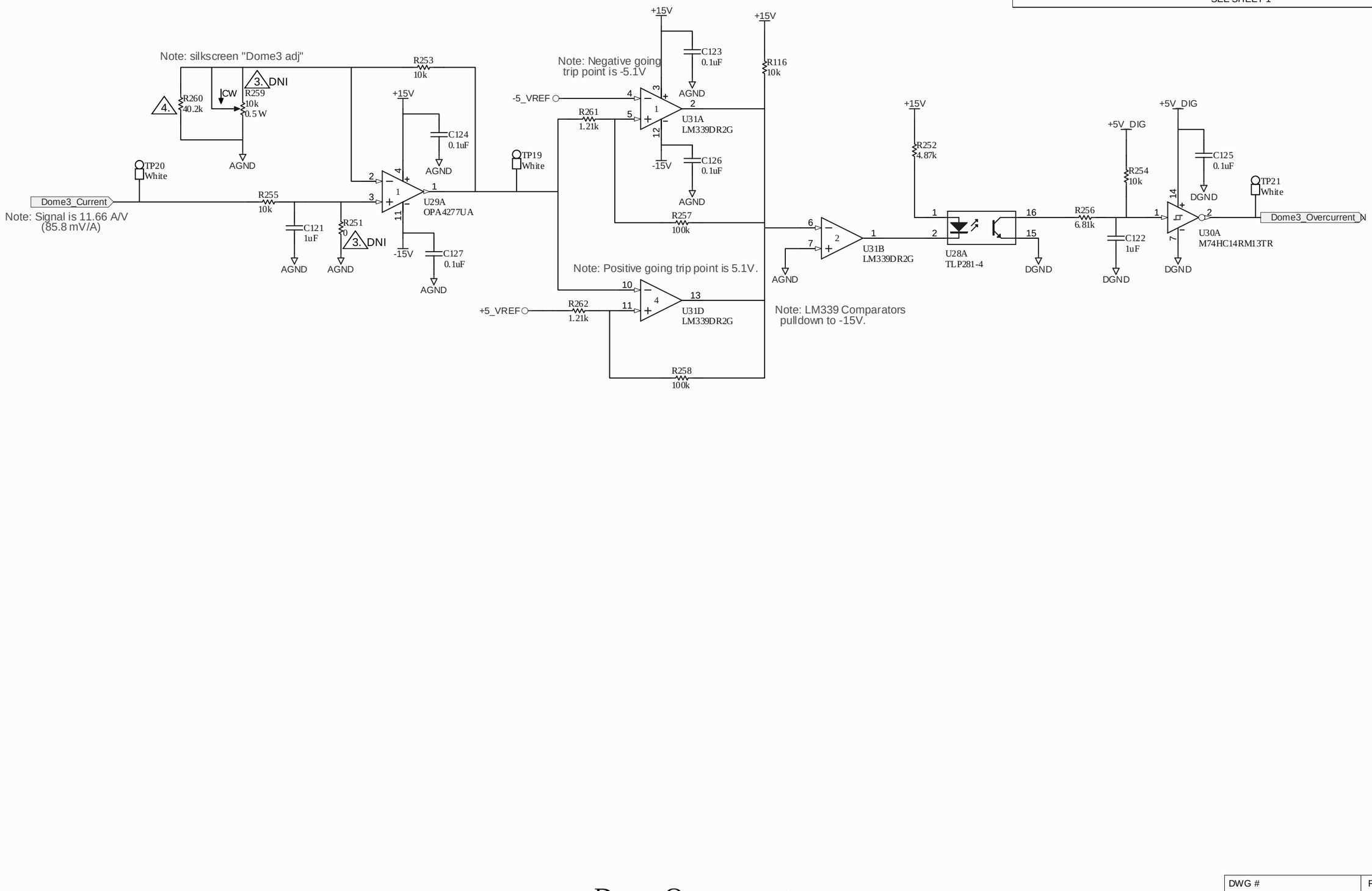
DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	11 of 16

REV -

DWG # TCS3-2070

REVISION BLOCK

SEE SHEET 1



REV -

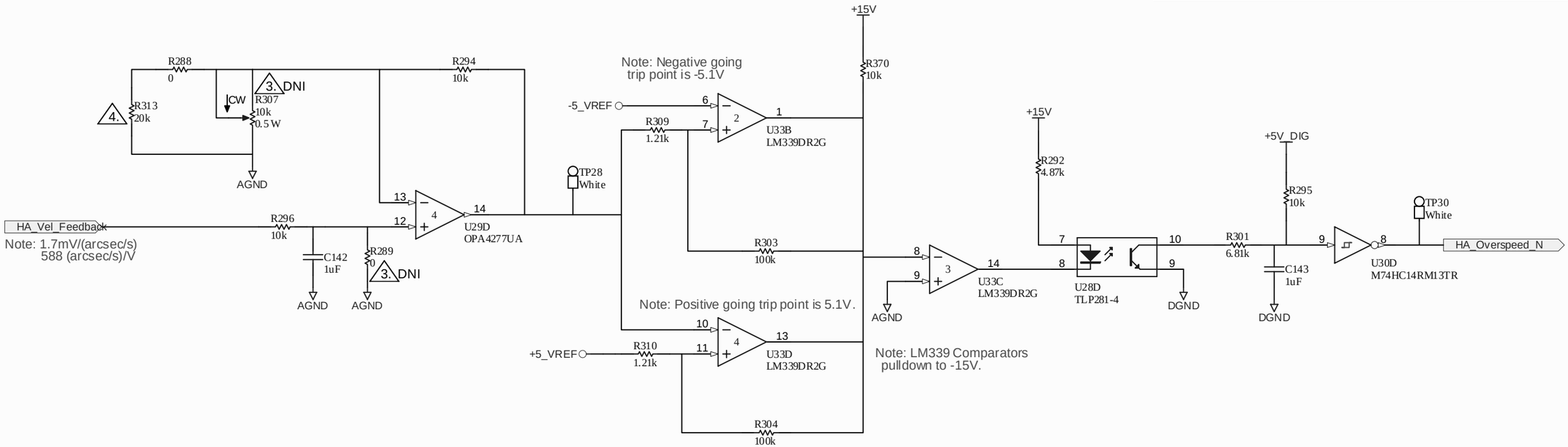
DWG# TCS3-2070

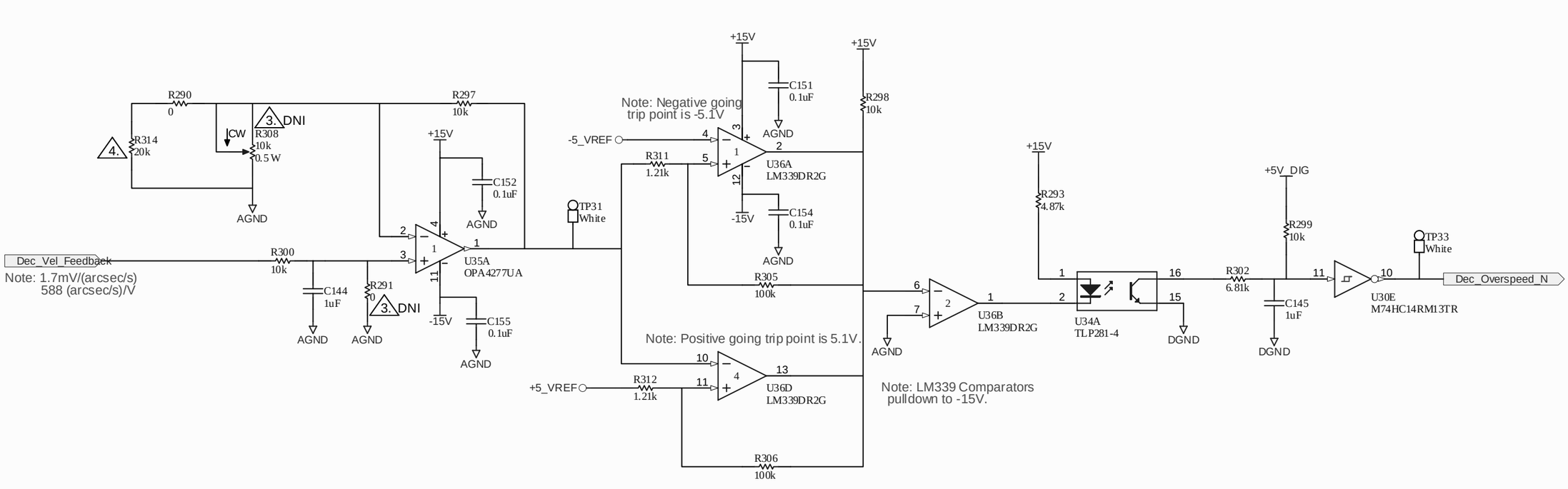
Dome Overcurrent

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	12 of 16

REVISION BLOCK

SEE SHEET 1





HA & Dec Overspeed

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	13 of 16

DWG # TCS3-2070

REV -

REVISION BLOCK
SEE SHEET 1

Note: silkscreen "East adj"

R315 0 — 3. DNI — CW — R334 10k 0.5 W — R321 10k — 4. R340 15k — AGND

TP35 White — East_Current

Note: Signal is 11.66 A/V (85.8 mV/A)

R323 10k — C156 1uF — AGND — R316 0 — 3. DNI — AGND

U35B OPA4277UA

TP34 White

Note: Negative going trip point is -5.1V

-5_VREF — R336 1.21k — U38A LM339DR2G — C160 0.1uF — AGND — C163 0.1uF — -15V — AGND — R330 100k

+15V — R371 10k

Note: Positive going trip point is 5.1V.

+5_VREF — R337 1.21k — U38B LM339DR2G — R331 100k

Note: LM339 Comparators pulldown to -15V.

+15V — R319 4.87k — U34B TLP281-4 — DGND

U36C LM339DR2G — AGND

+5V_DIG — R322 10k — R328 6.81k — C157 1uF — DGND

U30F M74HC14RM13TR — TP46 White — East_Overcurrent_N

Note: silkscreen "West adj"

R317 0 — 3. DNI — CW — R335 10k 0.5 W — R324 10k — 4. R341 15k — AGND

TP38 White — West_Current

Note: Signal is 11.66 A/V (85.8 mV/A)

R327 10k — C158 1uF — AGND — R318 0 — 3. DNI — AGND

U35C OPA4277UA

TP37 White

Note: Negative going trip point is -5.1V

-5_VREF — R338 1.21k — U39D LM339DR2G — R332 100k

+15V — R325 10k

Note: Positive going trip point is 5.1V.

+5_VREF — R339 1.21k — U38C LM339DR2G — R333 100k

Note: LM339 Comparators pulldown to -15V.

+15V — R320 4.87k — U34C TLP281-4 — DGND

U38D LM339DR2G — AGND

+5V_DIG — R326 10k — R329 6.81k — C159 1uF — DGND

C167 0.1uF — DGND

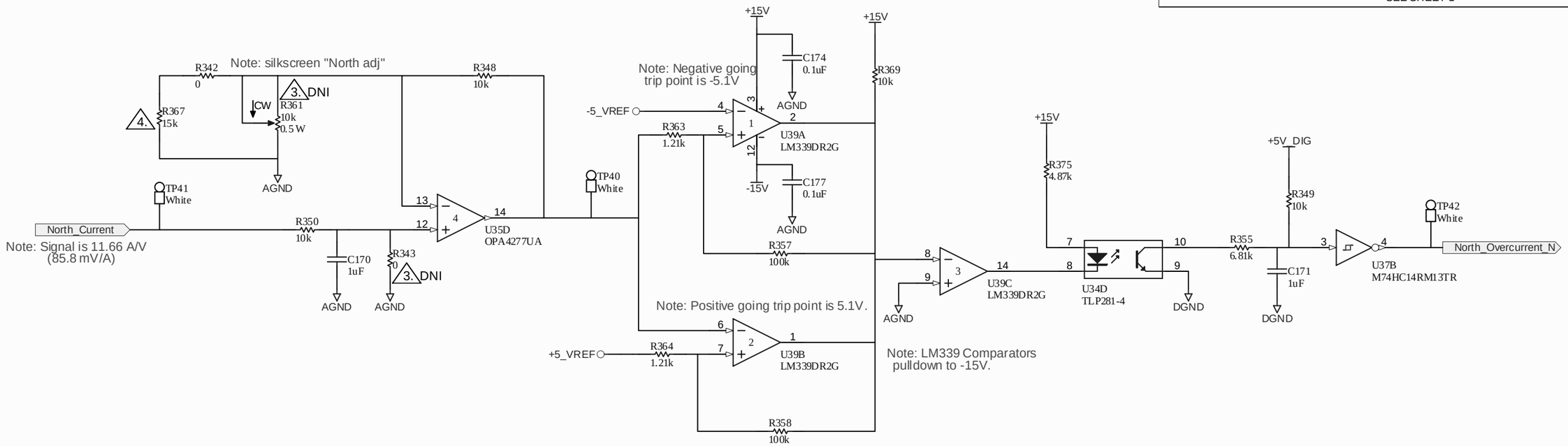
U37A M74HC14RM13TR — TP47 White — West_Overcurrent_N

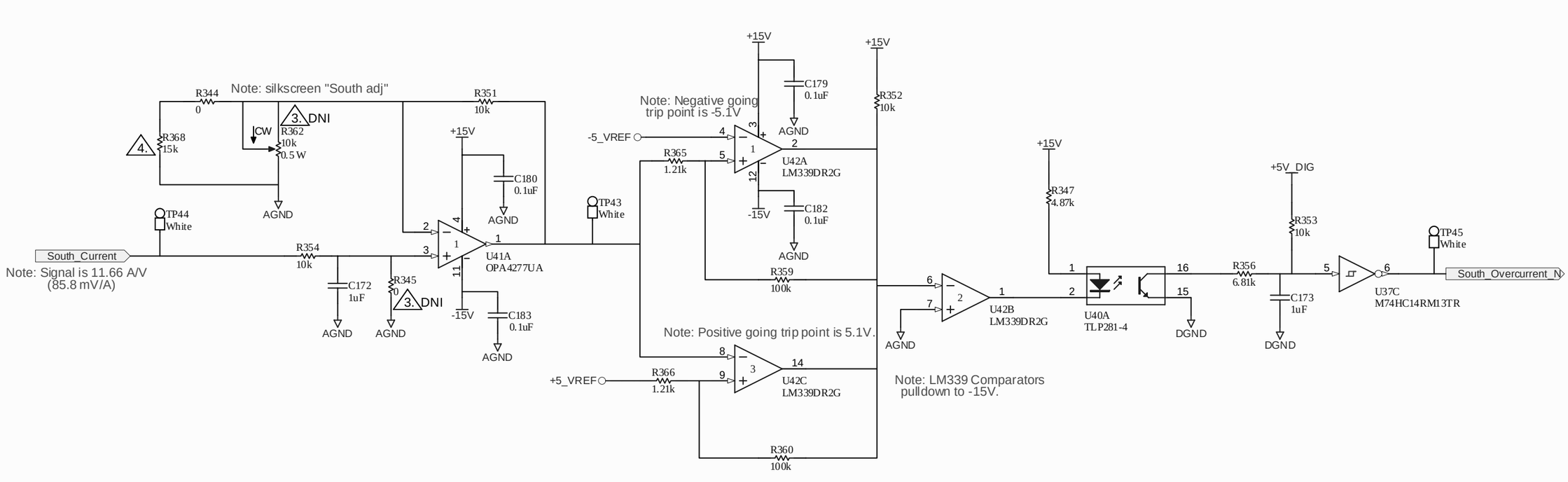
East & West Overcurrent

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	14 of 16

DWG # TCS3-2070 REV -

REVISION BLOCK
SEE SHEET 1





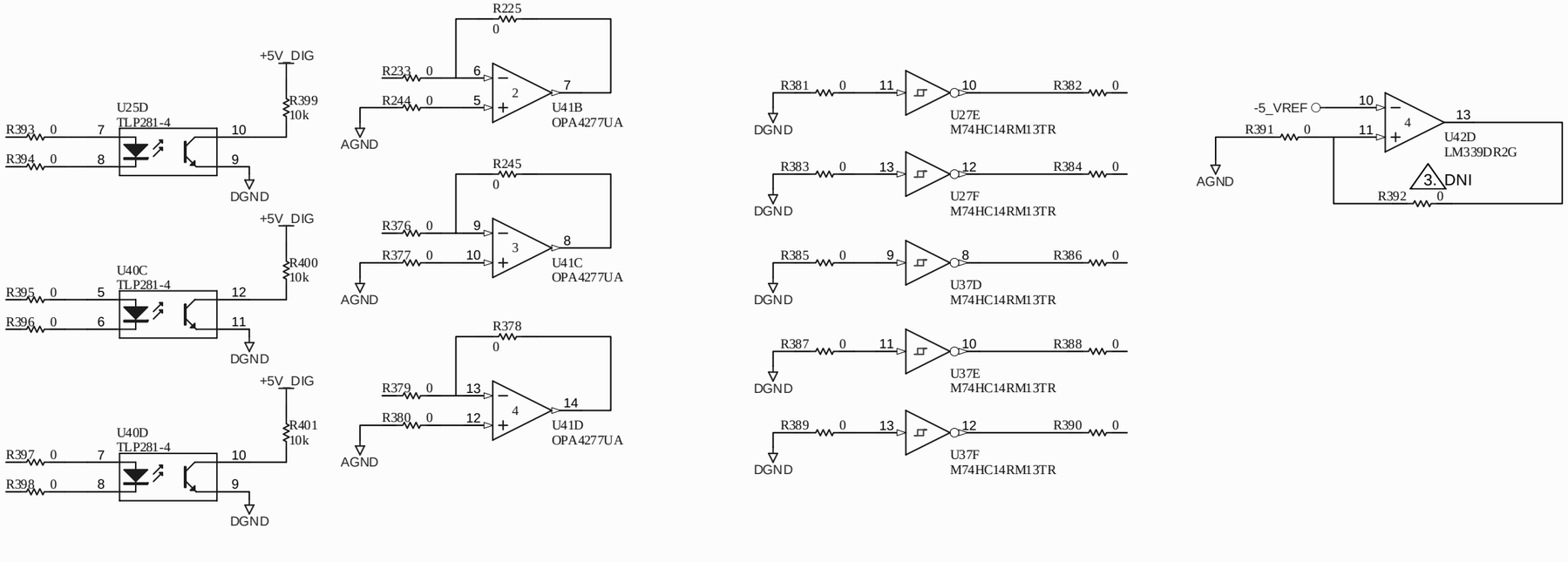
North & South Overcurrent

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	15 of 16

DWG # TCS3-2070

REV -

REVISION BLOCK
SEE SHEET 1



Spare / Unused Multipart Circuits

DWG #	REV	SIZE	SHEET
TCS3-2070	-	B	16 of 16

REV -

DWG # TCS3-2070