BACKGROUND

The IRTF is installing new motors for the dome upgrade.
An appropriate drive needs to be selected to drive the motors.
Wiring with appropriate current rating and breakers needs to be installed at the IRTF.
Keep in mind that our utility power is 3 phase, 208 VAC.
Stand alone or shared DC bus, braking resistors, line filters, etc. need to be determined.

SUMMARY

These are the main details:

Motor (x3)	BSM100C-3150BA
Drive (x3)	MFE460A021
TCP/IP to ESL Router	OPT036-501
Resolver Card (x3)	OPT-MF-013
Expanded Motion Control Card (x1)	OPT-MF-101
AC Supply Current	30A (derated for just 2x torque)
Breakers	40A

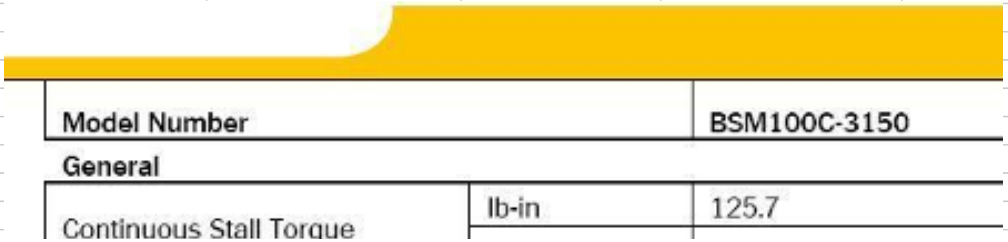
USEFUL LINKS

Document	Link
Motiflex e100 Servo Drive Installation Manual	http://www.multiprojekt.pl/ftp/baldor/manual/MN1943_01-11%20%28MotiFlex%29.pdf
Ethernet Powerlink Router	http://www.baldor.com/support/Literature/Load.ashx/FL1958?LitNumber=FL1958
Brushless Servo Istallation Manual	http://www.baldor.com/support/Literature/Load.ashx/MN1240?ManNumber=MN1240
AC Servo Motor Specs	http://www.baldor.com/support/Literature/Load.ashx/BR1202-E?LitNumber=BR1202-E
BSM100C-3150 specs only	http://www.baldor.com/products/servomotors/c_series/bsm_cseries_spec.asp?Catalognumber=BSM100C-3150AA
Real Time Internet Solutions (Mint Modules)	http://www.baldor.com/support/Literature/Load.ashx/BR1202-I?LitNumber=BR1202-I

MOTORS - New Baldors

Be careful with the part numbers. A slight change in part numbers can equal a large change in current requirements. Specifically, pay attention to the "C" in the part number.

Proposed Motor:	Manufacturer
BSM100C-3150BA	Baldor



Model Number		BSM100C-3150
General		
Continuous Stall Torque	lb-in	125.7

MOTORS - New vs. Original Torque

This section compares the original motors vs. the new motors.

Kollmorgen motor on the telescope:

Continuous Torque		
Kollmorgen (original) Stall Torque	5.5	lb-ft
Baldor (new) Stall Torque	10.5	lb-ft
Torque Increase	90.91%	
Peak Torque Specs		
Kollmorgen (original) Peak Torque Spec	30	lb-ft (@ 90A)
Baldor (new) Peak Torque Spec	31.42	lb-ft (@ 29A)
Torque Increase	4.72%	
Peak Torque Actual (limited by driver & supply)		
Kollmorgen (original) Peak Torque Spec	13.28	lb-ft (@ 35A limited)
Baldor (new) Peak Torque Spec	31.42	lb-ft (@ 29A)
Torque Increase	136.65%	
NOTE: NC307 drive limits motors to about 35A. Max current to Baldor should be near spec max.		

MOTOR RPM

Kollmorgen (present) motors are rated to run at a maximum of 3,000 RPM.
In the present system, they run at about a maximum of about 1200 rpm.

The Baldor drive use 208VAC 3-Phase. The DC bus in the servos are rectified 208VAC.
(Each phase is 120VAC for 208VAC 3 phase.) Everything is RMS.
Vpeak is sqrt(2) * RMS voltage.

For an ideal three-phase full-wave rectifier, the average output voltage is

$$V_{\mathrm{dc}} = V_{\mathrm{av}} = \frac{3\sqrt{3}V_{\mathrm{peak}}}{\pi}\cos\alpha$$

Where:

V_{dc}, V_{av} - the DC or average output voltage,
V_p - the peak value of half wave,
V_{rms} - the root-mean-square value of output voltage,
π = ~ 3.14159
α = firing angle of the thyristor (0 if diodes are used to perform rectification)

Vpeak (120 x sqrt(2))	170	Vpeak
Ideal Rectified 208VAC 3 Phase	281	VDC (ideal)

The datasheet above states : 2400 rpm @ 300V (I assume that they mean 300V bus)
This appears to be in agreement with the graph below.

Divide rpm/volts	8	rpm/V

The datasheet above also states : 4800 rpm @ 600V

Divide rpm/volts:	8	rpm/V

BSM C-Series P

BSM100C-3150

With an ideal bus of:	281	VDC (see above)	
Max rpm is:	2,246	rpm	

This is under IDEAL conditions. The true rpm will be lower due to a lower DC bus.
However, the present Kollmorgen motors run at 1200 rpm maximum in our system. The Baldor motors will attach directly to the same gear boxes, so the rpm requirements will be the same. 1200 < 2246 theoretical maximum, so there is plenty of margin.

NEW DRIVES

An appropriate drive needs to be chosen for the BSM100C-3150BA.

Current Requirements		
Continuous Current	11.40	A
Maximum Current	29.00	A

The MotiFlex e100 is a good line of AC Drives. The Baldor Rep recommended this line for our needs. There are multiple models to choose from with the current rating being the difference among models.

Baldor recommends derating:

Altitude	1000m (3300ft) nominal. Derate 1.1% /100m (per 330ft) above 1000m (3300ft)

Mauna Kea's peak is 13796 ft.

Derating: 34.99%

MotiFlex e100 Models (150% for 60s, 8 kHz mode)				
Model	Continuous Current (A)	Cont. Derated at 35% (A)	Peak Current (A)	Peak Derated at 35% (A)
MFE460A010	13	8.45	20	13
MFE460A016	16	10.4	24	15.6
MFE460A021	23	14.95	35	22.75
MFE460A026	26	16.9	39	25.35

MotiFlex e100 Models (200% for 3s, 8 kHz mode)				
Model	Continuous Current (A)	Cont. Derated at 35% (A)	Peak Current (A)	Peak Derated at 35% (A)
MFE460A010	10.5	6.825	21	13.65
MFE460A016	16	10.4	32	20.8
MFE460A021	21	13.65	42	27.3
MFE460A026	26	16.9	52	33.8

The MFE460A021 appears to be a good fit when derated. It can supply the continuous current and the maximum current is ~23A at 60 seconds derated, which is double the 11.40A continuous rating of the motor. The absolute peak current for the motor is 29A. How long 29A can be applied is a thermal issue. For 3 seconds, the drive can apply 27.3 A derated, and 42A with no derating.

Drive Current Ratings

Size A Drives		MFE460A010B		MFE460A016B		MFE460A021B		MFE460A026B	
Overload Mode	PWM	Continuous Arms	Overload Arms	Continuous Arms	Overload Arms	Continuous Arms	Overload Arms	Continuous Arms	Overload Arms
	4kHz	8	24	12	36	17	51	20	60

IRTF UTILITY POWER & WIRING

The MotiFlex drives can be powered from 3 phase 180 to 528 VAC (see table below).
IRTF uses 208VAC, 3 phase. Here is a link to the installation manual.
http://www.multiprojekt.pl/ftp/baldor/manual/MN1943_01-11%20%28MotiFlex%29.pdf

8.2.1 AC input voltage (X1) - all models

All models	Unit	AC input

Full load output current rating not exceeding (A)	AC supply current at full load (A)	Input fuse	Circuit breaker (B-type)
10	12.1	Ferraz Shawmut: A60Q20-2, 20 A (B214338)	16 A
14	17	Ferraz Shawmut: A60Q20-2, 20 A (B214338)	20 A
15	18.2	Ferraz Shawmut: A60Q25-2, 25 A (Z214842) or 6.600 CP URD 22x58/25 (B093956)	25 A
21	25.5	Ferraz Shawmut: A60Q30-2, 30 A (E215859) or 6.600 CP URD 22x58/32 (Z094828)	32 A
24	29	Ferraz Shawmut: A60Q35-2, 35 A (J216369) or 6.600 CP URD 22x58/32 (Z094828)	40 A
29	35.2	Ferraz Shawmut: A60Q40-2, 40 A (N216879) or 6.600 CP URD 22x58/40 (S094822)	40 A
33.5	40.7	Ferraz Shawmut: 6.600 CP URD 22x58/50 (W094779)	50 A
48	54.6	Cooper Bussmann: LPN-RK-80SP	80 A
65	78.9	Cooper Bussmann: LPN-RK-80SP	80 A

Table 8 - AC input current and protection device ratings - 21 A ~ 65 A models

To determine where the IRTF is on the above table, let's review our parameters:

Drive model: MFE460A021 (this is the 21A model)

Continuous Motor Current (A)	11.4	A
Maximum Motor Current (A)	29	A
Derated, 60 seconds, 150% drive current (A)	23	A
Derated, 3 seconds, 200% drive current (A)	27.3	A

The absolute allowable, peak motor current is 29A. The derated drive can supply 27.3A for 3 seconds. Therefore the 29A full load motor current with 35.2A AC supply and 40A breaker would be ideal. The option just above it would be suitable as well, since it is unlikely that motor would be driven at 29A to allow for derating.

The peak current will most likely be below 35A as stated above since the motor will need some derating. Since the breakers are 40A, let's size the fuses below that - they're faster acting and meant for protection. So, a fuse just above 30A would seem to offer good protection. 32A to 35A may be ideal.

Baldor recommends the A60Q35-2 fuse by Ferraz Shawmut. It is 35A.
http://www.georgiaoven.com/Support/Manuals/Circuit_Protection/Ferraz_A60Q-Fuse.pdf

Standard Fuse Ampere ratings, catalog and reference Numbers

Ampere Rating	Catalog Number	Reference Number	Ampere Rating	Catalog Number	Reference Number
5	A60Q5-2	E217400	20	A60Q20-2	B214338
6	A60Q6-2	M217913	25	A60Q25-2	Z214842
8	A60Q8-2	T218425	30	A60Q30-2	E215859
10	A60Q10-2	Z212289	35	A60Q35-2	J216369
12	A60Q12-2	M212807	40	A60Q40-2	E218879
15	A60Q15-2	X213322			

For ampere ratings and styles not listed, ask sales agent

Baldor alternatively recommends the 32A, 6.900 CP URD 22x58/32 (Z094828) fuse by Ferraz Shawmut. It is a French standard.

Littlefuse offers a 35A with a similar part#: LA60Q35-2. However, there doesn't seem to be stock of these either. Generically, they are 35A, fast acting fuses in a 1.5" x 0.406" cartridge with a 600 VAC, VDC rating. Looks like 30A, 32A, and 40A are more popular fuse values.

Vendor	Part#	Current	Voltage	Size
Mouser	FWC-32A10F	32	600 VAC	38.1mm x 10.3 mm
Mouser	LA60Q402	40	600 VAC	1.5" x 13/32"
Newark	BAN-30	30	250 VAC	1.5" x 13/32"
Digikey	FWC-32A10F	32	600 VAC	38.1mm x 10.3 mm

FWC-32A10F typical applications: DC bus, DC drive, power converters/rectifiers. We'll select this fuse. It's a standard size. If a higher rating is really needed, it can be changed.

Fuse holders are needed. In the 10mm x 38mm size (13/32" x 1.5") the maximum current is 32A, which is the maximum that is required.

Vendor	Part#	Current	Comment
Mouser	CB1038-3	32A max	3 fuses

Contactors/relays should be used to enable/disable power locally or disconnect the motors. Rating should be 40A or greater, 3 pole, and 208 VAC rated.
Need to be installed for safety reasons. If there is something wrong (e.g. safety board signal) the dome must stop

Vendor	Part#	Current	Coil Voltage
Digikey	P40P42D12P1-24	40A	24V
Mouser	P40P42D12P1-24	40A	24V
Newark	P40P42D12P1-24	40A	24V

STAND ALONE or DC BUS

In stand alone mode, each driver rectifies AC power for itself to PWM and drive the motor.
In shared DC bus mode, one unit rectifies the AC and shares it with the other drives by connecting bus bars together.

The advantage is energy savings if multiple motors are starting and stopping at the same time. One motor becomes a generator and this energy can be supplied to the another motor that is running.

Since all or the dome motors are essentially coupled together mechanically and commanded to do approximately the same thing, they are all running or decelerating at the same time. It doesn't appear that a shared DC bus would be beneficial in this situation.

Braking Resistor or Regen Resistor

When the motors are decelerating, they act as generators and that energy needs to go somewhere. In this case, the energy is dissipated as heat in a resistor. The wattage of the resistor can be determined through a worksheet in the installation manual. As a general guideline, below are the resistors from the MotiFlex brochure. Resistors can also be purchased from Digikey or other vendors. A 15 ohm, 500W resistor is generally recommended for the MFE460A021.

The IRTF may not even need a regeneration resistor. The duty cycle is very low and the deceleration period is very long. The inertia of the dome is high, however. The final equation is Power=Energy/Decel Period. This is the power over that deceleration period. The duty cycle on the dome is very low - a few seconds / minutes (or hours).

However, when the dome is stuck, the duty cycle increases (back and forth). Some type of resistor may be a good idea. It can be measured and confirmed when in operation. Resistor size and value can be adjusted if necessary.

Here's a good guide explaining regen resistors. Non-inductive is preferred.
http://www.parkermotion.com/manuals/APEX615n/615n_body_09.pdf

Let's select soemthing with realtively high power (100W+) and above the 15 ohm minimum.

Vendor	Part#	Value	Power Rating
Digikey	TGHLV25R0JE	25	200W
Mouser	TGHLV25R0JE	25	200W
Digikey	RPS0500DH22R0JB	22	500W

OPTIONAL DRIVER CARDS & ROUTER

The OPT-MF-013 is for resolver feedback. The Baldor rep recommended using resolver feedback since it is a more common motor feedback option.

The OPT-MF-101 is a "Multi-axis programmable Mint Machine Module". Includes incremental encoder input and digital I/O. Controls up to 4 axes of interpolated motion". This option eliminates the need to buy a full featured motion controller. It provides enough features to implement the PID velocity loop that the IRTF wants to run.

The e100 Powerlink Router is required. It converts TCP/IP to Ethernet Powerlink. It's really more like a bridge of sorts. TCP/IP isn't very deterministic and Ethernet Powerlink is.

AC LINE REACTORS & FILTERS

According to Baldor reps, AC line filters are not needed. They are a European CE requirement.

Line reactors, although not required, are recommended:

"The use of an AC input line filter is not required for use in the US. The use of the filter can help reduce potential interference with other equipment. The use of a line reactor is recommended as added protection to the input diode bridge. If you have a solid line with less than 1% impedance or other power related issues which could potential result in premature failure of the input bridge or cause nuisance DC Bus trip / faults." -Baldor Rep

MotiFlex e100 catalog number	Required line reactor inductance (mH)	Recommended Baldor AC line reactor
MFE460A001	1.2	LRAC02502
MFE460A003		
MFE460A006		
MFE460A010	0.8	LRAC03502
MFE460A016		
MFE460A021	0.5	LRAC05502
MFE460A026		
MFE460A033		
MFE460A048	0.4	LRAC08002
MFE460A065		

Table 4 - Baldor line reactor part numbers

A.1.3 AC line reactors

AC line reactors provide bi-directional protection, reducing unwanted electrical noise, harmonics and overvoltage trips. A line reactor should always be used when a MotiFlex e100 is sharing its DC bus with other drives (see section 3.5).

A.1.3.1 Catalog numbers

Baldor catalog number	Rated volts (VAC)	Rated power (kW)	Rated current (A)	Impedance (%)	Inductance (mH)	Weight kg (lbs)
LRAC00802	380/400/415	3.7	8	3	3.0	3.6 (8)
LRAC02502	380/400/415	11.1	25	3	1.2	6.4 (14)
LRAC03502	575	14.9	35	3	0.8	7.3 (16)
LRAC05502	575	29.8	55	3	0.5	12.2 (27)
LRAC08002	380/400/415	37.2	80	3	0.4	14.5 (32)

Since the IRTF is using the MFE460A021, Baldor recommends the LRAC05502.
A quick google search brought up Galco's site:
http://www.galco.com/scripts/cgiip.exe/wa/wcat/itemdtl.r?listtype=&pnum=LRAC05502-BLDR&tabid=sub
I called for a quote but they never got back on RL-05502.

It has a recommended alternative (RL-05502). Interestingly, the part numbers are very similar. I assume that Baldor isn't in the business of making line reactors and simply rebrands industry standard parts.

http://www.mtecorp.com/cad/rl-05502.htm

http://www.plccenter.com/Buy/MTE/RL05502 This is another vendor but not in stock and quote was $455.

Since the cost of the line reactos aren't that much relative to the overall cost, and based on the Baldor reps recommendation, I would recommend that we purchase these. We need 3, one for each AC 3 phase line, plus one spare seems prudent.

Cost of 4 AC reactors:	$1,320.00	(4 @ $330)

A quick search of ebay shows that the MTE part is fairly standard. 3 showed up on Ebay. MTE is a big name in this type of product.

Further cross reference:	http://www.transcoil.com/Public/Documents/ProductSelection/Selection-Charts-TCI-Reactors.pdf
And here:	http://www.hammondpowersolutions.com/upload_files/htp-10_sec3.pdf

TCI KDR	TCI KLR	Hammond	MTE
KDRC22H	KLR55ATB	RM0055P50	RL-05502

Key requirements for this device regardless of manufacturer are: 0.5mH, up to 30A, and 3 phase 208VAC at least.

Part #	Vendor	Price	Stock	Comment
KDRC22H				
KLR55ATB				
RM0055P50	Newark	$331.20	6	Trusted company.
RL-05502	Galco	$330.33	2	Didn't get back to me. Forget them.

Looks like RM0055P50 is the winner. In stock. 55A, 3% impedance, up to 600VAC, 0.5 mH. Approx same size & weight.

SAFETY & VOLTAGE MONITORS

The power is 208VAC, 3 phase. Care needs to be taken and safety is very important.

Voltage monitors such as the Crouzet 84873022 are good from a safety and fault detection point of view.
Newark carries them, so does digikey.
http://www.crouzet.com/english/catalog/c-lynx-control-relays-phase-control-single-function-phase-control-relay-17-5-mm-mws-Part%20number-84873020.pdf#zoom=100

Carlo Gavazzi, Inc. DPA01CM44 is another example.
http://www.gavazzionline.com/pdf/DPA01CM.eng.pdf

From a safety point of view, the Voltage Visions monitors look really good:
http://www.graceport.com/assets/files/VoltageVision_R3W_R3WSR_DataSheet.pdf

Can buy here:
http://www.mitchellinstrument.com/voltage-vision-r-3w.html?source=googleps
Ebay had a seller with brand new ones at $20 a piece. Good deal. $40 each with shipping.

Labels:
http://www.newark.com/grace-engineered-products/r-3w-l/adhesive-backed-warning-label/dp/44P9346?Ntt=R-3W-L

For 120V, a panel mount LED should be sufficient:

LE67C5R	Digikey	

http://www.arcolectric.com/pdfs/Indicators_199.pdf

WIRING

The most important wiring to spec is the drive to motor wiring. It will have to be heavy gauge. NOTE: AC power wiring will be contracted out. The selection of the drive to motor wiring will also be verified by the contractor.

Requirements of drive to motor wiring:

Current, max	35A	(motor absolute is 29A, NOT DERATED)
Breakers	40A	
Shielding	Yes	
Conductors	4	(3 phase + 1 ground, only 3 carry current)

Let's see what National Electric Code recommends:

Table 310-16. (1999 N.E.C.) Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts 60° to 90°C (140° to 194°F) Not More Than Three Current-Carrying Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

SIZE	Temperature Rating of Conductor. See Table 310-13.					
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)
	TYPES TW*	TYPES FEPW*	TYPES TBS, SA	TYPES TW*	TYPES FEPW*	TYPES TBS, SA

The NEC requires an 8 or 10 guage wire, depending on temperature rating of wire, however, circuit protection can't be over 30A for 10 AWG. We will be using 40A breakers. So, 8AWG is the allowable minimum.

3.4.12 Recommended wire sizes

All wire sizes are based on 75 °C (167 °F) copper wire. Use copper conductors only. Higher temperature smaller gauge wire may be used per National Electric Code (NEC) and local codes.

MotiFlex e100 catalog number	AC input & motor output wire size	
	AWG	mm^2
MFE..A001	14	2.5
MFE..A003	14	2.5
MFE..A006	14	2.5
MFE..A010	10	6.0

Baldor is in agreement with 8 AWG (MFE460A021 drive).
Alpha conveniently makes a line of wires for servos. They have low gauge with shielding and extra pairs for brakes.

Part #	Manufacturer	Vendor	Gauge	Conductors	Price	Stock	Comment
SF61108CY OR005	Alpha Wire	Allied Electric	8	4	$610.44 / 100ft	3	
SF61108CY OR005	Alpha Wire	Newark	8	4	$670 / 100ft	10	
SF61224CY OR005	Alpha Wire	Allied Electric	8 (+ 2pair 16AWG)	4 + 4	$684.80 / 100ft	2	in stock only 2x100ft, 500ft is $4,000, manufacturer only makes 1000ft now according to a distributor

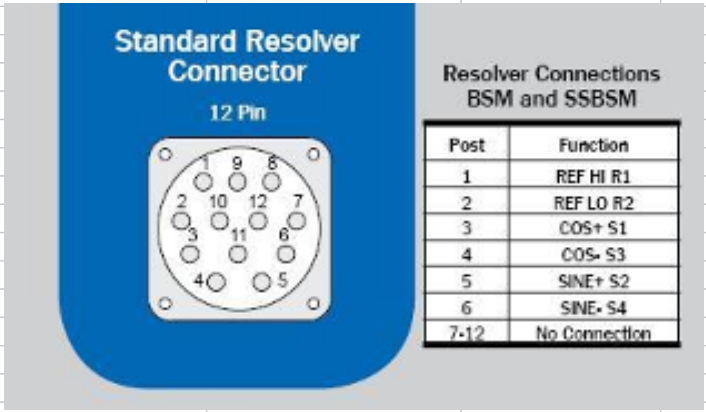
The 16 AWG pairs could be used for th thermal switch and break. Yes, it's overkill, but conveniently in one cable.

The brakes (2wires), thermal switch (2 wires), and resolver (6 wires) need to be wired. The only significant current will be the brakes. The brakes and thermal switch need to be separated from the resolver feedback.

Brake Data for BSM and SSB

Motor Code	Brake Holding Torque Nm (lb-in)	Watts	Brake Voltage	Brake Current (amps)
BSM50N	1.1 (10)	10.1	24	0.5
BSM63N	2 (18)	11.9	24	0.6
BSM80	4.5 (40)	19.7	24	0.7
BSM90	15.8 (140)	22.5	24	0.9

The BSM100 series requires 1.4A for the brakes.



Resolver Connections
BSM and SSBSM

Post	Function
1	REF HI R1
2	REF LO R2
3	COS+ S1
4	COS- S3
5	SINE+ S2
6	SINE- S4
7-12	No Connection

The brakes and thermal switch should be separated from the resolver.
This brake/thermal cable would need the minimum:

Pairs	2
Current	1.4A
Twisted	Yes
Shielded	Yes

From standard wiring tables, 20 AWG is sufficient for carrying 1.5A.
1.5A through 130 ft of 18AWG cable equals a 2.5V drop.

Part #	Manufacturer	Vendor	Gauge	Conductors	Price	Stock (3/26/12)
2242C SL005	Alpha	Newark	18AWG	2 pair	$209.02 / 100ft	14
2242C SL002	Alpha	Newark	18AWG	2 pair	$736.96 / 500 ft	1
2242C SL005	Alpha	Mouser	18AWG	2 pair	$164.81 / 100ft	3

2242C SL002	Alpha	Mouser	18AWG	2 pair	$670.33 / 500ft	1

Will have to splice for 130ft if buying 100ft rolls. 500ft isn't that much more expensive. Consider just buying 500ft to eliminate splicing hassle.

It's easier to carry the foil shield for the switch separate from the brake when entering the electrical box since it won't require cutting of the plastic outer jacket. I already purchased the above wire, which is fine for the brake. It appears that Baldor recommends shielding each separately. We can double up the brake wires then. If ever needed, the extra pair could be removed and used for something else. No big deal in the end. 22 AWG twisted, shielded pair is not expensive. Buy 500' and run that in the conduit.

Brake should be twisted due to current. However, the thermal switch doesn't have this requirement. Then again, the motor wires aren't twisted (8AWG), so twisting the brake wires doesn't mean much. At any rate, twisting the brake wires is the right thing to do. Since we are pulling this wire through conduit, a heavier gauge may be advisable solely for physical reasons. Baldor recommends using a twisted shielded pair for the motor temp circuit. It isn't clear if this includes a simple switch circuit. Just order twisted shielded pair - no need to analyze.

Part #	Manufacturer	Vendor	Gauge	Conductors	Price	Stock
8451 010500	Belden	Newark	22 AWG	1 pair	126.48	yes
8451 010500	Mouser	Newark	22 AWG	1 pair	126.48	yes
8451 010500	Belden	Newark	22 AWG	1 pair	126.48	yes

There will need to be 3 pairs for the resolver. Current is minimal. A few spare pair might be nice.

"Armored" cable may be a possibility since it will have to be run outside of the power conduit.

Part #	Manufacturer	Vendor	Gauge	Conductors	Price	Comment
6377 SL001	Alpha Wire	Newark	22 AWG	6 pair	$1,676.39 / 1000ft	
561-60-3404	Okonite	Colorado Wire & Cable	16 AWG	4 TSP	802.33/ 300 Ft = $2.67/ft	Armored. Only had 16 AWG in stock. Tried to order through Alpha, but they weren't very responsive.
23530	Belden	?	18 AWG	4 pair		Armored

http://www.okonite.com/adv/instock-catalog.pdf

PG22 has the 561-60-3404 armored cable.

Here's the catalog with technical details:

http://www.okonite.com/Product_Catalog/section5/section5-pdfs/5-42.pdf

CONNECTORS & ACCESSORIES

Connector Location / Use	Part Number	Manufactuter	Comments	Link
Resolver Cable	RC-12S2N8A80RK	CONINVERS	Baldor Part# MCSRES-12, looks like Phoenix makes it, part #1600158. Hard to get. 3-5 week lead. Forget it.	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0CFQQFjAG&url=http%3A%2F%2Fwww.baldor.com.au%2Fsend_download.php%3FDL_ID%3D360&ei=fEuDT8qWMOajiQL60vX_Ag&usg=AFQjCNEAsbUexmR--Z-qJFYzbajH_67i2w&sig2=esXOddhNYUEOAFAP9lwbig
Resolver Housing	MS3112E12-10P	ITT	IRTF changed connector to standard mil spec.	

Resolver Cable	MS3116F12-10S	ITT	IRTF changed connector to standard mil spec.
USB Bulkhead	SCRU-02	Samtec	Waterproof bulkhead
RJ45 Bulkhead	17-10000	Conec	Waterproof bulkhead
X17 (power)	IPC 16/ 3-ST-10,16	Phoenix	
9 pin (male) DSUB	5-747904-2		Used for RS-232 exiting enclosure
9 pin backshell	024657-0000	ITT	Used to strain relief the 9 pin DSUB
DSUB female screwlocks	5207719-1		Used for attaching outside connector.

http://www.samtec.com/documents/webfiles/cpdf/SCRU-XX-MKT.pdf

http://www.conec.com/catalogs/c1/media/catalog/product-pdf/64c9ffa6bc6a619eb65a44822eab09a9_004.pdf

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDUQFjAB&url=http%3A%2F%2Feshop.phoenixcontact.com%2Fphoenix%2Fpdf.do%3FUID%3D1969386%26general%3Dusen&ei=5QyOT8j5PKijiQK5n-CjDw&usg=AFQjCNHXugzg2qX-ndBeP9XZlS9T35CNRw&sig2=lBOuhnAW3lW5yxsnJKy0Vw

+24V POWER SUPPLY & FUSES

An external power supply is need to power the brakes and any other miscellaneous relays, etc. The servo drives internal power supply is not to be used. Will also need backup +24V power supply so that drives don't lose network connectivity in the case of 3 phase power outage (will use UPS for backup +24V).

Powered Item	Current	
Brake Relay	4.2	(1.4A x 3 is spec from Baldor)
Wattage @ 24V	100.8	

Powered Item	Current	
Drive +24V Backup	3.6	1.2A x 3max Baldor Spec
Wattage @ 24V	86.4	

Powered Item	Current	
contactors x 3	1	(286mA x 3 = 858 mA
Wattage @ 24V	24	

Baldor insists that the supply for the brakes and digital I/O CANNOT be the same supply. It's claims noise, but I suspect they are worried about spikes.

Does same logic apply to powering contactors? Instead of worrying about it, or analyzing, another supply is just $100. So go with 3 supplies.

Should derate for altitude - heat dissipation. Price difference isn't that high between models 240W and under. Just buy one model and use for all, even if it's overkill.

DIN mountable is nice and compact plus is easy to replace.

Part Number	Manufacturer	Distributor	Comments
DRP024V240W1AA	Delta	Digikey	240W

http://www.onlinecomponents.com/viewer.aspx?p=28910108

http://www.delta.com.tw/product/em/control/ps/download/catalogue/Power%20Supply_C_EN_201005017.pdf

Fuses should be installed. Since the maximum power output is 240W, the fuse should should be at a maximum of just over 2A due to power supply efficiency. However, the most that we need is 100W for the brakes. With efficiency headroom, a standard 2A fuse would be sufficient. 2A x 120V x 85% efficiency = 204W output. The feed off of the 3 phase should have a higher class of fuse.

Part Number	Manufacturer	Distributor	Comments
KTK-2	Cooper Bussmann	Digikey	2A, 10 x 38mm fuse
CB1038-1	Altech	Mouser	10 x 38 mm fuse holder, DIN mount

For the UPS 120V, other fuses are acceptable. Baldor recommends 2.5A, 5 x 20mm fuses for the +24V to each drive.

Part Number	Manufacturer	Distributor	Comments
5MT 2.5-R	Bel Fuse Inc.	Digikey	Baldor recommended and good enough for +24 backup AC input
5MT 1-R	Bel Fuse Inc.	Digikey	1A x 120V x 85% = 102W, enough for contactor drive
SPC11912	Multicomp (SPC)	Newark	5 x 20mm fuse block, DIN Rail
SPC10572	Multicomp (SPC)	Newark	Fuse end plate

DIN MOUNT RELAYS

Relays are required to control the 3 power contactors, the drive enable inputs, and the brakes.

The 3 contactors require 286mA x 3 = 858 mA of current @ 24V input.
The drives require 7mA x 3 = 21mA (the Safety Board could probably drive this with its optocouplers).
The 3 brakes require 1.4A each.

Part#	Manufacturer	Vendor	Comments
CKM0610	Crydom	Digikey	20A, but derate for altitude, buy same relay for both applications. It's oversized, but less spare items.

DISTRIBUTION BLOCKS & TERMINAL BLOCKS

To keep the wiring clean, safe, and manageable, distribution blocks are required. DIN mounted is nice, but not required. Probably want screw mount for junction boxes.

DIN Distribution Blocks for Large Wire (8AWG)

Input wire	Output Wire	Part Number	Manufacturer	Vendor
1 x 2-8AWG	6 x 6-14AWG	38041	Altech	Allied Electronics

DIN Distribution Blocks for Large Wire (8AWG)

Input wire	Output Wire	Part Number	Manufacturer	Vendor	Comment
12-24 AWG	feedthru (12-24 AWG)	2771010	Phoenix	Mouser	DIN Mount
NA	NA	2771023	Phoenix	Mouser	End plate

Direct Mount Terminal Blocks (one to one connection, straight thru)

Wire Size	# of Terminals	Part Number	Manufacturer	Vendor	Length	Comment
6-20 AWG	5	2716732	Phoenix Contact	onlinecomponents.com	68mm (2.7")	
12-22 AWG	7	39100-0807	Molex	Digikey	2.1"	

12-22 AWG	8	39100-0808	Molex	Digikey	2.4	I wanted to use all 7s, but I made a mistake on wiring and needed an 8 terminal block.	

ENCLOSURES

We need a large enclosure for the drives and electronics. Due to the overall cost of this project, voltage danger, and protection of personnel and equipment, a NEMA box should be used. A stand alone seems like the best idea. This way it can be completely wired in Hilo and simply carted up to the Summit and installed.

Part#	Manufacturer	Vendor	Size	Price	NEMA Type	Link	Comments
SCE-72EL2418FS		Omega	72" H , 24" W, 18" D	$815.00	NEMA 4	http://www.omega.com/ppt/pptsc.asp?ref=SCE_FS	
SCE-72EL3018FS		Omega	72" H , 30" W, 18" D	$880.00	NEMA 4	http://www.omega.com/ppt/pptsc.asp?ref=SCE_FS	$880 + $270 shipping. Ordered on 4/23/12 via phone and MasterCard. 1-2 week build and 10-14 day ship.

Small enclosures are need where the wire ends near each motor. Two are required per motor. One is for the motor and the other is for the enclosure. Also a splice box will be required for the 130 foot motor run since the wire comes in 100 foot spools. A total of 7 enclosures is required. The Copper XXX RTSC are carried in Hilo by Alpha Electric. Pick one of those. The terminal block are 2.7" and 2.1" long. Each box will require two blocks, so, worst case, it is 2.7 + 2.1 = 4.8". The splice block only requires 1 block. Wires are heavy gauge and hard to bend. Keep that in mind.

http://www.cooperindustries.com/content/dam/public/bline/Resources/Library/catalogs/electrical_enclosures/enclosures_and_wireway/T3RScrewCoverEnclosures.pdf

Part#	Manufacturer	Vendor	Comments
864 RTSC	Cooper	Alpha Electric in Hilo	8" x 6" x 4" (the dimensions are the part number)
664 RTSC	Cooper	Alpha Electric in Hilo	
644 RTSC	Cooper	Alpha Electric in Hilo	

DIN RAIL

We need some 35mm DIN rail. It's standard stuff, but for completeness, I added it.

Part#	Manufacturer	Vendor	Comments
9080MH379	Square D	Grainger	Honolulu has it in stock.

GROUNDING

Grounding is important for safety, proper operation, EMI, etc. Baldor has a good installation menu with recommendations.

Component	How to ground
Motor Cable	Earth ground right at drive. Connect to chassis lug on motor.

Resolver	Earth ground through backshells at motor and drive. AGND inner shields only at drive.
AC Power	If longer than 1ft, wires must be shielded to backplane.
Thermal switch	Ground to backplane near drive.
Brake	Baldor says to ground at one point only. Probably best near relay/diode.
Regen Resistor	Connect to backplane at drive and at resistor.
Analog Signals	Twisted shielded pair with overall tied to backplane at one end only.

RS-485 Adapter, Converter, etc.

It may be too difficult to use Ethernet. The RS-485 may be the easiest solution for feedback from the drive.

Part#	Manufacturer	Vendor	Comments	Link
PCI2S422ISO	StarTech.com	Amazon.com	Isolated.	http://www.amazon.com/StarTech-com-RS422-Serial-Adapter-PCI2S422ISO/dp/B0001KFWMK
IC526A-F		http://www.blackbox.com	Isolated, but DB25 connector	http://www.blackbox.com/Store/Detail.aspx/Async-RS-232-to-RS-485-Interface-Bidirectional-Converter-with-Opto-Isolation-DB25-Female-to-RJ-45/IC526A%C4%82F
ICD100A		http://www.blackbox.com	DIN rail moung, 10-30VDC input. Perfect.	http://www.blackbox.com/Store/Detail.aspx/RS-232-to-RS-422-RS-485-DIN-Rail-Converter-with-Opto-Isolation/ICD100A
485LDRC9		http://www.bb-elec.com/product11.asp?sku=485LDRC9	DIN rail moung, 10-30VDC input. Perfect. Looks like rebranded ICD100A.	http://www.bb-elec.com/product11.asp?sku=485LDRC9