SDC-91-123

SDC
SOLENOIDAL DETECTOR NOTES

60 Hz LINE SIDE FEEDER OPTIONS FOR THE 2 MW SOLENOID DC POWER SUPPLY

October 28, 1991

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October 28,1991

SDC
Rev.: 10/28/91

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Overview

The SSC Laboratory experimental region electrical distribution voltage will be at 12.4 KV, 3 Phase. There has been some discussion of adoption of a Conventional Construction Division supplied standard voltage of not less than 4160V, 3 Phase for large DC power supplies. If the collaboration wishes to power their supplies with 480V, 3 Phase, the cost of this conversion (4160/480) would be left to the collaboration. In this paper we will examine the cost impact of the (4160/480) stepdown for the 2 MW solenoid DC power supply and an alternate method of providing the AC power needed while avoiding the cost penalty associated with the 4160/480 transformation. Basic one line diagrams and a cost breakdown for each method are provided as well as notes for clarification. Power supplies rated less than 500 KW are recommended to be supplied from 480V 3ϕ lines.

Common Assumptions

In both cases examined in this paper, the high current DC power supply has been priced as a completely manufactured item with a load regulation of .05%. A quotation from a manufacturer was obtained for the power supplies. Material prices have been taken from the Means Electrical Cost Data Manual and are the median prices at the time of publication. Aluminum conductors and busing were used for all pricing. It may however be more reliable to use copper conductor materials to avoid possible electrical joint problems. The amount of conductor length is short (order of 100'). The cost savings with aluminum will therefore be small compared to copper. A copper cable and conduit system is the preferred way. It is the easiest to install, maintain, engineer to fit and it avoids connection, and settling problems. Contractor overhead and profit have been included, however, the various geographical and job size modifiers have not been factored into the figures. Thus, these estimates should be used for a comparison and not an absolute cost basis.

Packaged Supply With 480V Input Feed

Refer to the one line riser diagram "A". Power from the 12.45KV grid is stepped down to 4160V via a transformer through a secondary feeder breaker and again from 4160 to 480V for power delivery to 4 - 500KW prepackaged power supplies. The 4160 transformer is furnished and installed by the Conventional Construction Division. Since a load side voltage of 480V is desired another stepdown transformer is required.[1] From the secondary of this transformer a 3500A feed is routed to the DC power supplies distribution switchboard.

There are three methods in common use for transporting large amounts of low voltage 60Hz power to a load:

A. single or parallel multiple run(s) of cable type insulated conductors enclosed in rigid conduit.

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[1] It can be argued that a single 12.45KV to 480V transformer could be used in this application. However, since this would be a "non-standard" DC power supply transformer it is unlikely that the Laboratory would deviate from this.

B. multiple insulated cable conductors in a common rectangular enclosure usually called "cable bus"

C. solid bare metallic conductors, usually rectangular bar, with insulation between the conductors in a compact enclosure usually called "busway"

An allowance of 100 feet between the secondary side of the 480V source transformer and the connection to the distribution switchboard feeding the power supplies was used. Estimated costs for the three methods are as follows:

A. Rigid conduit and insulated conductors;

10 sets of 4-500MCM THHN Alum. in 4 inch conduit — $365/ft x 100 ft = $36,500

B. Cable bus

3500 A Alum. in common steel enclosure[2] — $302/ft x 100 ft = $30,200

C. Busway

3500A, 4W, 100% Alum.[3] — $438/ft x 100 ft = $43,800

We have used the Conduit/Conductor method in the estimate since there does not appear to be a significant cost savings in using Cable bus.

The 480V supply feeders are brought to a 3500A distribution switchboard located near the DC power supplies. The present design calls for 4 series connected 500KW, 100V, DC, self contained power supplies. The switchboard is fitted with a 3500A bolted type, fused main switch and a 4-1000A - 3P circuit breakers. (1000A Frame) A 50 foot allowance was used to cost the 1000A feeders between the distribution switchboard and the power supplies.

Estimated cost for this method is as follows:

4 Packaged Supplies with 480V Input Feed

Quantity	**Description**	**$ Cost**
1	4160/480 3MVA stepdown transformer	$70,000
100 ft	3500A feeder	$36,500
1	3500A switchboard section	$6,000
1	3500A main switch	$20,000
1	3500A distribution section	$5,000
4	1000A 3P distribution breakers	$9,000
200'	1000A distribution feeder	$16,000
4	500KW DC power supplies	$260,000
4	500KW DC power supply installation	$40,000
	TOTAL	**$462,500**

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[2] If the 480V supply transformer was located outside, a portion of the busway or cable bus would require NEMA 3R construction.

[3] Current limiters my have to be employed depending on the available short circuit currents, but were not costed at this time.

Alternate Method

Refer to one line riser diagram "B". A different approach in which the stepdown transformer functions as the rectifier transformer has been used for the construction of the DC power supplies. The rectifier transformer is separated from the supply and located outdoors adjacent to the building containing the balance of the converter components. These components occupy one large enclosure instead of the 4 separate cabinets previously described. Distribution grid voltage of 4160V (or 12.45KV) is used for the primary side of this rectifier transformer. The secondary voltage depends on the load and power supply circuit, but should be less than 600V which keeps this voltage within the NEC 600V classification. Cables are run between the rectifier transformer and the rectifier enclosure using 100 foot separation.

Using the previously made 60Hz feeder comparison, costs were calculated using the conduit/conductor method.

Estimated costs are as follows:
Alternate Method, Stepdown Rectifier Transformer Outside

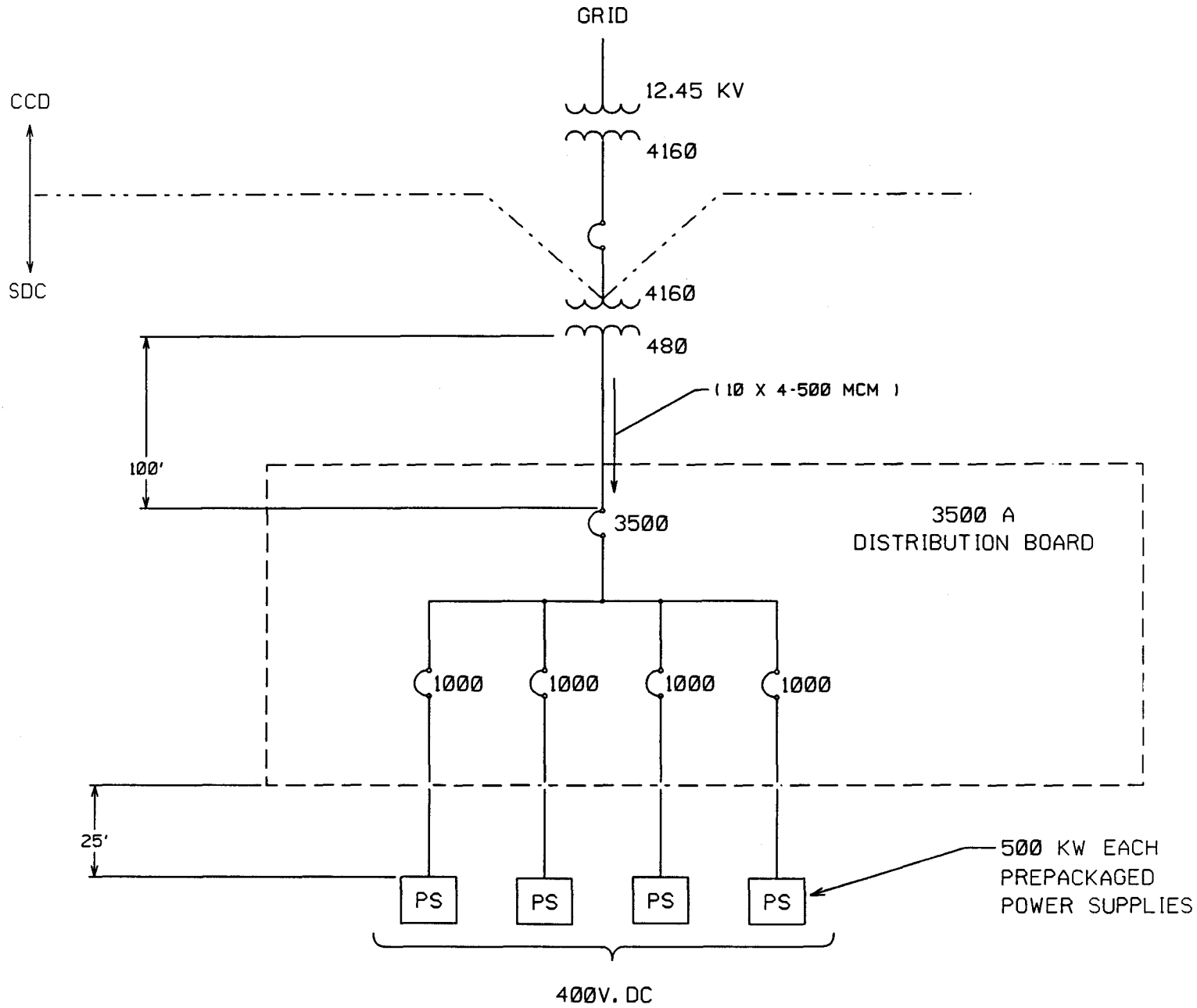
Quantity	Description	$ Cost
1	Rectifier transformer primary feed	$10,000
100'	Connection between transformer and rectifier assembly approximately 5000' of 400 MCM	$20,000
1	2 MW DC power supply, consisting of outdoor TRF, indoor rectifier, vacuum contactor	$208,000
1	2 MW DC power supply installation	$60,000
	TOTAL	**$298,000**

There are some additional cost savings that would be associated with the need to have one control/monitoring circuiting in lieu of 4, simplified coolant piping and floor space savings caused by locating the rectifier transformer outside the building. These savings were not factored into the estimate.

Conclusion

The method of using the rectifier transformer connected to the distribution grid voltage will effect a significant cost savings. The secondary remains within the 600V class so that the rectifier section can be serviced without the precautions required for the higher voltage classes. Floor space is saved and control wiring and coolant piping is simplified. A 2 MW power supply using this approach can be obtained from commercial manufacturers.

One disadvantage of this method is that replacement of a failed transformer takes longer.



SDC EXPERIMENTAL FACILITIES
PACKAGED SOLENOIDAL POWER SUPPLY

DIAGRAM 'A'

SSC EXPERIMENTAL FACILITIES

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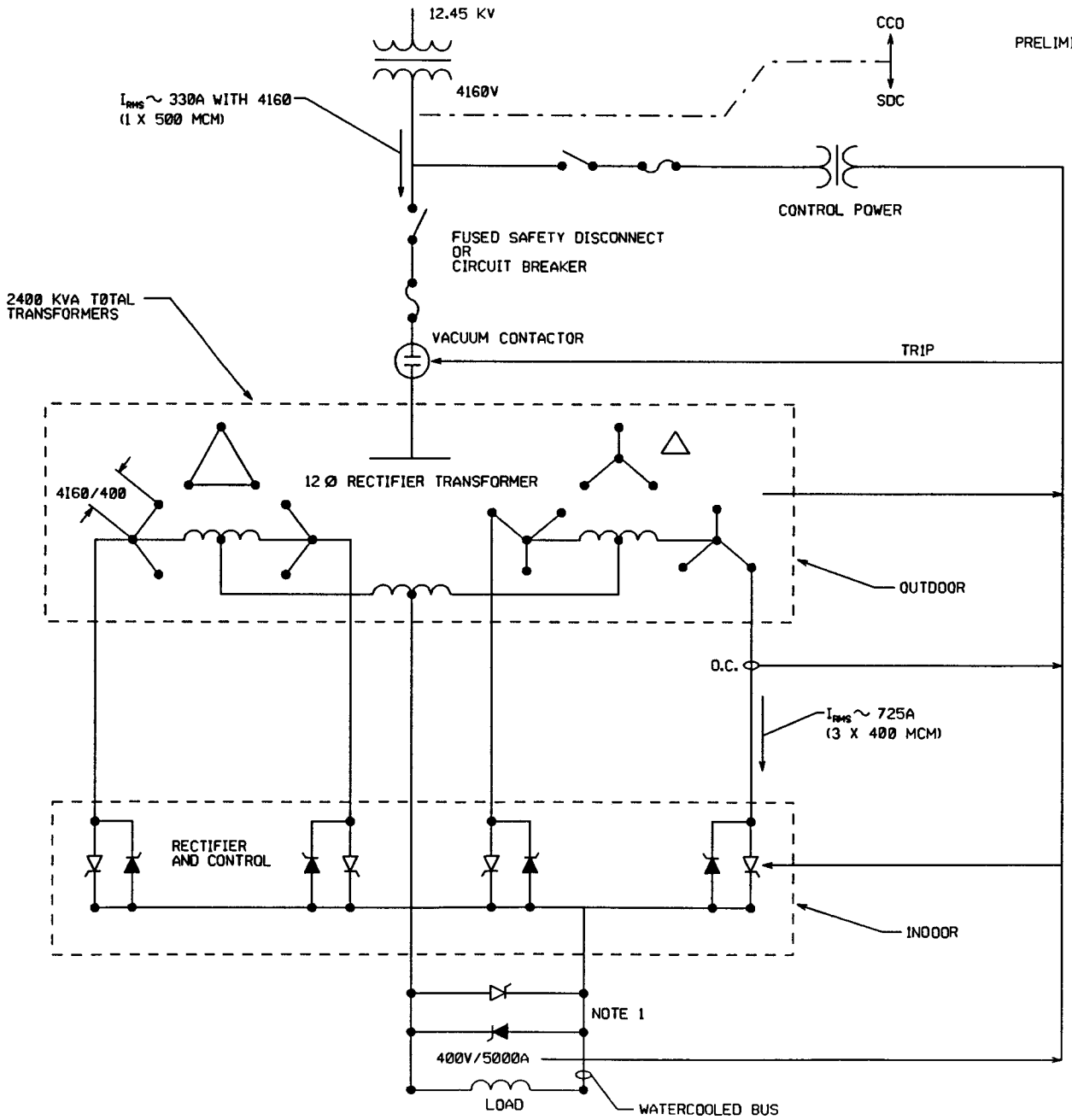

PRELIMINARY DESIGN - VALUES NEED FURTHER CHECKING/UPDATE WHEN LOAD IS KNOWN IN DETAIL.

12 Ø POWER SUPPLY - 2MW, 400V, 5000ADC

RECTIFIER SCHEME - WYE DELTA, 12 Ø
QUADRUPLE WYE *52
USAS C34.2 - 68

DC POWER SUPPLY WITH BUILT IN REVERSING CAPABILITY

NOTE 1: FREEWHEELING SCR'S NOT REQUIRED WITH SOLID IRON LOAD STEEL.

FORWARD SCR

REVERSE SCR

PRELIMINARY SDC SOLENOIDAL POWER SUPPLY

DIAGRAM "B"

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