Switching Signal Distribution System

VEGAS-005-A-REP

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Change Record

Version	Date	Affected Section(s)	Change Request #	Reason/Initiation/Remarks
A	2013-08-14	All	–	First release.

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1 Introduction and Scope

1.1 Scope

This document describes the Switching Signal Distribution System (SSDS) developed for the VErsatile GBT Astronomical Spectrometer (VEGAS) **[AD 01]**.

This document includes the electronics design, theory of operation, enclosure design, board configuration, assembly, and testing of the SSDS unit.

This document does not include information about the implementation of the switching signal generator in FPGA firmware or the switching signal selector in the GBT equipment room.

1.2 Introduction

VEGAS will be capable of processing up to 1.25 GHz bandwidth from 8 dual polarized beams or a bandwidth up to 10 GHz from a dual polarized beam.

The use of switching signals is required to provide injection of a calibrated noise source, as well as frequency switching. VEGAS is comprised of eight individual Roach2 boards that will each need to know the switching signal state to include in the data packets. This means that a switching signal distribution system is needed to receive the switching signals from the switching master Roach2, and distribute exact copies of those signals to the other seven Roach2 boards.

Along with distributing these signals to the Roach2 boards, the SSDS also sends them to the switching signal selector in the GBT equipment room, so they can be sent to the various receivers.

The SSDS can accommodate four switching signals – CAL, SIG/REF, BLANK, and ADV SIG/REF.

The SSDS can also receive switching signals from an external source (i.e., another backend) and distribute them to all eight roaches.

1.3 Abbreviations and Acronyms

ADC	Analog to Digital Converter
CASPER	Collaboration for Astronomy Signal Processing and Electronics Research
FPGA	Field Programmable Gate Array
GBT	Green Bank Telescope
IF	Intermediate Frequency
M&C	Monitor and Control
NRAO	National Radio Astronomy Observatory
RFI	Radio Frequency Interference
SSDS	Switching Signal Distribution System

2 Documentation

2.1 Applicable documents

No	Document Title	Reference
AD01	VEGAS Design Report	VEGAS-001-A-REP
AD02	VEGAS Shielded Rack Cabling	B35215S002
AD03	VEGAS SSDS Front Panel mechanical drawing	D35215M001
AD04	VEGAS SSDS Front Frame mechanical drawing	D35215M002
AD05	VEGAS SSDS Back Plate mechanical drawing	D35216M003
AD06	VEGAS SSDS Side Plate mechanical drawing	D35215M004
AD07	VEGAS SSDS Lid mechanical drawing	D35215M005
AD08	VEGAS SSDS Printed Circuit Board Layout	B35215Q001
AD09	VEGAS SSDS Internal Wiring Diagram	B35215S004
AD10	VEGAS SSDS PCB Assembly Manual	VEGAS-006-A-MAN

2.2 Reference Documents

No	Document Title	Reference
RD01	VEGAS Specification Document	link
RD02	VEGAS Block Diagram	B35215K003

3 SSDS Electronics Design

This section describes the electronics design of the SSDS. Figures 1 and 2 below show a fully assembled SSDS chassis.

Figure 1 - SSDS Front View

Figure 2 - SSDS Rear View

3.1 Theory of Operation

The SSDS is responsible for insuring that all ROACH boards in the VEGAS Spectrometer receive precisely aligned, coherent switching state signals which, in turn, are used to accurately "bin" the data being processed.

Normally, VEGAS will be configured such that a single ROACH serves as the "Switching Master"; and, as such, generates all the relevant switching state signals required by the entire system. These states are . . .

Sig / Ref . . . A low level on this signal line indicates that the data being processed are that from a "live" source.

A high level on this signal line indicates that the data being processed is from a "reference" source such as a calibrator.

Please note that this signal is most often used in "position switching" observations.

Cal . . . A low level on this signal line indicates that the data being processed is from a calibration source such as a noise diode located in a receiver's front end.

A high level on this signal line indicates that the noise source within the receiver has been switched off.

Blank . . . A high level on this signal line indicates that the system is in the midst of a switching state transition and that the data being processed should be discarded.

The SSDS receives these switching signals via a flat cable plugged into connector P15 on the "Switching Master" ROACH. It then utilizes low-skew, clock distribution chips along with flat cables which plug into the remaining "slave" ROACH boards' connectors P13; thereby distributing the switching signals as necessary.

The SSDS also has provisions for either "slaving" VEGAS to another Back End (which would provide the necessary switching signals) or "slaving" another Back End to VEGAS, in which case VEGAS would provide the necessary switching signals.

These connections are accomplished via clearly labeled BNC connectors located on the SSDS's back panel which are designed to utilize 50 ohm coaxial cables with all input and output signals being standard TTL levels.

Provisions are also made for one additional switching signal which is normally routed from an observatory's switched LO source. This switching signal is…

LO Blank . . . A high level on this signal line indicates that a switched LO frequency source has NOT settled to its target frequency.

A low level on this signal line indicates that a switched LO frequency source HAS settled to its target frequency.

Note that this switching signal is almost exclusively used during "frequency-switched" observations, and that it is usually logically ored with the Blank signal described above.

The SSDS's front panel contains a row of LEDs which indicate…

Power . . . The SSDS is powered up and ready for operation (LED ON)

Internal . . . VEGAS is providing the switching signals (LED ON)

External . . . Another Back End is providing the switching signals (LED ON)

LO Blank . . . External, switched LO generator has not settled (LED ON)

Sig / Ref . . . Data source is a "reference" (LED ON), or is "live" (LED OFF)

Cal. . . Receiver's noise diode is off (LED ON) or on (LED OFF)

Blank . . . Internal blanking is active (LED ON)

3.2 Main Circuit Board

Figures 3, 4, and 5 below are the schematics for the SSDS printed circuit board. There is a modification required on the circuit board if the SSDS is to be used with Roach2 boards. This modification is explained on sheet 3 (Figure 5).

The SSDS PCB Assembly Manual **[AD 10]** describes in great detail the procedure for assembling the circuit board.

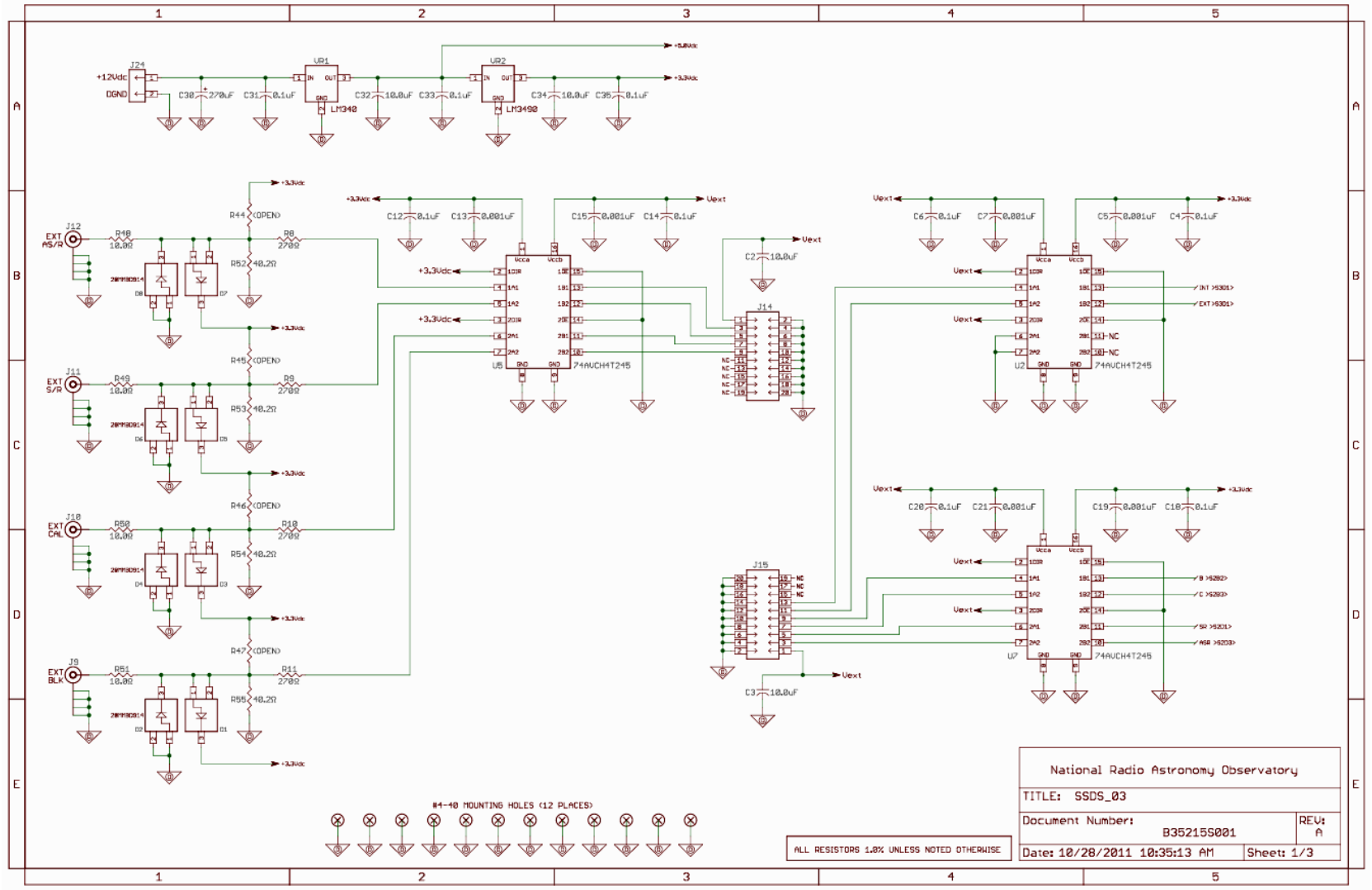

Figure 3 - SSDS PCB Schematic Sheet 1/3

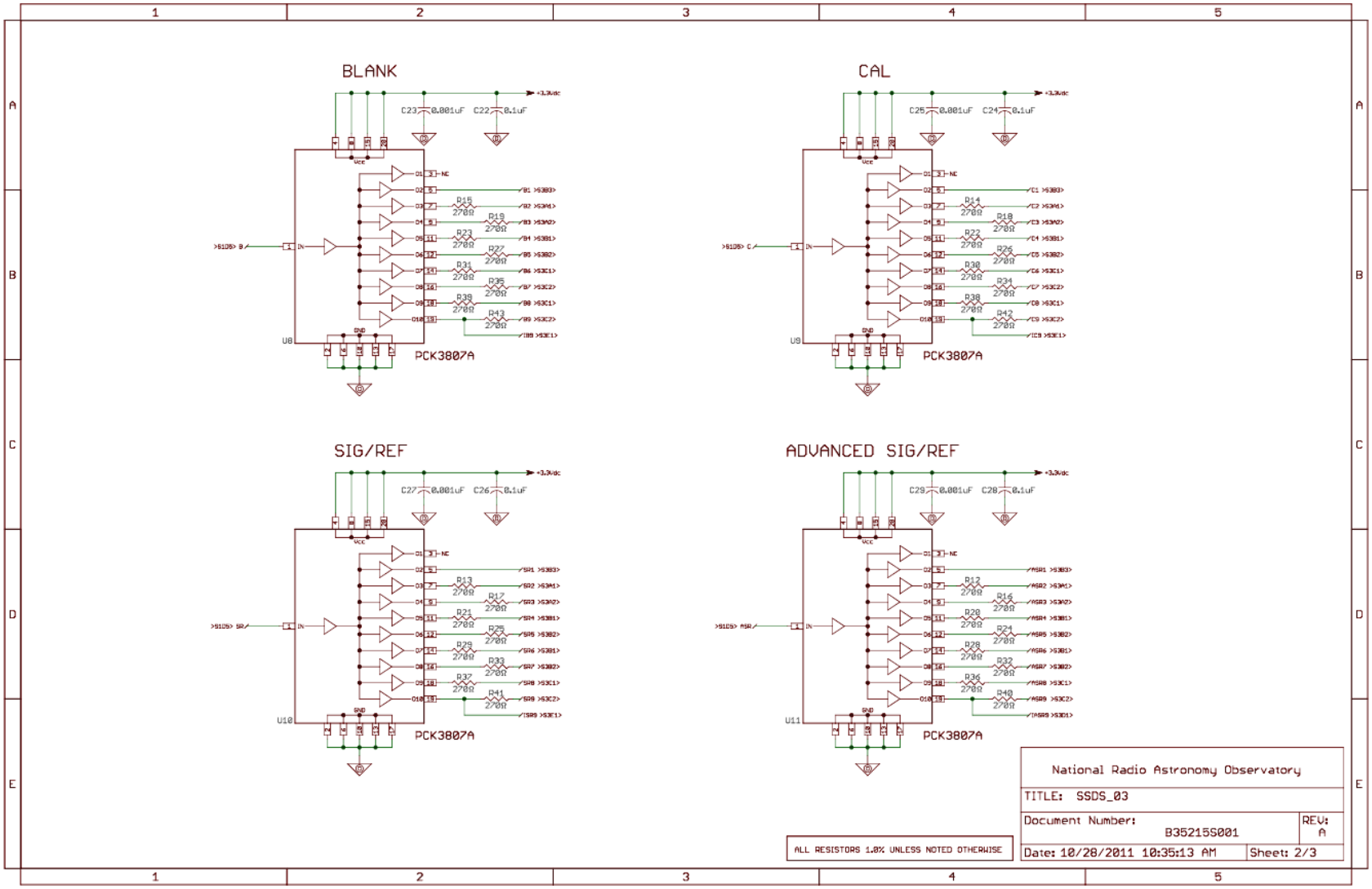

Figure 4 - SSDS PCB Schematic Sheet 2/3

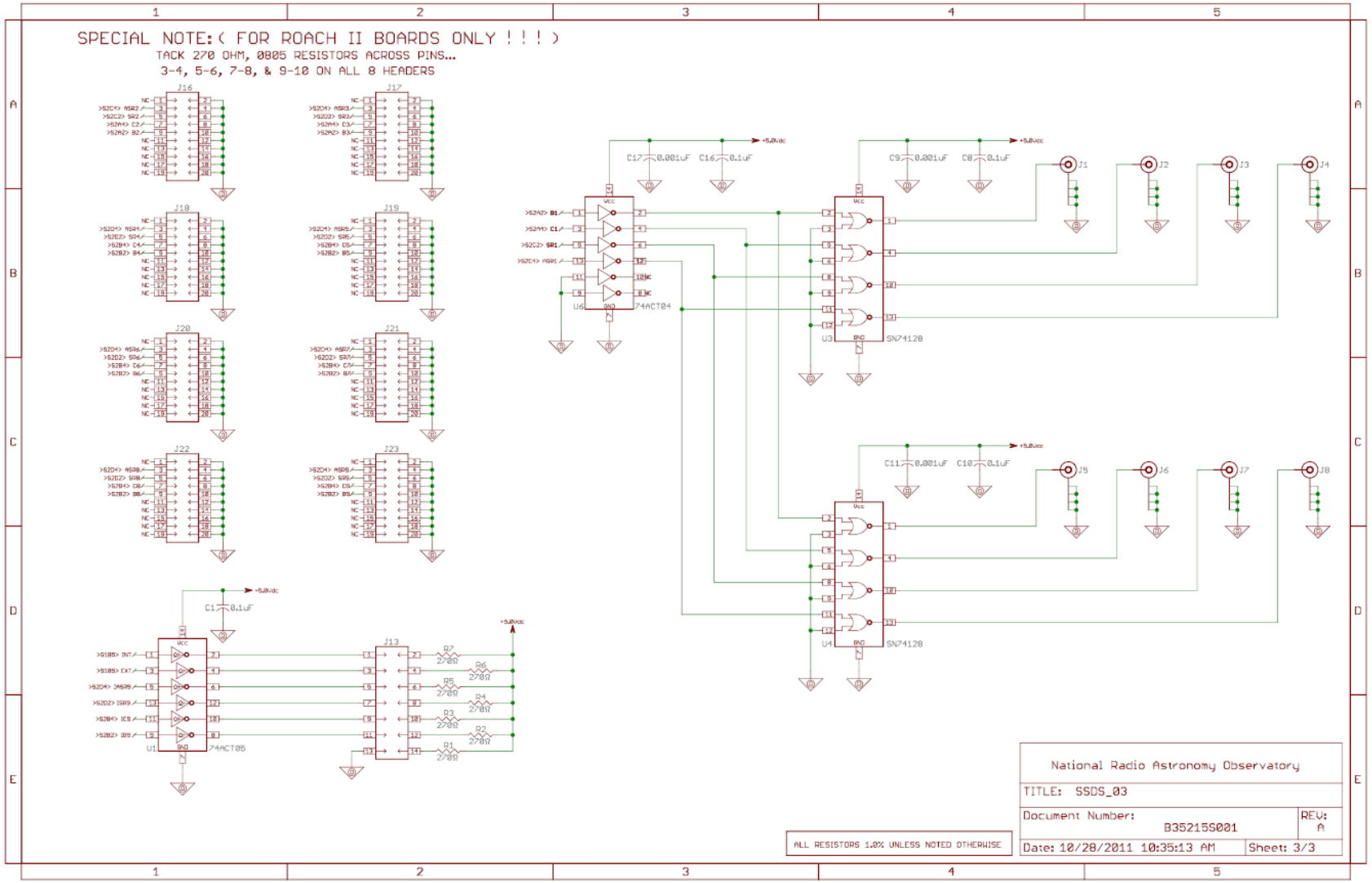

Figure 5 - SSDS PCB Schematic Sheet 3/3

3.3 Enclosure Components

There are a number of components installed in the chassis in support of the main circuit board.

The front panel contains seven LEDs indicating, power on, internal/external switching signal mode, and the states of the four switching signals.

The back plate **[AD 05]** contains the power entry items such as the AC connector plug, a fuse holder, and the power on/off switch. There are also 12 BNC bulkhead connectors for switching signals in and out of the chassis. The main circuit board is attached to the back plate inside the chassis. The back plate has 10 rectangular cutouts to allow the ribbon cable headers to protrude through the chassis.

There is a 12VDC power supply attached to the inside that provides power to the main circuit board.

3.4 SSDS Internal Wiring

There are several connections required inside the SSDS chassis **[AD 11]**. Figure 6 below is a schematic diagram of the internal wiring.

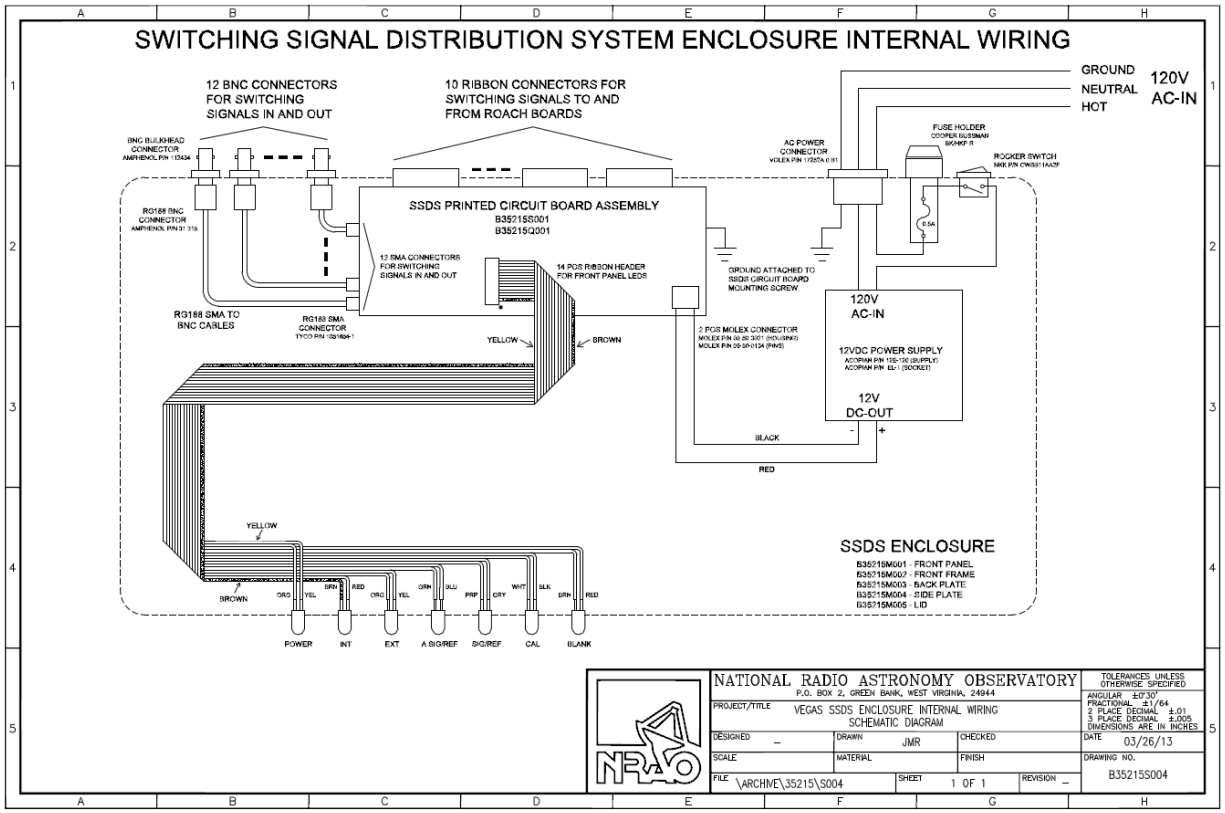

Figure 6 - SSDS Internal Wiring Diagram

AC power enters the enclosure and the hot wire passes through the 1/2A fuse and the power switch, before connecting to the 12VDC power supply. The output from that supply is attached to the main circuit board using a 2 position Molex connector. The power supply section is shown in Figure 7 below.

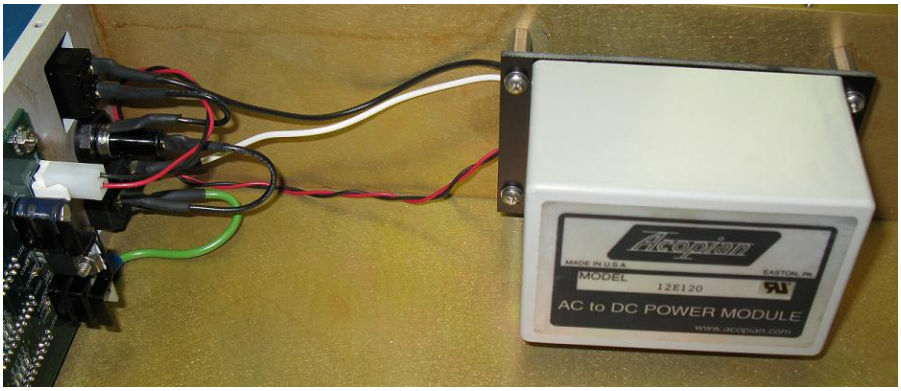

Figure 7 - Internal Wiring of Power Supply

The BNC signal inputs and outputs are connected to the main circuit board with short RG188 cables. These cables have a BNC connector on one end and an SMA connector on the other end, as shown in Figure 8.

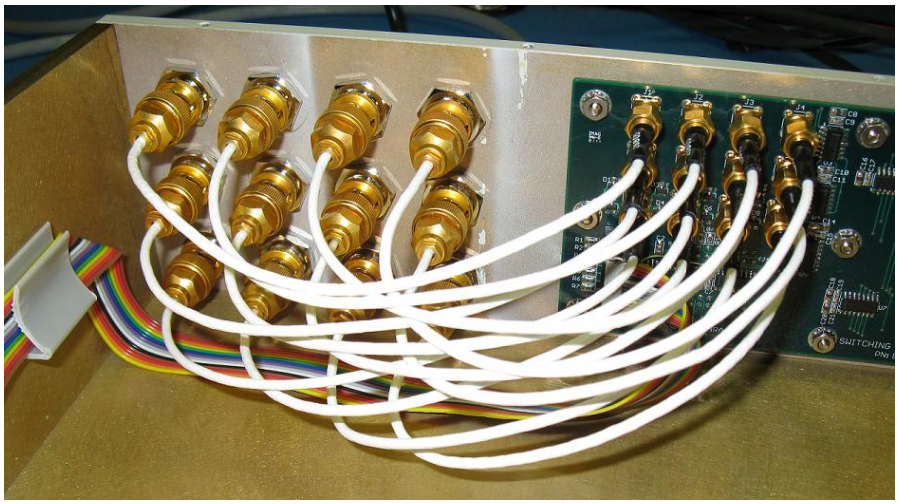

Figure 8 - Internal Wiring of BNC Connections

The LEDs are connected using a section of ribbon cable. There is a 14 position ribbon cable header on the main circuit board that carries the LED signals. The ribbon cable is dressed around the side wall of the enclosure, where the individual wires are split out and attached to the LEDs as shown in Figure 6 above, and Figure 9 below. The current limiting resistors are included on the main circuit board.

Figure 9 - Internal Wiring of Front Panel LEDs

3.5 SSDS External Connections

There are several external connections required to the SSDS chassis. All of these connections are shown in the VEGAS block diagram **[RD 02]**.

The AC power connection is made by a standard power cord connected to the power connector. The power connector, fuse holder, and on/off switch are shown in Figure 10.

Figure 10 - SSDS Power Entry Connection

The connections between the Roach2 boards and the SSDS are all made by a 20 position ribbon cables, attached to the header connectors shown in Figure 11.

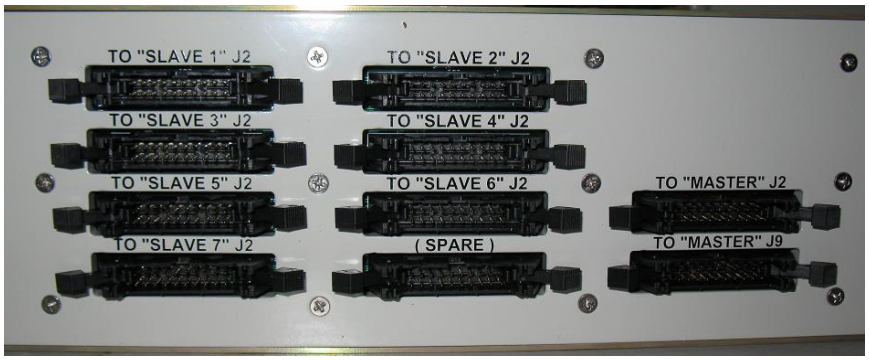

Figure 11 - SSDS Ribbon Headers

Before discussing the connections to the Roach2 boards, it should be noted that the SSDS was designed based on the Roach1 board. So, the silkscreened labels on the back plate reference connector labels from the Roach1 board (J2 and J9). However, VEGAS uses the Roach2 board which has different connector references. The equivalent Roach2 connectors to J2 and J9 are P13 and P15, respectively.

The switching master Roach2 board requires two connections to the SSDS. One cable carries the switching signals out of the Roach2 board and is attached to the connector labeled “TO MASTER J9”. The other cable carries the switching signals into the Roach2 board (from an external source) and is attached to the connector labeled “TO MASTER J2”

The slave Roach2 boards each require one connection to the SSDS. This cable carries switching signals into the Roach2 board, from either the switching master Roach2, or an external source. This cable is attached to a connector labeled “TO SLAVE n J2” where n is 1 through 7, depending on the connector used on the SSDS.

There is also a connector on the SSDS labeled “SPARE” which carries the same signals as those labeled “TO SLAVE n J2”

Due to the standalone nature of the Roach2 mounting plate design for VEGAS **[AD 01]**, the ribbon cables are not directly connected between the Roach2 board and the SSDS. There is a short cable connecting from the Roach2 board to “bracket 1” on the mounting plate. Then there is another cable connecting from “bracket 1” to the SSDS.

Details of the ribbon cables and their connections are shown in Figures 12, 13, and 14.

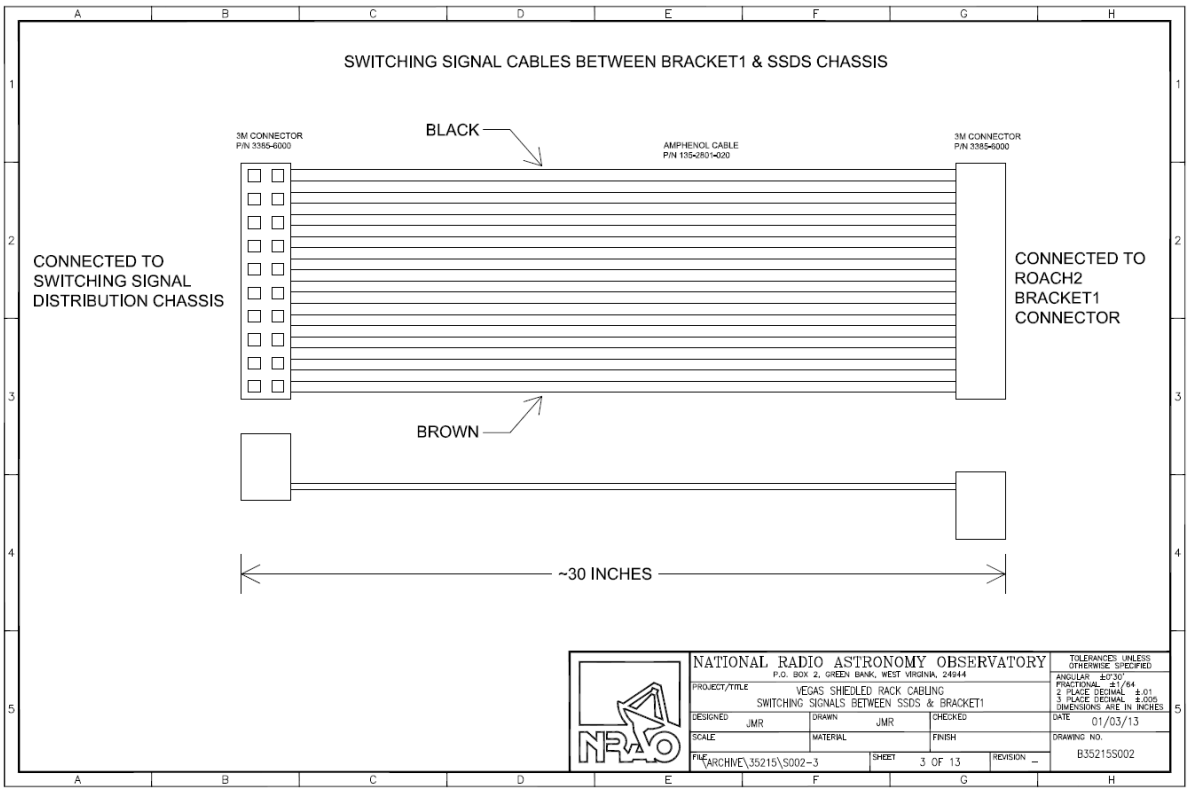

Figure 12 - SSDS Ribbon Cable, SSDS to Bracket1

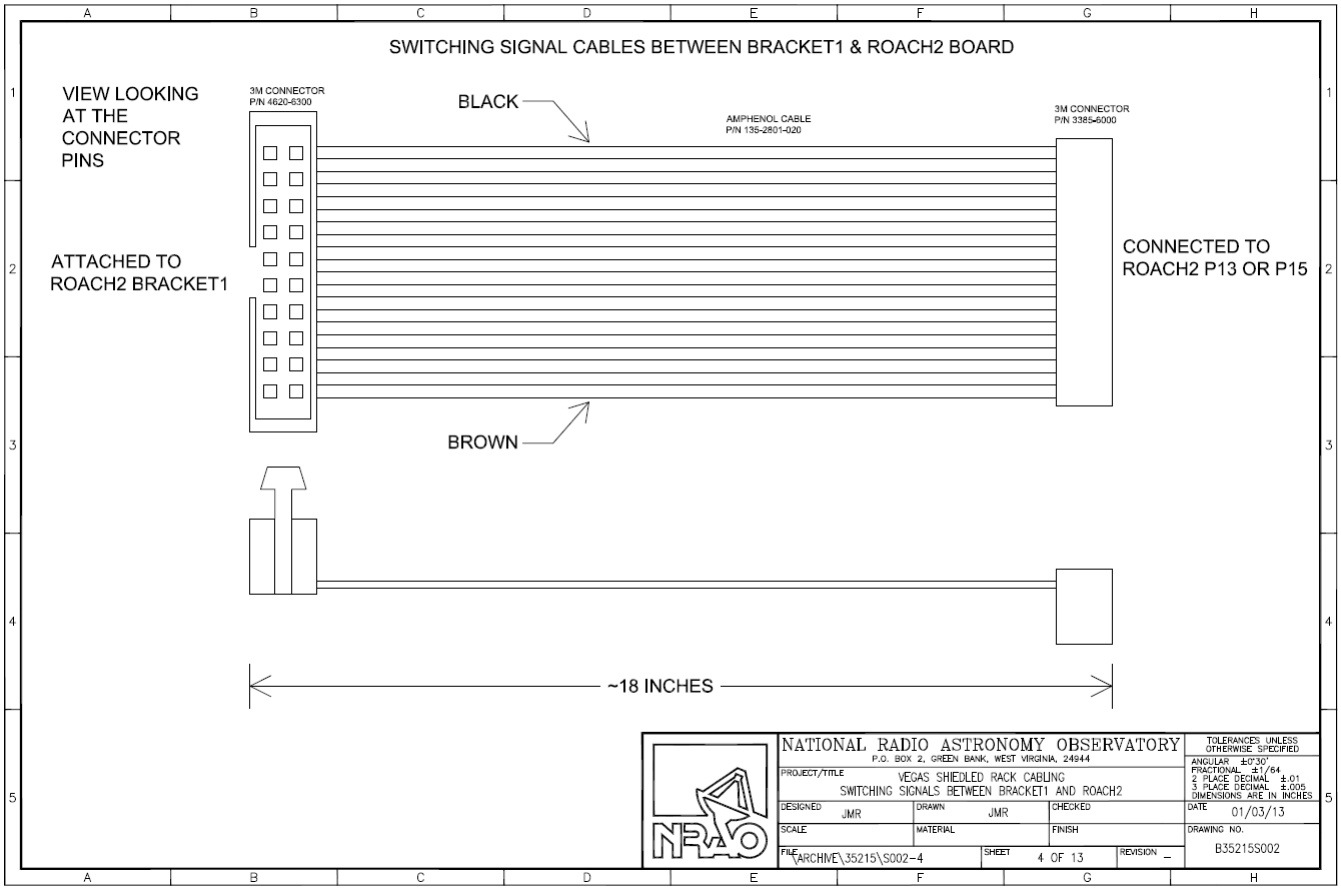

Figure 13 - SSDS Ribbon Cables, Bracket1 to Roach2

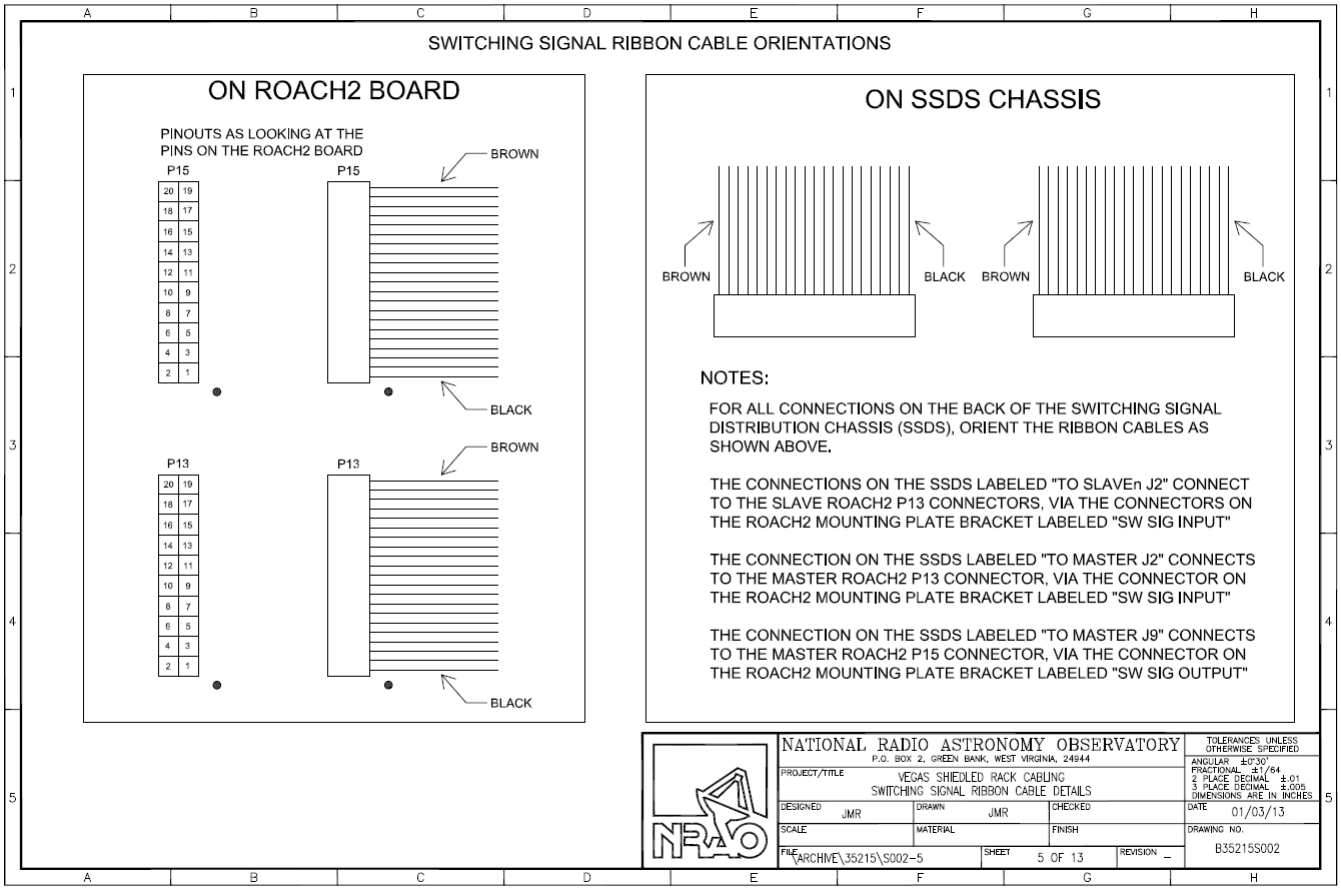

Figure 14 - SSDS Cable Connections & Orientation

The connections between the SSDS and the switching signal selector are attached to the BNC connectors on the back plate. There are two sets of output signals and one set of input signals, as shown in Figure 15.

Figure 15 - SSDS BNC Connections

The signals “SIG/REF”, “CAL”, and “BLANK” from the switching signal selector are connected to the output BNC connectors on the SSDS using long coaxial BNC cables **[AD 02]**.

The signals “BLANK” and “LO BLANK” from the switching signal selector are connected to the input BNC connectors on the SSDS, also using long coaxial BNC cables. Since the SSDS was not designed to accommodate the “LO BLANK” signal, the decision was made to re-assign the “ADV SIG/REF” BNC input to “LO BLANK”.

4 Mechanical Design

This section describes the mechanical design of the SSDS enclosure.

4.1 Main Enclosure

The main body of the enclosure for the SSDS is made from four 1/4” thick aluminum plates. The front frame, side plates, and back plate are attached at the corners forming the main rectangular body. There is a front panel attached to the front frame, and a 1/16” thick aluminum lid on the top and bottom. The assembly was designed to be the size of a standard 2U chassis that is 12” deep.

The front frame **[AD 04]** is where the front panel is attached, by screws installed from the inside.

The side plates **[AD 06]** are attached to the front frame. One of the side plates is drilled and tapped for mounting the power supply unit, on the inside wall.

The back plate **[AD 05]** is attached to the side plates

The top and bottom edges of all of the plates mentioned above are drilled and tapped to allow the enclosure lids **[AD 07]** to attach to the assembly.

4.2 Front Panel

The SSDS front panel **[AD 03]** is machined from a 1/4” thick piece of aluminum. The entire backside is machined down to 1/8” thick, except for a profile matching that of the front frame. This area is left thick so that it can be drilled and tapped to allow the front panel to be attached by screws from the inside of the chassis. These mounting screws can be seen in Figure 9 in section 3.4 above.

The front panel also contains seven thru holes to allow the LEDs to protrude from the inside, four thru holes for attaching the handles, and four other slots on the outer edges to allow it to mount in an equipment rack.

After machining, the front panel is painted white and sent away to have the labeling silkscreened on. The artwork was drawn in AutoCAD and then sent away to Garrett Film Services to convert the

AutoCAD file into a 1:1 photoplot. This photoplot, along with the panels, were sent to WWW Electronics for the silkscreen application.

4.3 Back Plate

The back plate contains many cutouts and features for attaching the various components described above. The cutouts for the ribbon headers were made larger than specified in the datasheet to allow the ejector tabs to be functional. There is also a 0.200" deep recessed area machined on the inside wall surrounding the ribbon header cutouts to help reduce the mounting depth of the ribbon headers. The combination of the mounting depth and the back plate thickness required these changes, otherwise the ejector tabs could not rotate far enough to release the connectors.

The cutouts for the AC power connector, fuse holder, toggle switch, and BNC cables were all made per their datasheets.

There is a recessed area machined on the inside wall of the back plate around the toggle switch cutout. This was to reduce the panel thickness to 1/16" inch per the datasheet for the switch.

Similar to the front panel, rear panel is painted white, and the labeling is silkscreened on.

5 RFI/EMI Considerations

The SSDS is not constructed in a shielded enclosure. Given that it is an integrated component of VEGAS, the SSDS is installed in the shielded rack, which resides in the shielded equipment room. No additional RFI mitigation is necessary.

6 Bill of Materials

Item	Qty	Description	Notes	Manufacturer	Mfg PN	Vendor	Vendor PN	Cost	Ext Cost
1	1	SSDS chassis front panel	Chassis assembly parts	NRAO	35215M001	NRAO	35215M001	0.000	0.00
2	1	SSDS chassis front frame	Chassis assembly parts	NRAO	35215M002	NRAO	35215M002	0.000	0.00
3	1	SSDS chassis back plate	Chassis assembly parts	NRAO	35215M003	NRAO	35215M003	0.000	0.00
4	2	SSDS chassis side plate	Chassis assembly parts	NRAO	35215M004	NRAO	35215M004	0.000	0.00
5	2	SSDS chassis lid	Chassis assembly parts	NRAO	35215M005	NRAO	35215M005	0.000	0.00
6	1	SSDS PCB Assy	Main SSDS PCB	NRAO	35215Q001	NRAO	35215Q001		0.00
7	1	2 pos connector housing	For +12V connection to PCB	Molex	09-50-3021	Digikey	WM2100-ND	0.320	0.32
8	2	Connector terminal, female	For +12V connection to PCB	Molex	08-50-0134	Digikey	WM2303-ND	0.153	0.31
9	1	14 pos rectangular connector	For front panel LED connections to PCB	3M	3385-6000	Digikey	MSC14K-ND	3.360	3.36
10	1	Power supply socket	For power supply mount to chassis wall	Acopian	EL-1	Acopian	EL-1	20.000	20.00
11	1	Power supply, 12V 1.2A	DC power supply for the SSDS PCB	Acopian	12E-120	Acopian	12E-120	149.000	149.00
12	2	Rack Handle	Handles	Bud Industries	H-9168-B	Digikey	377-1236-ND	5.700	11.40
13	12	BNC bulkhead connector	For external switching signal connections	Amphenol	112434	Digikey	ACX1844-ND	6.657	79.89
14	7	LED clip mount	For mounting front panel LEDs	VCC	CLP126BLK	Mouser	593-CLP126	0.090	0.63
15	1	AC panel mount receptacle	For AC power input connection	Volex	17252A 0 B1	Mouser	686-17252A	1.830	1.83
16	1	Panel mount fuse holder	For AC power input fuse protection	Cooper Bussman	BK/HKP-R	Digikey	283-2850-ND	5.430	5.43
17	1	SPST rocker switch	Main power switch for SSDS	NKK Switches	CWSB11AA2F	Digikey	360-1724-ND	2.860	2.86
18	16	4-40 x 5/16" flat head screws	For attaching top & bottom lids to chassis	McMaster Carr	91771A107	McMaster Carr	91771A107	4.320	69.12
19	26	4-40 x 3/8" socket head cap screws	For attaching front frame to chassis walls	McMaster Carr	92196A108	McMaster Carr	92196A108	2.870	74.62
20	16	4-40 x 1/2" socket head cap screws	For attaching front & back panels to side walls	McMaster Carr	92196A110	McMaster Carr	92196A110	3.250	52.00
21	4	6-32 x 5/16" phillips head screws w/ washer	For attaching PS mount to standoffs	McMaster Carr	95345A045	McMaster Carr	95345A045	7.800	31.20
22	4	6-32 M/F standoff, 3/4" long	For attaching PS mount to chassis wall	McMaster Carr	91075A444	McMaster Carr	91075A444	0.440	1.76
23	12	4-40 hex nut with washer	For attaching the PCB to the back wall	McMaster Carr	96278A005	McMaster Carr	96278A005	5.450	65.40
24	12	4-40 x 5/8" flat head screws	For attaching the PCB to the back wall	McMaster Carr	91771A112	McMaster Carr	91771A112	4.390	52.68
25	6	Red LED, T1-3/4	For front panel LEDs	Avago Tech	HLMP-3301	Digikey	516-1328-ND	0.306	1.84
26	1	Green LED, T1-3/4	For front panel power LED	Avago Tech	HLMP-3507	Digikey	516-1333-ND	0.306	0.31
27	1	20 conductor ribbon cablem, 100ft	For connections to/from SSDS and for LED conns	Amphenol	135-2801-020	Newark	78K6398	81.920	81.92
28	20	20 pos rectangular connector	For building cables for conns to/from SSDS	3M	3421-6000	Digikey	MSC20K-ND	3.150	63.00
29	1	Power cord, 6'	AC power input connection	Phihong USA	AC30UNA	Digikey	993-1039-ND	3.180	3.18
30	4	Ribbon Cable Clamp	For fastening LED cable inside the chassis	Pro Power	FC-25	Newark	24M2011	11.600	46.40
31	1	Silk screen artwork films	Front & back panel artwork for silkscreening	Garret Film Services	-	Garret Film Services	-	68.000	68.00
32	1	Silk screen application	For labeling front & back panels	3W Electronics	-	3W Electronics	-	118.200	118.20
33	7	LED clip mount spacer	For front panel LED connections to PCB	VCC	SPC125	Mouser	593-SPC125	0.110	0.77
34	12	SMA male to RG188 connector	For interior PCB to bulkhead cables	Tyco	1051654-1	TTI	1051654-1	7.250	87.00
35	12	BNC plug to RG188 connector	For interior PCB to bulkhead cables	NRAO	-	-	-	0.000	0.00
36	1	RG188 cable	For interior PCB to bulkhead cables (~10ft needed)	NRAO	-	-	-	0.000	0.00

Figure 16 - SSDS Enclosure BOM