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Description of the Analog Link Module and the Grounding and Shielding system in the Zeus Microvertex Detector

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Abstract: The Analog Link Module is described as part of the data path between the Silicon Detectors in the Microvertex Detector and the ADC's in the Data Acquisition System.

Grounding and Shielding, as an integral part of the system, is explained as a strategy as well as a physical realisation.

NIKHEF, DEPARTMENT OF ELECTRONIC TECHNOLOGY

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ANALOG LINK MODULE

INTRODUCTION

This documentation describes the function of the ANALOG LINK MODULE.
The module is used in the ZEUS MICROVERTEX detector set-up at DESY, Hamburg.

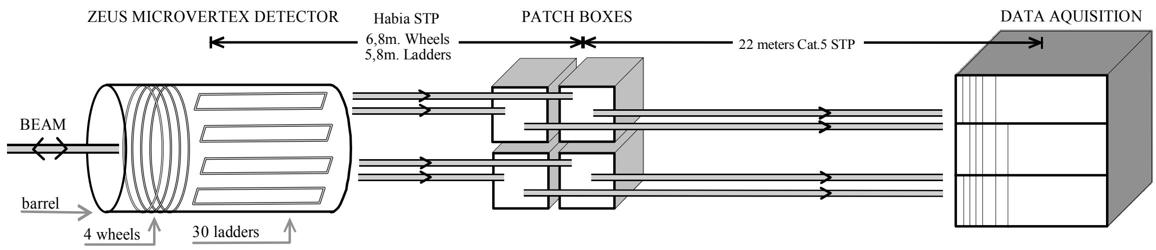


Fig.1

Fig. 1 shows a schematic drawing of the ZEUS MICROVERTEX DETECTOR (MVD), the innermost part of the detector configuration. The detectors used are Silicon Strip detectors, arranged on ladders and wheels.
The position of the barrel, around the beam pipe, and in the centre of the detector arrangement, does not leave much space for electronics and cabling.
After the assembly of the entire set-up has been completed, access to the MVD will be practically impossible. For that reason, and for the sake of minimizing the radiation length, the amount of electronics and cabling in and around the MVD has been kept to a minimum.

The analog signals leaving the barrel are transported over very thin STP(Shielded Twisted Pair) cables. Bandwidth limitations and signal attenuation impede the use of this kind of cable for the entire distance between the barrel and the DATA ACQUISITION crates in the Veto Wall area. Thus patch boxes had to be provided, as close as possible to the MVD. The nearest space available is in the RCAL area, resulting in a maximum cable length of 5,8 meters for the barrel and 6,8 meters for the wheels.

The remaining distance of 22 meters to the DATA ACQUISITION area is covered by Cat.5 STP cable, with much better signal transfer properties. This cable can be used, as from the patch boxes, space and radiation length are less critical.
For the analog signals the patch boxes only provide space to change from cable type: no active electronics is used in the signal path.

There are many other signals passing the patch boxes:
Detector Bias, Clock and Control, Low Voltage and Slow Control signals.
However, those signals fall outside the scope of this documentation.

As grounding and shielding is highly important for the performance of the experiment, this subject will be described also.

ANALOG SIGNALS

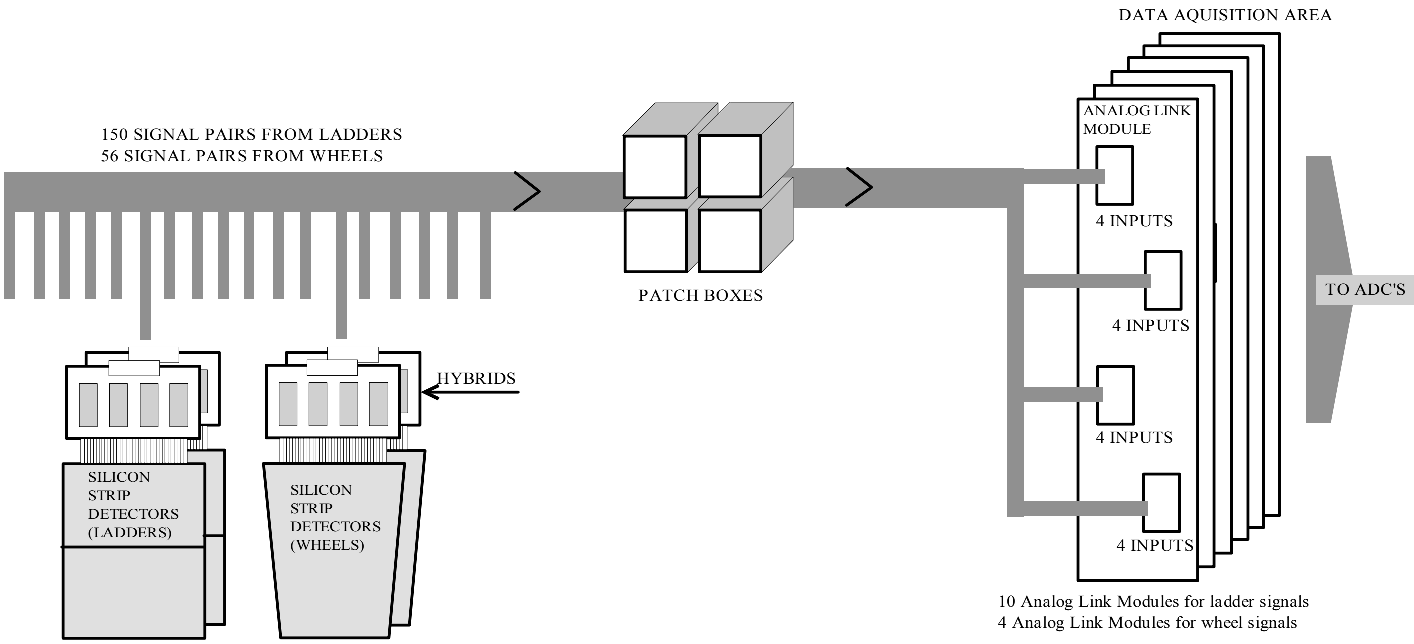


Fig.2

In the MVD, each of the 4 wheels, contain 14 modules.
Each module consists of two silicon strip detectors and two hybrids. Each of the 30 ladders contains 5 modules, consisting of 4 Si. Detectors. The silicon detectors on the ladders are different in size and shape from those on the wheels. The barrel MVD detectors have 512, the wheel MVD detectors have 480 readout strips.
Each module has one pair of output signals: Analog Out and Dummy Out, so the total number of signal pairs to be transported is:
4*14=56 for the wheels and 30*5=150 for the ladders, together 206 signal pairs.

The signals pass the patch boxes, where a change in cable type takes place, and arrive at the ANALOG LINK MODULES in the DATA ACQUISITION crates.
Each module has 16 identical inputs, divided over 4 RJ45 input connectors. For the ladder signals 10 modules are reserved, for the wheels signals 4 modules. The outputs of the modules connect to the ADC’s in the same crate.

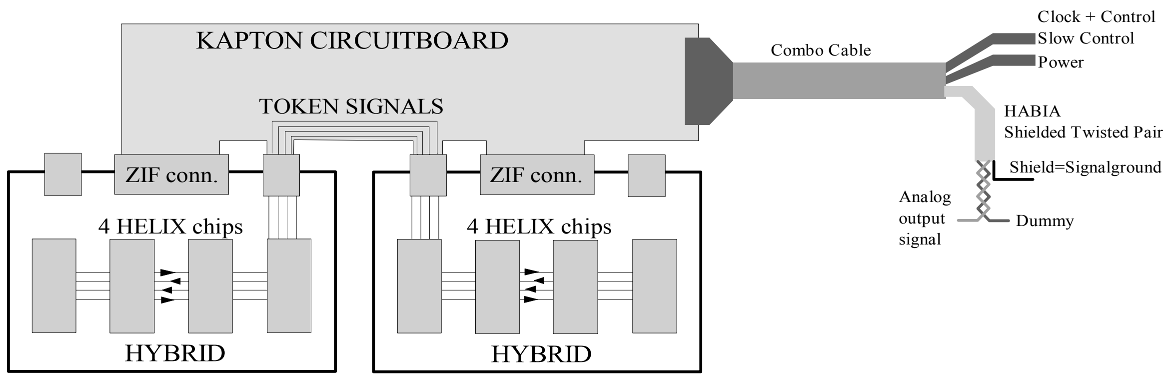


Fig. 3

The two hybrids in Fig. 2 are shown in more detail in Fig. 3. On each hybrid 4 HELIX 128-3.0 chips are bonded. The interconnection between the 2 hybrids is formed by a flexible kapton circuit board. This board provides space for the distribution of all of the supply voltages, the detector bias voltage, the slow control signals and the clock and control signals, as well as the signals: Analog Out and Dummy Out.
After an event has occurred, the read-out cycle starts with reading out the first HELIX chip.
Each of the 8 chips on 2 hybrids have their token in- and outputs connected to their neighbouring chips. During the read-out cycle the token is passed through, and the 8 chips are read out sequentially.
Fig. 4 shows a typical read-out cycle.

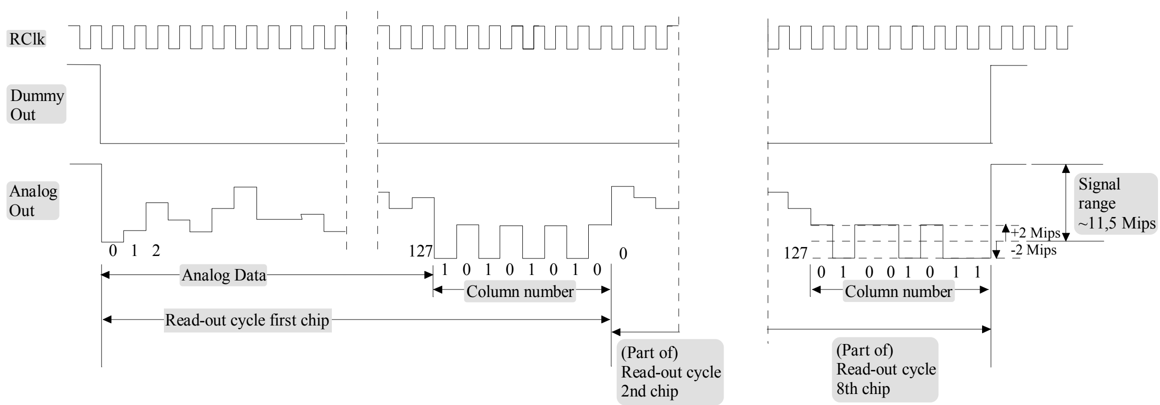


Fig. 4

On the falling edge of RClk the content of the 128 positions of the output register is being transferred to the Analog Out output. An 8-bit column number follows the data. The read-out cycle ends after the 8^{th} chip has been read out.
During the entire read-out cycle the Dummy Out signal is active. This signal contains the same noise, caused by clock signals etc. as the Analog Out signal. (The noise is not shown in Fig. 4).

Subtraction of the two signals in the Analog Link module leaves a clean analog data signal. There is no interruption of the Dummy signal when the read-out cycle crosses over from one chip to the next one.

From the kapton board in Fig. 3, a “Combo Cable” is leaving. In this cable all wires and cables for power, bias, clock and control etc. are bundled together.
Included also, is the HABIA STP-cable carrying the signals Analog Out and Dummy Out. There is one ”Combo Cable” for every module, avoiding interference caused by shared signal paths or ground connections.

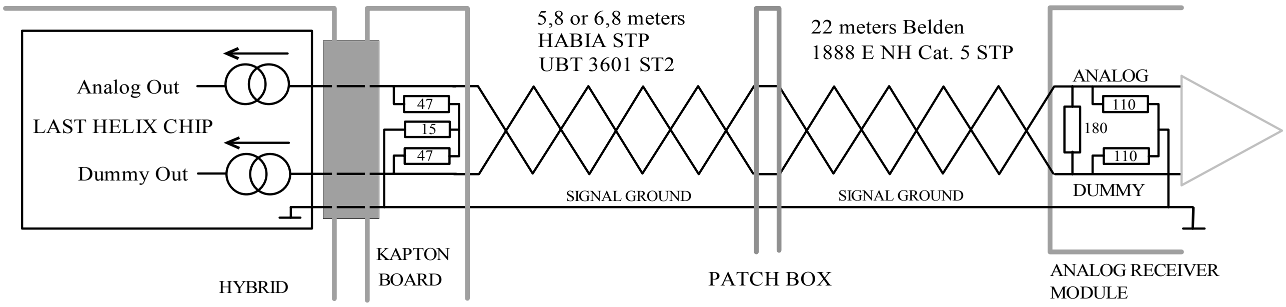


Fig. 5

The outputs Analog Out and Dummy Out are single ended current sources. Both outputs sink current to the –2V supply. When the outputs are active, Dummy Out will sink a current of –3,2mA. Analog Out, when active, sinks a current of –3,2mA + 280μA/MIP.
The signal range for analog output signals is: 3200/280=11,43 MIP’s.

During read out of the column number, the Analog Out output current is: –3,2mA + 2 MIP’s for a “0”, and: –3,2mA – 2 MIP’s for a “1” (see also Fig. 4).

TRANSPORTING THE OUTPUT SIGNALS

Choosing a cable to transport the signals, was lead by the following considerations:
-Both outputs are single ended.
-The cable should add a minimum to the material budget inside the MVD.

Considering the limited material budget in the barrel, and requirements of single-ended outputs, the cable choice fell on a Shielded Twisted Pair cable from Habia, UBT 3601 ST2 (Fig. 5).
STP cables are normally used to transport balanced signals, with only one terminating resistor between the 2 conductors. The balanced signal does not see the shield.The shield is then used as a real shield, and does not take part in the signal transportation.
In this case, the STP cable is not used in a balanced way. The twisted pair transports 2 independent signals, and the “shield” is used as a return for both signals (signal-ground in fig.5). This means that in this case not only the impedance between the twisted pair is important, but also the impedance between each conductor and “shield”.

Subtraction of the two signals should result in an analog signal with an accuracy of 8 bits. Consequently, the twisted pairs need termination on both sides. A star configuration on the input side and a triangle on the output side give the best results.
The impedance match of the two types of STP, coming together in the patch box, is so close that no matching circuitry is necessary. In the patch box care has been taken to avoid impedance mismatch on the circuit boards.
Both current sources Analog Out and Dummy Out see into the cable impedance parallel to the termination resistance. Thus only half of the output current travels down the line. On the way, the cable resistance takes away a part of the signal. The major contribution to the cable's resistance comes from the 5,8 or 6,8m of Habia cable.
Each conductor of the pair adds some 1,5 Ohms/m, and the shield 0,4 Ω /m.
For the Belden Cat.5 cable these values are 70 mΩ /m and 5 mΩ /m respectively.
Finally, a change on either input, has effect on the other input through the terminating resistors on both sides of the cable.
1mA change of Analog Out or Dummy Out, is calculated to produce a 24,7mV change on the 180 Ω resistor at the end of the twisted pair.

PHYSICAL PROPERTIES AND HOUSING OF THE ANALOG LINK MODULE

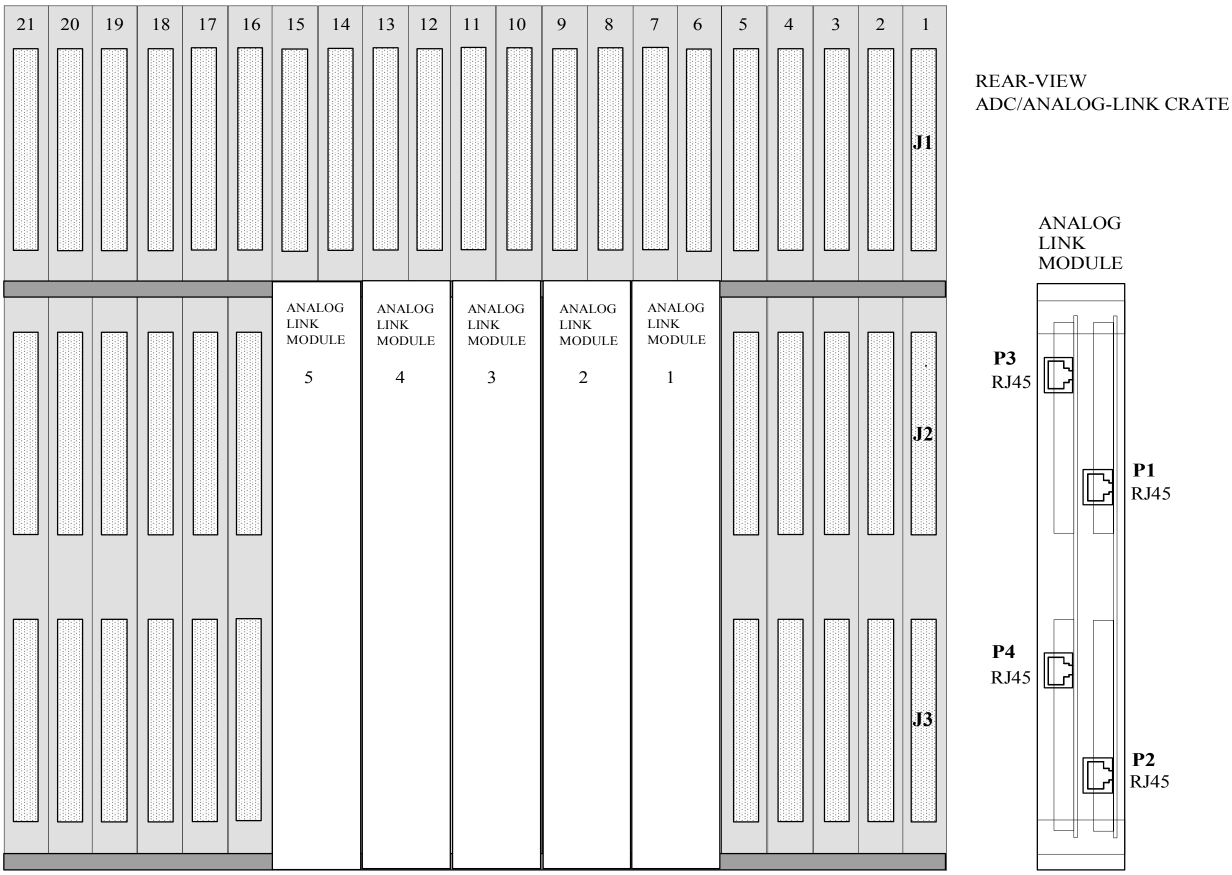


Fig.6

All Data Acquisition Electronics is located in the Vetowall area.
For handling the Analog signals, 3 VME crates are available. In each crate 10 slots can be used for ADC modules (Fig.6).
An ADC module with 8 inputs needs one slot. The first ADC module is housed in slot 6 of the ADC crate.
The Analog Link Module occupies 2 slots and serves 2 ADC's.
4 RJ45 connectors each receive 4 STP cables, so in total 16 input channels are divided over 2 boards in the Link Module.
The Link Modules only occupy back plane connectors J2 and J3. Power is taken from J2 mainly and the output signals enter the ADC through J3.

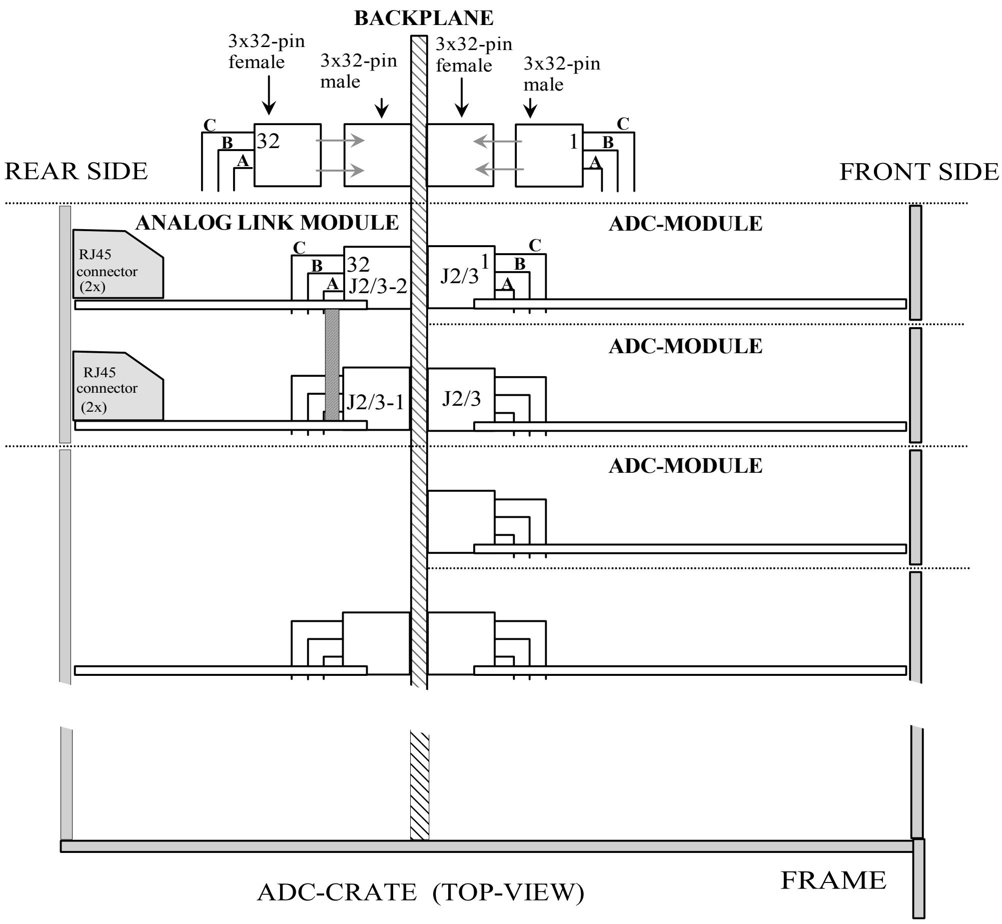


Fig. 7

Fig. 7 shows part of an ADC crate, seen from the top.
The frame of the crate extends beyond the back plane, so from the rear, standard 6U modules can be inserted. As shown in Fig. 6, the modules only occupy back plane connectors J2 and J3.
To keep the Analog Receiver Modules on the backside in line with the ADC modules on the front side, a special module layout was needed.
Facing the front panel of the rear module the components have to be mounted on the left-hand side of the board. A standard construction would sacrifice one slot.

Also the connectors J2 and J3 have to be mounted upside down, to connect to the pins from the front side connectors, sticking through the back plane.
Note that pin 1 becomes pin 32 and vice versa, but the rows A, B and C stay in place.
The module has a double width front panel, housing 2 boards with two RJ45 connectors each.
A single width module is too narrow to accommodate two RJ45 connectors; a double width can accommodate 4 connectors in two rows, without loosing the structural strength of the front panel.

Fig.8 gives an overview of the cable connections between the patch boxes and the ADC crates in the Veto Wall Area. Only shown are the Analog Signal connections.
206 channels are required: 150 for the ladders and 56 for the wheels.
The wheels and ladders signals are divided over the patch boxes A,B,C and D as indicated in the drawing.
Each ADC crate can house 5 Analog Link modules. Chosen is to group the ladders signals from patch box A and B into CRATE 1; those from patch box C and D in CRATE 2.
The wheel signals from patch box A,B,C and D, are grouped in CRATE 3.

A list of the cable mapping between the patch boxes and the ADC crates is given in appendix 3 on the pages 59 and 60.

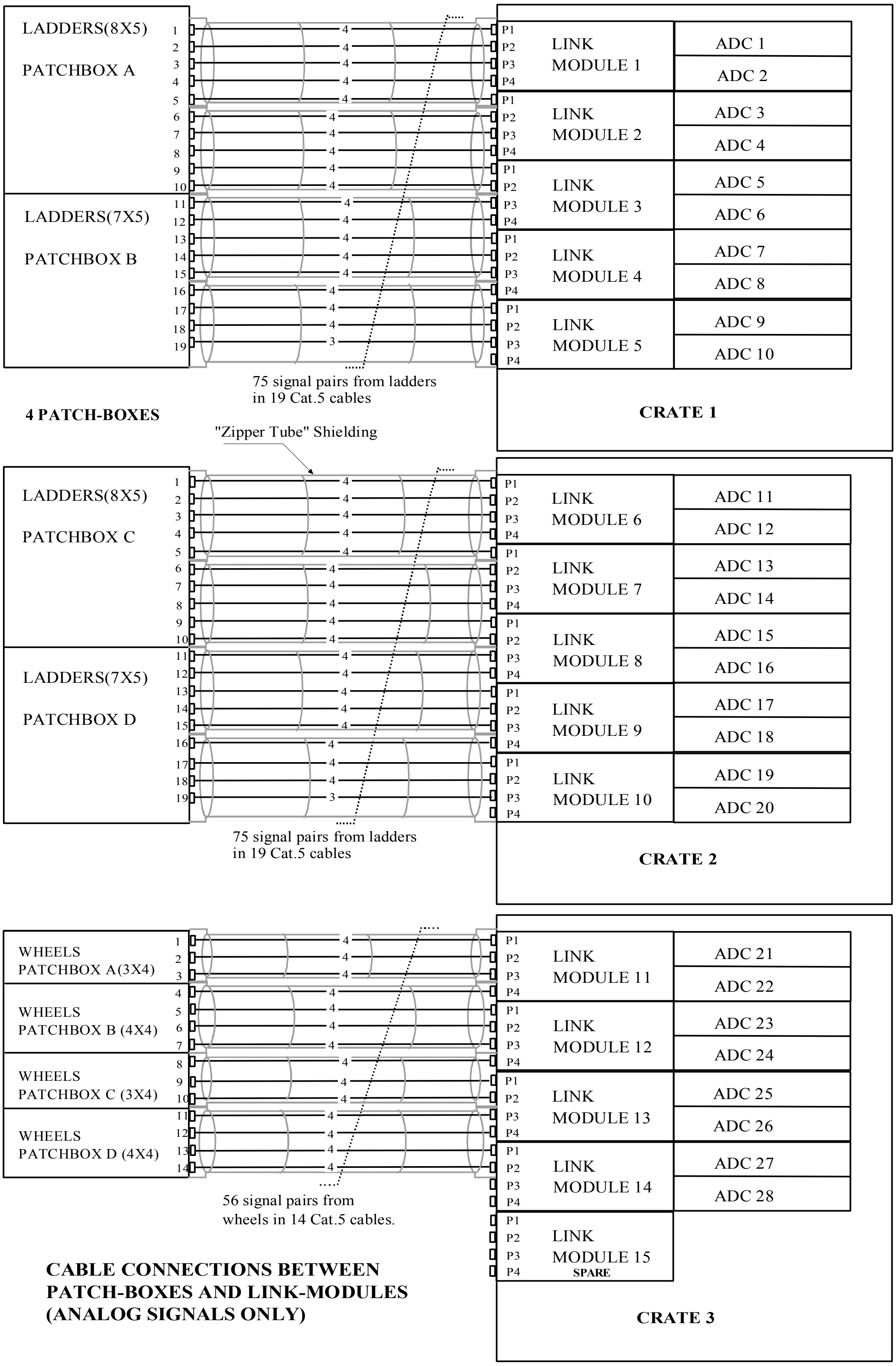
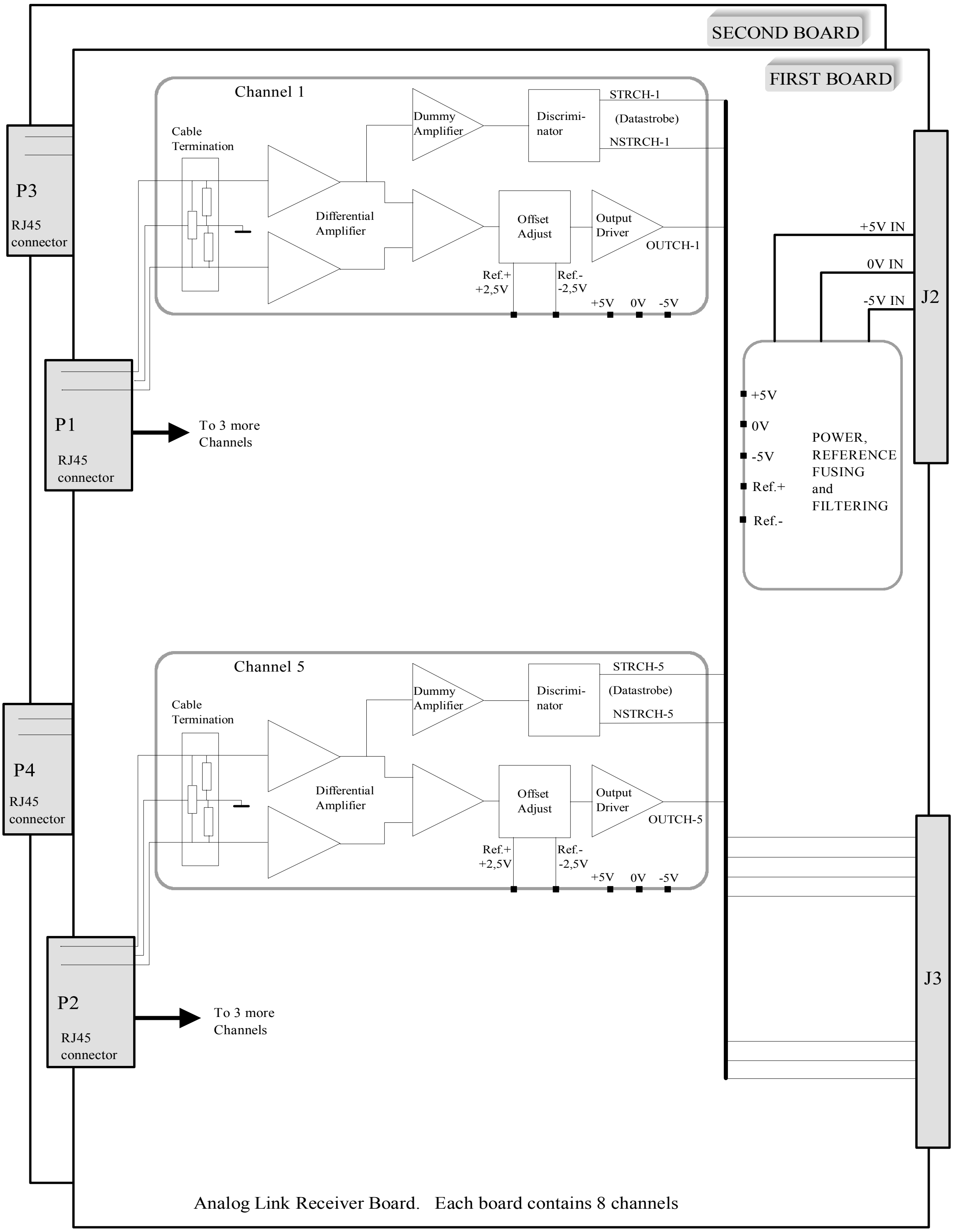

LADDERS(8X5)
PATCHBOX A
LADDERS(7X5)
PATCHBOX B
75 signal pairs from ladders in 19 Cat.5 cables
4 PATCH-BOXES
"Zipper Tube" Shielding
LINK MODULE 1
LINK MODULE 2
LINK MODULE 3
LINK MODULE 4
LINK MODULE 5
ADC 1
ADC 2
ADC 3
ADC 4
ADC 5
ADC 6
ADC 7
ADC 8
ADC 9
ADC 10
CRATE 1
LADDERS(8X5)
PATCHBOX C
LADDERS(7X5)
PATCHBOX D
75 signal pairs from ladders in 19 Cat.5 cables
LINK MODULE 6
LINK MODULE 7
LINK MODULE 8
LINK MODULE 9
LINK MODULE 10
ADC 11
ADC 12
ADC 13
ADC 14
ADC 15
ADC 16
ADC 17
ADC 18
ADC 19
ADC 20
CRATE 2
WHEELS PATCHBOX A(3X4)
WHEELS PATCHBOX B (4X4)
WHEELS PATCHBOX C (3X4)
WHEELS PATCHBOX D (4X4)
56 signal pairs from wheels in 14 Cat.5 cables.
LINK MODULE 11
LINK MODULE 12
LINK MODULE 13
LINK MODULE 14
LINK MODULE 15
SPARE
ADC 21
ADC 22
ADC 23
ADC 24
ADC 25
ADC 26
ADC 27
ADC 28
CRATE 3
CABLE CONNECTIONS BETWEEN PATCH-BOXES AND LINK-MODULES (ANALOG SIGNALS ONLY)

Fig.8

THE ANALOG LINK MODULE'S ELECTRICAL DESIGN



Schematic Block Diagram

Fig.9

As mentioned before, the Analog Link Module consists of 2 boards, each accommodating 8 channels. Fig.9 shows the schematic block diagram.
Both boards are identical. On the front the layout allows the mounting of each input connector in 2 positions. On the first board P1 and P2 are mounted in the lower positions; on the second board P3 and P4 occupy the upper positions.
Each RJ45 connector is input for a Cat.5 cable with 4 shielded pairs. The common shield, which in this case serves as a common signal return, is connected to the shield of the connector and from there to the signal ground at the input of the amplifier.
Note that the Analog Link Module is mounted in a standard VME crate, where electronics ground, power ground and shields are coming together, and basically are all connected to the metal frame of the crate. Here, special care must be taken to ensure the proper signal and ground routing.

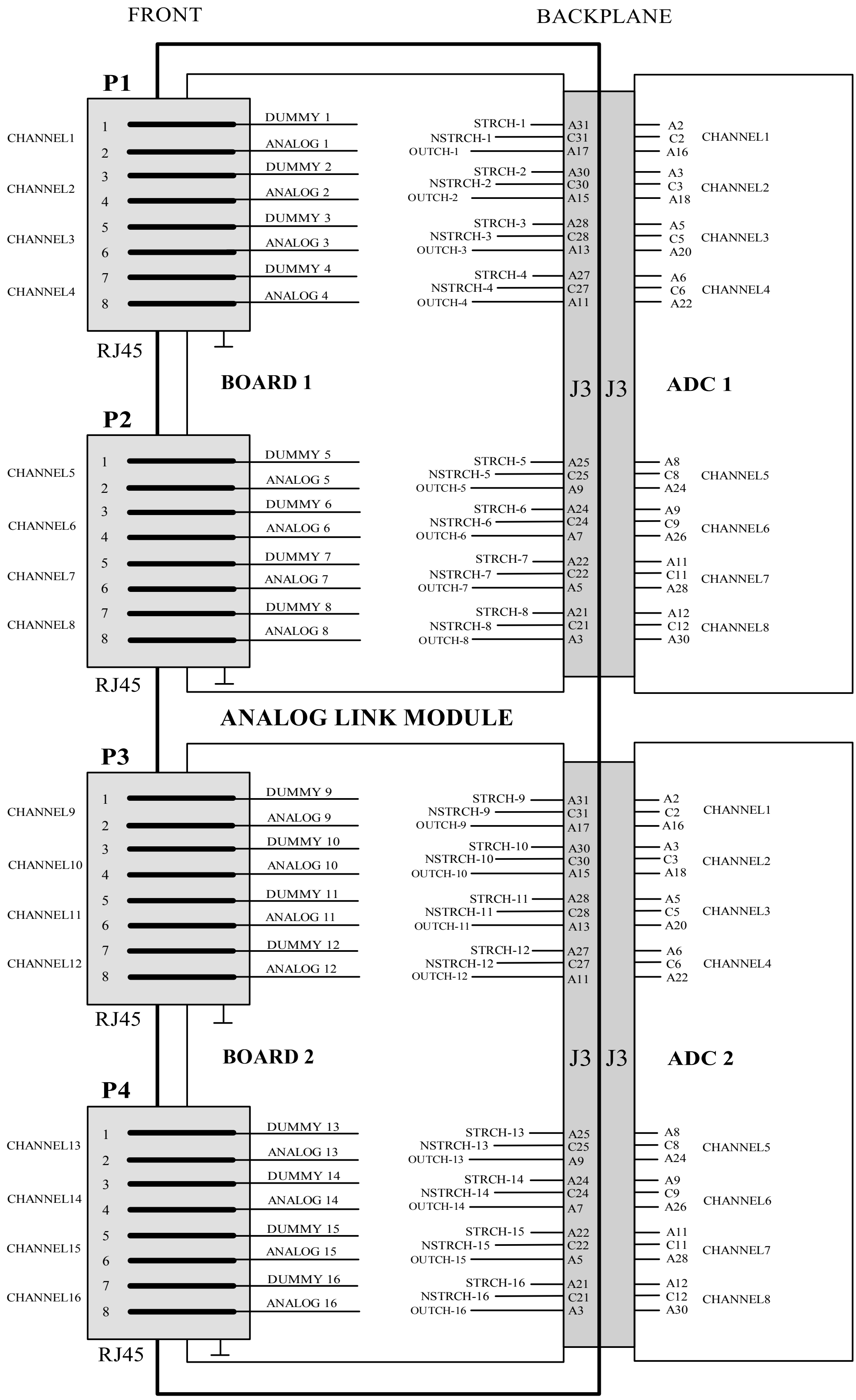
The input of each channel on the board is terminated. The upper input of the differential amplifier receives the Dummy signal, the lower one the Analog signal. The two are subtracted in the amplifier, and the result is sent to the output driver, after an eventual offset correction has taken place. Offset adjustment may be necessary to adjust the baseline of the analog signal, to fit into the ADC's input range of 0-2V. The output driver is able to drive the ADC's 50 ohms input between 0Vand +2V.

The Dummy signal is taken from the first amplifier stage, passes a second amplification stage and is input to the discriminator. The discrimination level is set approximately to half the value of the average Dummy signal, to eliminate noise.
The result is Datastrobe and Ndatastrobe, two complementary signals used in the ADC module to start a measurement.

Each board takes +5V and –5V from the corresponding J2 connector.
The power block provides short circuit protection, filtering and the two reference voltages Ref.+ and Ref.- are created here.

The Analog- and the Datastrobe signals all leave the board through J3.

The drawing Fig. 10 on the next page is an overview of the signals entering and leaving the Analog Link Module and their channel- and pin numbers.
Note that no power or ground connections are indicated. By nature of the VME system there is only one ground. The distinction between Analog- and Digital ground only has significance in the routing of the ground plane.



SIGNAL ROUTING between the INPUT of the ANALOG LINK MODULE and the ADC's.
(signals only, ground and power not indicated)

Fig.10

DETAILED DESCRIPTION OF THE ANALOG LINK ELECTRONICS.

The board design was done on an Ultiboard CAD system, so the schematic diagrams were generated on this system, and added as appendix 1 at the end of this documentation.

As Fig. 9 shows each Analog Link Module contains two Analog Link Boards. It also shows that the P1, P2 and P3, P4 input connector positions are staggered to optimally use the front panel space. To avoid the need of designing two different boards, each board has mounting locations for each of the 4 connectors. The position of the board in the module defines which mounting positions for the two input connectors are chosen. This means that the pins of the mounting positions for P1, P3 and P2, P4 respectively are connected together.
The above is explained to avoid confusion when looking at the Schematic Block Diagram of fig.20, where P1, P3 and P2, P4 respectively are in parallel.
Each board accommodates 8 channels. The input signals for each channel are: DUMMY, ANALOG and 0V. The "0V" connection on the RJ45 front connector is the signal return for both the signals DUMMY and ANALOG : i.e. the "shield" of the STP cable transporting DUMMY and ANALOG is not used as a shield, but as a signal return. For that reason this cable should not be seen as a shielded cable!
The complementary output signals STRCH-1-8 and NSTRCH-1-8 leave the board through J3, as do the single ended analog signals OUTCH-1-8.
Power is entering the board through J2 and J3.
The 5A fuses on the board (fig.21, the Power Diagram) are meant to prevent a board from burning out in case of a power short, but not to protect the individual components.
The LED's D1 and D2 indicate the presence of the +5V and the –5V. Two reference voltages of +2,5V and –2,5V are created. The maximum load on either reference is 20mA.

There are 8 basically identical channels on each board, and each channel needs its own schematic diagram, as the experiment may require modifications per channel. This way each component on the board has a unique number.

The power supplied to each channel (Channel 1 Diagram fig.22) is filtered to feed the first two amplifier I.C.'s. This avoids coupling through the power supply between the channels, and between the input- and output stages of each channel.
To achieve the required precision in handling the input signals DUMMY and ANALOG, it is very important to correctly terminate the STP cable. The position of R104 allows a precise termination of the impedance between the pair. The positions R101 or R102 allow for compensation of a difference in copper resistance between the two wires in the STP .
Depending on the asymmetry of the cable there may be a difference in propagation and rise time of the signals DUMMY and ANALOG. Compensation is possible by placing a capacitor in position C101 or C102.
U1.1A, U1.1B and U2.1B together with the surrounding resistors form a differential amplifier with a gain of 8x. Here DUMMY and ANALOG are subtracted and the data signal remains. For precision and stability all gain defining resistors are 0,1% 25ppm.

The DUMMY signal on the output of U1.1A is amplified 4 times in U2.1.A Some bandwidth limitation occurs through R114 and the input capacitance of U2.1.A. If more bandwidth limitation is required, C105 can be given a value, and R116 can be adjusted.
U4.1.A is a fast discriminator. The amplified DUMMY signal is formed into a differential Data strobe signal to strobe the analog output signal OUTCH-1 into the ADC. The discrimination level on U4.1.A is 300mV. To avoid cross talk of the +/- 5V, 1nS output of the discriminator into the Analog output signal two 470 ohm resistors are placed directly on the outputs of the discriminator. The input of the ADC's Data strobe is a differential line receiver with an input termination of 50 Ω. This way the board is transporting signals of +/- 400mV only, and the rise time induced noise is limited.
U3.1.A provides a gain of 2 times. In the feedback loop, two poles are added, to compensate for the roll off of the cables between the micro vertex detector and the Link Module. As the two poles have to be adjusted precisely, two resistor positions for each pole are provided.
Furthermore the output-offset voltage is adjusted at this amplifier stage.
The HELIX settings require an output offset on OUTCH-1-8 of +600mV. As output offset is a result of all active components in the channel, each channel needs individual adjustment. This is achieved by feeding a current into the inverting input of U3.1.A. Placing resistors from the REF+ in the positions R129 and JP101 sets this current.
A list of resistor values per channel is added in this documentation.
The same HELIX settings require gain adjustment, to create the correct signal range for the HELIX output. Board locations planned for gain adjustment are R131 and R132. In the current state, R131 has a value of 910 Ω, and R132 is not used. For that reason the jumper JP102 is shorted.
All channels do have the same output offset and the same overall gain.
<u>Note that changing the gain will also affect the offset voltage at the output.</u>

INSTALLING AND CONNECTING A MODULE

The Data Acquisition Racks in the Veto wall Area, contain 3 ADC crates with 21 module positions. ADC's can be placed in the slot positions 6 through 15. (fig.14)
5 double width Analog Link Modules can be housed in the rear of the crate, connected to the front side ADC's through the back plane connectors J2 and J3. Each of the 2 boards in one Link module, serves one ADC. (see also fig. 8)
The crate's Power Supply takes up the space behind the J1-row of connectors.
Cooling of the Link Modules and the Power Supply is provided by a fan tray and a Cooling Unit.
The steel L-profile supporting the crate, extends for 17 cm behind the crate.
On the horizontal legs of the profiles, and between the vertical legs, the Analog Cable Mounting Plate is placed (fig. 11).
In each of the 4 holes one Cable Clamp is mounted (fig.12).

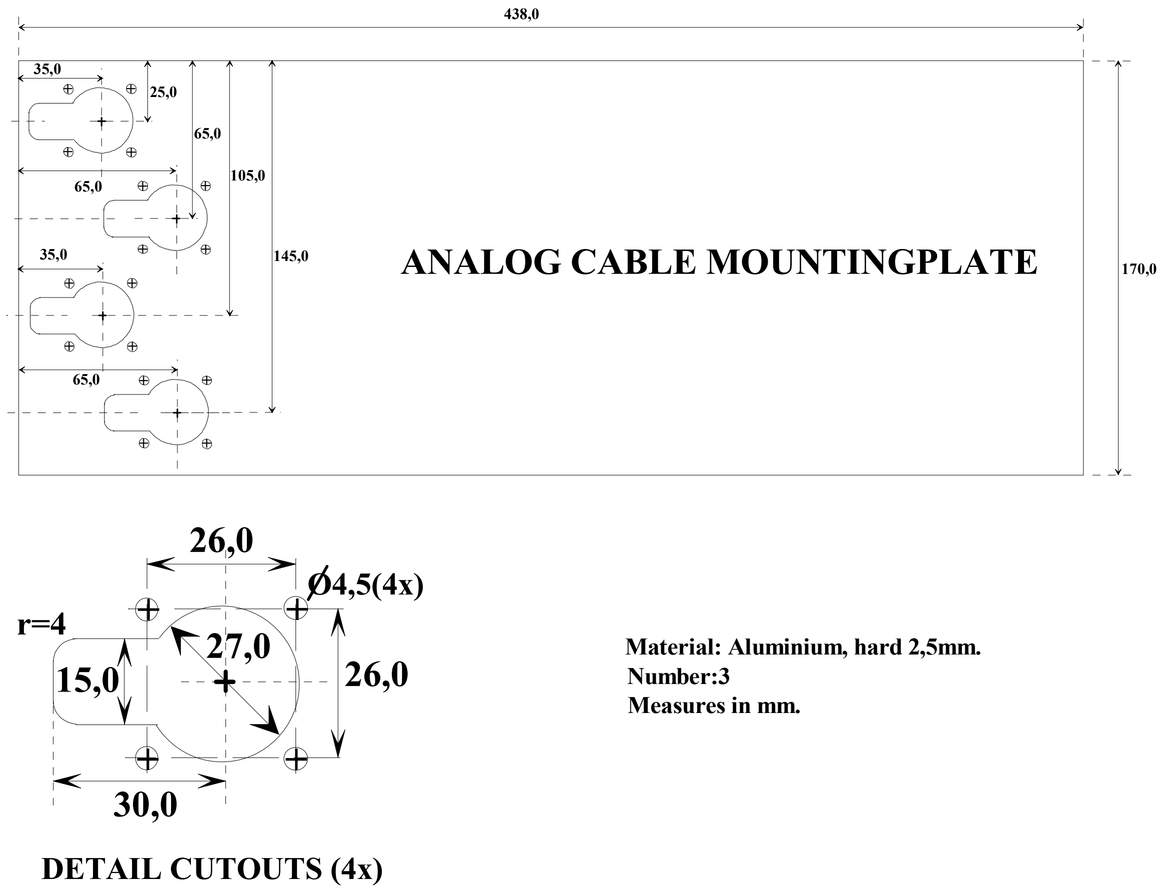

438,0
35,0
25,0
65,0
105,0
65,0
145,0
35,0
65,0
ANALOG CABLE MOUNTINGPLATE
170,0
26,0
Ø4,5(4x)
r=4
27,0
15,0
26,0
30,0
DETAIL CUTOUTS (4x)
Material: Aluminium, hard 2,5mm.
Number:3
Measures in mm.

Fig. 11

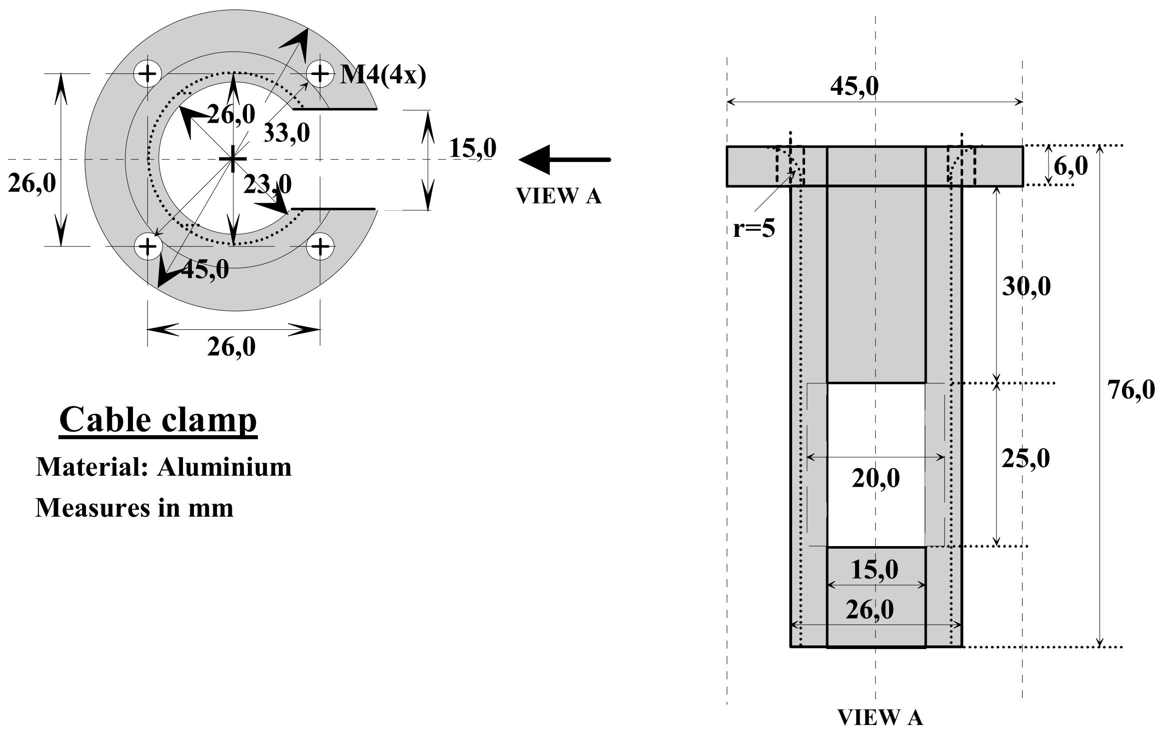

M4(4x)
26,0
33,0
15,0
26,0
23,0
VIEW A
45,0
26,0
Cable clamp
Material: Aluminium
Measures in mm
45,0
6,0
r=5
30,0
76,0
25,0
20,0
15,0
26,0
VIEW A

Fig.12

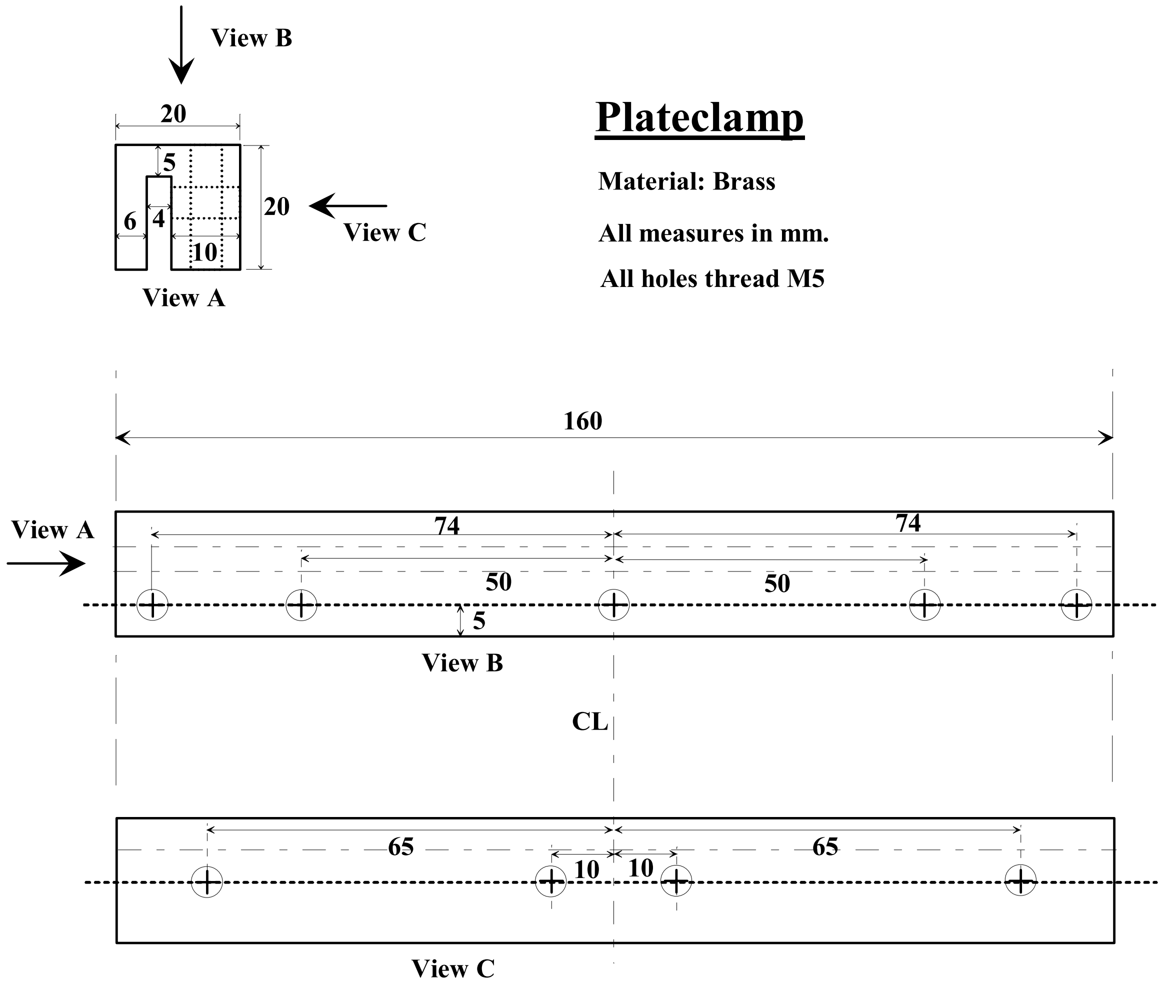


Fig.13

The mounting plate is secured with one Plate clamp (fig.13) on either side.

Each ADC crate houses a maximum of 5 Analog Link modules; a maximum of 20 input connectors are available. Each input connector receives the 4 signal pairs of 1 Cat.5 cable. The 20 or less cables are clamped in groups of 5 in either one of the 4 cable clamps.

To start the installation of the cable assembly, 4 cable clamps are inserted from the top into the mounting plate and secured from the bottom with 4 M4 bolts. Under 1 of the 4 bolts, a solder lug is fitted. Be sure to choose the bolt that is the most accessible after fitting the mounting plate. The lug should extend from under the bolt between the head of the bolt and the cylinder part of the cable clamp. The origin of the cable determines the routing of cables over the modules, and the number of cables in one zipper tube.

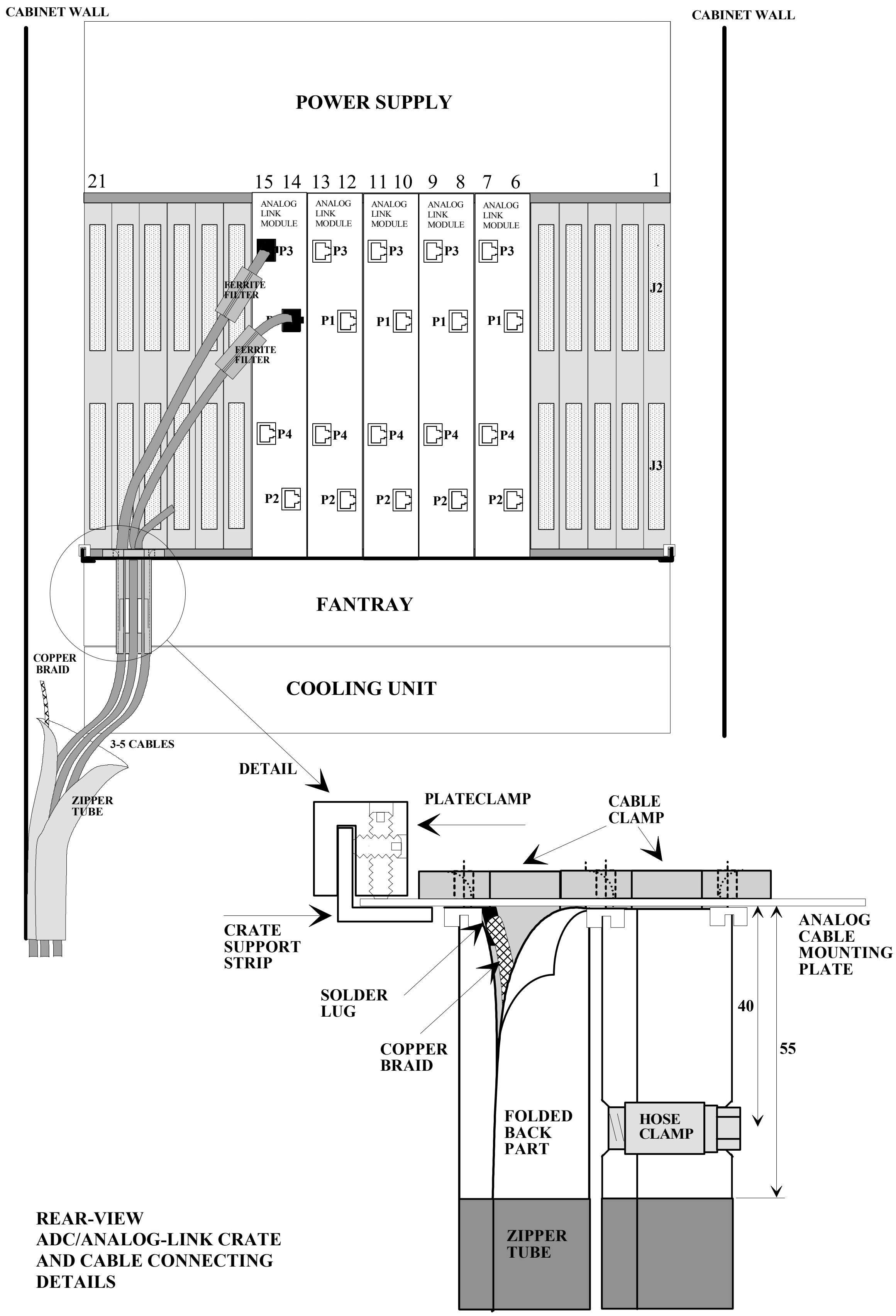

CABINET WALL
CABINET WALL
POWER SUPPLY
21
15 14 13 12 11 10 9 8 7 6
1
ANALOG LINK MODULE
ANALOG LINK MODULE
ANALOG LINK MODULE
ANALOG LINK MODULE
ANALOG LINK MODULE
P3
P3
P3
P3
P3
FERRITE FILTER
FERRITE FILTER
J2
P1
P1
P1
P1
P4
P4
P4
P4
P4
J3
P2
P2
P2
P2
P2
FANTRAY
COPPER BRAID
COOLING UNIT
3-5 CABLES
DETAIL
ZIPPER TUBE
PLATECLAMP
CABLE CLAMP
CRATE SUPPORT STRIP
ANALOG CABLE MOUNTING PLATE
SOLDER LUG
40
55
COPPER BRAID
FOLDED BACK PART
HOSE CLAMP
ZIPPER TUBE
REAR-VIEW ADC/ANALOG-LINK CRATE AND CABLE CONNECTING DETAILS

Fig.14

The cables enter the cabinets from the floor, packed in zipper tubes in numbers of 5,4 or 3, depending on their origin and function. One by one the cables from one zipper tube are fed through one of the cable clamp. The rectangular part of the hole in the mounting plate allows the passage of the RJ45 connector on the cables end.
Basically all cables do have the same length but due to cable routing, not all connectors end in the same plane. The connector that ends in the far most link module determines the length of the group of cables beyond the clamp. The excess length of the others has to be routed in the most relaxed and logical way. It is wise not to try to fit the connectors in the modules to temporarily secure the cables. The tension caused by the twist in the cable may destroy the connector.
Now the zipper tube can cut to length and be finished. Leave 55mm more length than necessary to reach the mounting plate and fold the 55mm back, so the aluminium shield is on the outside. The copper braid can be cut to length now and must be soldered to the lug under one of the 4 M4 bolts (see detail in fig. 14). After soldering the lug should lie directly against the body of the cable clamp, thus avoiding loops which may pick up noise.
Close the zipper tube, covering the solder lug, and install the hose clamp in the indicated position. Tighten the hose clamp loosely! Now twist each cable such, that the connector fits into the module without tension. The necessary twist to get the connector in the right position should be in the length of cable below the cable clamp. This is a somewhat elaborate job, as 5 cables have to be twisted and the cables tend to twist back a little. Now tighten the hose clamp, so the cables stay in position. Check the position of the connectors after some time.
The hose clamp will only secure when 5 cables pass the cable clamp. When 4 or 3 are passing, fill up the remaining space with 1 or 2 pieces of cable with a length of 10 cm. Fit a ferrite filter around each cable, close to the connector. The filter blocks common mode noise.
The mounting plate forms the end of the grounding and shielding system and should be in good electrical contact with the frame of the crate. The design of the mounting plate followed the installation of the crates in the cabinet and it was undesirable to drill holes in the support strips. For that reason the plate is fitted with the plate clamp as shown in fig. 13. After the plate is in position on the support strip, first tighten the horizontal bolts to secure the clamp onto the vertical leg of the support strip. Tighten firmly. Then secure the vertical bolts to clamp the mounting plate. The cutting of the bolts into the metal of strip and plate ensures a good electrical contact.

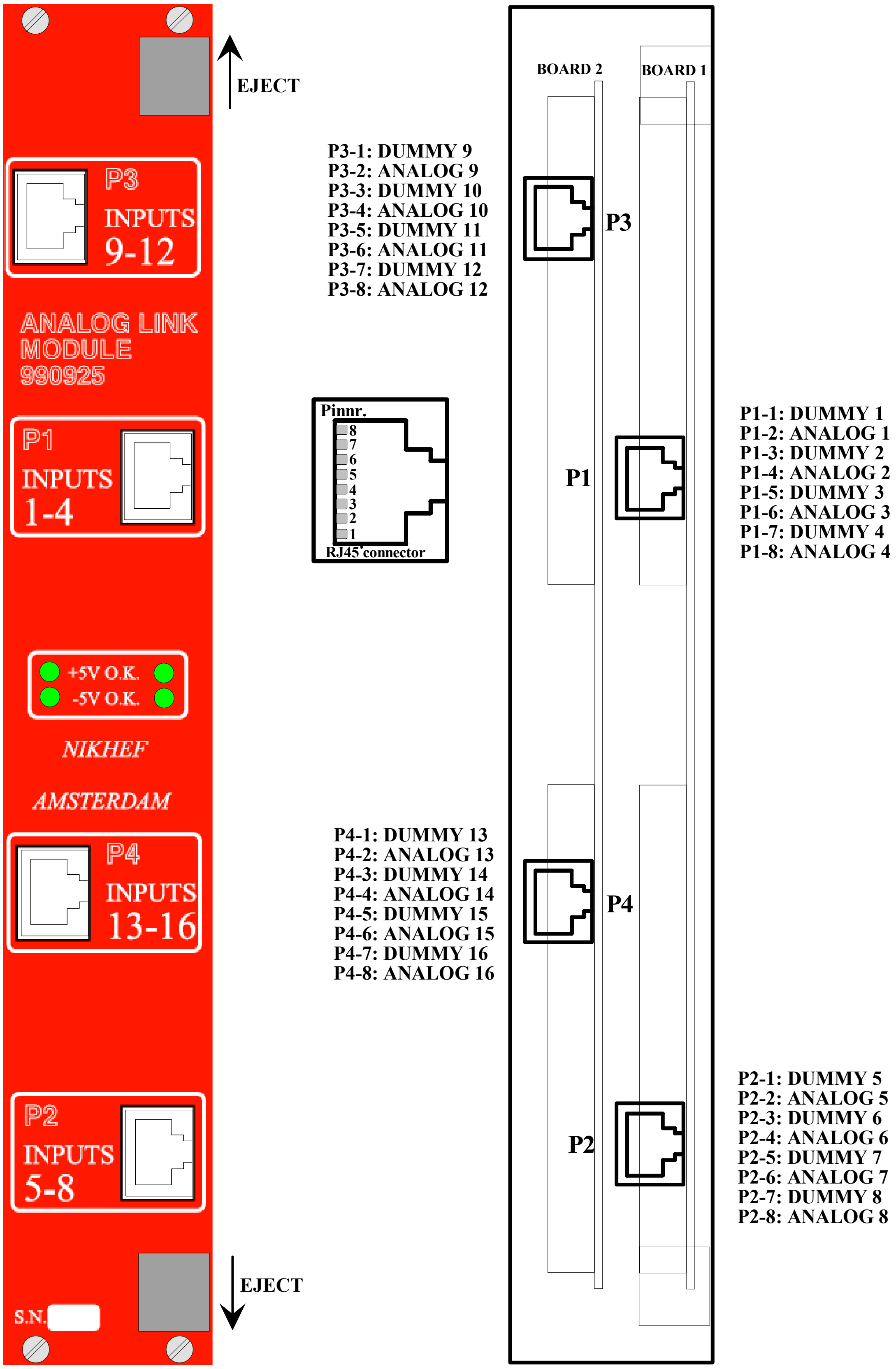

EJECT
P3
INPUTS
9-12
ANALOG LINK
MODULE
990925
P1
INPUTS
1-4
+5V O.K.
-5V O.K.
NIKHEF
AMSTERDAM
P4
INPUTS
13-16
P2
INPUTS
5-8
S.N.
EJECT
P3-1: DUMMY 9
P3-2: ANALOG 9
P3-3: DUMMY 10
P3-4: ANALOG 10
P3-5: DUMMY 11
P3-6: ANALOG 11
P3-7: DUMMY 12
P3-8: ANALOG 12
Pinnr.
8
7
6
5
4
3
2
1
RJ45 connector
P4-1: DUMMY 13
P4-2: ANALOG 13
P4-3: DUMMY 14
P4-4: ANALOG 14
P4-5: DUMMY 15
P4-6: ANALOG 15
P4-7: DUMMY 16
P4-8: ANALOG 16
BOARD 2
BOARD 1
P3
P1
P4
P2
P1-1: DUMMY 1
P1-2: ANALOG 1
P1-3: DUMMY 2
P1-4: ANALOG 2
P1-5: DUMMY 3
P1-6: ANALOG 3
P1-7: DUMMY 4
P1-8: ANALOG 4
P2-1: DUMMY 5
P2-2: ANALOG 5
P2-3: DUMMY 6
P2-4: ANALOG 6
P2-5: DUMMY 7
P2-6: ANALOG 7
P2-7: DUMMY 8
P2-8: ANALOG 8

Fig.15

TESTING AND TROUBLESHOOTING.

The Analog Link Module (fig.15) contains 16 channels divided in two boards. Each board uses 2 RJ45 connectors as inputs. The front cut-outs necessary for this type of connector would weaken the front too much.
For that reason a double width module with 2 boards and 4 shifted connectors was chosen. To keep the layout the same, footprints for all 4 connectors are provided on all boards. Electrically the pins of P1, P3 and P2, P4 respectively are connected together.
On board 1 the P1 and P2 positions are used and on board 2 the positions for P3 and P4.
The division of the 16 inputs and the pinning is given in Fig. 15 (see also the schematic block diagram fig.9). With all board layouts being the same, their schematic diagrams only show input numbers 1 through 8.

Checking the power

Each board occupies the J2 and J3 connector of 1 slot. Power taken from J2 is +5V and –5V. In the centre of the front two LED's "+5V O.K." and "-5V O.K." indicate the presence of power on each board. When all of the modules are missing one or both voltages, the crate's power supply may be defective or off. Power is taken from the crate from many pins, so when 1 LED is off, it is very likely that the fuse has blown. Both supply voltages are protected with a 5A fuse which does not serve as a protection for components, but is there to prevent further damage to the board in case of a short or a component failure. When replacement of the fuse does not solve the problem, the module should be given for repair.

Checking the output signals

With the power switched on and the input disconnected, the analog output voltage on the "Outch*" should be +600mV, and the data strobe signal "STRCH*" should be low.
When no data is being taken from the MVD, this situation should not change when connecting the input cable. The +600mV offset is created from the central reference voltage REF+. When all of the outputs show a faulty output voltage, the REF+ may be missing. To check this voltage or to perform other measurements on the board it is necessary to place the module on an extender or use a separate power supply.
Note that to be able to measure on both sides of a board, the other board of the module has to be removed. When placed on an extender, natural cooling will be sufficient.

There are various reasons for an incorrect signal magnitude on the analog output, or the incorrect behaviour of data strobe that have to do with incorrect settings of the Helix chip, or a malfunction of this chip:

The <u>Idrv</u> setting of the Helix chip controls the signal magnitude of its Analog and Dummy output currents. This leads to a lower output voltage per Mip and when the magnitude of Dummy becomes too low, the disappearance of data strobe.

<u>Voffset</u> controls the offset of both Analog and Dummy. As the two signals are subtracted in the second amplifier of the circuit, signal clipping does not easily occur. When the offset is too high, data strobe may become permanently high.

<u>Vd</u> and <u>Vdcl</u> control the zero level of the Analog output. The zero level should be –3,2mA for 0 Mip and should be the same as the Dummy level. Incorrect settings may result in a positive or negative offset voltage on Outch* and eventual clipping of the signal.

Connecting the cable to a different input will clarify whether the failure is in the module or in the Helix chip.

In the same way a failure in a cable can be determined. Should it be necessary to change a connector, then the procedure follows below.

Although the supplier of the Cat.5 cable repeatedly had assured us that he would provide us cables with RJ45 connectors, when it came to production, it proved impossible to him to combine the cable and the connector. The reason is that the RJ45 connector uses a pitch of 1mm, while the wire insulation of the Cat. 5 <u>STP</u> cable has a diameter of 1,2mm.
A suitable combination of other brands of connector and cable has not been found. For that reason we had to use the somewhat complicated and elaborate method described in appendix 2: <u>Production procedure for the Zeus MVD Cat.5 cables</u>.

SPECIFICATIONS ANALOG LINK MODULE

Mechanical

Mirrored VME module: i.e. to be used on the rear of a 9HU VME-crate.
Height: 6HU
Board depth: 160mm
Front width: 2U (40,34mm)
Number of ANALOG LINK BOARDS per module: 2

Connectors per board:
Front connectors:
Two shielded RJ45 connectors.
Rear connectors: J2 and J3, connecting to J2 and J3 of a 9HU VME-crate.
Board dimensions: 233x160x1,6mm

Electrical

Number of channels per board: 8

Operating temperature range: 0-70 °C

Transfer impedance Dummy input to output: - 937,2Ω
Transfer impedance Analog input to output: + 937,2Ω
Uoutput = (Ianalog – I dummy).937,2Ω + Uoffset.
Stability: +/-25 ppm/ °C

Analog output (OUTCH1-8)

Uoffset = 600mV +/- 2% (@25 °C)
Offset stability:‹ 0,4 mV/ °C (0-70 °C)
Bandwidth: DC-30MHz
Rise time < 10nS
Fall time <10nS
Settling time to 0,1%: <50nS
Noise: <3,5mV RMS (DC-30MHz)
Delay Analog output to Datastrobe: 0-3nS
Advised sampling timing: 70nS after rising edge Datastrobe

Datastrobe outputs (STRCH1-8 and NSTRCH1-8)

Differential output
Output impedance: 470Ω
Output voltage into 50Ω DSTRCH*: 0-300mV
Output voltage into 50Ω NDSTRCH*: 300mV-0
The terminating resistors are located in the ADC module.
Rise and fall time DSTRCH* and NDSTRCH*: <3nS

Power requirements per board

+5V: 0,43A
-5V: 0,24A

BILL OF MATERIALS (each board)

CAPACITOR 100nF, X7R, Philips, KPV U1, 50V, 1206

C103, C203, C303, C403, C503, C603, C703, C803
C106, C206, C306, C406, C506, C606, C706, C806
C107, C207, C307, C407, C507, C607, C707, C807
C109, C209, C309, C409, C509, C609, C709, C809
C110, C210, C310, C410, C510, C610, C710, C810
C111, C211, C311, C411, C511, C611, C711, C811
C112, C212, C312, C412, C512, C612, C712, C812
C113, C213, C313, C413, C513, C613, C713, C813
C114, C214, C314, C414, C514, C614, C714, C814
C115, C210, C310, C410, C510, C610, C710, C810
C121, C221, C321, C421, C521, C621, C721, C821
C122, C222, C322, C422, C522, C622, C722, C822
C123, C223, C323, C423, C523, C623, C723, C823
C124, C224, C324, C424, C524, C624, C724, C824
C125, C225, C325, C425, C525, C625, C725, C825
C126, C226, C326, C426, C526, C626, C726, C826

CAPACITOR, ceramic, 0pF, np0, 50V, 1206

C101, C201, C301, C401, C501, C601, C701, C801
C102, C202, C302, C402, C502, C602, C702, C802
C105, C205, C305, C405, C505, C605, C705, C805

CAPACITOR, ceramic, 47pF, Philips KPH series, np0, 50V, 1206

C108, C208, C308, C408, C508, C608, C708, C808

CAPACITOR, ceramic, 330pF, Philips KPH series, np0, 50V, 1206

C120, C220, C320, C420, C520, C620, C720, C820

CAPACITOR, electrolytic, Philips KPS 10UV16, 10uF/16V, SMD

C116, C216, C316, C416, C516, C616, C716, C816
C117, C217, C317, C417, C517, C617, C717, C817
C118, C218, C318, C418, C518, C618, C718, C818
C119, C219, C319, C419, C519, C619, C719, C819

CAPACITOR, solid aluminium, 10uF/16V, radial

C3, C4

CAPACITOR, electrolytic, Philips KPS 47UV25, 47uF/25V, SMD

C1, C2

OPERATIONAL AMPLIFIER, AD8056KR, SO8

U1.1, U1.2, U1.3, U1.4, U1.5, U1.6, U1.7, U1.8
U3.1, U3.2, U3.3, U3.4, U3.5, U3.6, U3.7, U3.8

OPERATIONAL AMPLIFIER, CLC5602IM, SO8

U2.1, U2.2, U2.3, U2.4, U2.5, U2.6, U2.7, U2.8

COMPARATOR, AD9698KR, SO16

U4.1, U4.3, U4.5, U4.6

LED 3mm, horizontal, green, O*226-316

D1, D2

VOLTAGE REF. DEVICE, TL431CLP, 2,5V, TO92

IC5, IC6

FUSE, 5AT, Wickmann 581-422

F1, F2

FUSEHOLDER, Wickmann TR5 fuseholder 581-446

For F1,F2

RESISTOR, 180Ω, 0,1%, MPC01, 25ppm, 1206

R103, R203, R303, R403, R503, R603, R703, R803
R122, R222, R322, R422, R522, R622, R722, R822
R125, R225, R325, R425, R525, R625, R725, R825
R126, R226, R326, R426, R526, R626, R726, R826
R127, R227, R327, R427, R527, R627, R727, R827

RESISTOR, 360Ω, 0,1%, MPC01, 25ppm, 1206

R107, R207, R307, R407, R507, R607, R707, R807
R108, R208, R308, R408, R508, R608, R708, R808
R109, R209, R309, R409, R509, R609, R709, R809
R112, R212, R312, R412, R512, R612, R712, R812
R113, R213, R313, R413, R513, R613, R713, R813
R117, R217, R317, R417, R517, R617, R717, R817
R128, R228, R328, R428, R528, R628, R728, R828

RESISTOR, 120Ω, 0,1%, MPC01, 25ppm, 1206

R110, R210, R310, R410, R510, R610, R710, R810
R111, R211, R311, R411, R511, R611, R711, R811

RESISTOR, 110Ω, 0,1%, MPC01, 25ppm, 1206

R105, R205, R305, R405, R505, R605, R705, R805
R106, R206, R306, R406, R506, R606, R706, R806

RESISTOR, 910Ω, 0,1%, MPC01, 25ppm, 1206

R131, R231, R331, R431, R531, R631, R731, R831

RESISTOR, 0Ω, 1206

R101, R201, R301, R401, R501, R601, R701, R801
R102, R202, R302, R402, R502, R602, R702, R802
R104, R204, R304, R404, R504, R604, R704, R804
R134, R234, R334, R434, R534, R634, R734, R834

RESISTOR, 91Ω, 5%, 100ppm, 1206

R115, R215, R315, R415, R515, R615, R715, R815

RESISTOR, 470Ω, 5%, 100ppm, 1206

R114, R214, R314, R414, R514, R614, R714, R814
R120, R220, R320, R420, R520, R620, R720, R820
R121, R221, R321, R421, R521, R621, R721, R821

<u>RESISTOR, 22Ω, 5%, 100ppm, 1206</u>

R116, R216, R316, R416, R516, R616, R716, R816

<u>RESISTOR, 330Ω, 5%, 100ppm, 1206</u>

R118, R218, R318, R418, R518, R618, R718, R818

<u>RESISTOR, 4K7, 5%, 100ppm, 1206</u>

R119, R219, R319, R419, R519, R619, R719, R819

<u>RESISTOR, 1K2, 5%, 100ppm, 1206</u>

R133, R233, R333, R433, R533, R633, R733, R833

<u>RESISTOR, 680Ω, 5%, 100ppm, 1206</u>

R123, R223, R323, R423, R523, R623, R723, R823

<u>RESISTOR, 15Ω, 5%, 100ppm, 1206</u>

R124, R224, R324, R424, R524, R624, R724, R824

<u>RESISTOR, RK1/3*100Ω</u>

R1,R3

<u>RESISTOR, RK1/3*470Ω</u>

R2,R4

<u>INDUCTOR, PHILIPS, 1uH, SMD</u>

L101, L201, L301, L401, L501, L601, L701, L801
L102, L202, L302, L402, L502, L602, L702, L802

<u>CONNECTOR, RJ45 shielded, MOLEX 473-236</u>

P1, P2, or P3,P4 depending on board

<u>CONNECTOR 3x32-pin Din 41612 female, J*269</u>

J2, J3

<u>JUMPERPOSITION, Dual Solder Pad, normally open.</u>

JP101, JP201, JP301, JP401, JP501, JP601, JP701, JP801
JP102, JP202, JP302, JP402, JP502, JP602, JP702, JP802

<u>BOARD</u>

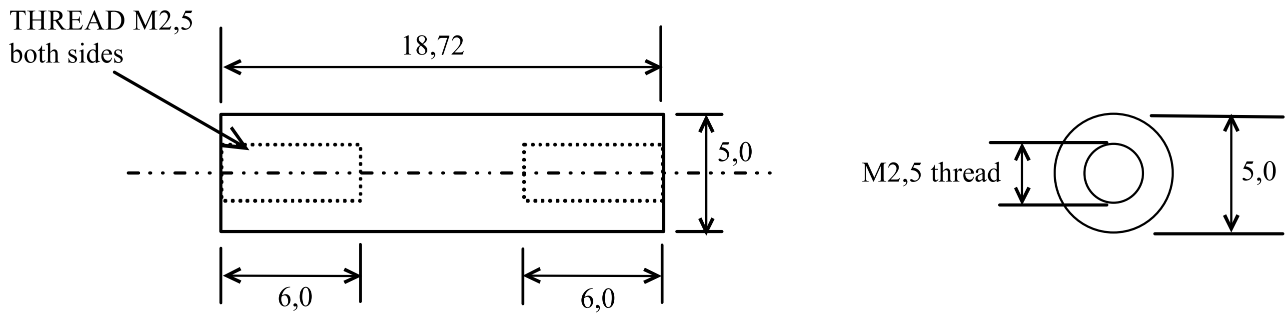
<u>"Analog Link Board 270100PdG"</u>

<u>FRONT PANEL</u>

"Analog Link Module 990925", including mounting materials.
1 Front panel serves 2 boards, together forming 1 module.

<u>STANDOFF POSTS</u>

2 Standoff posts are required for each module to localise the two boards to the correct pitch. See drawing below.



STANDOFF POST, ALUMINIUM, measures in mm.

OFFSET ADJUSTMENT RESISTOR VALUES

Resistor values to create +600mV +/- 2% output offset. The resistors are located in the positions R*29 and JP*01.
Resistor type: Metal film, MPC01 0,1% 25ppm

MODULE 1

	Board 1		Board 24	
Channel 1	R129= 3K9	JP101= 470	R129= 2K7	JP101= 470
Channel 2	R229= 3K3	JP201= 390	R229= 3K3	JP201= 220
Channel 3	R329= 3K3	JP301= 470	R329= 3K3	JP301= 220
Channel 4	R429= 2K7	JP401= 47	R429= 2K2	JP401= 1K
Channel 5	R529= 3K9	JP501= 220	R529= 2K7	JP501= 270
Channel 6	R629= 2K7	JP601= 270	R629= 2K2	JP601= 909
Channel 7	R729= 2K7	JP701= 220	R729= 3K9	JP701= 220
Channel 8	R829= 3K3	JP801= 82	R829= 4K7	JP801= 10

MODULE 2

	Board 2		Board 16	
Channel 1	R129= 2K7	JP101= 390	R129= 3K3	JP101= 68
Channel 2	R229= 2K7	JP201= 390	R229= 3K3	JP201= 100
Channel 3	R329= 2K7	JP301= 470	R329= 3K3	JP301= 560
Channel 4	R429= 2K7	JP401= 0	R429= 2K7	JP401= 330
Channel 5	R529= 2K7	JP501= 330	R529= 2K2	JP501= 820
Channel 6	R629= 3K3	JP601= 390	R629= 3K3	JP601= 330
Channel 7	R729= 2K2	JP701= 180	R729= 2K7	JP701= 560
Channel 8	R829= 3K3	JP801= 1K2	R829= 2K7	JP801= 560

MODULE 3

	Board 14		Board 17	
Channel 1	R129= 2K7	JP101= 560	R129= 2K2	JP101= 820
Channel 2	R229= 3K3	JP201= 100	R229= 3K3	JP201= 390
Channel 3	R329= 2K7	JP301= 220	R329= 2K7	JP301= 560
Channel 4	R429= 3K9	JP401= 33	R429= 2K7	JP401= 330
Channel 5	R529= 2K2	JP501= 220	R529= 2K2	JP501= 1K
Channel 6	R629= 3K9	JP601= 82	R629= 2K7	JP601= 82
Channel 7	R729= 2K2	JP701= 390	R729= 3K3	JP701= 470
Channel 8	R829= 3K3	JP801= 560	R829= 2K7	JP801= 68

MODULE 4

	Board 18		Board 5	
Channel 1	R129= 3K3	JP101= 220	R129= 3K3	JP101= 180
Channel 2	R229= 3K9	JP201= 270	R229= 2K7	JP201= 390
Channel 3	R329= 2K7	JP301= 390	R329= 3K9	JP301= 330
Channel 4	R429= 2K7	JP401= 560	R429= 2K7	JP401= 68
Channel 5	R529= 3K3	JP501= 0	R529= 2K7	JP501= 1K8
Channel 6	R629= 2K7	JP601= 180	R629= 2K7	JP601= 470
Channel 7	R729= 2K7	JP701= 82	R729= 2K7	JP701= 1K8
Channel 8	R829= 2K7	JP801= 120	R829= 3K3	JP801= 470

MODULE 5

	Board 15		Board 19	
Channel 1	R129= 2K7	JP101= 560	R129= 3K3	JP101= 180
Channel 2	R229= 2K7	JP201= 390	R229= 2K2	JP201= 1K5
Channel 3	R329= 3K3	JP301= 56	R329= 3K3	JP301= 180
Channel 4	R429= 2K7	JP401= 470	R429= 2K7	JP401= 180
Channel 5	R529= 3K3	JP501= 180	R529= 2K7	JP501= 1K
Channel 6	R629= 3K3	JP601= 560	R629= 3K3	JP601= 390
Channel 7	R729= 2K2	JP701= 680	R729= 2K7	JP701= 560
Channel 8	R829= 2K7	JP801= 560	R829= 2K7	JP801= 82

MODULE 6

	Board 6		Board 20	
Channel 1	R129= 3K3	JP101= 150	R129= 3K3	JP101= 27
Channel 2	R229= 2K7	JP201= 560	R229= 2K7	JP201= 270
Channel 3	R329= 3K3	JP301= 82	R329= 2K2	JP301= 390
Channel 4	R429= 2K7	JP401= 82	R429= 3K9	JP401= 22
Channel 5	R529= 3K3	JP501= 0	R529= 2K2	JP501= 470
Channel 6	R629= 3K3	JP601= 180	R629= 2K7	JP601= 220
Channel 7	R729= 2K7	JP701= 150	R729= 3K9	JP701= 180
Channel 8	R829= 2K7	JP801= 220	R829= 3K3	JP801= 120

MODULE 7

	Board 7		Board 21	
Channel 1	R129= 3K3	JP101= 560	R129= 2K7	JP101= 220
Channel 2	R229= 2K2	JP201= 1K5	R229= 3K9	JP201= 150
Channel 3	R329= 3K3	JP301= 33	R329= 3K9	JP301= 270
Channel 4	R429= 3K3	JP401= 82	R429= 3K3	JP401= 470
Channel 5	R529= 2K7	JP501= 470	R529= 3K3	JP501= 150
Channel 6	R629= 2K7	JP601= 390	R629= 3K9	JP601= 330
Channel 7	R729= 3K3	JP701= 22	R729= 3K3	JP701= 82
Channel 8	R829= 2K7	JP801= 150	R829= 2K7	JP801= 270

MODULE 8

	Board 8		Board 22	
Channel 1	R129= 5K6	JP101= 470	R129= 3K3	JP101= 22
Channel 2	R229= 2K7	JP201= 390	R229= 2K7	JP201= 82
Channel 3	R329= 2K7	JP301= 560	R329= 3K3	JP301= 2K2
Channel 4	R429= 2K2	JP401= 220	R429= 1K5	JP401= 1K5
Channel 5	R529= 2K2	JP501= 1K	R529= 2K7	JP501= 220
Channel 6	R629= 2K7	JP601= 470	R629= 2K7	JP601= 220
Channel 7	R729= 3K9	JP701= 120	R729= 2K7	JP701= 390
Channel 8	R829= 2K7	JP801= 10	R829= 2K7	JP801= 330

MODULE 9

	Board 9		Board 23	
Channel 1	R129= 4K7	JP101= 220	R129= 3K3	JP101= 180
Channel 2	R229= 2K7	JP201= 390	R229= 2K7	JP201= 22
Channel 3	R329= 3K3	JP301= 100	R329= 3K3	JP301= 180
Channel 4	R429= 2K7	JP401= 120	R429= 3K9	JP401= 330
Channel 5	R529= 2K7	JP501= 68	R529= 3K3	JP501= 220
Channel 6	R629= 2K7	JP601= 220	R629= 3K9	JP601= 22
Channel 7	R729= 3K3	JP701= 470	R729= 3K9	JP701= 22
Channel 8	R829= 2K7	JP801= 220	R829= 2K7	JP801= 470

MODULE 10

	Board 10		Board 25	
Channel 1	R129= 2K7	JP101= 820	R129= 2K2	JP101= 680
Channel 2	R229= 3K3	JP201= 470	R229= 2K7	JP201= 330
Channel 3	R329= 2K7	JP301= 470	R329= 3K3	JP301= 150
Channel 4	R429= 2K7	JP401= 10	R429= 2K2	JP401= 909
Channel 5	R529= 2K7	JP501= 220	R529= 3K3	JP501= 470
Channel 6	R629= 2K7	JP601= 330	R629= 2K2	JP601= 1K
Channel 7	R729= 3K3	JP701= 68	R729= 3K3	JP701= 18
Channel 8	R829= 2K7	JP801= 180	R829= 2K7	JP801= 270

MODULE 11

	Board 11		Board 26	
Channel 1	R129= 3K9	JP101= 0	R129= 4K7	JP101= 470
Channel 2	R229= 4K7	JP201= 120	R229= 2K7	JP201= 330
Channel 3	R329= 2K7	JP301= 220	R329= 3K9	JP301= 0
Channel 4	R429= 3K3	JP401= 180	R429= 2K7	JP401= 470
Channel 5	R529= 3K9	JP501= 100	R529= 1K8	JP501= 680
Channel 6	R629= 2K7	JP601= 270	R629= 2K7	JP601= 150
Channel 7	R729= 2K7	JP701= 150	R729= 3K3	JP701= 220
Channel 8	R829= 5K6	JP801= 0	R829= 2K7	JP801= 390

MODULE 12

	Board 12		Board 28	
Channel 1	R129= 2K7	JP101= 560	R129= 1K5	JP101= 1K2
Channel 2	R229= 2K7	JP201= 330	R229= 3K3	JP201= 270
Channel 3	R329= 3K9	JP301= 120	R329= 1K5	JP301= 1K5
Channel 4	R429= 3K3	JP401= 270	R429= 3K3	JP401= 0
Channel 5	R529= 3K3	JP501= 0	R529= 3K9	JP501= 68
Channel 6	R629= 2K7	JP601= 470	R629= 3K3	JP601= 150
Channel 7	R729= 3K9	JP701= 120	R729= 2K7	JP701= 820
Channel 8	R829= 3K3	JP801= 33	R829= 3K9	JP801= 270

MODULE 13

	Board 13		Board 29	
Channel 1	R129= 2K7	JP101= 150	R129= 3K3	JP101= 0
Channel 2	R229= 2K7	JP201= 270	R229= 2K7	JP201= 909
Channel 3	R329= 4K7	JP301= 220	R329= 2K7	JP301= 330
Channel 4	R429= 3K9	JP401= 150	R429= 3K3	JP401= 10
Channel 5	R529= 2K2	JP501= 1K	R529= 4K7	JP501= 0
Channel 6	R629= 2K2	JP601= 909	R629= 3K3	JP601= 150
Channel 7	R729= 2K2	JP701= 220	R729= 3K3	JP701= 82
Channel 8	R829= 3K3	JP801= 180	R829= 1K8	JP801= 820

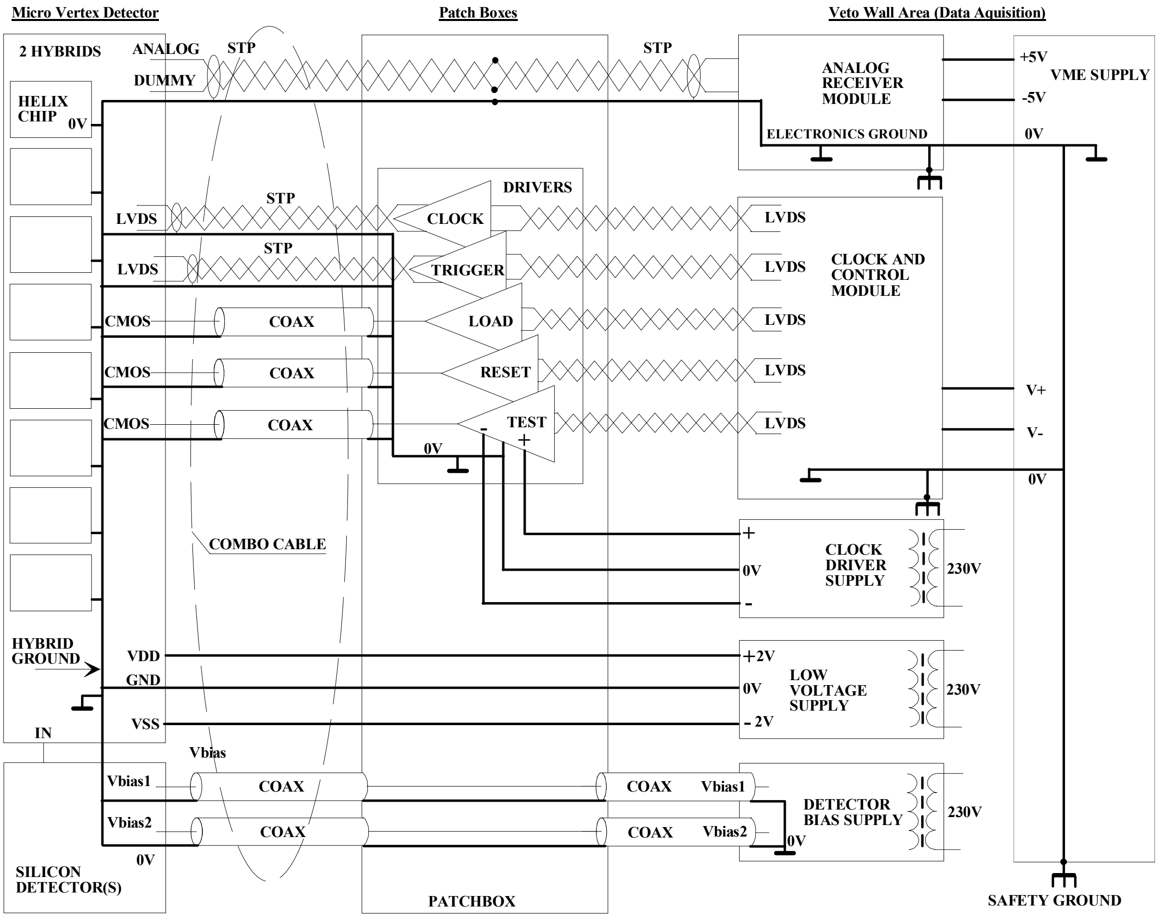
MODULE 14

	Board 3		Board 30	
Channel 1	R129= 2K7	JP101= 270	R129= 2K7	JP101= 100
Channel 2	R229= 1K8	JP201= 120	R229= 3K9	JP201= 150
Channel 3	R329= 1K8	JP301= 0	R329= 2K2	JP301= 820
Channel 4	R429= 1K8	JP401= 47	R429= 3K3	JP401= 47
Channel 5	R529= 1K8	JP501= 82	R529= 2K7	JP501= 270
Channel 6	R629= 1K8	JP601= 22	R629= 3K3	JP601= 390
Channel 7	R729= 1K8	JP701= 0	R729= 2K7	JP701= 47
Channel 8	R829= 1K8	JP801= 270	R829= 3K9	JP801= 330

MODULE 15

	Board 27		Board 4	
Channel 1	R129= 3K3	JP101= 270	R129= 2k2	JP101= 270
Channel 2	R229= 2K7	JP201= 470	R229= 2k7	JP201= 150
Channel 3	R329= 3K9	JP301= 120	R329= 3k3	JP301= 120
Channel 4	R429= 3K3	JP401= 82	R429= 2k7	JP401= 3k3
Channel 5	R529= 3K3	JP501= 0	R529= 2k7	JP501= 820
Channel 6	R629= 2K7	JP601= 120	R629= 3k9	JP601= 330
Channel 7	R729= 2K2	JP701= 820	R729= 2k7	JP701= 56
Channel 8	R829= 3K3	JP801= 0	R829= 3k3	JP801= 390

GROUNDING AND SHIELDING



MVD ELECTRONICS GROUNDING SCHEME

Fig. 16

The above diagram shows the ground connections for the MVD electronics. For details the documentation of the individual units must be consulted.
There are two “grounds” involved: electronics ground, usually referred to as 0V in an electronic circuit and safety ground. Usually all cabinets, cable supports, cooling- and water pipes etc. are connected to safety ground.
By nature of the VME system in the Veto Wall Area electronics ground is connected to safety ground in the crate. This goes for 0V of the back plane in the crate as well as for all modules which make use of the VME power supply.
To avoid ground loops, electronics ground should be connected to safety ground in one place only. This should be where the analog signals Analog and Dummy enter the Data Acquisition crates: i.e. in the Analog Receiver Modules.
On the other end, in the Micro Vertex Detector, electronics ground and the ground connections of signals to and from the hybrids, share the Hybrid Ground.

All power and signal wires used for 2 hybrids are packed together in one cable:
the Combo Cable, which for reasons of space limitations around the MVD is very thin. The Patch Boxes between the MVD and the Veto Wall Area provide space to change from the Combo Cable to cables with more copper.
The only active electronics in the Patch Boxes are the driver- and fanout circuits for the signals Clock, Trigger, Load, Reset and Test. All signal and power connections in the patch boxes are free from ground.
Hybrid Ground is where all signal- and power ground connections come together.
It is important to keep the return paths for power and signal separated. A power return current should not flow through the shield of a coax cable or a STP cable as this will cause an offset in the signal. Specially the STP cable for Dummy and Analog is very sensitive as it carries small analog signals and because the braiding is not a shield, but a signal return for Analog and Dummy. The same goes for the CMOS signals transported over coax cables. The STP braiding for the LVDS signals only serves as a shield and is not connected to power ground.

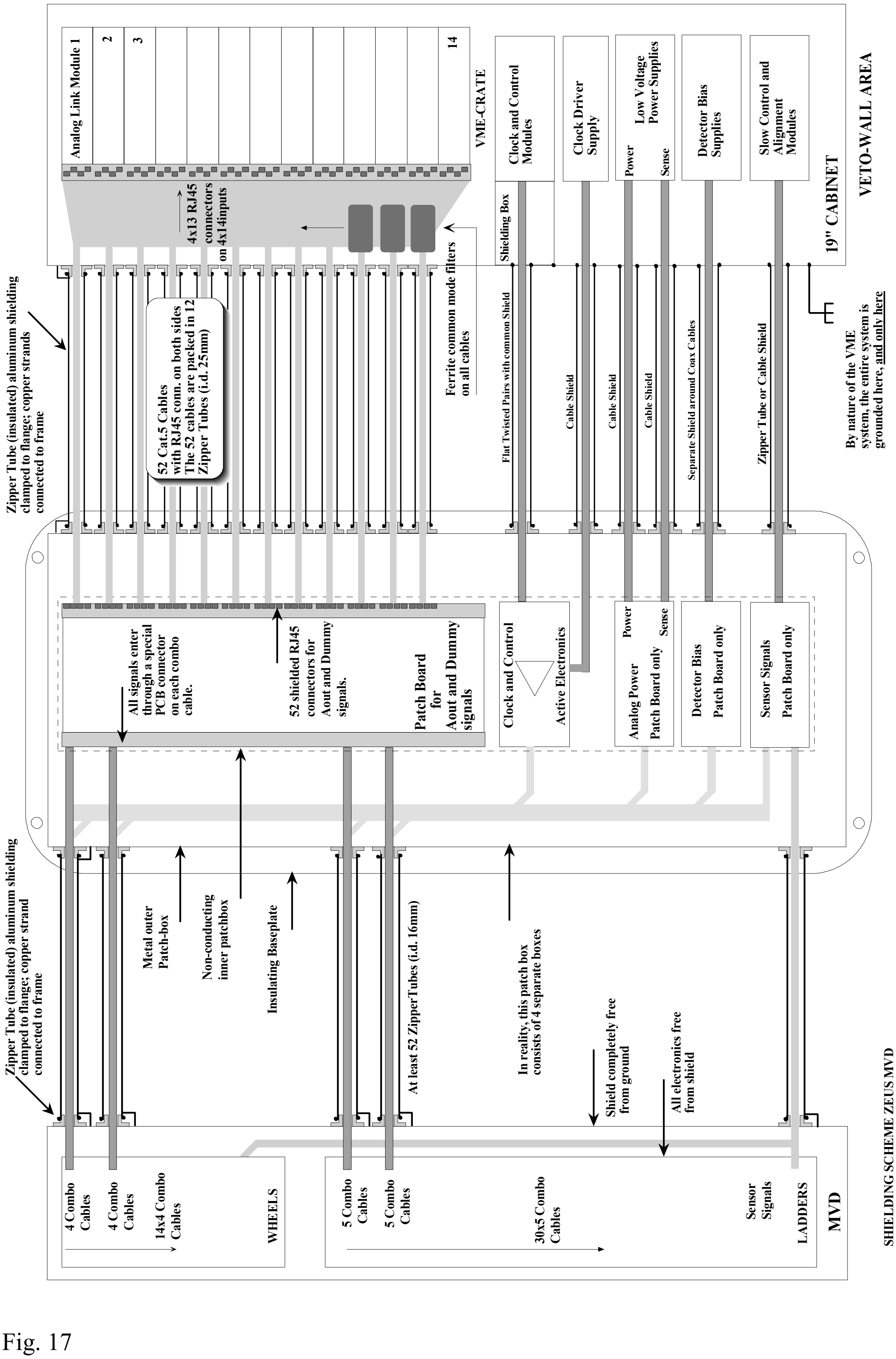
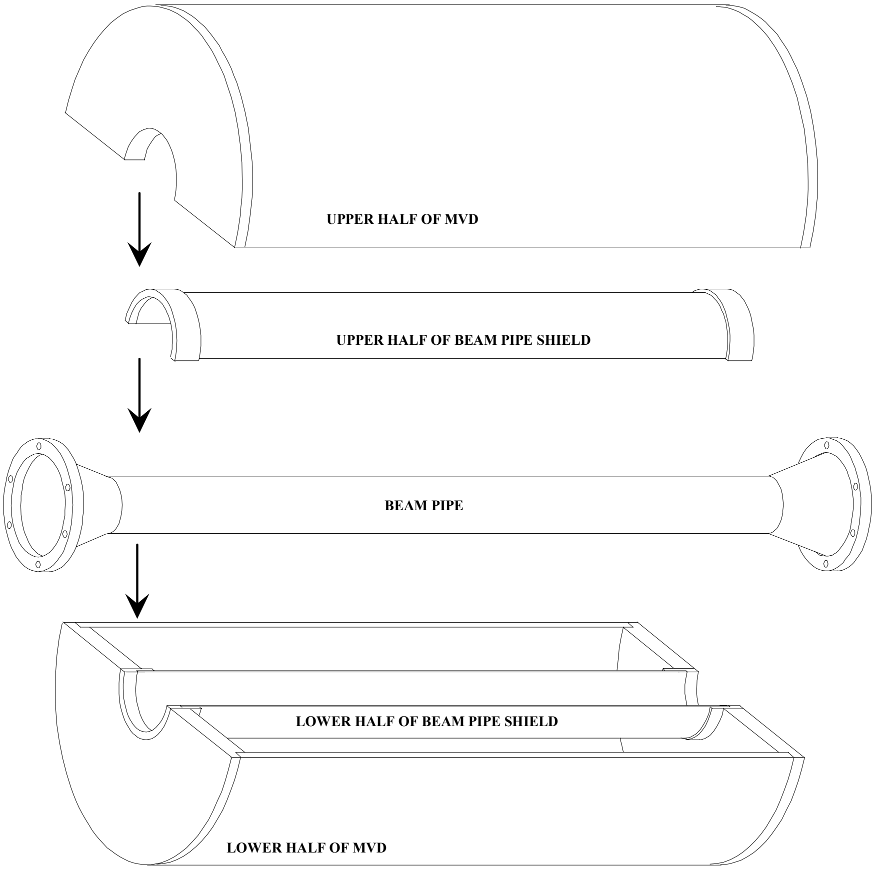

Analog Link Module 1
2
3
14
VME-CRATE
4x13 RJ45 connectors on 4x14inputs
Ferrite common mode filters on all cables
Clock and Control Modules
Shielding Box
Clock Driver Supply
Low Voltage Power Supplies
Power
Sense
Detector Bias Supplies
Slow Control and Alignment Modules
19" CABINET
VETO-WALL AREA
Zipper Tube (insulated) aluminum shielding clamped to flange; copper strands connected to frame
52 Cat.5 Cables with RJ45 conn. on both sides The 52 cables are packed in 12 Zipper Tubes (i.d. 25mm)
Flat Twisted Pairs with common Shield
Cable Shield
Cable Shield
Cable Shield
Separate Shield around Coax Cables
Zipper Tube or Cable Shield
By nature of the VME system, the entire system is grounded here, and only here
All signals enter through a special PCB connector on each combo cable.
52 shielded RJ45 connectors for Aout and Dummy signals.
Patch Board for Aout and Dummy signals
Clock and Control
Active Electronics
Power
Sense
Analog Power
Patch Board only
Detector Bias
Patch Board only
Sensor Signals
Patch Board only
Zipper Tube (insulated) aluminum shielding clamped to flange; copper strand connected to frame
Metal outer Patch-box
Non-conducting inner patchbox
Insulating Baseplate
At least 52 ZipperTubes (i.d. 16mm)
In reality, this patch box consists of 4 separate boxes
Shield completely free from ground
All electronics free from shield
4 Combo Cables
4 Combo Cables
14x4 Combo Cables
WHEELS
5 Combo Cables
5 Combo Cables
30x5 Combo Cables
Sensor Signals
LADDERS
MVD
SHIELDING SCHEME ZEUS MVD

Fig. 17

After the description of the grounding system, the shielding system will be explained from Fig. 17.
206 Combo Cables are leaving the MVD. The Combo Cables contain, among others, the STP for the signals Analog and Dummy. The shield of the STP is used as signal return, so this cable should not be seen as a shielded cable. Likewise for the 3 coax cables, which basically are unshielded cables. For that reason the Combo Cables are shielded with “Zipper Tubes” in groups of 3-5 cables.
A Zipper Tube is a flat strip of some insulating material, with an aluminium coating on one side. Lengthwise a copper braid is stitched to the strip, in contact with the aluminium, as a drain wire. When the strip is folded around the cables, forming a tube, a zipper on the insulating outside can be closed and eventually reopened. To save space we are using a “Zipper Tube” without a zipper, but with an adhesive strip. When closed, the Zipper Tube is fully insulating on the outside, avoiding unwanted ground contact with cabinets or cable supports. The aluminium om the inside, together with the braid provides the desired shielding. Between the MVD and the Patch Boxes a Zipper Tube with an inner diameter of 16mm is used. (see also Fig.15 and Fig.19)

The MVD consists of an inner and an outer cylinder, closed on both sides with a flange. The beam pipe is passing through the inner cylinder without electrical contact. As all outer parts of the MVD are conductive or provided with a conductive layer, the MVD housing forms a Faraday Cage. The cage is fully insulated from its environment, and the electronics inside do not connect electrically to the cage.
The idea is to extend the cage all the way to the VME Crate, where the cage is connected to the VME frame and thus to safety ground.
The transfer from the compact Combo Cables to cables with a lower loss takes place in the Patch Boxes, located in the Cryo Tower. The active electronics as well as the cable transfer boards are fully isolated from the all metal Patch Boxes which are floating too. Between the Patch Boxes and the Veto Wall Area, groups of up to 5 analog cables are packed in Zipper Tubes with an inner diameter of 25mm.
In front of the Clock and Control Modules a shielding box is placed. The shield of the 16 twisted pairs is connected here. The power- and sense wires from the Clock Driver Supply are shielded with a braid , as goes for the wires from the Low Voltage Supplies.
All braids are connected to the patch box outer shell on one side and to the VME racks on the other side. All cables do have an outer insulation to avoid false ground contact along the way.
Each 4 coax cables for the Detector Bias are packed into a shield.
Some cables for Slow Control, Alignment and for the Radiation Monitors do have their own shield, but are packed together in a Zipper Tube, connected as explained above.


UPPER HALF OF MVD
UPPER HALF OF BEAM PIPE SHIELD
BEAM PIPE
LOWER HALF OF BEAM PIPE SHIELD
LOWER HALF OF MVD

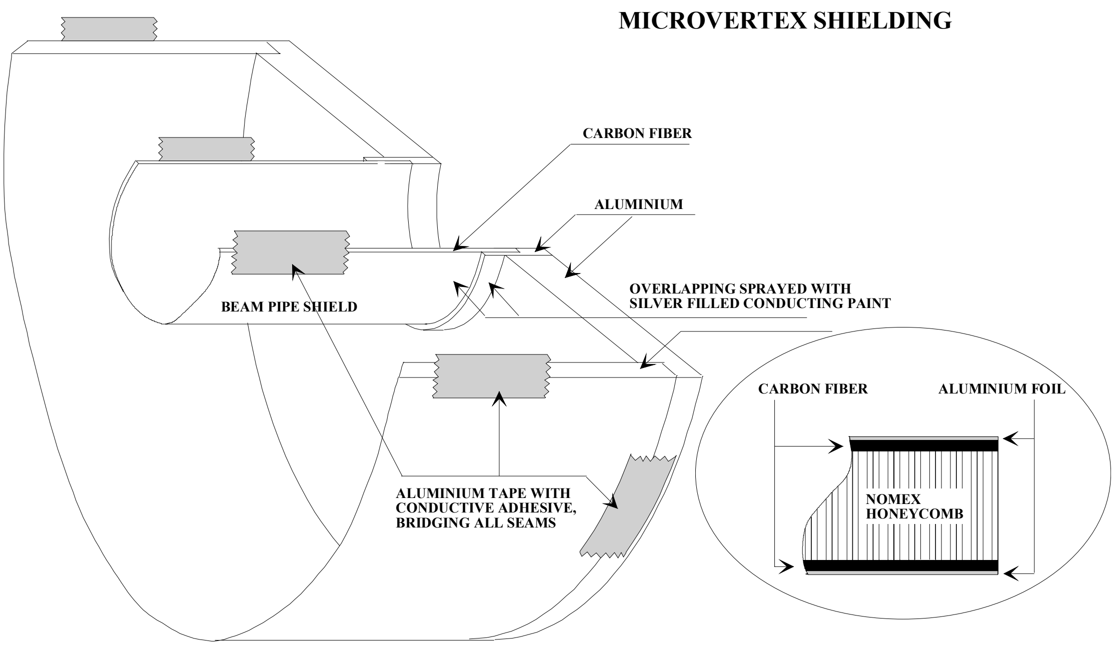

MICROVERTEX SHIELDING
CARBON FIBER
ALUMINIUM
OVERLAPPING SPRAYED WITH
SILVER FILLED CONDUCTING PAINT
BEAM PIPE SHIELD
ALUMINIUM TAPE WITH
CONDUCTIVE ADHESIVE,
BRIDGING ALL SEAMS
CARBON FIBER
ALUMINIUM FOIL
NOMEX
HONEYCOMB

Fig.18

EMC ASPECTS OF THE MVD's CONSTRUCTION

Fig. 18 is a simplified drawing of the MVD barrel, only showing details important to explain how the Faraday Cage is constructed. For ease of assembly the MVD is constructed in two halves: the upper half and the lower half.
The half flanges are constructed from aluminium. The two outer shells consist of two layers of carbon fibre glued around a Nomex honeycomb structure. Although carbon fibre has a relatively low surface resistance, a thin aluminium foil is integrated in the construction on both sides.
The upper- and lower halves of the beam pipe shield are constructed of carbon fibre also
and glued to aluminium end parts. Both halves are sprayed with 30 microns of silver filled acrylic paint, overlapping the aluminium end parts to assure good electrical contact.

The paint used is: Chromerics Cho-Shield 4900
Shielding performance : 45dB @ 10Mhz
60dB @ 100Mhz up to 1Ghz
Measured square resistance: 50mΩ

After installing the silicon detectors and the hybrids in both halves, the lower half of the beam pipe shield is installed in the lower half of the MVD. The beam pipe follows and is covered with the upper half of the beam pipe shield. After final assembly, the beam pipe stays free from the shield. When the upper half of the beam pipe shield is placed, the seams are covered with aluminium tape with a conductive adhesive. In the same way, the upper and lower half of the MVD is sealed with aluminium tape.

The tape used is: Chromerics Cho-Foil CCJ-36-201-0200 with a thickness of 0,05mm.
Measured contact resistance between tape and silver paint: 10mΩ over 30 cm^2.
Measured square resistance between tape and aluminium: 60mΩ.

Now the Faraday Cage is closed and must stay closed, also where the cables leave.
Before closing the MVD the cables are shielded and secured in the following way:
All cables leave from one side of the MVD through both half flanges as shown on the next page, fig. 19.
Depending on their origin (wheels or ladders) up to 5 Combo Cables are packed in one Zipper Tube. There are 4 holes in each half flange for the cables to leave the MVD. Up to 7 "Zippered" cable bundles can pass each hole. Next to each hole a solder lug is placed where the drain wires from the Zipper Tubes are connected.
Before packing the cable bundles, the Zipper Tube has to be prepared.

Step 1:
Cut away 75mm of the adhesive strip.
Cut a slit 3x13mm, 120mm from the start of the Zipper.
After removing the stitches, cut off 75mm of the braid.
Solder a tinned copper wire, 0,7mm diameter and 70mm long to the end of the braid.
Make sure not to melt the Zipper and do not unravel the braid.

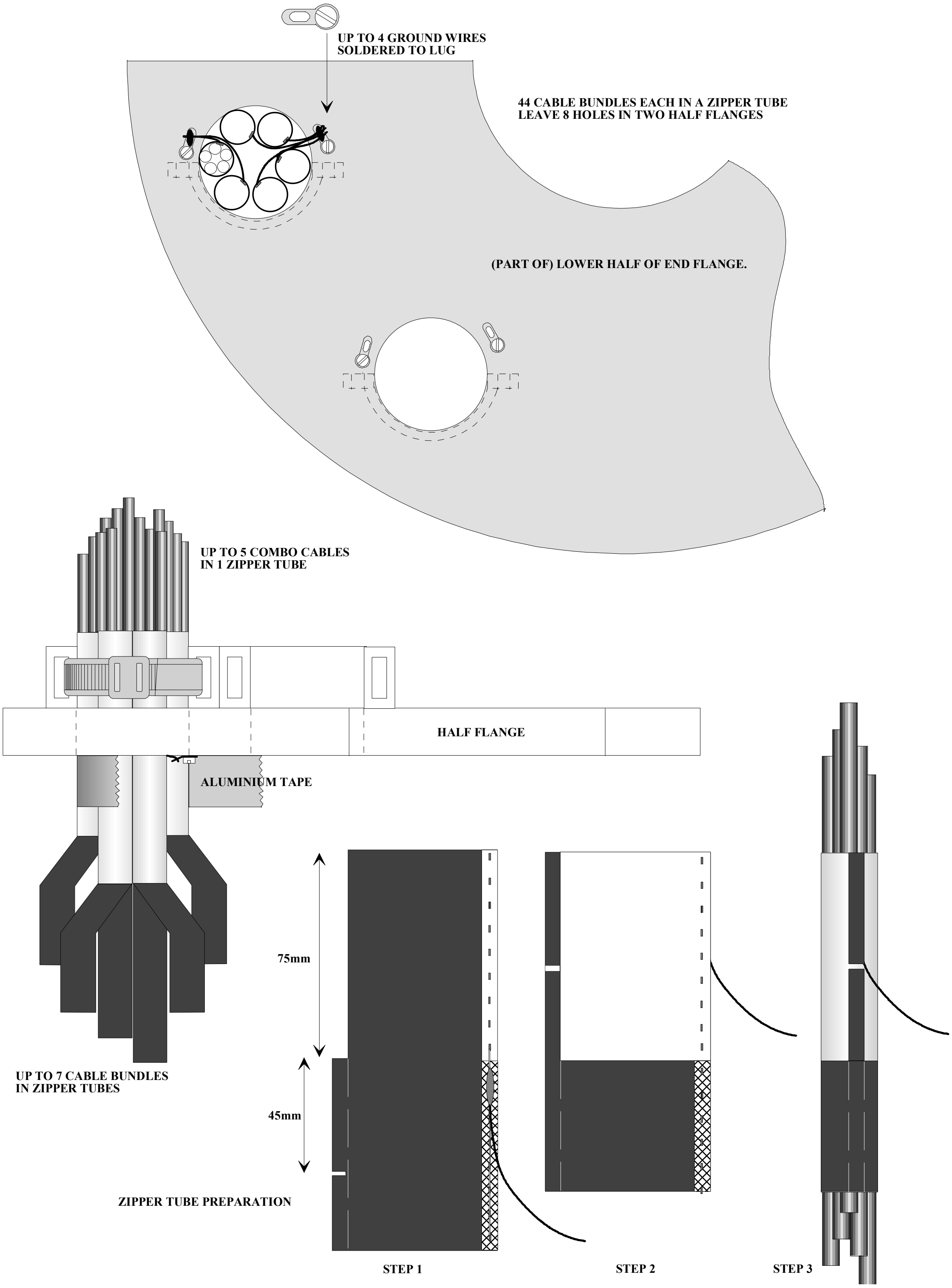

UP TO 4 GROUND WIRES
SOLDERED TO LUG
44 CABLE BUNDLES EACH IN A ZIPPER TUBE
LEAVE 8 HOLES IN TWO HALF FLANGES
(PART OF) LOWER HALF OF END FLANGE.
UP TO 5 COMBO CABLES
IN 1 ZIPPER TUBE
HALF FLANGE
ALUMINIUM TAPE
UP TO 7 CABLE BUNDLES
IN ZIPPER TUBES
75mm
45mm
ZIPPER TUBE PREPARATION
STEP 1
STEP 2
STEP 3

Fig. 19

Step 2:
Fold back the first 75mm of the Zipper, so the conductive side is showing.
Let the drain wire come out from under the fold opposite the slit.

Step 3:
Remove the protective paper from the adhesive strip and fold the Zipper Tube around the cable bundle. Make sure the glue tacks behind the braid and not on it, so the braid is completely covered. Make sure that the tube fits loosely around the cables, so it can slide over them. The drain wire is coming out of the slit now.

Perform steps 1-3 for all cable bundles leaving the same hole. Slide all Zipper Tubes into the hole, so the slit where the drain wire comes out aligns with the outside of the flange.
With all bundles in position secure them to the "ear" on the inner side of the flange with a strong tie-rap. Solder all drain wires to one or two lugs. Make sure the wires come the shortest way from between the bundles and that no wire loops are created. Finally firmly tape the bundles together with aluminium tape, covering the lugs completely. Performing the same actions for the cables leaving the other holes in the half flanges completes the job of extending the Faraday's Cage up to the patch boxes. Termination of the Zipper tubes at the side of the patch boxes is done in basically the same way.
All 4 patch boxes consist of a closed metal housing, with the electronics and patch boards floating. The metal housing is insulated from the structure where it is mounted on.
The Cat.5 cables transporting the signals Analog and Dummy are on both sides provided with shielded RJ45 connectors. In the patch boxes the connection is made inside the box on the patch board; on the receiver side the connectors are plugged into the Analog Receiver Modules. In between, the cables are packed in Zipper Tubes in groups of 4 or 5 cables. Termination of the Zipper Tubes leaving the patch box is done the same way as on the input side; the termination on the receiver side is shown in Fig.14.
The inner diameter of the Zipper Tube between Patch Box and Veto Wall is 25mm, where between MVD and Patch Box 16mm is used.
The type of Zipper Tube is the same: ZT96-04-029.
The damping of the shield from 10Mhz to 20Ghz is between 87 and 116dB.

APPENDIX 1

The next following pages show the schematic diagrams of the Analog Link Board.
Fig.20 is the block schematic diagram.
Each board contains 8 identical channels. For the first channel components are numbered in the range 101 through 199; the second channel uses 201 through 299, while the numbers for the eighth channel are from 801 through 899.
The power part, as a common part and only one time present on the board, uses the numbers 1 through 99.

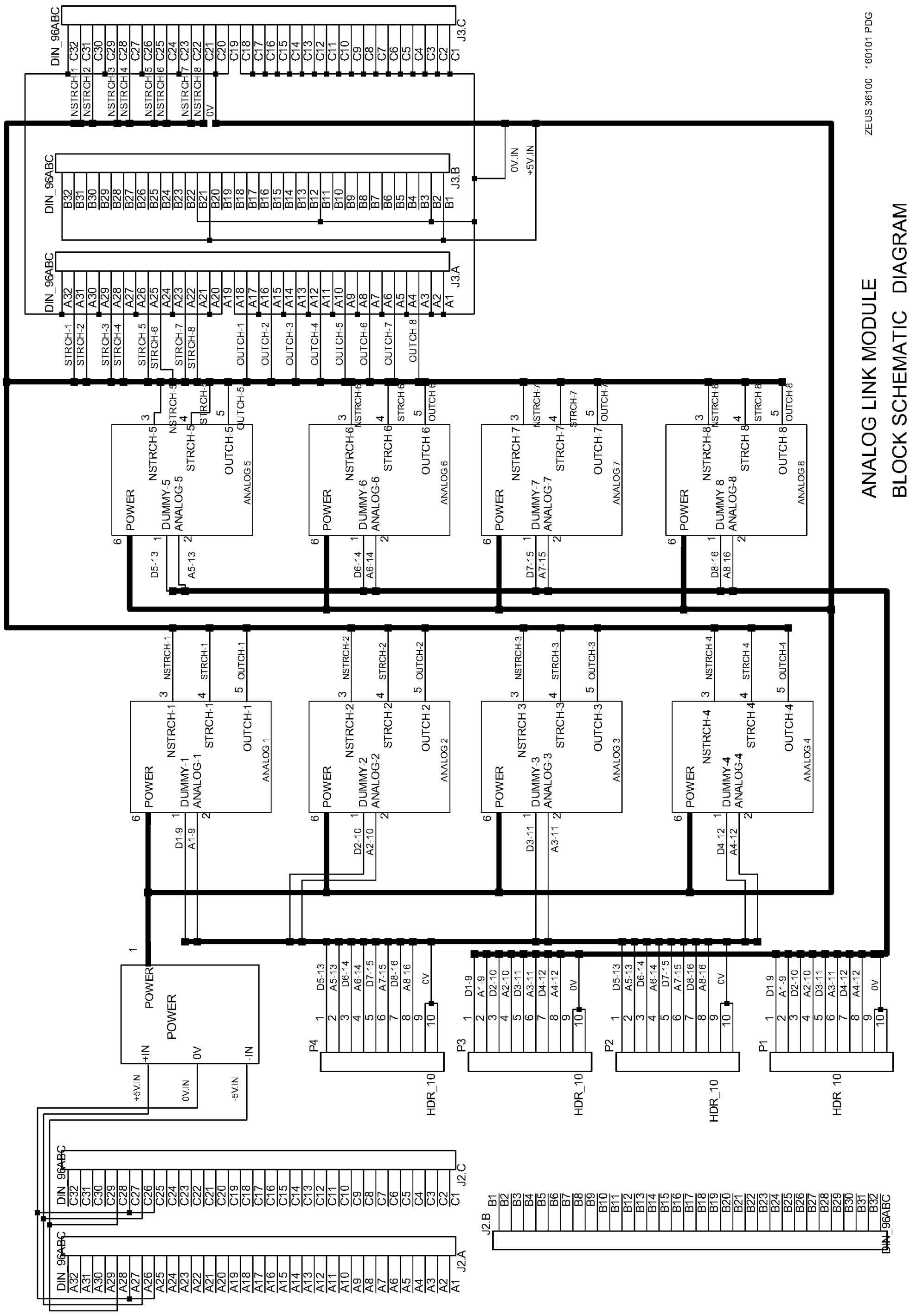

ANALOG LINK MODULE
BLOCK SCHEMATIC DIAGRAM
ZEUS 36100 160101 PDG

Fig. 20

POWER DIAGRAM

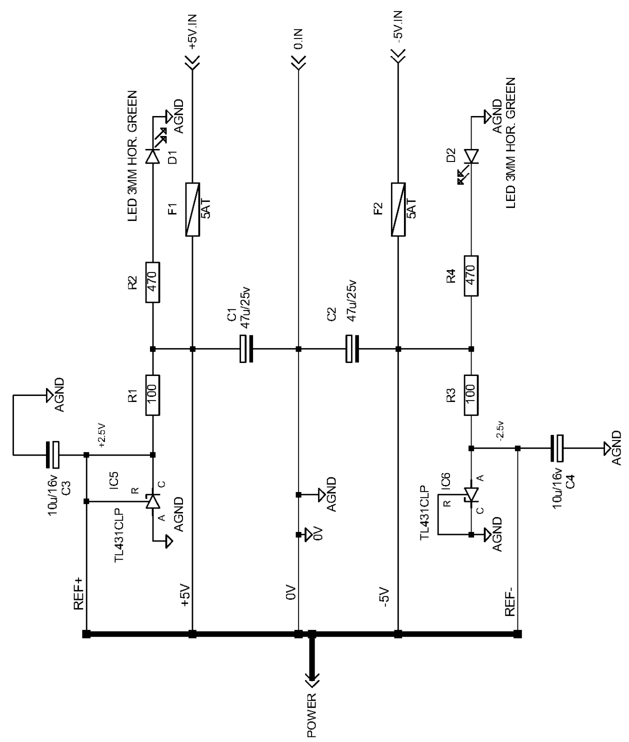


Fig. 21

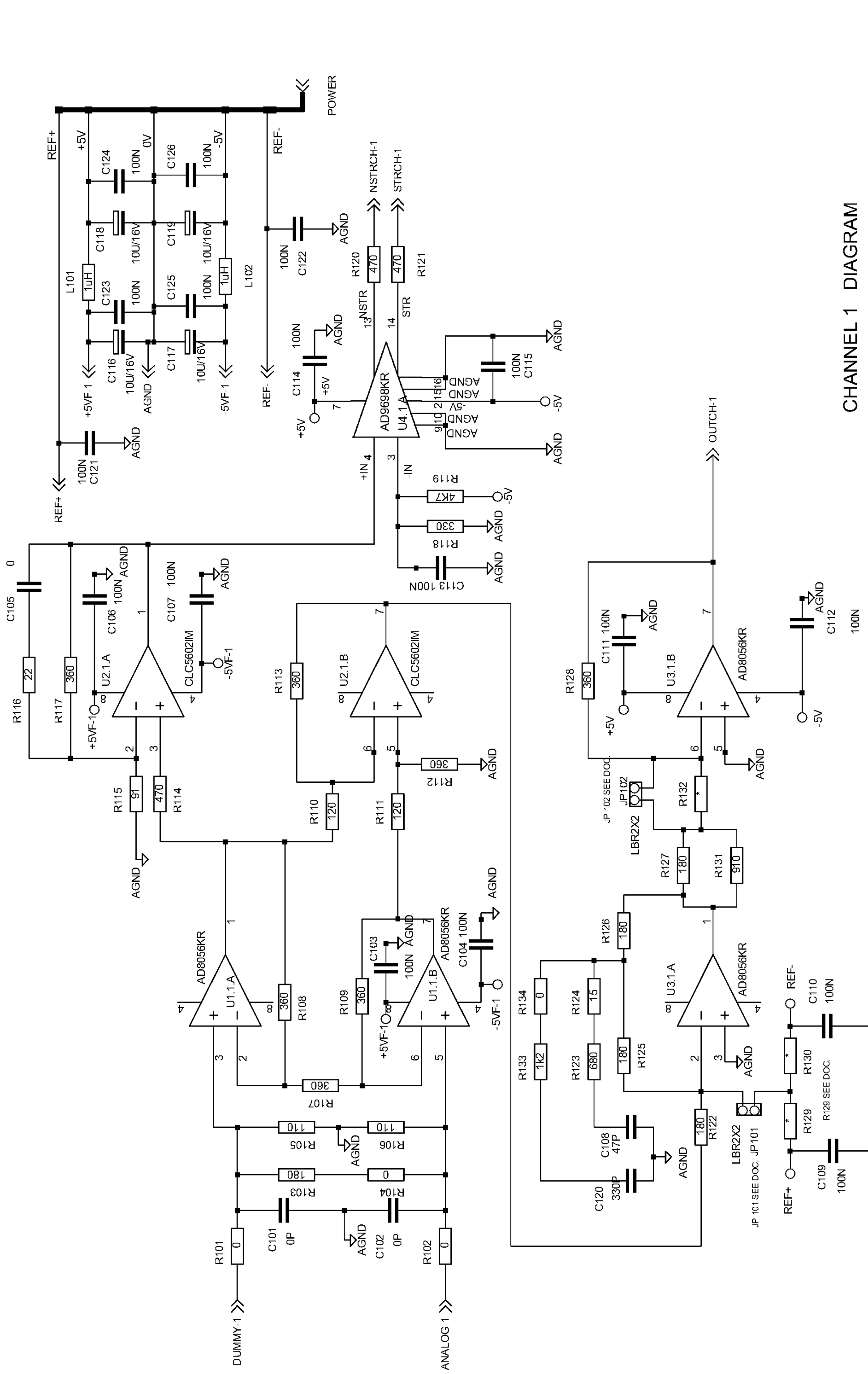


Fig. 22

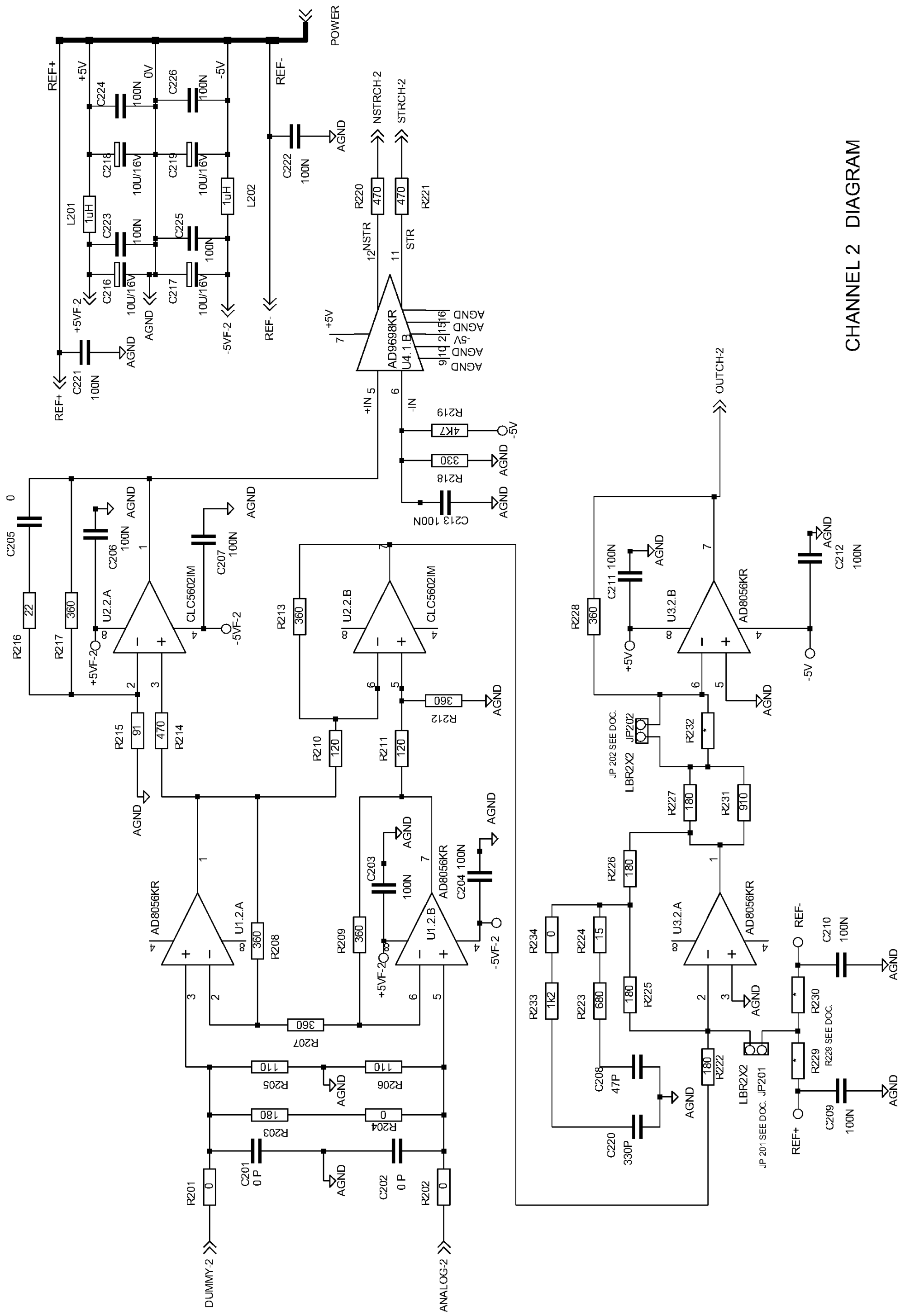

CHANNEL 2 DIAGRAM
POWER
DUMMY 2
ANALOG 2
OUTCH 2
NSTRCH 2
STRCH 2

Fig. 23

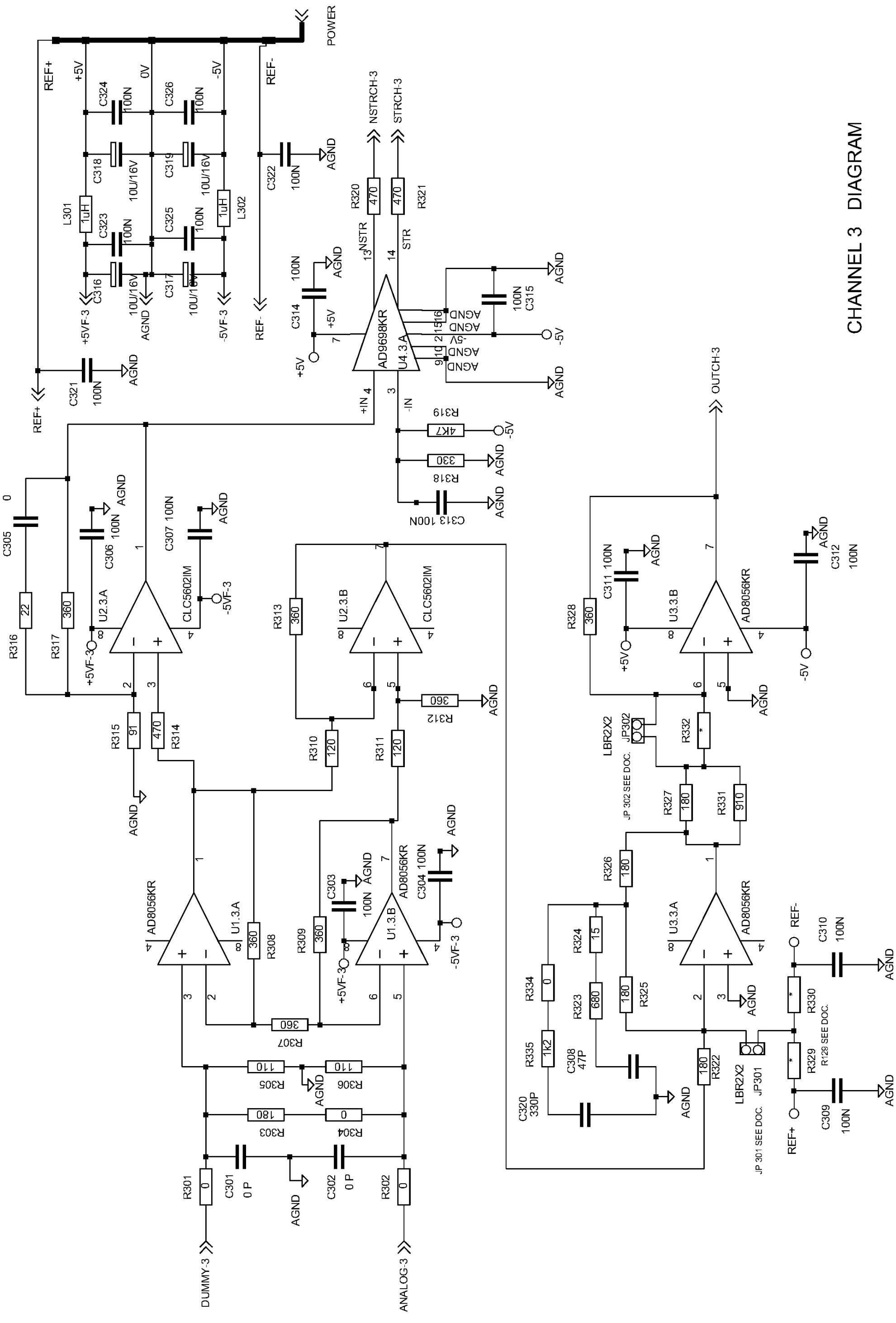

CHANNEL 3 DIAGRAM
POWER
NSTRCH-3
STRCH-3
OUTCH-3
DUMMY 3
ANALOG 3
AD9698KR
CLC5602IM
AD8056KR

Fig. 24

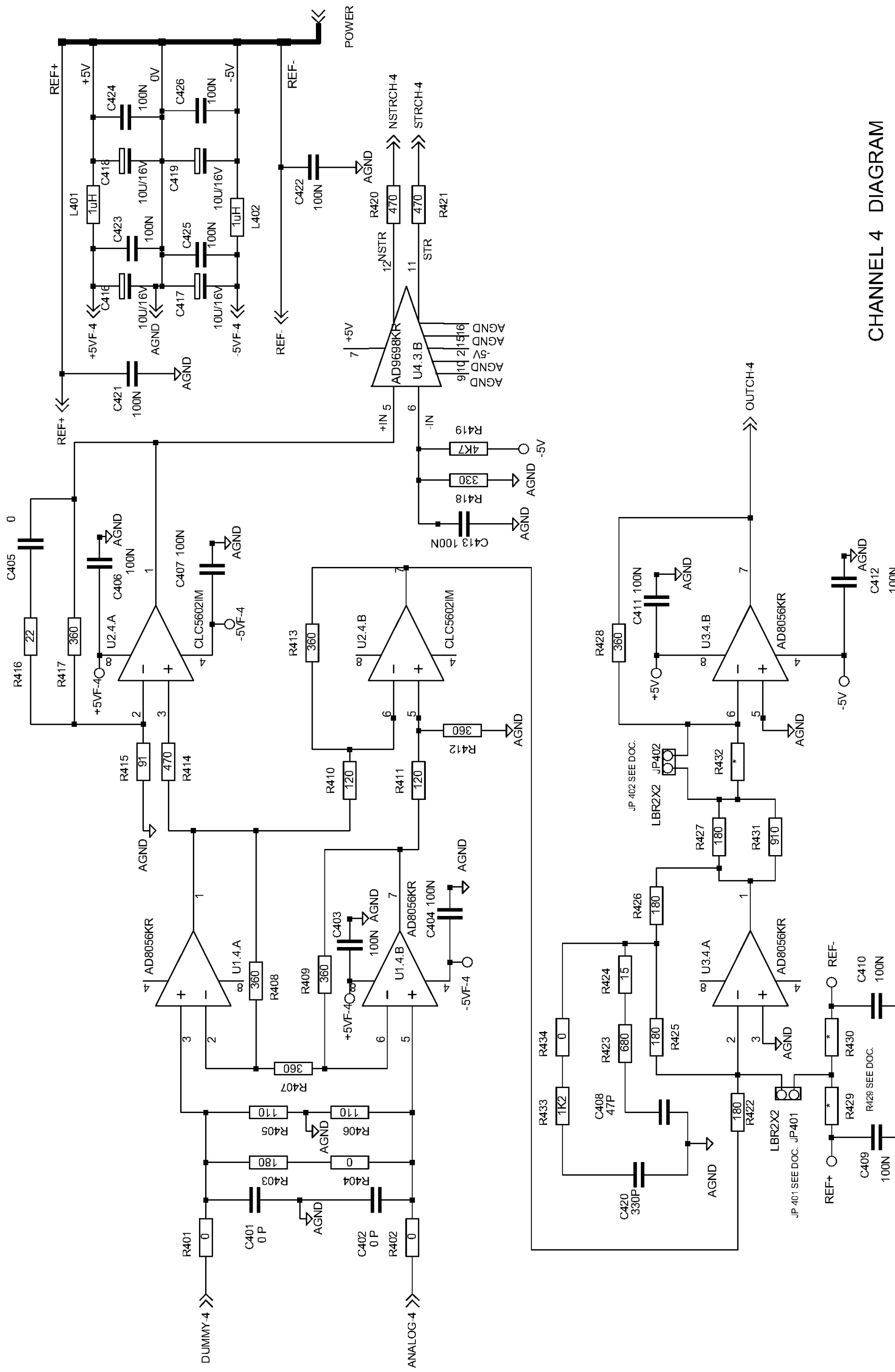

CHANNEL 4 DIAGRAM
POWER
REF+
+5V
0V
-5V
REF-
NSTRCH-4
STRCH-4
OUTCH-4
DUMMY 4
ANALOG 4
AD9698KR
U4.3.B
CLC5602IM
U2.4.A
U2.4.B
AD8056KR
U1.4.A
U1.4.B
U3.4.A
U3.4.B
LBR2X2
JP401
JP402
AGND
+5VF-4
-5VF-4

Fig. 25

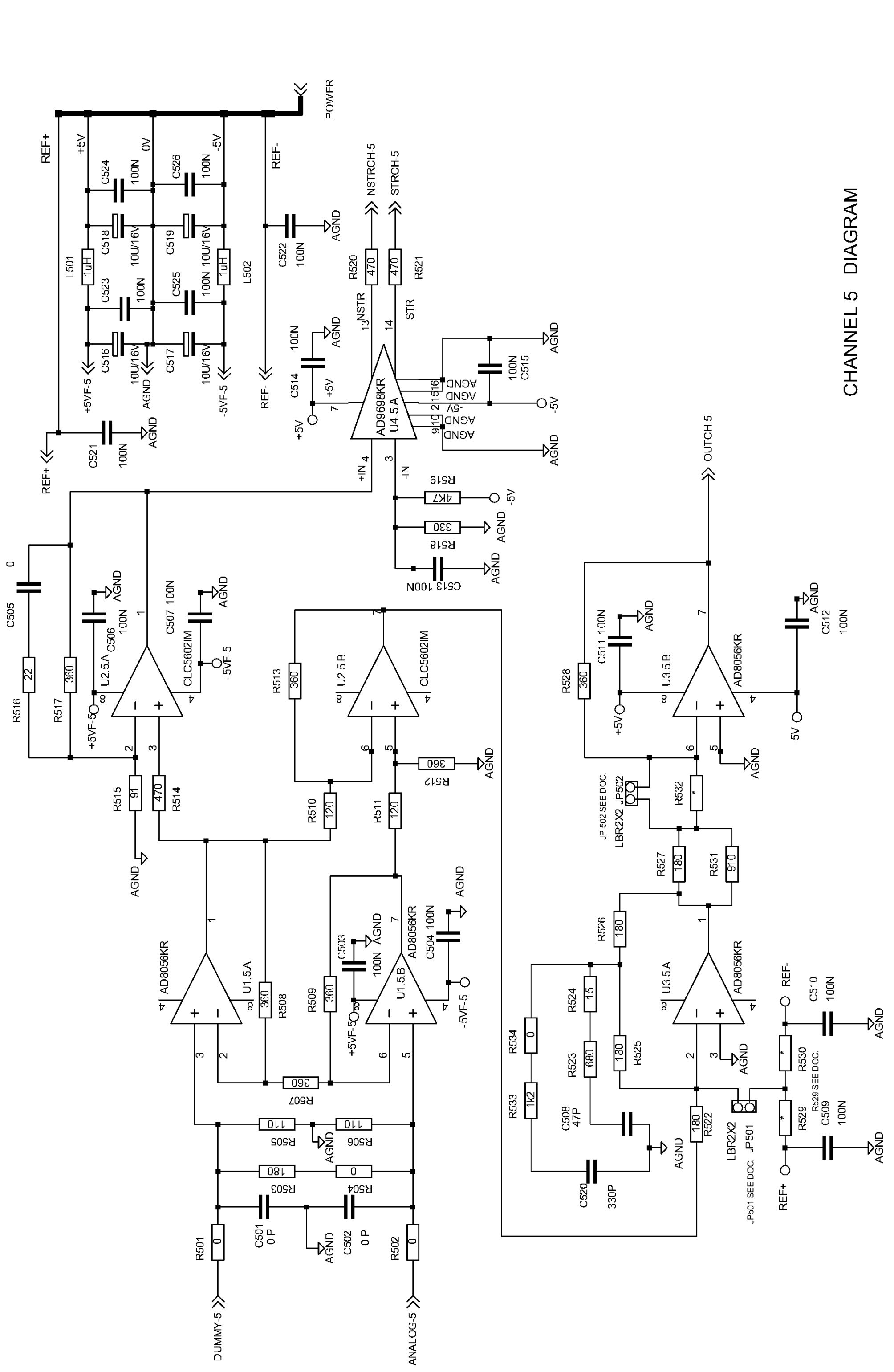

CHANNEL 5 DIAGRAM
POWER
NSTRCH-5
STRCH-5
OUTCH-5
DUMMY 5
ANALOG 5
AD9698KR
CLC5602IM
AD8056KR

Fig. 26

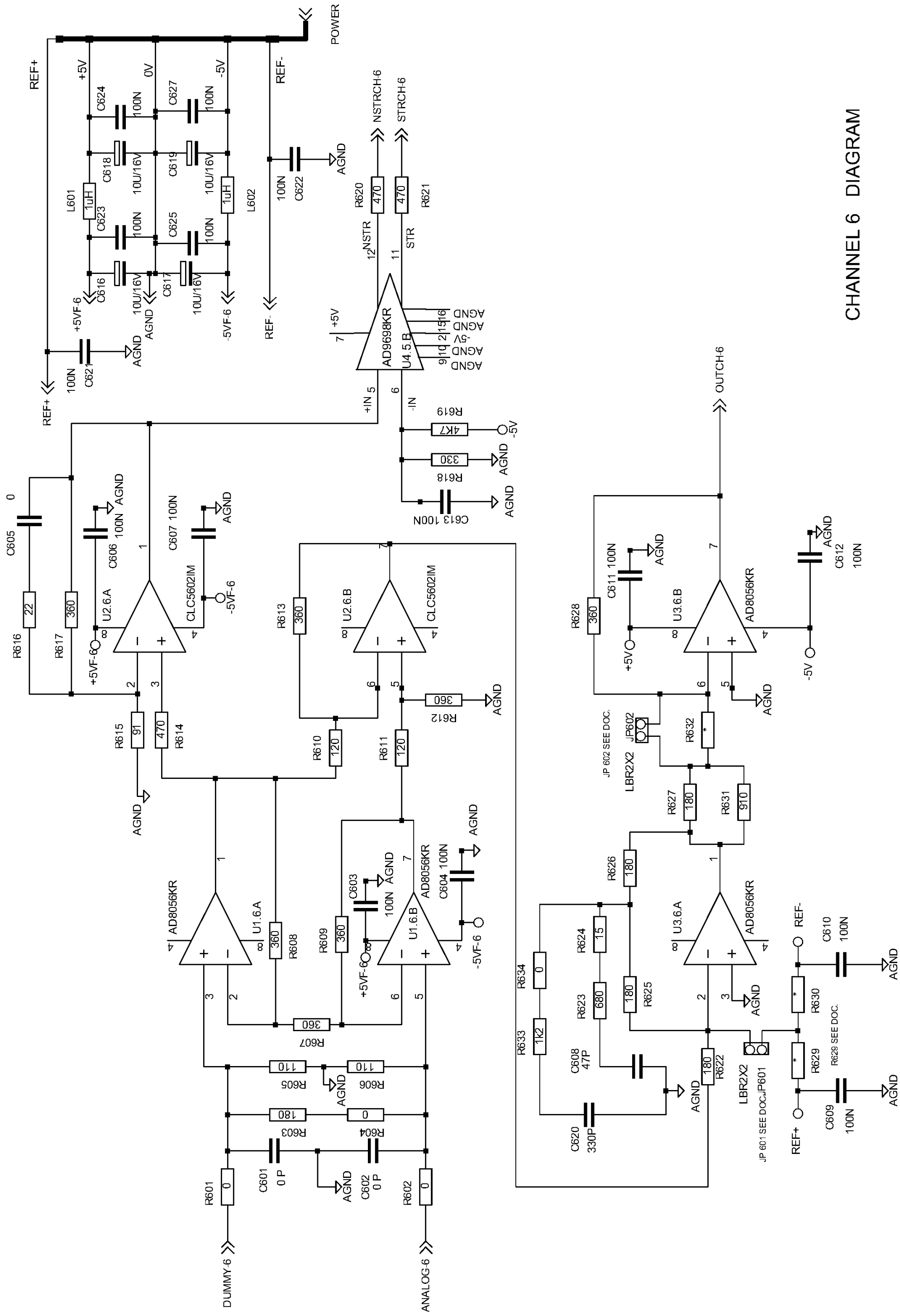

CHANNEL 6 DIAGRAM
POWER
REF+
REF-
+5V
0V
-5V
AGND
NSTRCH 6
STRCH 6
AD9698KR
U4.5.B
CLC5602IM
U2.6.A
U2.6.B
AD8056KR
U1.6.A
U1.6.B
U3.6.A
U3.6.B
OUTCH 6
DUMMY 6
ANALOG 6
JP 601 SEE DOC.
JP 602 SEE DOC.
R629 SEE DOC.
LBR2X2

Fig 27

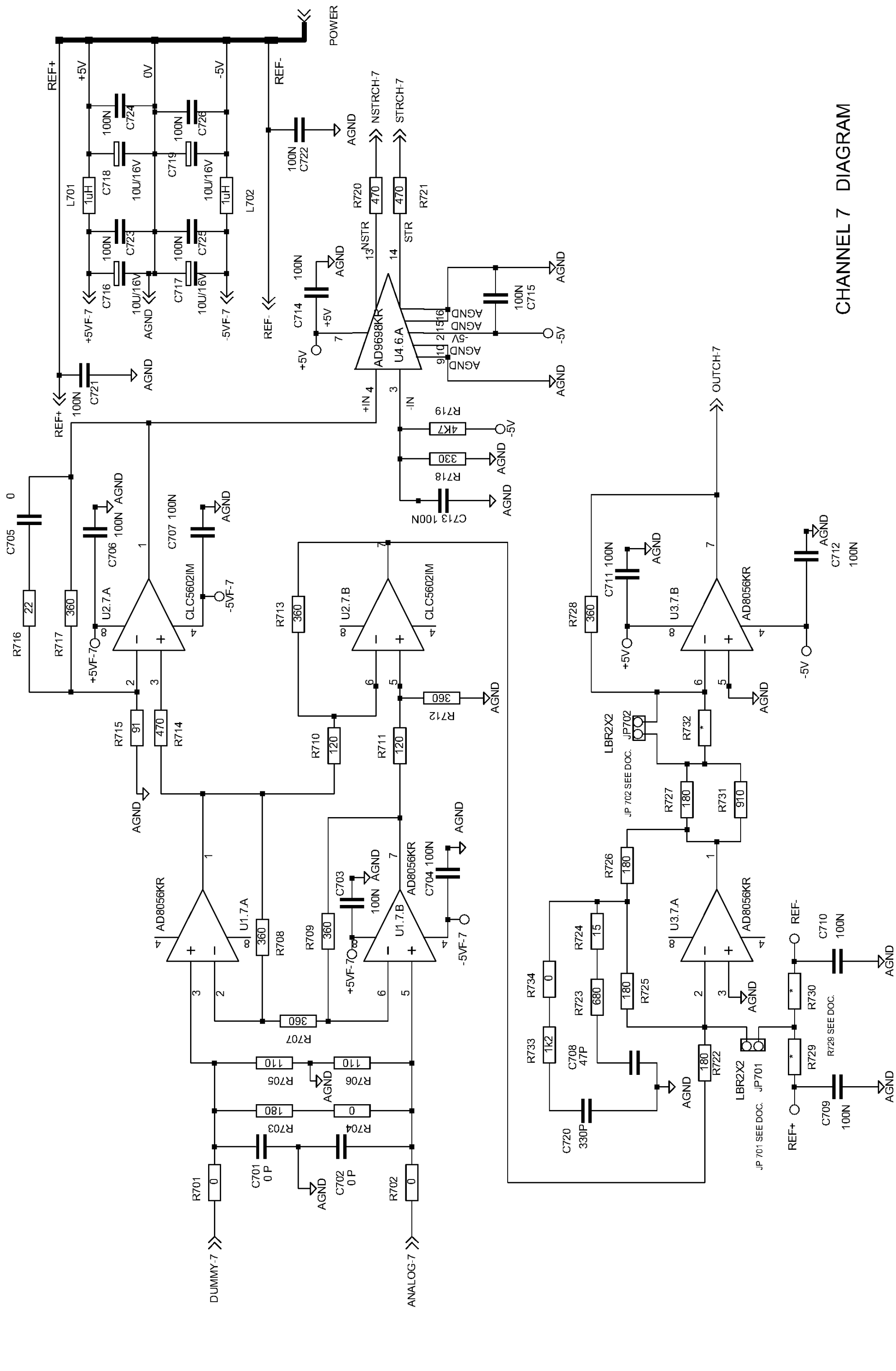


Fig. 28

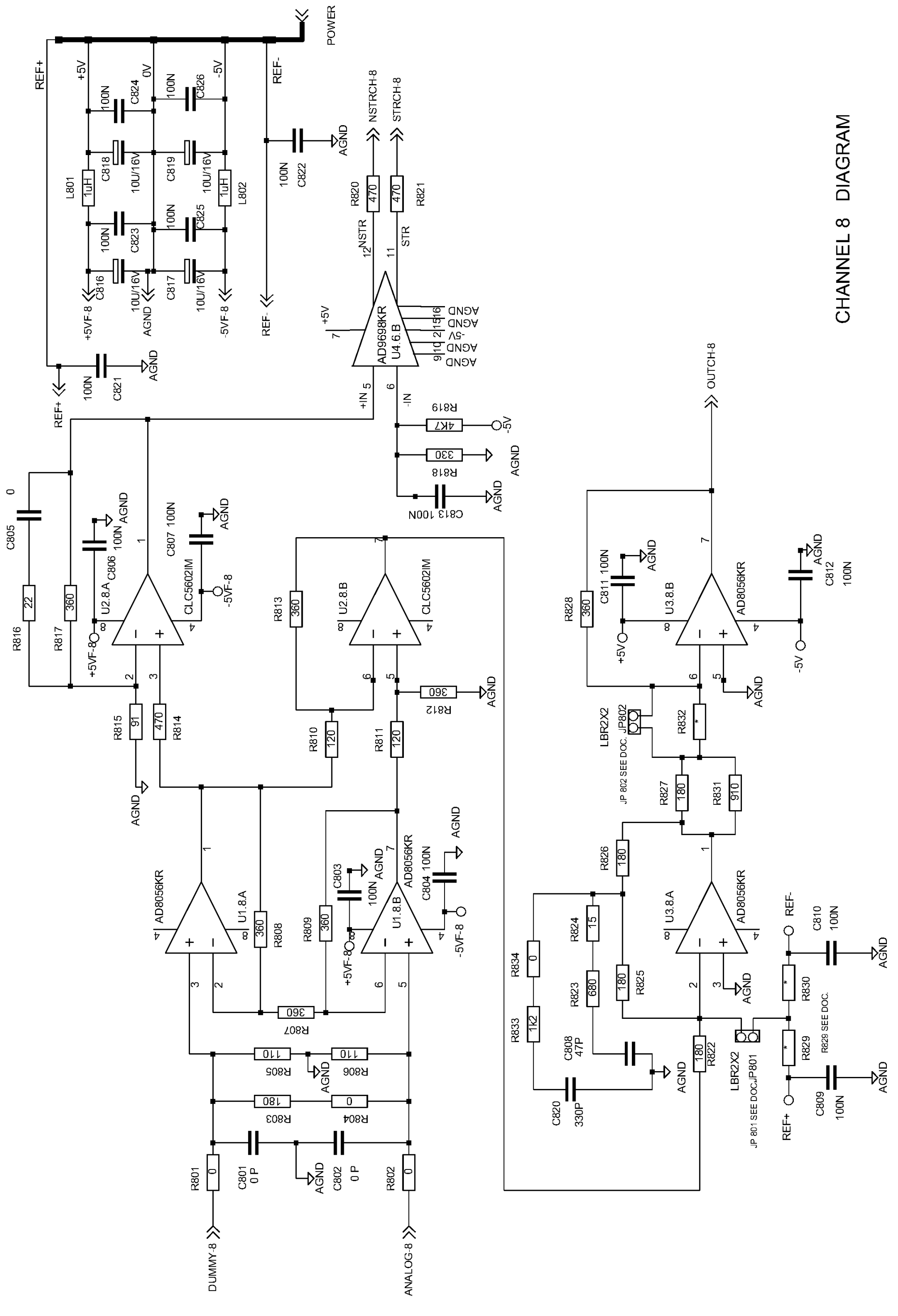
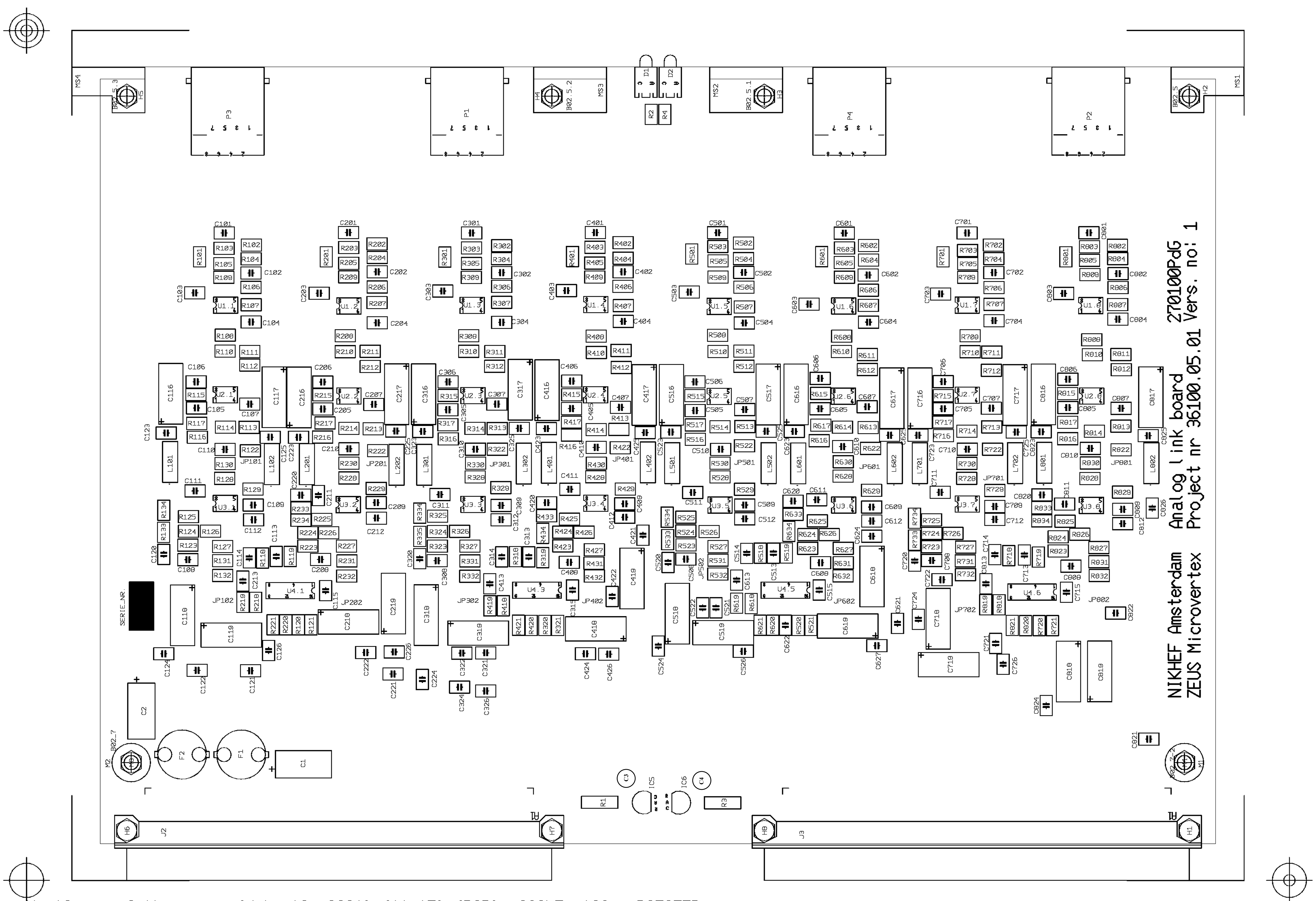


Fig. 29



Vme12_rev, Silkscreen (Jul. 19, 2001) (11:17) (PCB) SCALE: 100% ROTATED
Drill Ref Pnt: 0.000, 0.000 (mm)

APPENDIX 2

PRODUCTION PROCEDURE FOR THE ZEUS MVD CAT.5 CABLES

To be produced: 56 pieces with a length of 22 meters.
Connector type: RJ45.
Manufacturer RS, partnr. 455-220, which is a set of 5 connectors.
Necessary special tools: Shrinking tool RS 486-072 and OUK-0090-2 with OUK-0090-8.

Numbered pictures will support the explanation.
The cables will be fitted with shielded RJ45 connectors on both sides

Picture 1.

Make sure both cable ends are within reach and secured.
Remove the outer insulation over a length of 80mm
Make sure not to damage the copper wires of the shield

Picture 2.

Carefully move the braiding backwards and cut 10mm from the cables end. Make sure not to unravel the braiding. Stretch the braiding firmly in the old position, and twist the end. Move 4cm shrink tube with an internal diameter of 14mm over the cable's end.
Move the cover of the RJ45 connector over the braiding of the cable, until it comes upon the outer insulation of the cable.

Picture 3.

Cut the braiding's twisted 10mm
Make a fold in the braiding, partly folding it inside out with the least possible unravelling. Make sure the fold is located 40 +/- 1mm from the outer insulation.
It is important that the braiding is tight around the cable again; otherwise the cover of the connector will not be able to move into place.
Firmly secure the braiding with a small tie-rap or a piece of copper tape. Do not use ordinary tape as it may leave glue after removal.
Bend the signal wire pairs outward and remove the shielding foil as close as possible to the braiding.

Picture 4.

Unravel the signal wire pairs and carefully straighten the wires.
The length of the wires sticking out of the braiding should be 30mm.
Use a wire stripper for 0,6mm and adjust it to a strip length of 20mm.
The copper diameter of the wires is 0,5mm and the copper is very brittle.
When removing the 20mm of insulation be sure not to carve the copper as this often leads to breaking of the wire during the rest of the assembling procedure or after.
Replace the insulation by Teflon insulation with an outer diameter of 1mm.
Do this over the entire length of the wire. Try not to touch the copper of the wire.

Picture 5.

Now the 8 wires, with their new insulation must be rearranged. The idea is to feed them tightly next to each other, in one plane, and in the right sequence into the plastic comb.
The sequence from top to bottom is: brown/white, blue/white, orange/white, green/white.
Caution: brown/white means: pin1 brown; pin 2 the white wire that was twisted with the brown wire, and not a white wire from a different signal pair.

Bring the comb into place: make sure that the distance between the right-hand side of the comb and the braiding is 24mm. Make sure that the wires are well in line with the rest of the cable, and that the face of the comb makes a right angle with the wires
Now cut the 8 wires to the right of the comb and closely along its face at exactly the same length.

The most critical part of the assembling procedure is now to come: the shrinking of the contacts.

First prepare the connector body, by bending the grounding clamp almost 90 degrees backwards. Now the prepared cable, with the comb still in the right position, must be fed into the connector as straight as possible. Make sure that the brown wire is in the top position, while facing the gold plated contacts of the connector. Take care that the comb does not stick anywhere and slides smoothly into place. Apply some gentle force to push the wires into the position where the copper of each wire is visible through the transparent plastic of the connector.
Also the junction between the original wire insulation and the Teflon insulation must fall well inside the connector's body. This will prevent an eventual partly exposure of copper from shorting to sharp edges of the connector's housing.

Picture 6.

This is what it looks like when the above steps were performed successfully.
.

Pictures 7 and 8.

For the shrinking of the contacts in the connector we use the RS 486-072 tool.
Carefully position the connector into the block of the tool. Make sure that the plastic locking clicks in positively. When the cable still is correctly positioned in the connector block: close the tool completely until it releases.
Remove the connector from the tool and gently pull on the cable. When no movement of the copper on the front side of the connector is visible, one can rely that the strain relief inside the plastic body is effective

<u>Picture 9.</u>

Remove the tie-rap or the copper tape without unravelling the braiding. The fold must stay in place and the braiding must stay tight around the cable. Bend the clamp (picture 5) back into its original position.

<u>Picture10.</u>

For the following step the tool with the code: OUK-0090-2 is required.
Adjust the connector in the tool as indicated in the picture. The purpose is, to bend the two guiding strips alongside the conductors. Make sure that this is possible without distorting one or more conductors or putting them under mechanical stress
Be sure that the connector is positioned in the tool correctly and that the locking strip falls freely into the slit. Close the tool to perform the action.

<u>Picture 11.</u>

The same tool is used for the folding of the ground connection/strain relief.
This is a very important step, as the braiding, normally the shield, here functions as the signal return path.
Position piece OUK-0090-8 over the shaft of tool OUK-0090-2.
Enter the connector into this piece and check if the ground clamp is positioned correctly. The fold in the braiding must align with the front side of the clamp when closed. Also the braiding must still be tightly around the cable, otherwise the cover of the connector will not come into position later. The closing of the ground connection goes more secure when the two lips of the clamp are pre-folded inwards a little.
Gently close the tool and remove the connector from the tool.

<u>Picture 12.</u>

This is how it looks now.
Cut the wires of the braiding that stick out of the ground connection.

<u>Picture 13.</u>

Like this.

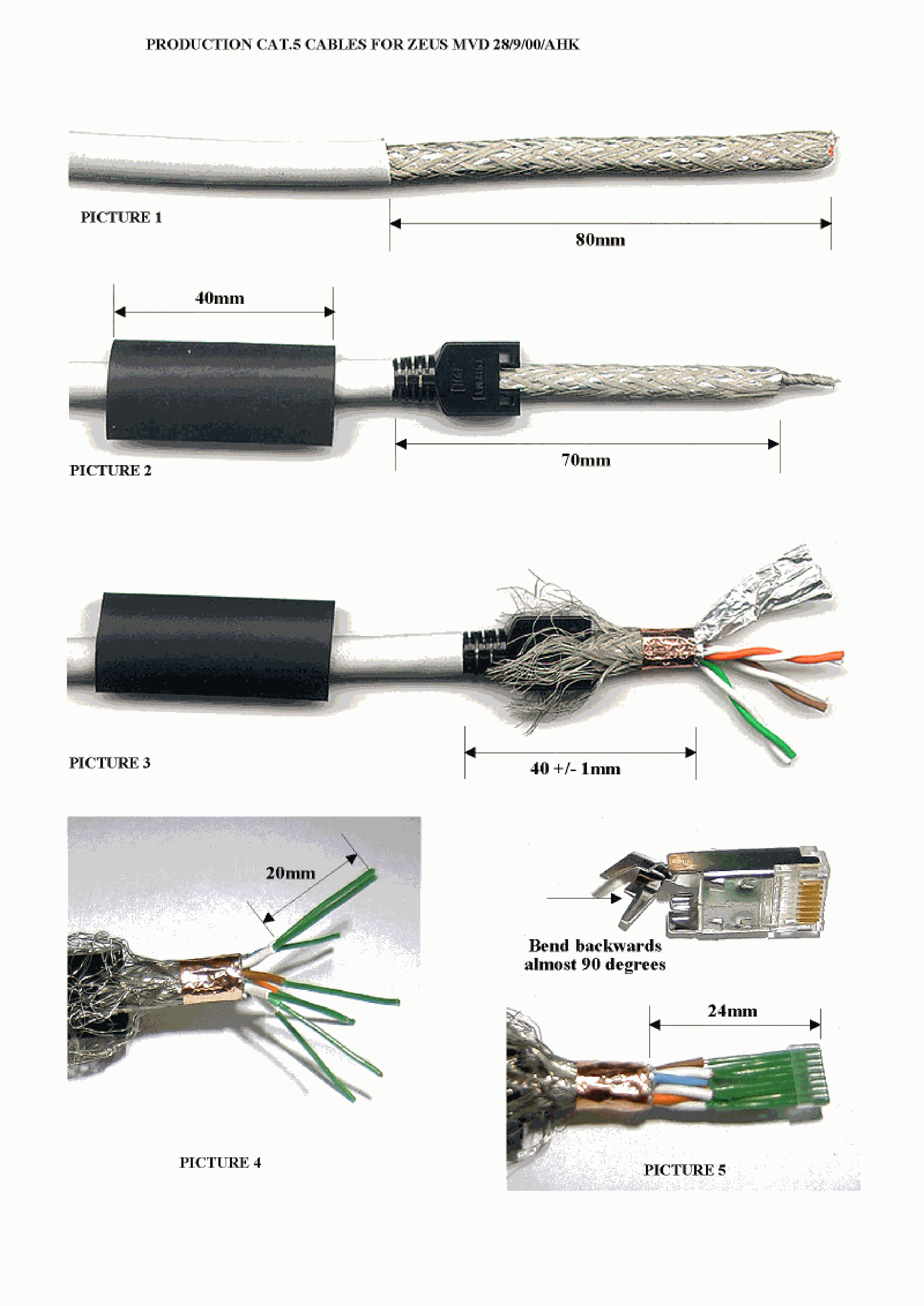
<u>Picture 14.</u>

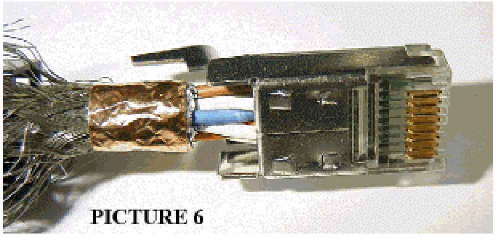
Slide the cover forward until it clicks in on both sides of the connector body.

<u>Picture 15.</u>

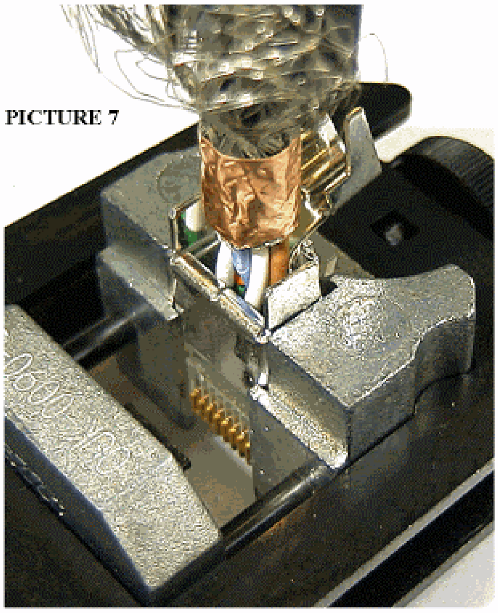
Shrink the sleeve flush with the connector’s housing covering the braiding.
This completes the procedure.

Follow the same procedure for the other side of the cable.
Finally test the cable for the right connections of the wires, the connectivity of the braid, and test for the absence of shorts.

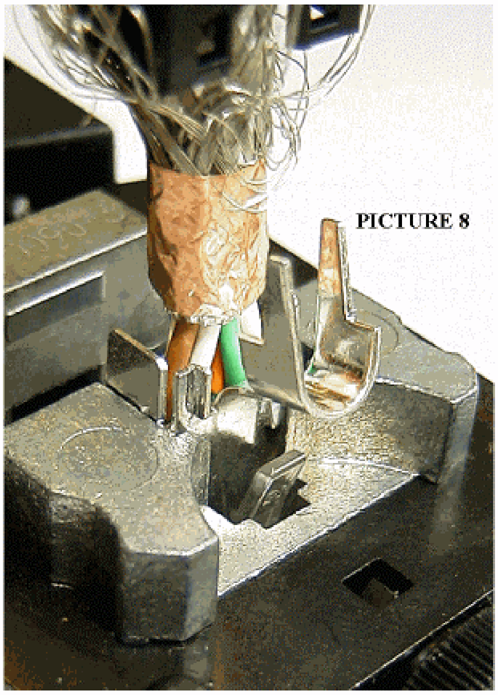

PRODUCTION CAT.5 CABLES FOR ZEUS MVD 28/9/00/AHK
PICTURE 1
80mm
40mm
PICTURE 2
70mm
PICTURE 3
40 +/- 1mm
20mm
PICTURE 4
Bend backwards
almost 90 degrees
24mm
PICTURE 5



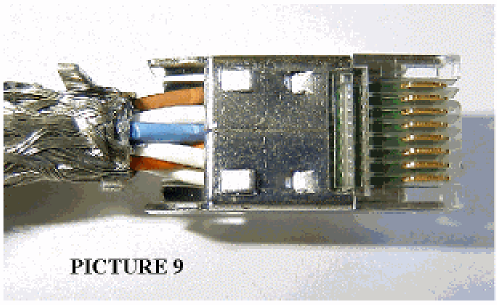
PICTURE 6



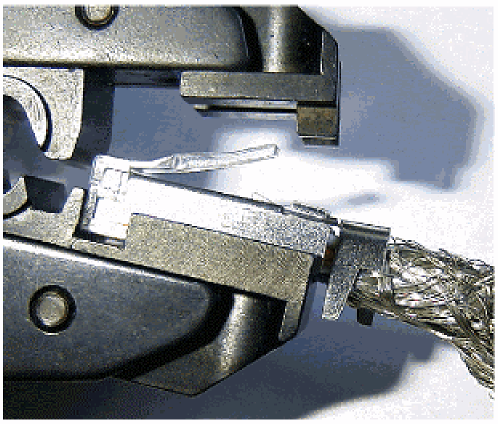
PICTURE 7



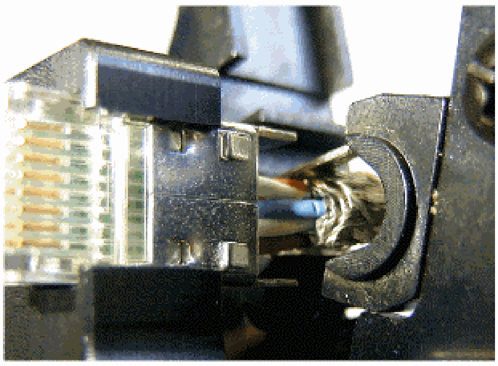
PICTURE 8



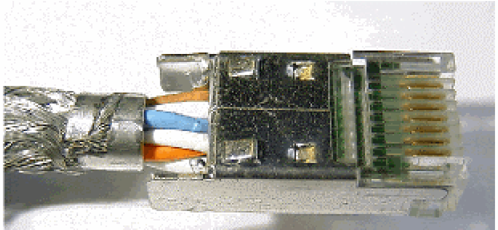
PICTURE 9



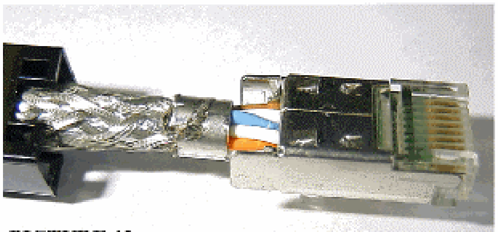
PICTURE 10



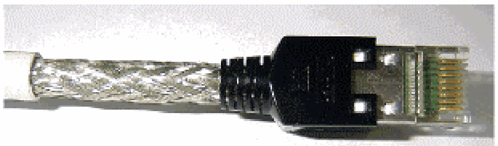
PICTURE 11



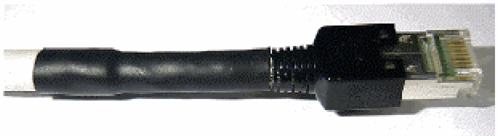
PICTURE 12



PICTURE 13



PICTURE 14



PICTURE 15

APPENDIX 3

Cable Mapping between patch boxes and ADC crates.

HARDWARE POSITION   PATCHBOX CABLE LABEL

```
# ----------------------------\
# CRATE 0    Barrel 1st half   ---------------------------------------------
# ----------------------------/
#
# Patch Box A ..............................................................
#
crate 0 adcm 0 adcu 0     # A-7-1
crate 0 adcm 0 adcu 4     # A-7-2
crate 0 adcm 1 adcu 0     # A-7-3
crate 0 adcm 1 adcu 4     # A-7-4
crate 0 adcm 2 adcu 0     # A-7-5
crate 0 adcm 2 adcu 4     # A-13-1
crate 0 adcm 3 adcu 0     # A-13-2
crate 0 adcm 3 adcu 4     # A-13-3
crate 0 adcm 4 adcu 0     # A-13-4
crate 0 adcm 4 adcu 4     # A-13-5
#
# Patch Box B ..............................................................
#
crate 0 adcm 5 adcu 0     # B-7-1
crate 0 adcm 5 adcu 4     # B-7-2
crate 0 adcm 6 adcu 0     # B-7-3
crate 0 adcm 6 adcu 4     # B-7-4
crate 0 adcm 7 adcu 0     # B-7-5
crate 0 adcm 7 adcu 4     # B-13-1
crate 0 adcm 8 adcu 0     # B-13-2
crate 0 adcm 8 adcu 4     # B-13-3
crate 0 adcm 9 adcu 0     # B-13-4

# ----------------------------\
# CRATE 1    Barrel 2nd half   ---------------------------------------------
# ----------------------------/
#
# Patch Box C ..............................................................
#
crate 1 adcm 0 adcu 0     # C-7-1
crate 1 adcm 0 adcu 4     # C-7-2
crate 1 adcm 1 adcu 0     # C-7-3
crate 1 adcm 1 adcu 4     # C-7-4
crate 1 adcm 2 adcu 0     # C-7-5
crate 1 adcm 2 adcu 4     # C-13-1
crate 1 adcm 3 adcu 0     # C-13-2
crate 1 adcm 3 adcu 4     # C-13-3
crate 1 adcm 4 adcu 0     # C-13-4
crate 1 adcm 4 adcu 4     # C-13-5
#
# Patch Box D ..............................................................
#
crate 1 adcm 5 adcu 0     # D-7-1
crate 1 adcm 5 adcu 4     # D-7-2
crate 1 adcm 6 adcu 0     # D-7-3
crate 1 adcm 6 adcu 4     # D-7-4
crate 1 adcm 7 adcu 0     # D-7-5
```

```
crate 1 adcm 7 adcu 4     # D-13-1
crate 1 adcm 8 adcu 0     # D-13-2
crate 1 adcm 8 adcu 4     # D-13-3
crate 1 adcm 9 adcu 0     # D-13-4

# ----------------------------\
# CRATE 2    Forward Wheels    ---------------------------------------------
# ----------------------------/

#
# Patch Box A ..............................................................
#
crate 2 adcm 0 adcu 0    # A-1-1
crate 2 adcm 0 adcu 4    # A-1-2
crate 2 adcm 1 adcu 0    # A-1-3
#
# Patch Box B ..............................................................
#
crate 2 adcm 1 adcu 4   # B-1-1
crate 2 adcm 2 adcu 0   # B-1-2
crate 2 adcm 2 adcu 4   # B-1-3
crate 2 adcm 3 adcu 0   # B-1-4
#
# Patch Box C ..............................................................
#
crate 2 adcm 3 adcu 4    # C-1-1
crate 2 adcm 4 adcu 0    # C-1-2
crate 2 adcm 4 adcu 4    # C-1-3
#
# Patch Box D ..............................................................
#
crate 2 adcm 5 adcu 0    # D-1-1
crate 2 adcm 5 adcu 4    # D-1-2
crate 2 adcm 6 adcu 0    # D-1-3
crate 2 adcm 6 adcu 4    # D-1-4

---------------------------------------------------------------------------
```