

BES IT LV DISTRIBUTION SYSTEM

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LV DISTRIBUTION SYSTEM MAIN FEATURES

The key points of the Low Voltage Distribution System are:

- 80 TIGER Boards and 22 GEM-ROC (DAQ) boards
- TIGER Board V/I requirements: 1.08A@1.4V and 0.32A@2.5V (about 200W for the full detector)
- GEMROC board V/I requirements: 1.1A@15V (about 400W for the full detector)

The system is divided in two sections:

- The main power supplies for both on-detector and off-detector electronics are located about 7 meters far from the GEMROC modules and are made up by:
 - A SY5527 BASIC (600W) mainframe with four A2519 to power the GEMROCs (32 channels, max 5 A/channel or 50 W/channel)
 - A SY5527 BASIC (600W) mainframe with three A2517 boards to power the TIGER boards (24 channels, max 5 A/channel or 50 W/channel)

- The TIGER boards supply chain that is made of three types of interconnections:
 - Main power supply – GEMROC modules that host the TIGER boards distribution section (7 m – four cores 13 AWG shielded cables);
 - GEMROC - DLVPC boards (10 m – four cores 17 AWG shielded cables)
 - DLVPC – TIGER boards (1 m – seven cores 24 AWG unshielded)

Single channel on/off and voltage/current monitor are managed by the Experiment Slow Control system.

TIGER BOARD REQUIREMENTS

The BES C-GEM IT Low Voltage distribution system has been designed to supply C-GEM Front End Electronics (TIGER Boards and GEMROC) allowing the monitoring of voltages and currents together with the capability of turn on/off single on-detector channel.

The detail of the voltage/current requirements for the Tiger Board and the GEMROC are summarized in Table 1 while Table 2 shows the current requirements for each IT layer of the on-detector front-end.

| ASIC BOARD V/I REQUIREMENTS | |
|--------------------------------|--------|
| 1,4 V (analog) | 1,08 A |
| 2,5 V (digital) | 0,32 A |
| GEM-ROC BOARD V/I REQUIREMENTS | |
| 15,0 V | 1.1A A |

Table 1: Tiger Board (2 chips – 128 channels) current requirements

| LAYER | BOARDS | I[1.4V Analog] A | I[2.5V Digital] A |
|-------|--------|------------------|--------------------|
| 1 | 16 | 17,28 | 5,12 |
| 2 | 28 | 30,24 | 8,96 |
| 3 | 36 | 38,88 | 11,52 |
| TOTAL | 80 | 86,4 | 25,6 |

Table 2: voltage and current requirements for each C-GEM tracking layer

ON-DETECTOR LV DISTRIBUTION BLOCK DIAGRAM

On-detector LV Distribution modularity has been chosen to match the A2517 features (Table 3) and the following front-end requirements:

- the total amount of Tiger boards (80)
- the number of power lines required by each board (analog/GND, digital/GND)
- the maximum number of channels available on each A2517 board (8 channels)
- the maximum A2517 single channel current delivering capability (15A)
- the A2517 board single channel maximum power dissipation (50W)

The best matching has been found using a single A2517 channel to supply four TIGER boards.

| A2517 - 8 Channel 5 V/15 A (50 W) Individual Floating Channel Boards |
|---|
| 8 independently controllable Low Voltage channels |
| Individual Floating Channel |
| Individual remote sense lines |
| Full Digital PID Control Loop |
| 8 pin D-Sub connectors |
| 1÷5 V output voltage with 1 mV set resolution |
| 15 A current full scale with 10 mA set resolution |
| 50 W Max channel output power |
| 1 mV Voltage Monitor resolution |
| 1 mA Current Monitor resolution |

Table 3: A2517 board main features

ON-DETECTOR LV BLOCK DIAGRAM

The on-detector LV Distribution system diagram is shown in Figure 1. Cables have been labelled according to the detector gas entering/exiting points (GIN and GOUT) and IT layer (see Appendix 1, Appendix 2, Appendix 3).

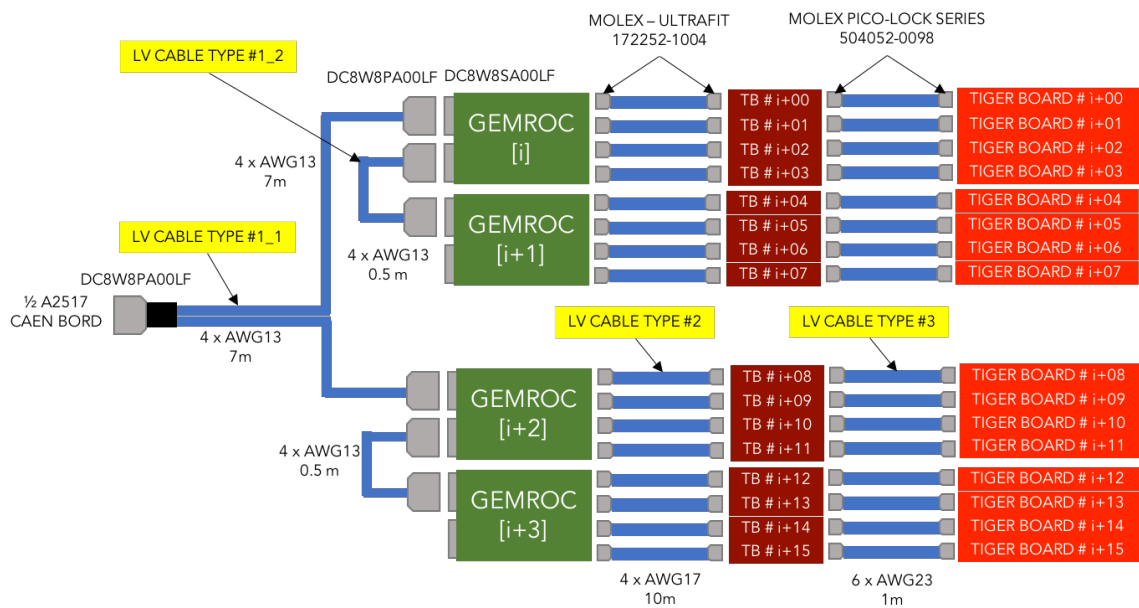


Figure 1: LV Distribution System block diagram

Two out of eight A2517 outputs are used to distribute power to two GEMROCS (that is eight TIGER board).

As can be inferred from Figure 1 in the LV distribution system there are 3 types of cables:

- the A2517 - GEMROC cable: 7 m of cable carrying (about) 9 A
- the GEMROC – DLVPC boards cable: 10 m of cable carrying (about) 1.1 A single (DLVPC boards are used to interconnect on/off detector electronics)
- the DLVPC boards – TIGER Board cable: about 1 m of cable carrying (at most) 1.1A

The first section of cables requires large area conductors to reduce voltage drop; moreover the cable connector must match the A2517 board connector and must be enough flexible to simplify routing. This section has been implemented using a couple of four conductor AWG13 shielded cables assembled on a single custom connector.

The second section of the cable connects one of the four LV distributor outputs available on each GEMROC to one DLVPC board. A four conductor AWG 17 shielded cable has been chosen to match the requirements.

The last section of the cable requires high flexibility to be routed in tight spaces, then an unshielded multicore AWG24 has been selected to power the single TIGER boards.

The main features of connectors and cables used in the system are summarized in Table 4 and Table 5 while Table 6 shows the chain voltage drop (about 2 V).

Finally Appendix 5, Appendix 6, Appendix 7 show the details of the cables used in the chain.

| A2517 - GEMROC connectors | | | | |
|---------------------------|----------------------------|--------------------------|-----------------------------------|--------|
| Company | PN | RS | Description | Number |
| Amphenol FCI | DC8W8PA00LF | 121-7449 | D-Sub Connector - Male contacts | 16 |
| RS | D-Sub RS Pro - 12 → 16 AWG | 301-6812 | Male contact | 96 |
| Amphenol FCI | DC8W8SA00LF | 542-7602 | D-Sub Connector - Female contacts | 24 |
| RS | D-Sub RS Pro - 12 → 16 AWG | 301-6828 | Female contact | 96 |
| Amphenol FCI | 8630CH37UNCLF | 740-1176 | Plastic gray connector cap | 40 |

| GEMROC - DLVPC boards connectors | | | | |
|----------------------------------|-------------|--------------------------|----------------------|--------|
| Company | PN | RS | Description | Number |
| Molex Ultra-Fit Connector | 172256-1004 | 895-1814 | 4 way connector | 176 |
| Molex Ultra-Fit Connector Contz | 172253-3023 | 895-1791 | copper alloy contact | 704 |

| DLVPC board - TIGER board connectors | | | | |
|--------------------------------------|-------------|--------------------------|---|--------|
| Company | PN | RS | Description | Number |
| Molex Pico-Lock Series | 504050-0691 | 789-8362 | 6 way connector | 192 |
| Molex Pico-Lock Series Contact | 504052-0098 | 789-8378 | Crimp Terminal, Female, 28AWG to 24AWG, | 1152 |

Table 4: LV distribution system connectors

| A2517 - GEMROC cable | | | | | |
|----------------------|---------------------|---------|--------------------------|--------|--|
| Company | Cable Type | PN | FARNELL/RS | Meters | |
| Lapp | 4 x AWG 13 Shielded | 1123342 | 719-1677 | 119 | |

| GEMROC - LV PATCH board cable | | | | | |
|-------------------------------|---------------------|---------|--------------------------|--------|--|
| Company | Cable Type | PN | FARNELL/RS | Meters | |
| LAPP KABEL | 4 x AWG 17 Shielded | 1123269 | 719-1658 | 880 | |

| LV PATCH board - TIGER board cable | | | | | |
|------------------------------------|---------------------|----------|--------------------------|--------|--|
| Company | Cable Type | PN | FARNELL/RS | Meters | |
| NEXANS | 7xAWG 24 Unshielded | 10038939 | 252-5214 | 96 | |

Table 5: LV distribution system cables

| AWG | Length [m] | Current [A] | Voltage Drop [V] | |
|---|------------|-------------|------------------|---------|
| 13 | 7 | 8,64 | 0,79 | ANALOG |
| 17 | 10 | 1,08 | 0,36 | |
| 24 | 1 | 1,08 | 0,18 | |
| 13 | 7 | 2,56 | 0,24 | DIGITAL |
| 17 | 10 | 0,32 | 0,11 | |
| 24 | 1 | 0,32 | 0,05 | |
| Total Cables Voltage Drop - Analog [V] | | | 1,34 | |
| Total Cables Voltage Drop - Digital [V] | | | 0,40 | |

Table 6: voltage drop

CONCLUSIONS

The IT LV system has been designed to power the BES C-GEM FEE minimizing the number of primary channels. The system allows to turn on/off the single ASIC board and monitor both voltages and currents. The chain is split in two sections: the main channels (located in the experimental area), and the distribution system (located near the detector). The total power delivered is about 200 W for the on-detector electronics and about 400 W for the off-detector electronics.

APPENDIX

SY5527 #1

| | | |
|---|----------------------|---------------------------------------|
| A2517 #1 [CH1-ANALOG & CH2-DIGITAL] | L1 - GIN - GR #1 #2 | L1 - GIN - GR #1 L1 - GIN - GR #2 |
| A2517 #1 [CH3-ANALOG & CH4-DIGITAL] | L2 - GIN - GR #3 #4 | L2 - GIN - GR #3 L2 - GIN - GR #4 |
| A2517 #1 [CH5-ANALOG & CH6-DIGITAL] | L2 - GIN - GR #5 #6 | L2 - GIN - GR #5 L2 - GIN - GR #6 |
| A2517 #2 [CH1-ANALOG & CH2-DIGITAL] | L3 - GIN - GR #7 #8 | L3 - GIN - GR #7 L3 - GIN - GR #8 |
| A2517 #2 [CH3 - ANALOG & CH4 - DIGITAL] | L3 - GIN - GR #9 #10 | L3 - GIN - GR #9 L3 - GIN - GR #10 |
| A2517 #2 [CH5 - ANALOG & CH6 - DIGITAL] | L3 - GIN - GR #11 | L3 - GIN - GR #11 |

SY5527 #2

| | | |
|---|----------------------|---|
| A2517 #1 [CH1-ANALOG & CH2-DIGITAL] | L1 - GOUT - GR #1 #2 | L1 - GOUT - GR #1 L1 - GOUT - GR #2 |
| A2517 #1 [CH3-ANALOG & CH4-DIGITAL] | L2 - GOUT - GR #3 #4 | L2 - GOUT - GR #3 L2 - GOUT - GR #4 |
| A2517 #1 [CH5-ANALOG & CH6-DIGITAL] | L2 - GOUT - GR #5 #6 | L2 - GOUT - GR #5 L2 - GOUT - GR #6 |
| A2517 #2 [CH1-ANALOG & CH2-DIGITAL] | L3 - GOUT - GR #7 #8 | L3 - GOUT - GR #7 L3 - GOUT - GR #8 |
| A2517 #2 [CH3 - ANALOG & CH4 - DIGITAL] | L3 - OUT - GR #9 #10 | L3 - GOUT - GR #9 L3 - GOUT - GR #10 |
| A2517 #2 [CH5 - ANALOG & CH6 - DIGITAL] | L3 - GOUT - GR #11 | L3 - GOUT - GR #11 |

Appendix I: labels cable type I_1 & I_2

SY5527 #1

| L1 - A2517 1C1 [CH1-ANALOG & CH2 -DIGITAL] | | | | |
|--|-------------------|-------------------|-------------------|-------------------|
| GEMROC #01 | L1 - GIN - LVP#01 | L1 - GIN - LVP#02 | L1 - GIN - LVP#03 | L1 - GIN - LVP#04 |
| GEMROC #02 | L1 - GIN - LVP#05 | L1 - GIN - LVP#06 | L1 - GIN - LVP#07 | L1 - GIN - LVP#08 |

| L2 - A2517 1C1 [CH3-ANALOG & CH2 DIGITAL] | | | | |
|---|-------------------|-------------------|-------------------|-------------------|
| GEMROC #03 | L2 - GIN - LVP#01 | L2 - GIN - LVP#02 | L2 - GIN - LVP#03 | L2 - GIN - LVP#04 |
| GEMROC #04 | L2 - GIN - LVP#05 | L2 - GIN - LVP#06 | L2 - GIN - LVP#07 | L2 - GIN - LVP#08 |
| L2 - A2517 1C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #05 | L2 - GIN - LVP#09 | L2 - GIN - LVP#10 | L2 - GIN - LVP#11 | L2 - GIN - LVP#12 |
| GEMROC #06 | L2 - GIN - LVP#13 | L2 - GIN - LVP#14 | | |

| L3 - A2517 2C1 [CH1-ANALOG & CH2-DIGITAL] | | | | |
|---|-------------------|-------------------|-------------------|-------------------|
| GEMROC #07 | L3 - GIN - LVP#01 | L3 - GIN - LVP#02 | L3 - GIN - LVP#03 | L3 - GIN - LVP#04 |
| GEMROC #08 | L3 - GIN - LVP#05 | L3 - GIN - LVP#06 | L3 - GIN - LVP#07 | L3 - GIN - LVP#08 |
| L3 - A2517 2C1 [CH3-ANALOG & CH4-DIGITAL] | | | | |
| GEMROC #09 | L3 - GIN - LVP#09 | L3 - GIN - LVP#10 | L3 - GIN - LVP#11 | L3 - GIN - LVP#12 |
| GEMROC #10 | L3 - GIN - LVP#13 | L3 - GIN - LVP#14 | L3 - GIN - LVP#15 | L3 - GIN - LVP#16 |
| L3 - A2517 2C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #11 | L3 - GIN - LVP#17 | L3 - GIN - LVP#18 | | |

SY5527 #2

| L1 - A2517 3C1 [CH1-ANALOG & CH2 -DIGITAL] | | | | |
|--|--------------------|--------------------|-----------------------|--------------------|
| GEMROC #12 | L1 - GOUT - LVP#01 | L1 - GOUT - LVP#02 | L1 - GOUT - LVP#03 | L1 - GOUT - LVP#04 |
| GEMROC #13 | L1 - GOUT - LVP#05 | L1 - GOUT - LVP#06 | L1 - GAS OUT - LVP#07 | L1 - GOUT - LVP#08 |

| L2 - A2517 3C1 [CH3-ANALOG & CH2-DIGITAL] | | | | |
|---|--------------------|--------------------|--------------------|--------------------|
| GEMROC #14 | L2 - GOUT - LVP#01 | L2 - GOUT - LVP#02 | L2 - GOUT - LVP#03 | L2 - GOUT - LVP#04 |
| GEMROC #15 | L2 - GOUT - LVP#05 | L2 - GOUT - LVP#06 | L2 - GOUT - LVP#07 | L2 - GOUT - LVP#08 |
| L2 - A2517 3C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #16 | L2 - GOUT - LVP#09 | L2 - GOUT - LVP#10 | L2 - GOUT - LVP#11 | L2 - GOUT - LVP#12 |
| GEMROC #17 | L2 - GOUT - LVP#13 | L2 - GOUT - LVP#14 | | |

| L3 - A2517 4C1 [CH1-ANALOG & CH2-DIGITAL] | | | | |
|---|--------------------|--------------------|--------------------|--------------------|
| GEMROC #18 | L3 - GOUT - LVP#01 | L3 - GOUT - LVP#02 | L3 - GOUT - LVP#03 | L3 - GOUT - LVP#04 |
| GEMROC #19 | L3 - GOUT - LVP#05 | L3 - GOUT - LVP#06 | L3 - GOUT - LVP#07 | L3 - GOUT - LVP#08 |
| L3 - A2517 4C1 [CH3-ANALOG & CH4-DIGITAL] | | | | |
| GEMROC #20 | L3 - GOUT - LVP#09 | L3 - GOUT - LVP#10 | L3 - GOUT - LVP#11 | L3 - GOUT - LVP#12 |
| GEMROC #21 | L3 - GOUT - LVP#13 | L3 - GOUT - LVP#14 | L3 - GOUT - LVP#15 | L3 - GOUT - LVP#16 |
| L3 - A2517 4C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #22 | L3 - GOUT - LVP#17 | L3 - GOUT - LVP#18 | | |

Appendix 2: labels cable type #2

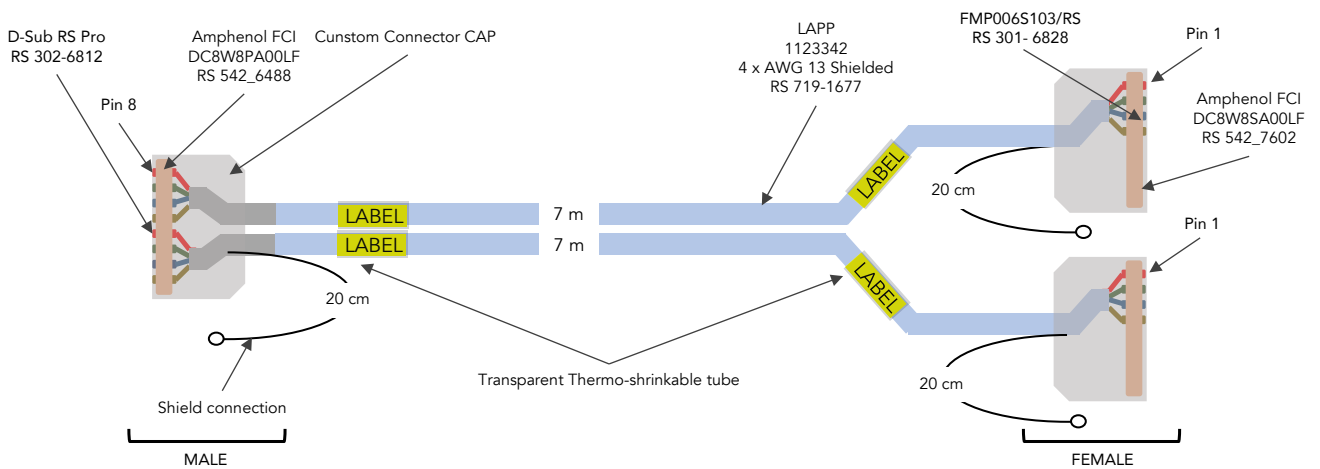
SY5527 #1

| L1 - A2517 1C1 [CHI-ANALOG & CH2-DIGITAL] | | | | |
|---|------------------------|------------------------|------------------------|------------------------|
| GEMROC #01 | L1 - GAS IN - TIGER#01 | L1 - GAS IN - TIGER#02 | L1 - GAS IN - TIGER#03 | L1 - GAS IN - TIGER#04 |
| GEMROC #02 | L1 - GAS IN - TIGER#05 | L1 - GAS IN - TIGER#06 | L1 - GAS IN - TIGER#07 | L1 - GAS IN - TIGER#08 |
| L2 - A2517 1C1 [CH3-ANALOG & CH2-DIGITAL] | | | | |
| GEMROC #03 | L2 - GIN - TIGER#01 | L2 - GIN - TIGER#02 | L2 - GIN - TIGER#03 | L2 - GIN - TIGER#04 |
| GEMROC #04 | L2 - GIN - TIGER#05 | L2 - GIN - TIGER#06 | L2 - GIN - TIGER#07 | L2 - GIN - TIGER#08 |
| L2 - A2517 1C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #05 | L2 - GIN - TIGER#09 | L2 - GIN - TIGER#10 | L2 - GIN - TIGER#11 | L2 - GIN - TIGER#12 |
| GEMROC #06 | L2 - GIN - TIGER#13 | L2 - GIN - TIGER#14 | | |
| L3 - A2517 2C1 [CHI-ANALOG & CH2-DIGITAL] | | | | |
| GEMROC #07 | L3 - GIN - TIGER#01 | L3 - GIN - TIGER#02 | L3 - GIN - TIGER#03 | L3 - GIN - TIGER#04 |
| GEMROC #08 | L3 - GIN - TIGER#05 | L3 - GIN - TIGER#06 | L3 - GIN - TIGER#07 | L3 - GIN - TIGER#08 |
| L3 - A2517 2C1 [CH3-ANALOG & CH4-DIGITAL] | | | | |
| GEMROC #09 | L3 - GIN - TIGER#09 | L3 - GIN - TIGER#10 | L3 - GIN - TIGER#11 | L3 - GIN - TIGER#12 |
| GEMROC #10 | L3 - GIN - TIGER#13 | L3 - GIN - TIGER#14 | L3 - GIN - TIGER#15 | L3 - GIN - TIGER#16 |
| L3 - A2517 2C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #11 | L3 - GIN - TIGER#17 | L3 - GIN - TIGER#18 | | |

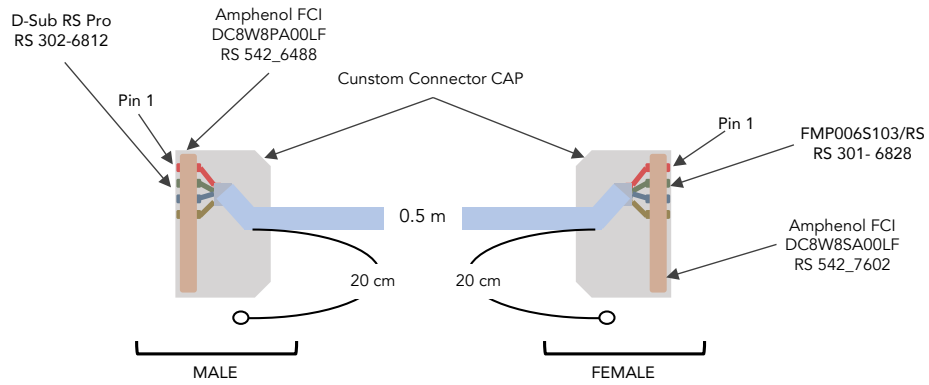
SY5527 #2

| L1 - A2517 3C1 [CHI-ANALOG & CH2-DIGITAL] | | | | |
|---|----------------------|----------------------|----------------------|----------------------|
| GEMROC #12 | L1 - GOUT - TIGER#01 | L1 - GOUT - TIGER#02 | L1 - GOUT - TIGER#03 | L1 - GOUT - TIGER#04 |
| GEMROC #13 | L1 - GOUT - TIGER#05 | L1 - GOUT - TIGER#06 | L1 - GOUT - TIGER#07 | L1 - GOUT - TIGER#08 |
| L2 - A2517 3C1 [CH3-ANALOG & CH2-DIGITAL] | | | | |
| GEMROC #14 | L2 - GOUT - TIGER#01 | L2 - GOUT - TIGER#02 | L2 - GOUT - TIGER#03 | L2 - GOUT - TIGER#04 |
| GEMROC #15 | L2 - GOUT - TIGER#05 | L2 - GOUT - TIGER#06 | L2 - GOUT - TIGER#07 | L2 - GOUT - TIGER#08 |
| L2 - A2517 3C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #16 | L2 - GOUT - TIGER#09 | L2 - GOUT - TIGER#10 | L2 - GOUT - TIGER#11 | L2 - GOUT - TIGER#12 |
| GEMROC #17 | L2 - GOUT - TIGER#13 | L2 - GOUT - TIGER#14 | | |
| L3 - A2517 4C1 [CHI-ANALOG & CH2-DIGITAL] | | | | |
| GEMROC #18 | L3 - GOUT - TIGER#01 | L3 - GOUT - TIGER#02 | L3 - GOUT - TIGER#03 | L3 - GOUT - TIGER#04 |
| GEMROC #19 | L3 - GOUT - TIGER#05 | L3 - GOUT - TIGER#06 | L3 - GOUT - TIGER#07 | L3 - GOUT - TIGER#08 |
| L3 - A2517 4C1 [CH3-ANALOG & CH4-DIGITAL] | | | | |
| GEMROC #20 | L3 - GOUT - TIGER#09 | L3 - GOUT - TIGER#10 | L3 - GOUT - TIGER#11 | L3 - GOUT - TIGER#12 |
| GEMROC #21 | L3 - GOUT - TIGER#13 | L3 - GOUT - TIGER#14 | L3 - GOUT - TIGER#15 | L3 - GOUT - TIGER#16 |
| L3 - A2517 4C2 [CH5-ANALOG & CH6-DIGITAL] | | | | |
| GEMROC #22 | L3 - GOUT - TIGER#17 | L3 - GOUT - TIGER#18 | | |

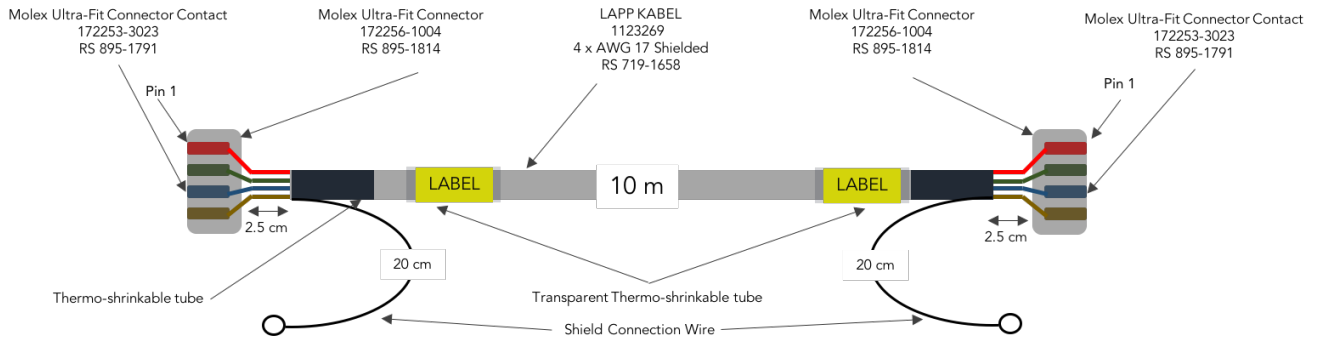
Appendix 3: labels cable type 1_2



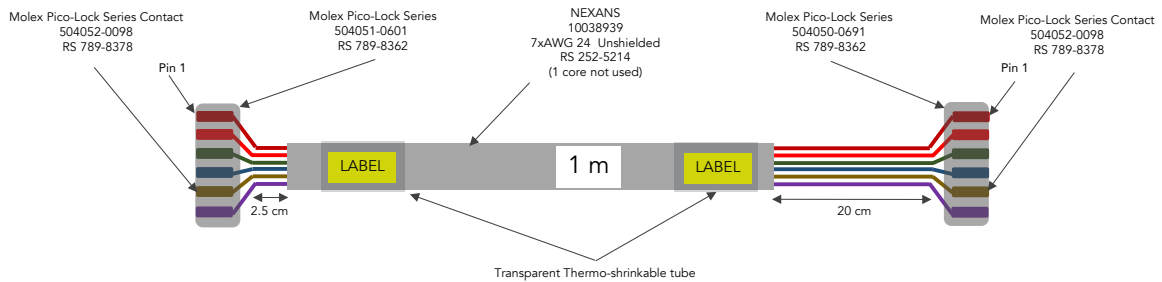
Appendix 4: Type 1_2 cable



Appendix 5: cable type 2



Appendix 6: cable type 3



Appendix 7: cable type 5