CDR of the

Wire Scanner Acquisition System

Safety Information

Author	Checked by – date	Approved by – date
Mario Ferianis		
Raffaele De Monte		
Sandi Grulja		

Table of Contents

1. Introduction

According to the current EU laws, regarding the electrical safety, the electrical supply systems can be classified as per Table 1.

IEC voltage range	AC (V_{rms})	DC (V)	Defining risk
High voltage (supply system)	> 1000	> 1500	Electrical arcing
Low voltage (supply system)	50–1000	120–1500	Electrical shock
Extra-low voltage (supply system)	< 50	< 120	Low risk

Table 1 –Classification of electrical supply systems

1.1. Purpose of this document

In this documents, the recommended safety precautions to avoid the risk of injuries to the personnel and/or damages to the equipment are presented.

The safety rules, directives and standards that have been applied to the Wire Scanner Acquisition System to be used for the wire scanners on the ESS accelerator has been presented in detail in [1].

As a reminder, the EU directives are here listed in the following Table 2.

EU Directive	
2006/42/EC	Machinery's essential health and safety requirements
2006/95/EC	Low Voltage Directive
2004/108/EC	EMC emission and immunity
2011/65/EU	RoHS Restriction of Hazardous Substances in Electrical and Electronic Equipment

Table 2 – list of EU Directives

A DoC (Declaration of Conformity) for the WSAS is requested to acknowledge the compliance to the IEC standard and the 2006/95/CE rule

1.2. References

[1] WS ACQUISITION SYSTEM SAFETY AND STANDARDS, PDR-1 WSACQ SAFETY 2016_06_28

2. System description

From the electrical safety stand point, the WS Acquisition System is composed of different hardware (HW) modules and μ-TCA COTS boards. The hardware modules are partially located in the accelerator tunnel and partially in dedicated diagnostic racks in the service gallery. The μ-TCA boards are all housed in dedicated diagnostic racks.

The HW modules along with the safety relevant information are listed in Table 3.

Considering that all voltages generated by are lower than 120 VDC, we can conclude that all in-house developed hardware modules of the WS ACQ SYS are classified as Extra Low Voltage (ELV) supply systems.

item	location	power supply voltage	PS source	generated voltages / amps / to	Extra Low Voltage
AFE	MEBT/ tunnel	+/- 5V	BE	<100V DC / 1mA / wire	yes
BE	service gallery	220V AC	mains	+5V / AFE 100V DC / wire	yes
OFE	service gallery	+/- 5V	BE	none	yes
BE_{mod}	service gallery	220V AC	mains	+5V / OFE 120V DC / wire	yes

Table 3 – list of in-house developed hardware modules for the WS ACQ SYS

2.1. The AFE power supply system

The AFE is a ELV module and it is powered directly from the BE (figure 1). Also the high voltage (<120 V DC) needed to polarize the wire is generated inside the BE.

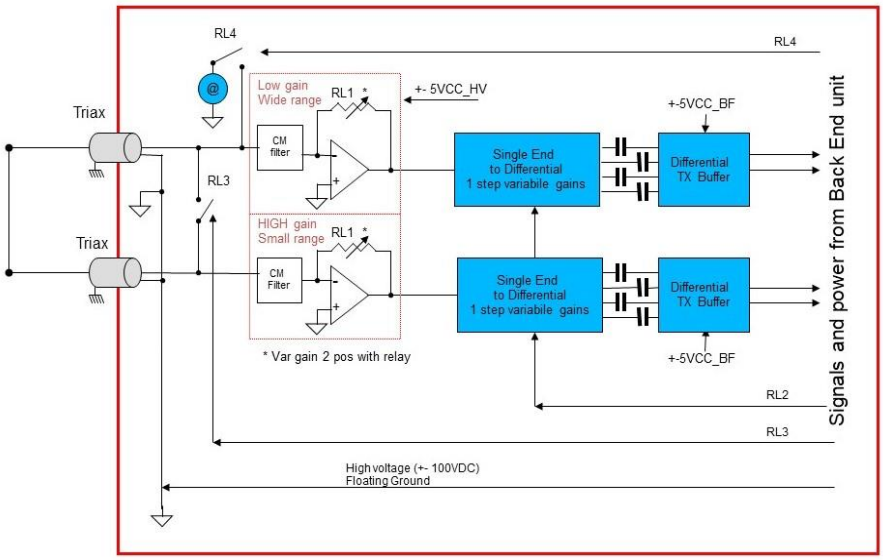

Figure 1 Block diagram of the AFE with power supply and wire polarizing voltages

2.2. The BE power supply scheme

The power supply scheme of the BE is shown in figure 2. As previously mentioned the BE acts as a generator for all the voltage used by the AFE in such a way to keep all power supplies outside the machine tunnel.

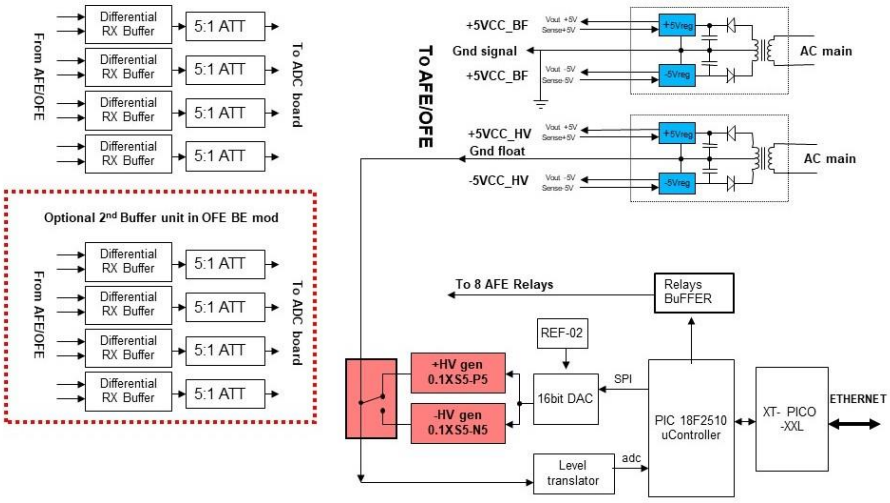

Figure 2 Block diagram of the BE with all the generated voltages;
in the red dotted box, the circuitry fitted to the BE modified is shown.

The high voltage needed for the wire polarization is generated by two monolithic high voltage generators from Ultravolt. The XS Series (specifications in Table 4) of extra-small high-voltage power supplies is the smallest regulated DC-DC high-voltage power supply for applications that require a bias voltage ranging from 0 to 100V. The output current is limited by 1 mA. The voltage output is controlled by a PIC microcontroller that drive a 16 bit DAC that drive the DC-DC high voltage converter.

PARAMETER	SPECIFICATION	UNITS
Input voltage Vin (pins 1 & 2)	5VDC ±0.5 (recommended) maximum: 12Vdc (reverse: -0.2V)	VDC
Input current	For 0V output voltage: <1.6 For 100V, no load: <3 At full output voltage, full load: <50	mA
HV output Vout (pin 4)	0 to 100 programmable	VDC
Output Power	**0 to 100**	**mW**
Polarity	Fixed positive or negative	-
HV setting (pin 3)	Via external voltage source 0/2.5V Accuracy: ±2% at full scale	-
Max. output current Iout	**1 nominal**	**mA**
Load voltage regulation	±0.01% of full output voltage for no load to full load	-
Line voltage regulation	±0.01% of full output voltage over specifed input voltage range	-
Residual ripple	<50mV peak-to-peak – ripple can be reduced to less than 10mV by adding an external 100nF small CMS capacitor	-
Temperature coeffcient	<50	PPM/°C
Output HV monitoring	Not available on this product	-
Output reference voltage	Not available on this product	-
HV power ON/OFF	Not available on this product	-
Operating temperature	-10 to +65, Full load, Max Eout, Case Temp	°C
Storage temperature	-10 to +70	°C
Safeguards	**Output current internally limited** **Soft start feature: low overshoot**	-
Shielding	Ground return is to metal enclosure	-

Table 4 characteristics of the XS high voltage module

In figure 3 a top view of the BE printed circuit board, with all power sources, is shown.

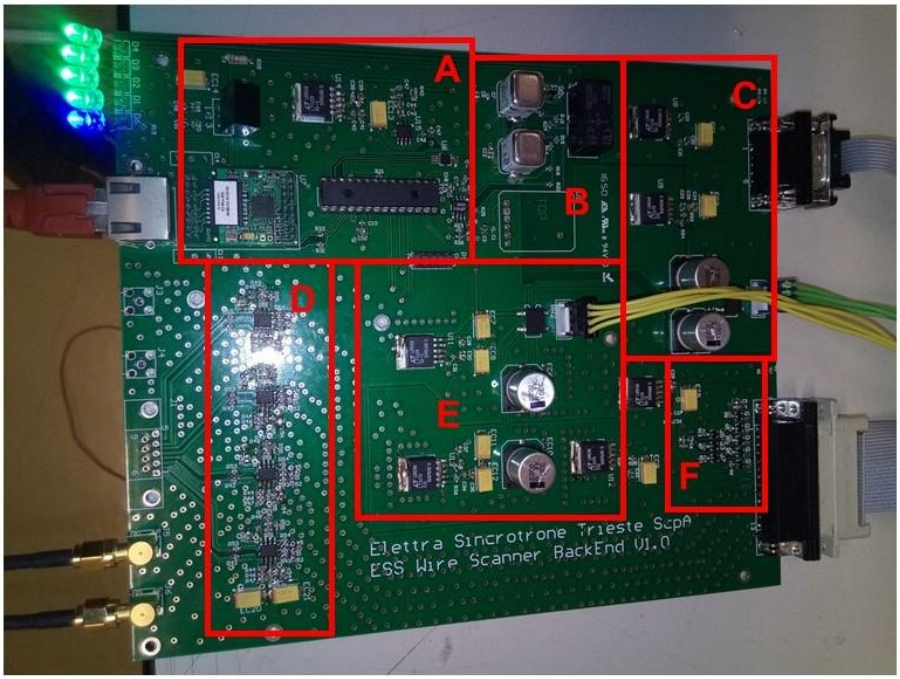

Figure 3 Top view of the BE PCB with all power sources;
A: PIC controller; B: High Voltage for wire polarization; C: floating +/- 5V; D: line receiver; E: non floating /-5V; F: relay driver.

In addition, for safety purposes, a 120VDC/1W Zener diode has been mounted in parallel to the line: any possible issue with software / hardware is prevented, avoiding any possibility of injury.

2.3. The OFE power supply scheme

High Voltage units are encapsulated in a tinned steel case with mounting tabs. The case and tabs are internally connected to the input power return and soldered to the system ground plane. In Table 5 the power supply specs of the OFE are shown.

Main power supply (BEmod)	-5	+5	+- 5%	VDC
Main current max	-100	+200	--	mA
Bias High Voltage (BE) input	+5	--	±0.5 0V to max +120V	VDC
Input Current Inhibition mode:	< 5	--	at full output voltage, full load	mA
Output Voltage	0 to 200	--	--	VDC
Output Current	500	--	--	µA

Table 5 OFE power supply specifications

The HV is for APD photo detector biasing that comes from modified BE unit via double shielded and twisted pair cable terminated by DSUB 9 Female connector to avoid any person, who operate with it, any accidental contact. For the same reason all cables terminations come with DSUB Female connectors and their Front End sockets are Male type when cables part connector connected to them pins are closed and covered.

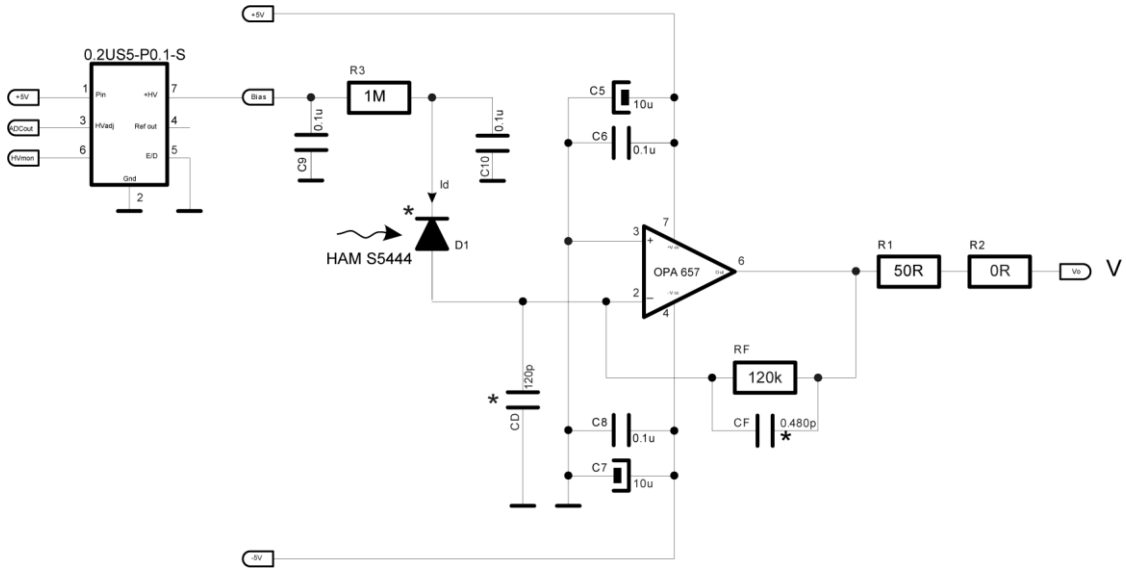

Figure 4 High Voltage power supply to the APD photo diode thru DSUB 9 connector

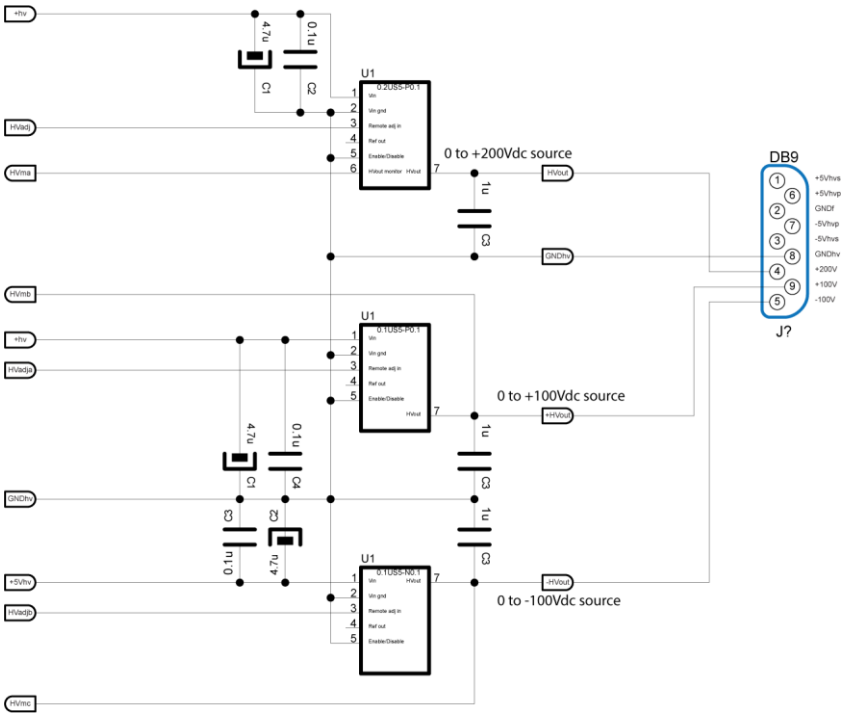

Figure 5 HV supply for APD photo diode in BE unit

Main power supply for rest of electronic circuit of OFE unit (figure 6) are delivered to OFE through double shielded and twisted pairs cable terminated by DSUB 25 Female connector.

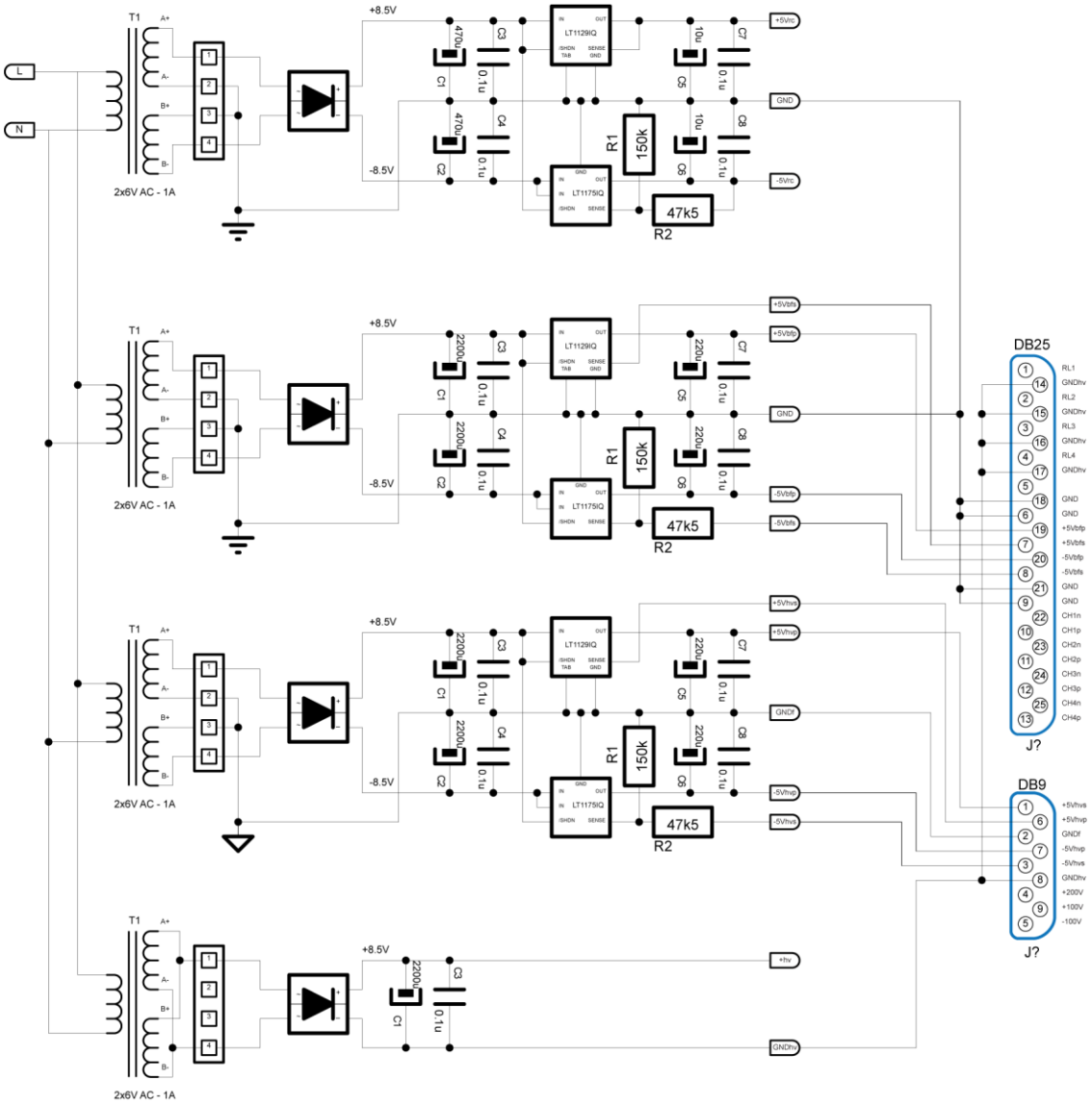

Figure 6 Schematic of main power supply for OFE in BE unit

3. Injury and Damage Precautions

As per previous paragraphs, given the ELV classification of the WS ACQ SYS hardware modules, there are no particular electrical safety rules to be followed when operating them.

The normal rules for operating electrical systems powered from mains using double isolation apply.

The HW modules (AFE, OFE, BE and BE_{mod}) have to be used only for the purpose they have been designed and built for; to avoid any hazard, use the product only as specified.

The following safety precautions must be observed during all phases of operation, service and repair of this equipment. Failure to comply with the safety precautions or warnings in this document violates safety standards of design, manufacture and intended use of this equipment and may impair the built-in protections.

- Do Not Operate Without Covers.
- To avoid electric shock or fire hazard, do not operate the HW modules with covers or panels removed.
- Do Not Operate the HW modules in Wet/Damp Conditions.
- Do not operate the HW modules in an explosive atmosphere.
- Do Not Operate with suspected failures.

3.1. Grounding

To minimize shock hazard, the HW modules must be connected to an electrical ground, when provided.
The ground terminal is present on the mains sockets on the BE and BE_{mod} modules.

3.2. Input ratings

Do not use AC supply that exceeds the input voltage and frequency rating of the BE and BE mod modules. Refer to relevant manuals.

3.3. Output connectors

Do not plug or unplug output connectors when HW modules are powered.

3.4. Color Codes

The push buttons and led colors shall have the following meaning and standard:

- RED Emergency, fault
- ORANGE Warning
- YELLOW Abnormal condition
- GREEN Normal, safe operation, clear to proceed

3.5. Protection Types

According to the IEC/EN 60529 the electrical equipment's enclosure and covers shall have an Ingress Protection IP2x, protection against contact with live parts with a finger. The second numeral shall be chosen after the evaluation of any

water or steam leak risk. However, no harmful effect shall occur in case of any type of accidental contact of the cooling water with the enclosures.

3.6. Material

All polymer material and cable's insulator shall be halogen free, flame retarding and shall not release any toxic or corrosive products when subjected to fire.

3.7. Rating plate

An easily visible rating plate shall be attached to the main cabinet as well as to individual devices and any associated circuits displaying, in English, electrical parameters.

3.8. Marking

All external terminals and connectors shall be clearly identified by a durable label. Marking on the drawings shall correspond with those in the equipment. All wires shall be clearly identified by a durable label or coding scheme. Wiring labels or coding shall appear on the diagrams such that it is easy to follow the circuit on the drawings as well as in the equipment.