VERY LARGE TELESCOPE

TECHNICAL REPORT
ESO Adaptive Optics System
MACAO-VLTI Electronics – APD

Doc. No. VLT-TRE-ESO-15600-2269
Issue 2.0

Date 06-Mar-2001

	Name	Date	Signature
Prepared :	R. Reiss	06-03-01	.
Approved :	J. Brynnel		.
Released :	N. Hubin		.

Change Record

Issue/Rev	Date	Section/Page affected	Reason
1	22-09-00	All	First issue
2	06-03-01	All	Revised for FDR

1 Introduction

1.1 Purpose

1.2 Scope

This document describes APD electronics components for the Macao Adaptive Optics system, namely the APD power supply, the APD junction box and line drivers, the APD interlocks and the electronics racks for the APD counter modules. The Figure 1.1shows a simplified block diagram.

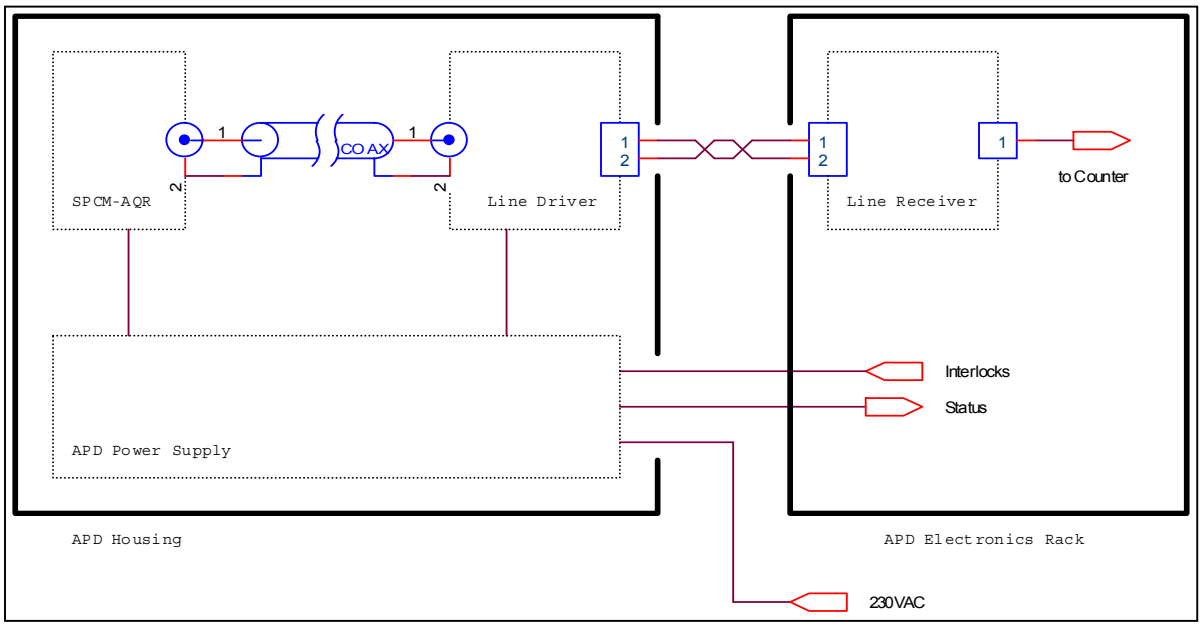


Figure 1.1

1.3 Applicable Documents

- [AD1] VLT-SPE-ESO-10000-0015 VLT Electronic Design Specifications
- [AD2] VLT-SPE-ESO-10000-0002 EMC and power quality specification - Part 1.
- [AD3] VLT-SPE-ESO-10000-0003 EMC and power quality specification - Part 2.
- [AD4] VLT-TRE-ESO-15600-2251 MACAO for VLTI System Overview
- [AD5] VLT-SPE-ESO-15600-2082 Top Level Requirements for MACAO-VLTI
- [AD6] VLT-SPE-ESO-15600-2061 MACAO-VLTI Software Functional Specification - OS/ICS
- [AD7] VLT-SPE-ESO-15600-2062 MACAO-VLTI Software Functional Specification: RTC
- [AD8] VLT-TRE-ESO-15600-2268 MACAO-VLTI Electronics - Overview

1.4 Reference Documents

- [RD1] ESO Adaptive Optics System APD Counter Module (VLT-SPE-ESO-11640-. . . . Issue 1.0)

1.5 Acronyms

RD	Reference Document
AIT	Assembly, Integration and Tests
AO	Adaptive Optics
APD	Avalanche Photo Diode

ASM	Atmospherical Site Monitor
BOB	Broker of Observation Blocks
CCS	Central Control Software
CWFS	Curvature Wavefront Sensor
DM	Deformable Mirror
ESO	European Southern Observatory
FITS	Flexible Image Transport System
FOV	Field of View
HO	High Order
HW	Hardware
ICS	Instrument Control Software
ICD	Interface Control Document
IR	Infrared (1.0-2.2μm)
ISS	Interferometer Supervisor Software
LCU	Local Control Unit
LOS	Line of Sight, the seeing in the direction that the scope is looking
MACAO	Multiple Applications Curvature Adaptive Optics
Mas	Milli arcsec on the sky
ND	Neutral Density filter
NGS	Natural Guide Star (a point source < 0.2” in size)
OB	Observation Block
OLDB	Online Database
OS	Observing Software
PSF	Point Spread Function
STRAP System	for Tip-tilt Removal with Avalanche Photodiodes
SW	Software
TBC	To Be Confirmed
TBD	To be determined
TRS	Time Reference System
UT	Unit Telescope (8.2-m diameter)
VLT	Very Large Telescope
VLTI	VLT Interferometer
WFE	Wavefront Error
WFS	WaveFront Sensor
WRT	with respect to
WS	Workstation

2 Electronics Design

2.1 APD Modules

The APD modules selected for Macao-VLTI are Perkin Elmer SPCM-AQR. The data sheet can be found in Appendix A.

2.2 APD Power Supply

A single APD module draws a maximum current of 2A at 5V as specified in the SPCM-AQR data sheet. The total maximum current which has to be supplied adds up to a total of 120A.

The power consumption of one sample SPCM-AQR module has been measured in the lab to check the values of the data sheet. Table 1shows the results obtained:

Condition	Current [A]	Remarks
t = 0	1.27	power up
t >= 120s	0.48	after warm up
t >= 120s (dark count)	0.48	'dark' consumption
t >= 120s (500kHz)	0.56	'light' consumption

Table 1

According to experts from Perkin Elmer the maximum current flow occurs at high count rates and elevated case temperatures mainly due to the characteristics of the peltier elements within the APD modules. For the Macao application the count rate will not reach the maximum of 5MHz and the water cooling of the APD modules guarantees fairly low case temperatures.

A power supply with 230VAC input and 5VDC output using Vicor DC/DC converter and auto ranging rectifier modules has been designed. The nominal power output is 800W @ 5V and is well above the peak power consumption of 10W per APD module as specified in the data sheet. Two DC/DC converters with 400W each are used in a semi-redundant configuration. Failure of one DC/DC module has virtually no impact to operation except for a possibly longer start up time of the APD array. Each DC/DC module delivers a 'Power Good' signal. Failure of one or both modules is detectable by SW.

There is a two stage protection (varistor, gas discharge tubes) against mains conducted over voltage transients. An additional over voltage protection will be provided by crow bar modules located directly at the 5V power distribution.

The power supply will be placed directly inside the APD cabinet to keep the high current 5V connections as short as possible. To dissipate the generated heat the DC/DC and rectifier modules will be directly attached to a water cooled plate inside the APD cabinet.

The schematic of the APD power supply can be found in Appendix C.

2.3 APD Junction Box and Line Driver Interface

The APD modules generate a 25ns TTL pulse for each photon detected. The TTL pulses are fed by coax cables to a junction box within the APD housing to simplify wiring, interconnection and handling of the various components. The APD junction box will be used to convert the 60 coax signals into 60 differential signal pairs with line driver circuits. The connection to the counter modules will be done with two off-the-shelf 68-pin Wide-SCSI cables. Figure 2.1 shows a simplified schematic of the line driver and line receiver. The advantage of the this solution is not only a simplified handling but also an increased noise immunity and lower EM emission levels.

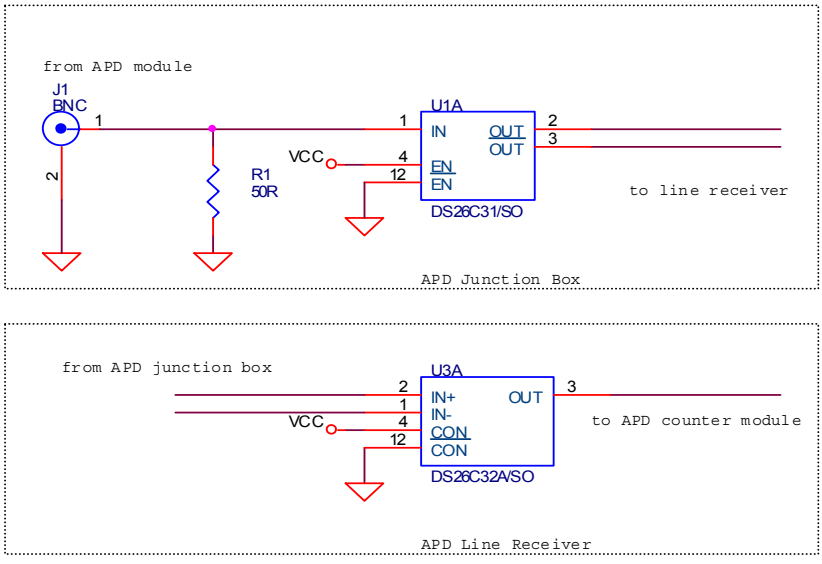


Figure 2.1

A detailed schematic of the line driver is shown in Appendix E.

2.4 APD Counter Module

The specification of the counter modules can be found in [RD1]. A price inquiry was sent out to potential suppliers in August, 2000. Shakti was selected as supplier and awarded a contract in December, 2000. The counter module is located inside the RTC rack.

2.5 Interface to RTC
Defined in [RD1].

2.6 Interlocks
There is a risk of physical damage to the APDs if exposed to excessive illumination. To avoid this risk there are safety features at software and hardware level. Additional risks are a rise of APD module case temperature caused by a cooling failure.

In software the current count rate is constantly monitored by the RTC and the protective shutter closed and the filter wheel is placed at its blocking position when the APD counts exceed a safety threshold. A hardware interlock is implemented within the APD counter modules that monitors the count rate of several APDs. If the count rate goes above a safety threshold, power to the APD modules is shut off.

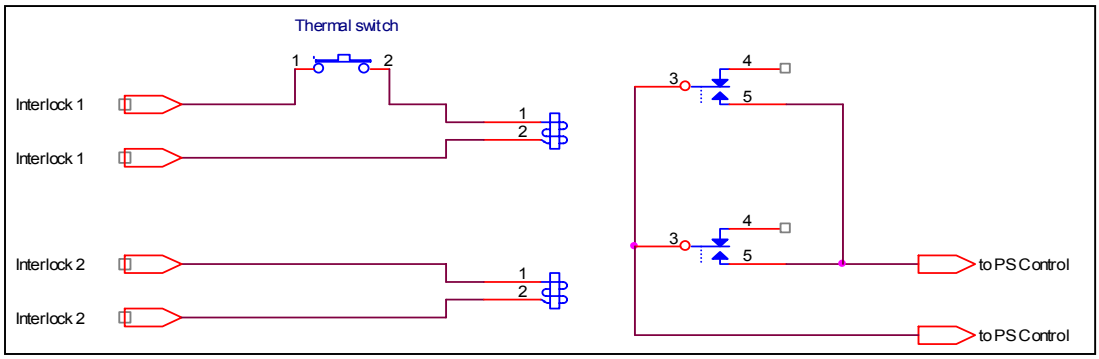


Figure 2.2

Two interlock relays are located on the APD power supply module. In order to turn on power both relays must be powered by the counter module and the RTC respectively. The interlock signals must be able to drive a relay of type Siemens V23042-DPDT or equivalent.

In addition to these two interlock signals a normally closed temperature switch is located physically on the cooling plate and electrically in series with one of the interlock relays. If the cooling plate temperature exceeds 70 deg. C power will be shut off.

It is further possible to add a flow control switch in the same way if desired. Figure 2.2 shows the simplified interlock concept. Detailed schematics of the interlock relays can be found in Appendix C.

2.7 APD Counter Electronics Rack
The APD counter is realised as a single VMEbus compatible board and is plugged into the RTC LCU which is located inside the MACAO cabinet 1.

3 Interface Design

3.1 Connectors

3.1.1 Fiber Connectors
For fiber interface connectors, refer to [RD1]

3.1.2 APD Connectors
Sixty 50 Ohms BNC cables from the APD modules to junction box. Two 68-pin Mini-SCSI connectors on both the APD line driver and the APD counter board. Recommended connector type is Thomas & Betts HFR068RA29JSI. Cables are of the off-the-shelf available Fast Wide SCSI type.

3.1.3 Interlock Connectors

Sub-D 15-pin male connector on the APD power supply and electronics rack. See details in Appendix D.

3.1.4 Power Connectors

There are 2 times 4 FASTON 6.3mm connectors on APD power supply to conenct the 5V power with 4 cable pairs to 4 bipolar Schroff power bars inside the APD cabinet. The power cables of each individual APD module are then connected to the most convenient power bar.

4 Mechanical Design

4.1 APD Power Supply

Located inside APD cabinet. See Appendix B for a mechanical drawing of the cooling plate prototype and appendix C for a complete schematic diagram.

The first version of the prototype failed early during lab tests, most likely due to thermal and/or electrical overload of the front end recitifier and auto ranging module (Vicor ARM). The design was changed to a stronger version of the ARM, some component values were also changed. In particular the capacity of the buffer capacitors was increased by a factor of 3.

The revised power supply was tested in the lab for an extended period (in total two weeks) and all critical points were checked with the appropiate equipment. The output voltage was stable up to a load of 40A (limited by the electronic load). A dynamic load test was performed using a load current toggling at 1kHz between 10A and 30A. The test passed flawlessly and showed no areas of concern.

The prototype power supply is now mounted in the APD cabinet and is used for lab tests.

The final version of the APD power supply and/or cabling of the APD cabinet will be equipped with additional crow bar switches which will trigger in the case of an elevated voltage level to protect the APD modules.

The issue of 'brown out' (output voltage degradation during mains power failure) will be studied and if necessary appropriate protective circuitry will be added.

4.2 APD Junction Box and Line Drivers

Located inside APD housing.

5 Project Status

5.1.1 APD Power Supply

- prototype schematics revised
- revised prototype assembled and tested
- prototype cooling plate delivered and assembled

5.1.2 APD Junction Box

- protoype design finished
- test of single channel prototype completed

5.1.3 APD Counter Boards

- Contract awarded to Shakti.

__oOo__

A. Perkin Elmer SPCM-AQR Series Datasheet

EG&G®

Single Photon Counting Module
SPCM-AQR Series

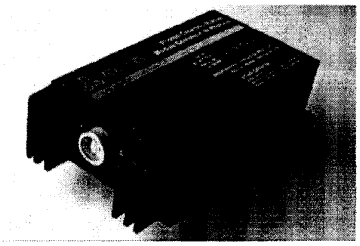
Description

The SPCM-AQR is a self-contained module which detects single photons of light over the wavelength range from 400 nm to 1060 nm ... a range and sensitivity which often outperforms photomultiplier tubes.

The SPCM-AQR-1X utilizes a unique silicon avalanche photodiode which has a circular active area whose peak photon detection efficiency over a 180 mm diameter exceeds 70% at 630 nm. If a bigger detection area is required, the SPCM-AQR-2X has a peak photon detection efficiency over a 475 mm diameter that exceeds 35% at 630 nm. The photodiode is both thermoelectrically cooled and temperature controlled, ensuring stabilized performance despite changes in the ambient temperature.

The SPCM-AQR module utilizes an improved "active quench" patent pending circuit which can count to speeds exceeding 10 million counts per second for the SPCM-AQR-1X and 7 million counts per second for the SPCM-AQR-2X. There is a "dead time" of 40 ns between pulses and single photon arrival can be measured with an accuracy of 300 ps FWHM.

The SPCM-AQR requires a +5 volt power supply (a mating cable is supplied with each module). A TTL pulse, 2.5 volts high in a 50 Ω load and 25 ns (SPCM-AQR-1X) or 65 ns (SPCM-AQR-2X) wide, is output at the rear BNC connector as each photon is detected. To avoid a degradation of the module linearity and stability, the case temperature should be kept between 5° C and 40° C during operation.



Features

- Peak Photon Detection Efficiency @ 630 nm:
  SPCM-AQR-1X: 70% TYPICAL
  SPCM-AQR-2X: 35% TYPICAL
- Active Area:
  SPCM-AQR-1X: ≥ 170 mm
  SPCM-AQR-2X: ≥ 425 mm
- Timing Resolution of 300ps FWHM
- User Friendly

Applications

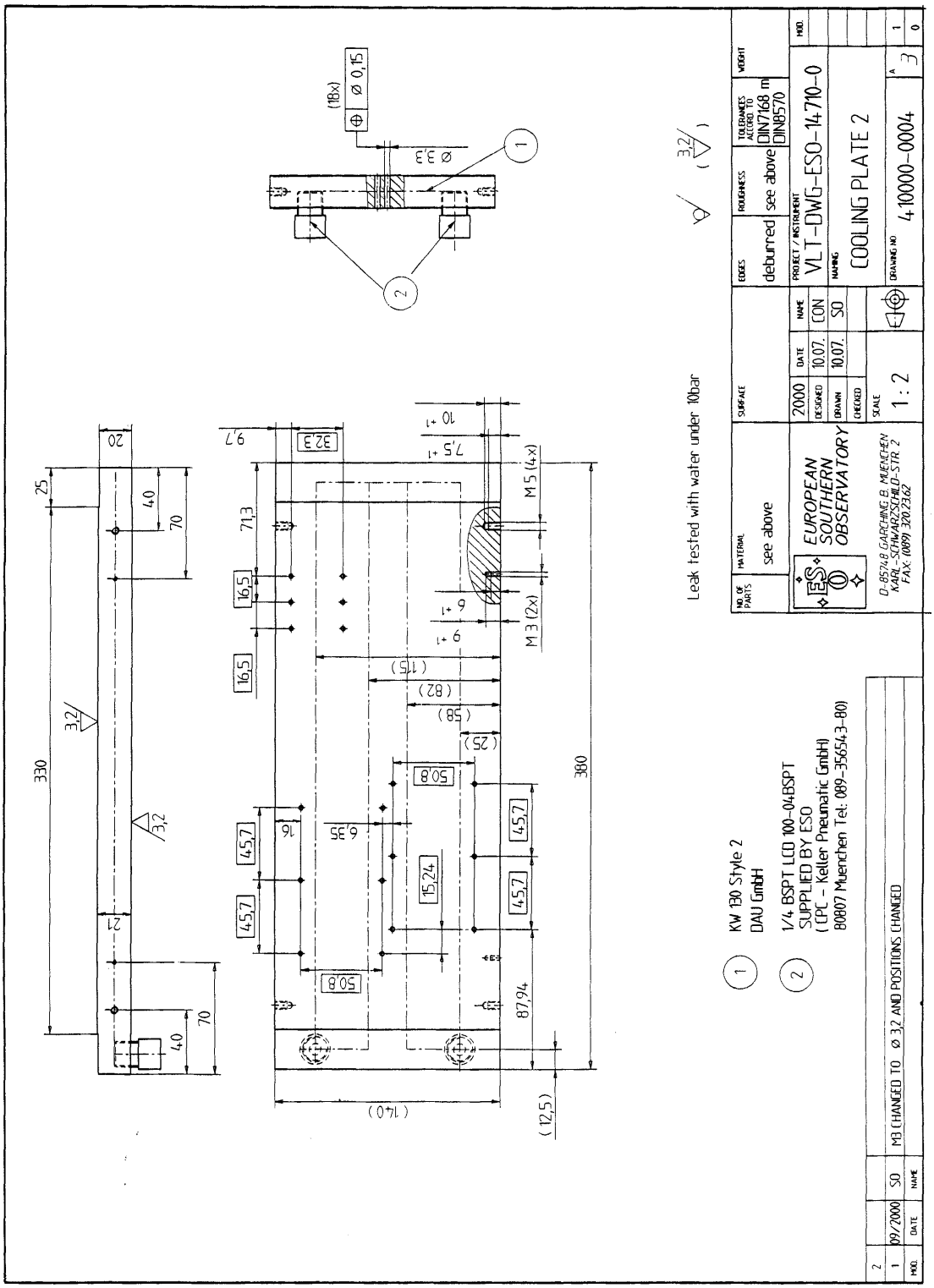
- LIDAR
- Photon Correlation Spectroscopy
- Astronomical Observations
- Optical Range Finding
- Adaptive Optics
- Ultra Sensitive Fluorescence
- Particle Sizing

EG&G®
OPTOELECTRONICS

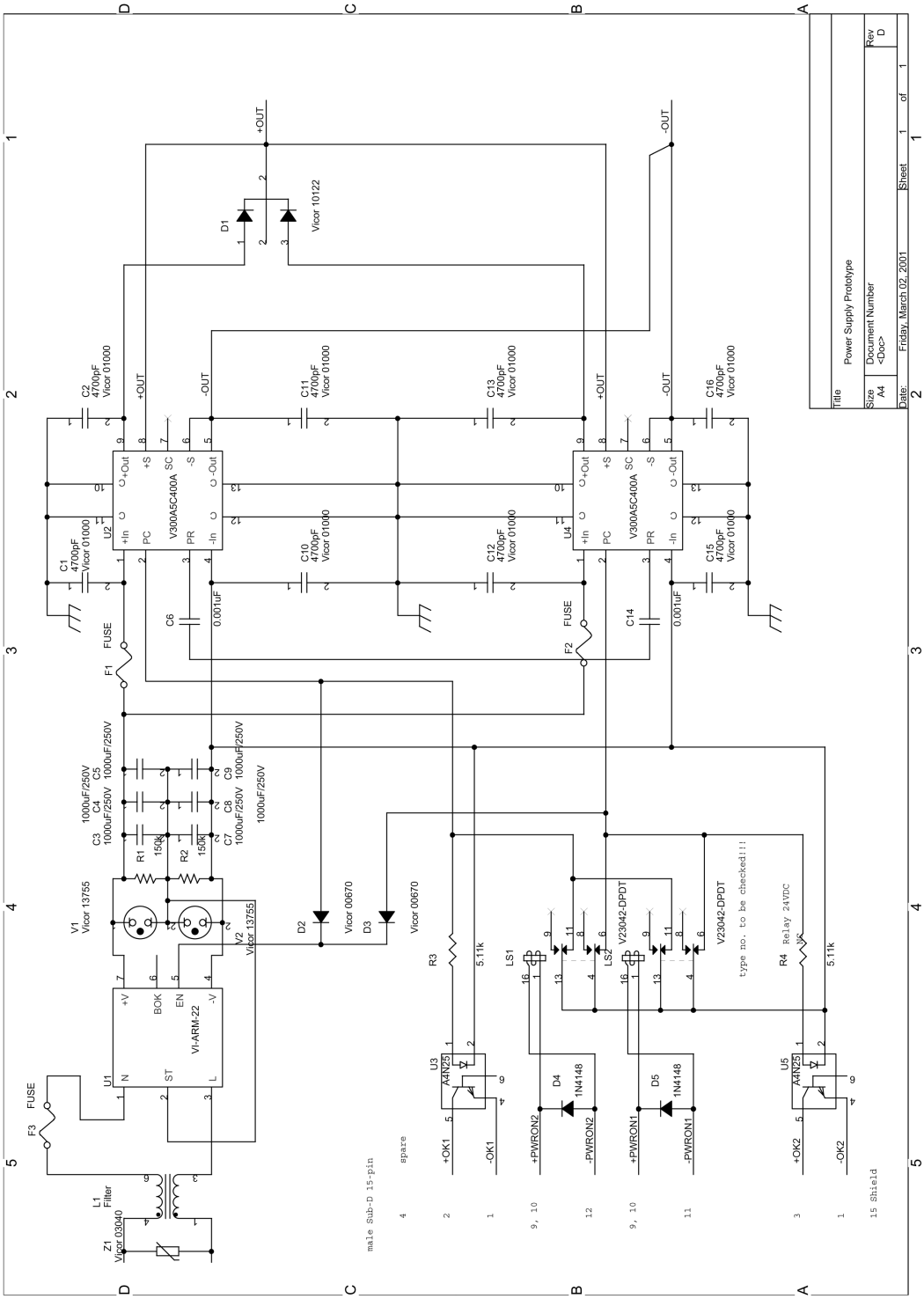
Specifications: SPCM-AQR-WX @ 22°C, all models, unless otherwise indicated.

PARAMETER	MIN		TYP		MAX		UNITS
Supply voltage: 1.9A max., 0.5 A typ. [1,2] @ the module connector	4.75		5.0		5.25		V
EG&G power cable total resistance			0.2				Ω
Case operating temperature [1,4]	5				40		°C
Active area (diameter) @ minimum P_d	**1X** 170	**2X** 425	**1X** 180	**2X** 475			µm
Photon detection efficiency (P_d) @ λ = 400nm	**1X** 2.0	**2X**	**1X** 5.0	**2X** 1.5			
630nm	55	TBD	70	35			%
830nm	40		50	25			
1060nm	1.0		2.0	1.0			
P_d variation at constant case temperature (2h @ 25 °C)			± 1		± 3		%
P_d variation, 5 °C to 40 °C case temperature			± 4		± 10		%
Dark count [5] SPCM-AQR-21			1,000		2,000		Counts/s
SPCM-AQR-W2			250		500		
SPCM-AQR-W3			150		250		
SPCM-AQR-14			50		100		
SPCM-AQR-15			-		50		
SPCM-AQR-16			-		25		
Average dark count variation at constant case temperature (6 hrs @ 25 °C) for [5,6]:							
SPCM-AQR-21 & -W2 & -W3					± 10%		
SPCM-AQR-14 & -15 & -16					± 1σ		
Average dark count variation, 5 °C to 40 °C case temperature for [5,6]:							
SPCM-AQR-21 & -W2 & -W3					± 20%		
SPCM-AQR-14 & -15 & -16					± 2σ		
Single Photon Timing Resolution			**1X** 300	**2X** 3000			ps FWHM
Dead time (Count rates below 5Mc/s)			**1X** 40	**2X** 85	**1X** 50	**2X** 100	ns
Output count rate before saturation [1]	**1X** 10	**2X** 5	**1X** 15	**2X** 10			Mc/s
Linearity correction factor: [7]			**1X**	**2X**	**1X**	**2X**	
@ 200 kc/s			1.01				
@ 1 Mc/s			1.08	TBD	1.15	TBD	
@ 5 Mc/s			1.40		1.67		
Afterpulsing probability			**1X** 0.15	**2X** 1.0	**1X** 0.30	**2X** TBD	%
Settling time following power up (1% stability) @ 1 Meg counts/sec and 25 °C			15		30		s
Threshold setting required for digital output pulse (terminate in 50 ohms)	0.75		1.0		2.0		V
Pulse Width			**1X** 25	**2X** 65			ns
Gating turn on/off: (50 Ω input)							
Disable = TTL Low			2		4		ns
Enable = TTL High			45		55		ns
Gate Threshold voltage (@ V_{supply} = 5V)							
Low level (sink current > 90mA)	0				0.4		V
High Level (sink current < 30mA)	3.5				5.25		V

B. Drawing of Cooling Plate for APD Power Supply



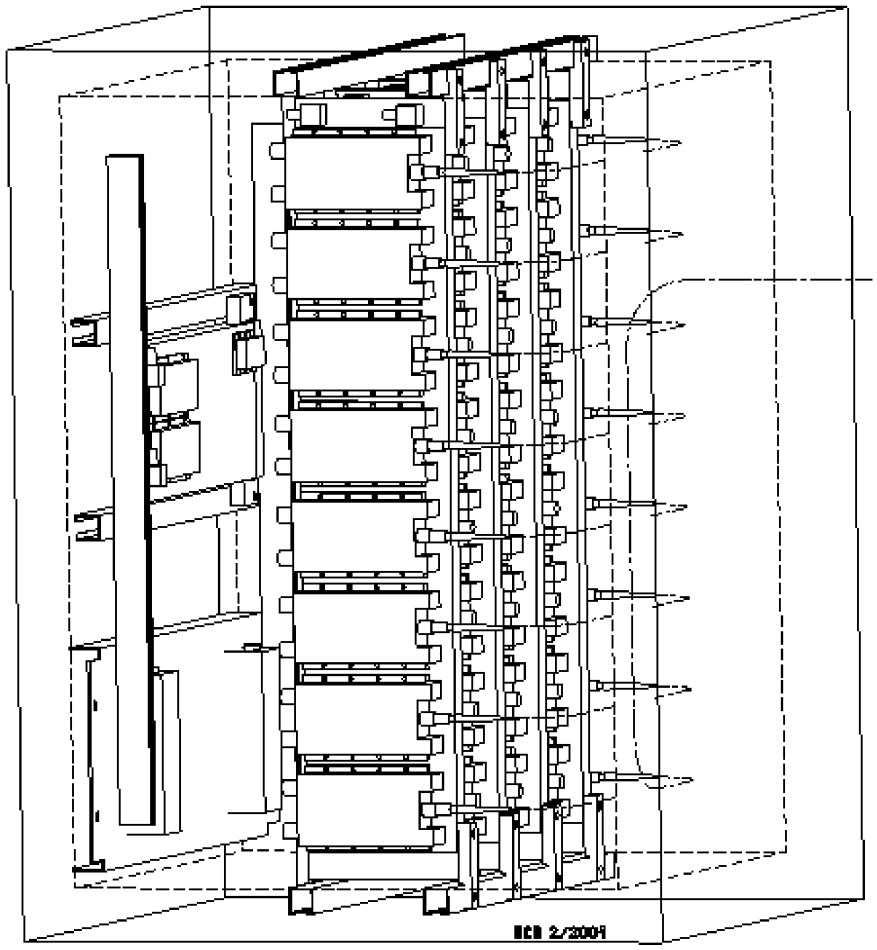
C. Schematic of APD Power Supply



D. Interlock Connector

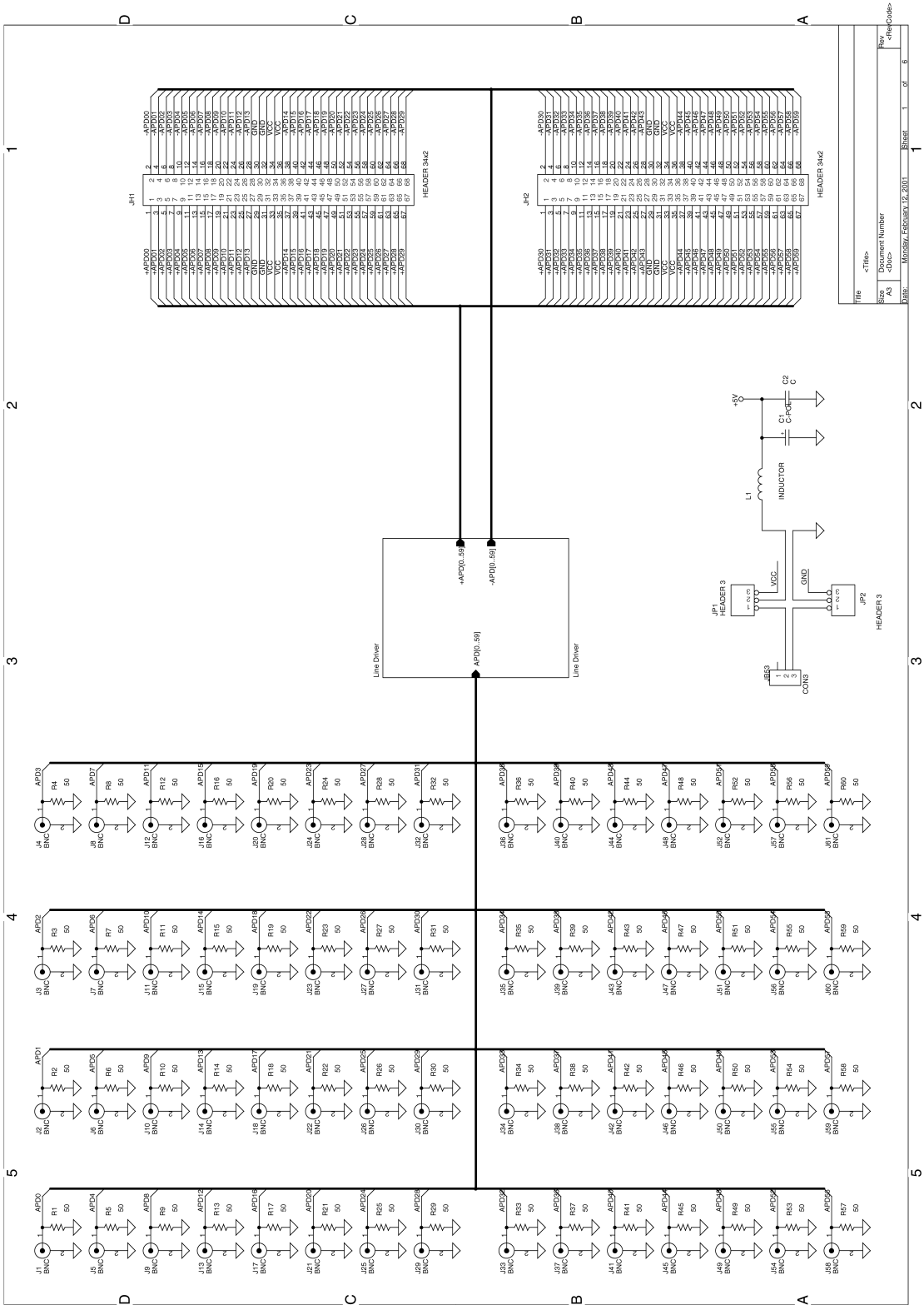
To be added

E. APD Cabinet

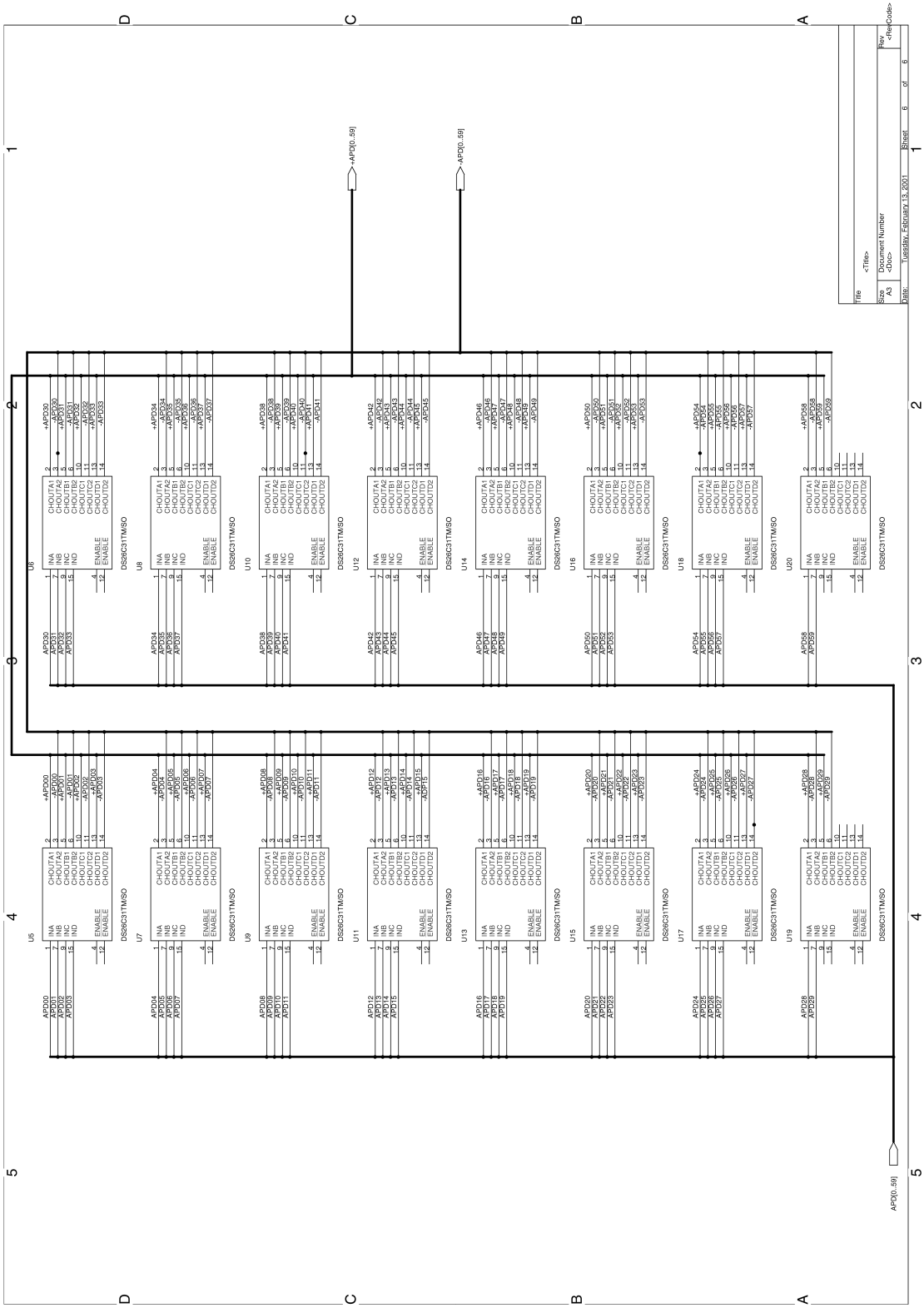


F. Line Driver Schematics

Part 1



Part 2


+APD[0..59]
-APD[0..59]
Title <Title>
Size A3
Document Number <Doc>
Rev <RevCode>
Date: Tuesday, February 13, 2001
Sheet 6 of 6
U5
U6
U7
U8
U9
U10
U11
U12
U13
U14
U15
U16
U17
U18
U19
U20
DS26C31TMSO