tec5
live
Technology for Spectroscopy

Electronics for CCD Arrays: Modular Components for UV-VIS Spectroscopy

tec5 OEM operating electronics modules support a range of FFT CCD area image sensors designed for optical spectroscopy. The two-phase CCD arrays feature high sensitivity and dynamic range. Available sensor boards cover cooled and non-cooled CCD arrays as well as front- and back-illuminated types and resistive gate CCDs with electronic shutter. While line binning mode is preset as standard operation, full image readout and various partial binning modes are available.

In addition to operating the CCD arrays, the electronics modules can be used to operate Spectral Sensors types MCS-CCD and CGS manufactured by Carl Zeiss, based on array types supported.

In case of Peltier-cooled CCDs, low temperature operation reduces dark current and noise. For this purpose, a temperature controller module is available with the tec5 CCD preamplifier electronics. Data are passed to follow-on processing by various interfaces, e.g. PCI, USB or Ethernet for a standard PC or by a parallel interface to a customer microcomputer's digital I/O.

Key Features

- High precision and high dynamic range
- Fast readout with 16 bit A/D conversion
- Various PC interfaces supported

Application areas

- Diffuse reflectance
- Fluorescence
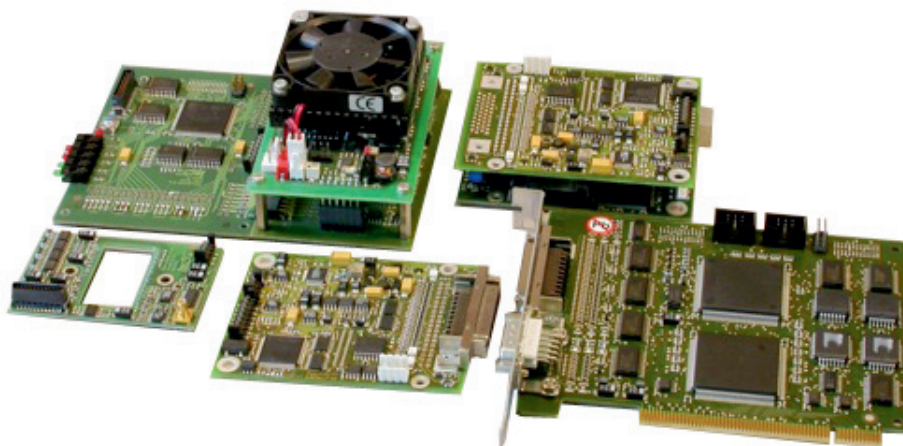- Strongly absorbing media
- Low light-level detection

Figure 1: Electronics modules for CCD arrays

Characteristics

- Various Hamamatsu FFT and resistive gate CCDs types supported
- Operation of Carl Zeiss MCS-CCD and CGS sensors
- 16 bit A/D conversion
- Line binning, image mode or partial binning operation (array type dependent)
- Fast readout allowing acquisition rates of up to 500 spectra per second
- Cooling controller electronics for cooled CCD types
- Available PC interfaces
  - USB
  - PCI
  - Ethernet
  - Other (contact tec5)
- Embedded applications and data pre-processing options
- Customization available
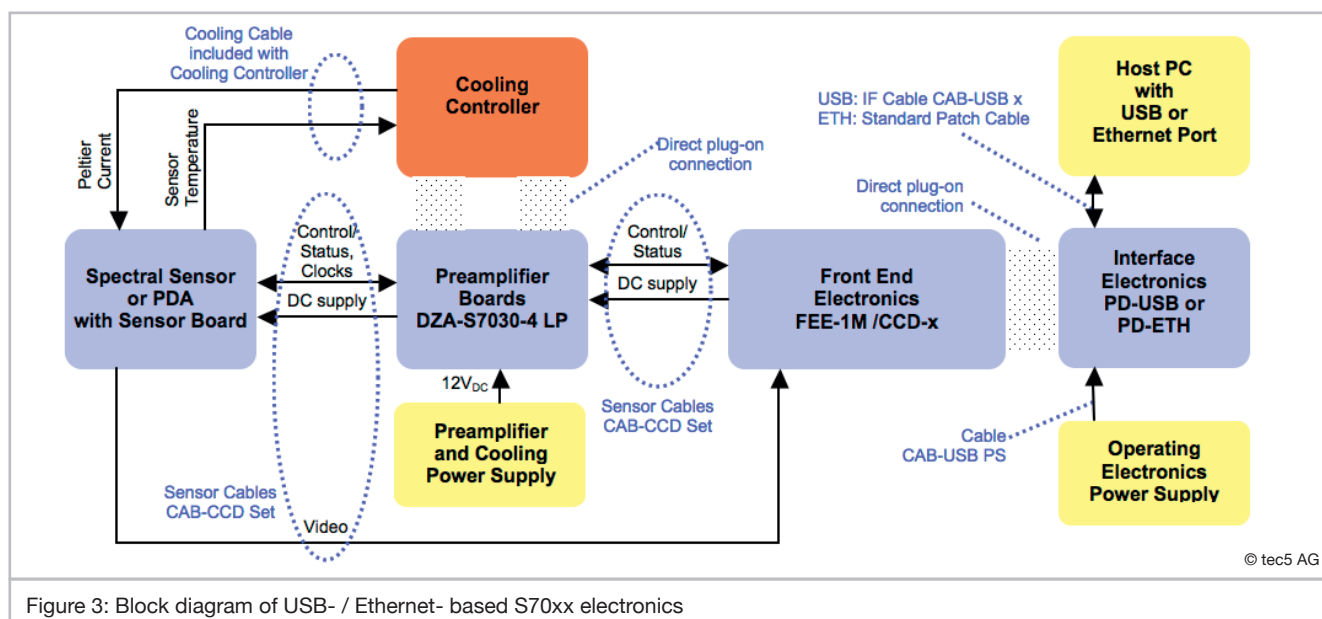
Electronics Configurations

Several electronics modules are used with the arrays or spectral sensors according to the block diagrams shown in figures 2 to 4. The function of each of the blocks is described in detail below.

Figure 2: Block diagram of PCI- based S70xx electronics
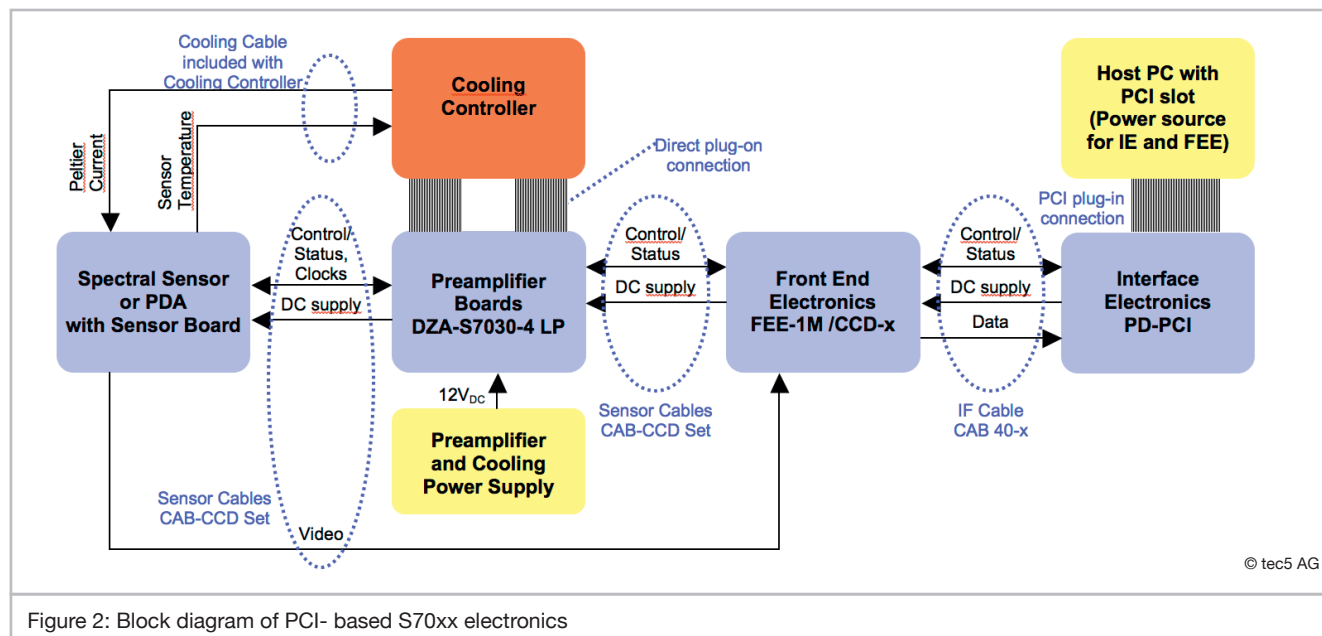
In configuration for PCI bus operation, a dedicated interface electronics board is plugged into a PC with PCI slot. The other boards and the sensor are designed for being included into a customer's hous-

ing, connected to the PC by a 40-pin interface cable available in standard lengths of 2 m or 5 m.
Shown in figure 2, the Front End Electronics and Interface are supplied from the PC's internal power supply.

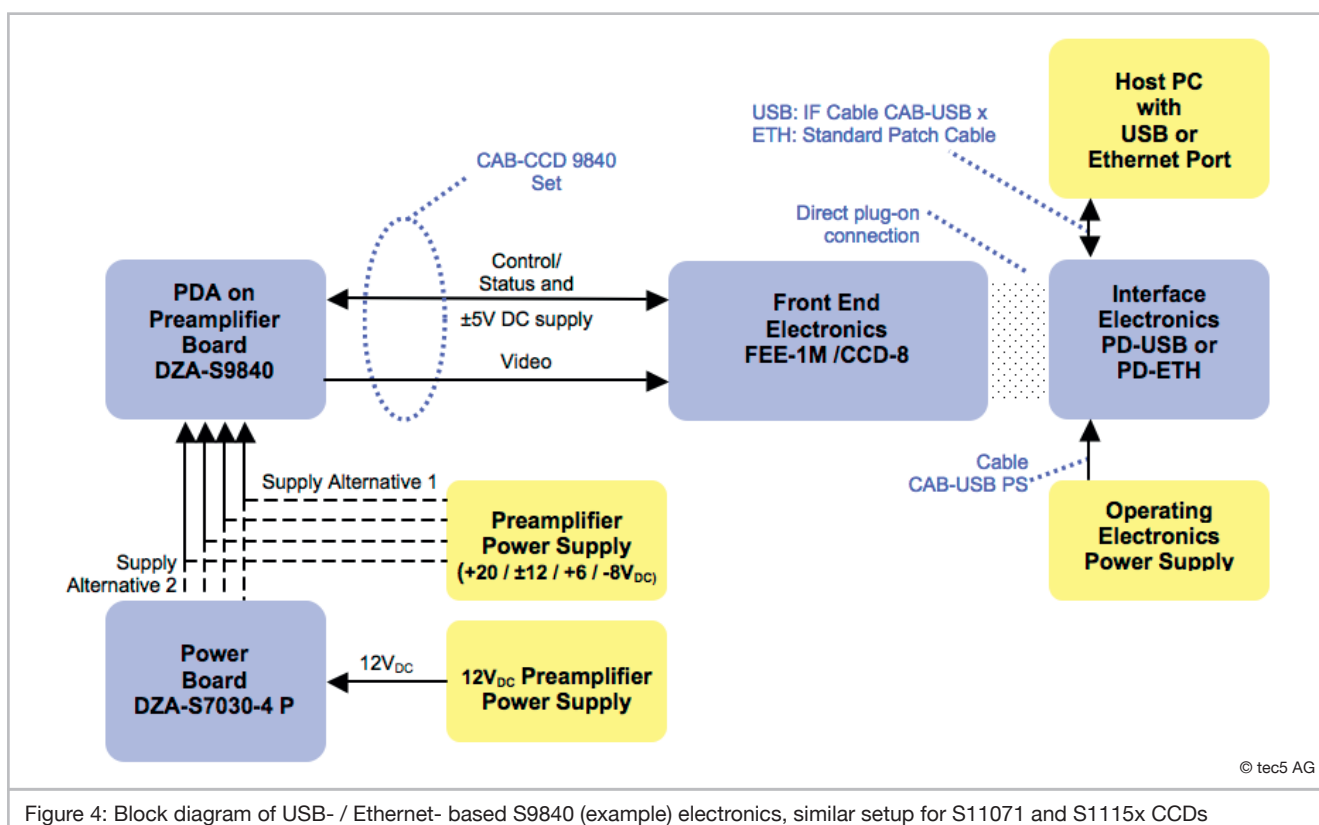Figure 3: Block diagram of USB- / Ethernet- based S70xx electronics

The USB- or Ethernet- based interface electronics with the Front End Electronics is supplied externally by an additional 5VDC power supply (self-powered). In all configurations, the preamplifier requires a number of supply voltages which can be generated by a tec5 power board DZA-S7030-4-P from a single +12VDC source. Alternatively, a customer-provided multivoltage power supply unit may be used.

The electronics is connected to the PC by a standard USB or Ethernet interconnection cable according to the block diagram shown in figure 4.

The electronics is compatible to standards USB 1.1, 2.0 and 3.0 for PD-USB01 or Ethernet 802.3 10, 100 and 1000Base-T for PD-ETH01. We recommend to use a Hi-Speed USB 2.0 port or an Ethernet 802.3 100Base-T or faster interconnection for best performance.

All electronics boards are designed for integration into a customer's housing.

Figure 4: Block diagram of USB- / Ethernet- based S9840 (example) electronics, similar setup for S11071 and S1115x CCDs

Preamplifier Electronics Modules

The CCD preamplifier electronics consists of one or more printed circuit boards, each supporting a subset of the functionality required for CCD operation.
In addition to the CCD types mentioned, compatible types may be available and can be operated with one of the preamplifiers. Additional arrays can be supported by modifications of the sensor / preamplifier board. In case of any uncertainty, please contact tec5 to assure compatibility.

For cooled operation of the CCD sensor, appropriate heat sinking has to be considered to remove thermal power dissipated by the detector array and by the Peltier element. A rectangular clearance in the sensor printed circuit board allows to attach a heat conductor to the bottom of the photo detector array for this purpose.
If a Carl Zeiss spectral sensor type MCS-CCD is used, CCD heat-sinking is provided with the spectral sensor.

Operating Hamamatsu S70xx FFT-CCD arrays

S70xx Sensor Boards

For each S70xx array type supported, a suitable sensor board is available, where the sensor array can be directly plugged in. The sensor board contains circuitry which should be located in close proximity to the CCD array.

Available S70xx Sensor Boards

■ **DZA-S7030-4-S** for Hamamatsu back-thinned, back-illuminated CCD array types S7030, S7031, S7033, S7034 and compatibles

■ **DZA-S7010-1-S** for Hamamatsu front-illuminated CCD array types S7010, S7011 and compatibles

S70xx Logic Board   DZA-S7030-4-L

This printed circuit board, which is part of the pream-plifier, generates the CCD array clock sequences and permanently checks a number of preamplifier operating conditions. If an error condition is detected, operating voltages for the CCD array are disrupted to protect the sensor array. Operation is based on a programmable logic device (CPLD).

A number of settings can be hardware-programmed by solder jumpers to support different sensor pixel counts, binning modes, cooled or non-cooled operation and timing parameters. To assure proper factory configuration of the logic board, please indicate the type designation of the CCD or spectral sensor to be used when ordering the preamplifier electronics.

S70xx Power Board   DZA-S7030-4-P

From a single DC voltage input of 12 V, all voltages required to operate a S70xx CCD array are generated on the power board.

In S70xx configuration, all voltages are range checked and can be disabled by the logic if an error is detected. This feature is particularly useful for cost-intensive arrays or Spectral Sensors.

S70xx Cooling Controller   DZA-S7030-4-tc

The cooling controller unit, which has been specifically designed to operate the cooled CCD arrays supported by the DZA-S7030-4, is used to decrease and stabilize the detector array temperature in order to reduce dark current and detection noise. Containing a linear PI-type

Sensor Board
DZA-S7030-4-S
or DZA-S7010-1S

Cooling Board
DZA-S7030-4-tc

Logic Board
DZA-S7030-4-L

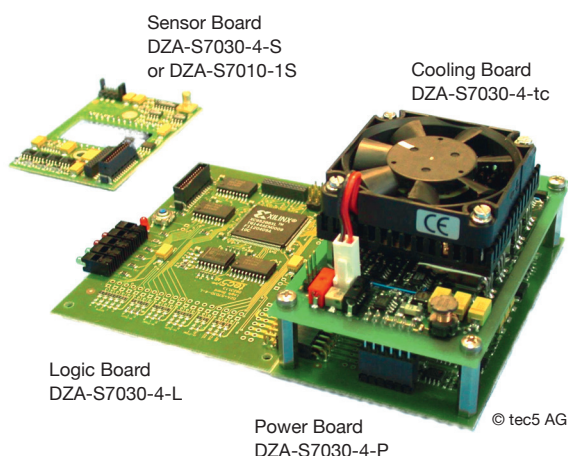Power Board
DZA-S7030-4-P

© tec5 AG

Figure 5: S70xx preamplifier boards arrangement

control circuit, possible interactions and cross-talk to the weak optical signal are minimized. Depending on the system configuration, a temperature stability of better than 0.1 K can be achieved.

All important parameters for control loop operation are selectable on the board. For the CCD types supported, the modules are preconfigured according to the relevant parameters of the Peltier element and the thermistor.

Depending on the module version, a maximum cooling current of 1.5 A or 3 A is preset. The modules are supplied by 12 VDC applied to the preamplifier electronics via the power board. For specifications and configuration details please refer to the technical data sheet of the module.

In most applications, the logic and power boards are directly connected by on-board connectors, the cooling controller is mounted on top of the power board to result in a stack of boards with a remote sensor board. The typical stacked setup is shown in figure 5.

Available Cooling Controller Board Versions

■ **DZA-S7030-4-tc /1.5A** for Hamamatsu back-thinned, back-illuminated CCD array types S703x-090x and Carl Zeiss MCS-CCD UV

■ **DZA-S7030-4-tc /3A** for Hamamatsu back-thinned, back-illuminated CCD array types S703x-100x and Carl Zeiss MCS-CCD UV-NIR

Operating Hamamatsu S9840, S11071 and S1115x CCD arrays

CCD Preamplifier Boards DZA-S9840, DZA-S11071, S1115x

For these Hamamatsu CCD types, the complete preamplifier functionality is provided by a single board, the DZA-Sxxx. The power board can be added optionally to reduce the number of power supply voltages required.
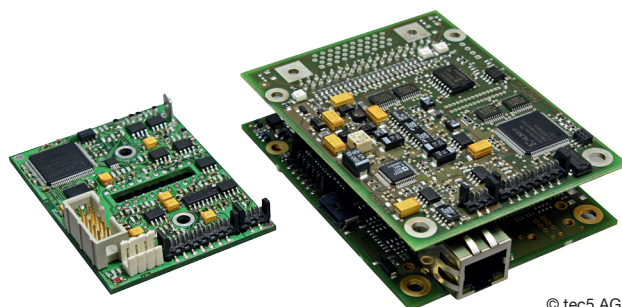
Available Preamplifier board versions

▌ **DZA-S9840** for Hamamatsu S9840
   back-thinned, back-illuminated CCD sensor
▌ **DZA-S11071** for Hamamatsu S11071 back-thinned, back-illuminated CCD sensor and compatibles
▌ **DZA-S1115x** for Hamamatsu S11155 and S11156 resistive gate CCD and Carl Zeiss CGS Spectral Sensor

© tec5 AG

Figure 6: Complete Ethernet Operating Electronics arrangement for S9840: Preamplifier Board, Front End- and Ethernet-Interface Electronics stack

Power Board DZA-S7030-4-P

From a single DC voltage input of 12 V, all voltages required to operate the S11071, S1115x CCD array are generated on the power board.

Alternatively, a customer-provided multivoltage power supply unit may be used.

CGS Spectral Sensor with USB Interface

© tec5 AG

System Operational Specifications

Example performance data obtained using a tec5 PC Operating Electronics, 'CCD' version, in line binning operation

	S-7031	S9840	S11071	S1115x
Sensor Type	S7031-0907 / at 0 °C	S9840 / at 25 °C	S11071	S1115x
Pixel Clock Rate	500 kHz	1 MHz	1 MHz	1 MHz
Intensity Resolution	16 bits	16 bits	16 bits	16 bits
Dynamic Range typ.	15 bits[1]	12 bits[1]	12 bits[1]	12 bits[1]
Electronics Thermal Drift typ.	< 2 counts / K	< 4 counts / K	< 4 counts / K	< 4 counts / K
Sensitivity typ.	16 e- / count	2 e- / count	3 e- / count	4 e- / count

[1]line binning mode

tec5
live
Technology for Spectroscopy

Front End Electronics

Featuring 16 bit A/D conversion, the FEE-1M /CCD supports all tec5 sensor preamplifier modules for CCD arrays. Sensor readout is performed at a rate of 500 or 1000 kpixels per second, allowing to read more than two hundred full spectra per second.

Matching the different preamplifier requirements and the different types of interface electronics supported, various board versions of the FEE-1M are available from tec5. Please refer to the configuration details below or to the FEE-1M technical data sheet for additional information concerning the FEE-1M board versions.

Available Front End Electronics

▮ **FEE-1M /CCD-2** for Hamamatsu S703x CCDs and Carl Zeiss MCS-CCD Spectral Sensors

▮ **FEE-1M /CCD-8** for Hamamatsu S9840, S11071 and S1115x CCDs and Carl Zeiss CGS Spectral Sensors

Interface Electronics

Depending on the preferred type of connection to the host PC, a PCI plug-in interface, a USB-or an Ethernet Interface may be used. Other alternatives for interfacing are available, please contact tec5 for details.

The Interface Electronics modules retrieve digitized data from the Front End and forward the data to a host PC. The circuitry contains the read out scan cycle control logic with precise integration timing and hardware sequencing of all functions with real-time requirements. A FIFO buffer memory is used to assure consistent data transfer to the computer's main memory.

The interface modules offer peripheral control and synchronization with digital I/O lines, e.g. flash trigger output, external trigger input and general purpose digital I/O lines.

Available Interface Electronics

▮ **PD-ETH01** for Ethernet networks
▮ **PD-USB01** for USB connection
▮ **PD-PCI01** for PCI bus connection

Embedded Solutions

Data processing and evaluation can be partly or completely performed in compact electronics. This reduces data traffic and host processing requirements. In addition, stand-alone solutions may be provided, in which no host PC is required for regular operation.

Allowing averaging, linearization, dark correction and region-of-interest (ROI) selection during data acquisition in real-time, the standard product PD-ETH01 /DP can be effectively used for in-line applications with high speed requirements.

Our hardware and software building blocks are a powerful platform for developing customized solutions for embedded applications. Please contact us to discuss the possibilities suited to your requirements.

Electronics with Data PreProcessing

▮ **PD-ETH01 /DP** with FPGA realtime data preprocessing for Ethernet networks.

Carl Zeiss MCS-CCD Spectral Sensors

If ordered as OEM spectral sensor modules, the MCS-CCD or MCS-flex CCD series Spectral Sensors manufactured by Carl Zeiss are supplied with a mounted sensor board manufactured by tec5. For operation, additional tec5 preamplifier components (logic, power and cooling boards), Front End and Interface Electronics are required.

Carl Zeiss CGS Spectral Sensors

The compact Spectral Sensor can be operated with the preamplifier DZA-S1115x and all available interface solutions (PCI, USB, Ethernet).

Software

For configurations based on Interface Electronics manufactured by tec5, drivers for Windows 2000, XP, Vista and Windows 7 are supplied. The free Admin-Tool program can be used for verifying hardware operation and simple data acquisition. In addition, various application programs and software development kits are available from tec5. Please contact us if you intend to use alternative operating systems or for custom software development.

Software Development Kits

- SDK for the function library SDACQ32MP.DLL supporting C/C++, Visual Basic and Delphi programming languages
- SDK for the function library SDPROC32.DLL with ready-to-use dialogs for data acquisition, configuration and parameter setting
- LabVIEW function library (VIs) for programming in a LabVIEW development environment

MultiSpec® Pro

Multi-purpose modular spectroscopy software package with various data acquisition modes, data display, processing and output options, designed for process applications. It runs all current tec5 operating electronics and spectrometer systems. The basic version can be upgraded by a number of optional add-on modules, e.g. for color measurement, chemometric prediction (compatible to The Unscrambler, GRAMS, SensoLogic) as well as for process communication to cover numerous applications. Trial licenses available.

MultiSpec® Pro Lite

In cases especially requiring data acquisition, display and export functionality, a lite version of the MultiSpec Pro software package is offered. Trial licenses available.

Configuration Details

For each CCD or Spectral Sensor supported, the basic hardware configuration is shown in figure 7. The tables below contain detailed ordering information for the most popular sensors and interfaces.
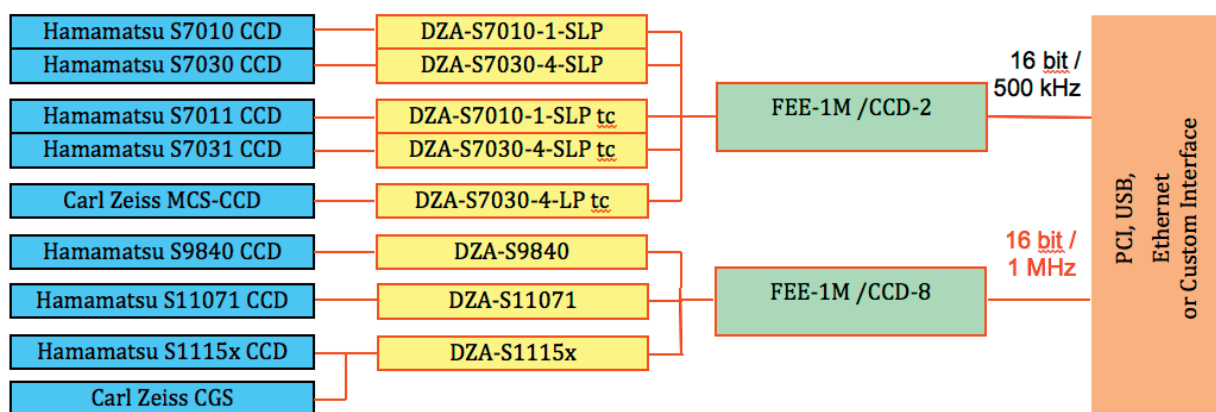
Figure 7: Si-FFT CCD Arrays and MCS-CCD Spectral Sensors configurations overview

USB / Ethernet Configurations

Sensor Type	Preamplifier	Front End	Interface	Cable Assy
CCD S7010 Hamamatsu	DZA-S7010-1-SLP bundle	FEE-1M /CCD-2 EMB 11-0106107-11	PD-USB01V2 /STD 11-0106015-00 or PD-ETH01V1 /STD 11-0106020-00	CAB-CCD 7030 Set 11-1501004-15
CCD S7030 Hamamatsu	DZA-S7030-4-SLP bundle			
CCD S7011 Hamamatsu	DZA-S7010-1-SLP tc bundle			
CCD S7031 Hamamatsu	DZA-S7030-4-SLP tc bundle			
MCS-CCD Spectral Sensor, Carl Zeiss	DZA-S7030-4-LP tc bundle			
CCD S9840 Hamamatsu	DZA-S9840	FEE-1M /CCD-8 EMB 11-0106107-61		CAB-CCD 9840 Set 11-1501004-16
CCD S11071 Hamamatsu	DZA-S11071			CAB-CCD 11xxx Set 11-1501004-23
CCD S1115x Hamamatsu	DZA-S1115x			CAB-CCD 11xxx Set 11-1501004-23
CGS Spectral Sensor, Carl Zeiss	DZA-S1115x			CAB-CCD 11xxx Set 11-1501004-23

Optional for USB configurations: USB cable CAB-USB 2, 11-1501007-00 or CAB-USB 5, 11-1501007-01. **|** DC power supply for USB or Ethernet signal chain NT-USB, 11-0302001-01. **|** Additional DC power supply required for CCD preamplifier.

PCI Configurations

Sensor Type	Preamplifier	Front End	Interface	Cable Assy
CCD S7010 Hamamatsu	DZA-S7010-1-SLP bundle	FEE-1M /CCD-2 STD 11-0106107-10	PD-PCI01V1 /52 11-0106012-30	CAB-CCD 7030 Set 11-1501004-15
CCD S7030 Hamamatsu	DZA-S7030-4-SLP bundle			
CCD S7011 Hamamatsu	DZA-S7010-1-SLP tc bundle			
CCD S7031 Hamamatsu	DZA-S7030-4-SLP tc bundle			
MCS-CCD Spectral Sensor, Carl Zeiss	DZA-S7030-4-LP tc bundle			
CCD S9840 Hamamatsu	DZA-S9840	FEE-1M /CCD-8 STD 11-0106107-60		CAB-CCD 9840 Set 11-1501004-16
CCD S11071 Hamamatsu	DZA-S11071			CAB-CCD 11xxx Set 11-1501004-23
CCD S1115x Hamamatsu	DZA-S1115x			CAB-CCD 11xxx Set 11-1501004-23
CGS Spectral Sensor, Carl Zeiss	DZA-S1115x			CAB-CCD 11xxx Set 11-1501004-23

For all PCI configurations: PCI interconnection cable CAB40-2, 11-1501005-00 or CAB40-5, 11-1501005-01.
Additional DC power supply required for CCD preamplifier.

tec5

Technology for Spectroscopy