

Becker & Hickl GmbH  
Nahmitzer Damm  
12277 Berlin  
Tel. +49 30 787 56 32  
Fax. +49 30 787 57 34  
email: [info@becker-hickl.de](mailto:info@becker-hickl.de)  
<http://www.becker-hickl.de>

dpcdll.doc



# **SPCM- 32 Bits Dynamic Link Libraries**

## **User Manual for DPC module**

Version 2.7

June 2008

## Introduction

The SPCM 32 bits Dynamic Link Library contains all functions to control the whole family of SPC and DPC modules which work on PCI bus. This manual is oriented to the functions which are used to control DPC-230 module. Up to eight DPC modules can be controlled using the SPCM DLL. The functions work under Windows NT/2000/XP/Vista. The program which calls the DLLs must be compiled with the compiler option 'Structure Alignment' set to '1 Byte'.

The distribution disks contain the following files:

SPCM32.DLL	dynamic link library main file
SPCM32.LIB	import library file for Microsoft Visual C/C++, Borland C/C++ compilers
SPCM_DEF.H	Include file containing Types definitions, Functions Prototypes and Pre-processor statements
SPCM.INI	DLL initialisation file for SPC modules
DPC230.INI	DLL initialisation file for DPC modules
DPCDLL.DOC	This description file
SPCMDLL.DOC	Description file for SPC modules
USE_DPC.XXX	Set of files to compile and run a simple example of using SPC DLL functions for DPC-230 module. Source file of the example is the file use_dpc.c.
USE_SPCM.XXX	Set of files to compile and run a simple example of using SPC DLL functions for SPC modules. Source file of the example is the file use_spcm.c.

There is no special installation procedure required. Simply execute the setup program from the distribution CD and follow its instructions.

## SPCM-DLL Functions list

The following functions implemented in the SPCM-DLL are used for DPC-230 module:

### Initialisation functions:

- SPC\_init
- SPC\_get\_init\_status
- SPC\_get\_module\_info
- SPC\_test\_id
- SPC\_set\_mode
- SPC\_get\_mode

### Setup functions:

- SPC\_get\_parameters
- SPC\_set\_parameters
- SPC\_get\_parameter
- SPC\_set\_parameter
- SPC\_get\_eeprom\_data
- SPC\_write\_eeprom\_data

SPC\_read\_parameters\_from\_inifile  
SPC\_save\_parameters\_to\_inifile

**Status functions:**

SPC\_test\_state  
SPC\_get\_sync\_state  
SPC\_get\_time\_from\_start  
SPC\_get\_break\_time  
SPC\_get\_actual\_coltime  
SPC\_read\_rates  
SPC\_clear\_rates  
SPC\_get\_scan\_clk\_state  
SPC\_get\_fifo\_usage

**Measurement control functions:**

SPC\_start\_measurement  
SPC\_stop\_measurement

**DPC memory transfer functions:**

SPC\_read\_fifo

**Other functions:**

SPC\_get\_error\_string  
SPC\_init\_phot\_stream  
SPC\_close\_phot\_stream  
SPC\_get\_phot\_stream\_info  
SPC\_get\_photon  
SPC\_convert\_dpc\_raw\_data  
SPC\_get\_start\_offset  
SPC\_close

Functions listed above must be called with C calling convention which is default for C and C++ programs.

Identical set of functions is available for environments like Visual Basic which requires `_stdcall` calling convention. Names of these functions have 'std' letters after 'SPC', for example, `SPCstd_read_fifo` it is `_stdcall` version of `SPC_read_fifo`.

Description and behaviour of these functions are identical to the functions from the first (default) set – the only difference is calling convention.

## **Application Guide**

### **Initialisation of the SPC Measurement Parameters**

Before a measurement is started the measurement parameter values must be written into the internal structures of the DLL functions (not directly visible from the user program) and sent to the control registers of the SPC module(s). This is accomplished by the function **SPC\_init**. This function

- checks whether DLL is correctly registered ( looks for a BH license number and verifies it)
- reads the parameter values from a specified file

- sends the parameter values to the DPC control registers
- performs a hardware test of the DPC module(s)

The initialisation file is an ASCII file with a structure shown in the table below. We recommend either to use the file dpc230.ini or to start with dpc230.ini and to introduce the desired changes.

```
; SPCM DLL initialisation file for DPC230 module
; DPC parameters have to be included in .ini file only when parameter
; value is different from default.
; for SPC modules use file spcm.ini instead of this one

[spc_base]
simulation = 0                ; 0 - hardware mode(default) ,
                             ; >0 - simulation mode (see spcm_def.h for possible values)
pci_bus_no= -1               ; PCI bus on which DPC modules will be looking for
                             ; 0 - 255, default -1 ( all PCI busses will be scanned)
pci_card_no= -1              ; number of the DPC module on PCI bus
                             ; 0 - 7, default -1 (all modules on PCI bus)

[spc_module]                 ; DPC hardware parameters
cfd_limit_low = -30.0         ; = CFD_TH1 threshold of CFD1 -510 ..0 mV, default -30
cfd_limit_high = -30.0        ; = CFD_TH2 threshold of CFD2 -510 ..0 mV, default -30
cfd_zc_level = -30.0          ; = CFD_TH3 threshold of CFD3 -510 ..0 mV, default -30
cfd_holdoff = -30.0           ; = CFD_TH4 threshold of CFD4 -510 ..0 mV, default -30

sync_zc_level = 0.0           ; = CFD_ZC1 Zero Cross Level of CFD1 -96 ..96 mV, default 0
sync_holdoff = 0.0            ; = CFD_ZC2 Zero Cross Level of CFD2 -96 ..96 mV, default 0
sync_threshold = 0.0          ; = CFD_ZC3 Zero Cross Level of CFD3 -96 ..96 mV, default 0
tac_limit_high = 0.0          ; = CFD_ZC4 Zero Cross Level of CFD4 -96 ..96 mV, default 0

mem_bank = 6                  ; bit 1 - DPC 1 active, bit 2 - DPC 2 active,
                             ; default 6 - both TDCs active
detector_type = 0             ; type of active inputs : bit 1 - TDC1, bit 2 - TDC2,
                             ; bit value 0 , CFD inputs active,
                             ; bit value 1 , TTL inputs active
                             ; default 0 - both TDCs have CFD inputs active

chan_enable = 0x3ff3ff        ; enable(1)/disable(0) input channels
                             ; bits 0-7 - en/disable TTL channel 0-7 in TDC1
                             ; bits 8-9 - en/disable CFD channel 0-1 in TDC1
                             ; bits 12-19 - en/disable TTL channel 0-7 in TDC2
                             ; bits 20-21 - en/disable CFD channel 0-1 in TDC2
                             ; default 0x3ff3ff - all inputs enabled
chan_slope = 0                ; active slope of input channels
                             ; 1 - rising, 0 - falling edge active
                             ; bits 0-7 - slope of TTL channel 0-7 in TDC1
                             ; bits 8-9 - slope of CFD channel 0-1 in TDC1
                             ; bits 12-19 - slope of TTL channel 0-7 in TDC2
                             ; bits 20-21 - slope of CFD channel 0-1 in TDC2
                             ; default 0 - all inputs falling edge
mode = 8                       ; module's operation mode , default 8
                             ; 6 - TCSPC FIFO
                             ; 7 - TCSPC FIFO Image mode
                             ; 8 - Absolute Time FIFO mode
                             ; 9 - Absolute Time FIFO Image mode
rate_count_time = 1.0         ; rate counting time in sec default 1.0 sec
                             ; 0.0 - don't count rate outside the measurement
collect_time = 2.0            ; 0.0001 .. 100000s , default 2.0 s
stop_on_time = 1              ; 0,1 , default 1
sync_freq_div = 1             ; 1,2,4 default 1 in TCSPC modes

trigger = 0                    ; external trigger condition
                             ; bits 1 & 0 mean : 00 - ( value 0 ) none(default),
                             ; 01 - ( value 1 ) active low,
                             ; 10 - ( value 2 ) active high

pixel_clock = 0                ; source of pixel clock in Image modes
                             ; 0 - internal, 1 - external, default 0

chan_spec_no = 0x8813          ; channel numbers of special inputs
```

```

; bits 0-4 - reference chan. no ( TCSPC and Multiscaler modes)
;      default = 19, value:
;      0-1 CFD chan. 0-1 of TDC1, 2-9 TTL chan. 0-7 of TDC1
;      10-11 CFD chan. 0-1 of TDC2, 12-19 TTL chan. 0-7 of TDC2
; bits 8-10 - frame clock TTL chan. no ( imaging modes ) 0-7, default 0
; bits 11-13 - line clock TTL chan. no ( imaging modes ) 0-7, default 1
; bits 14-16 - pixel clock TTL chan. no ( imaging modes ) 0-7, default 2
; bit 17 - TDC no for pixel, line, frame clocks ( imaging modes )
;      0 = TDC1, 1 = TDC2, default 0
; bits 18-31 - not used

```

After calling the SPC\_init function the measurement parameters from the initialisation file are present in the module control registers and in the internal data structures of the DLLs. To give the user access to the parameters, the function **SPC\_get\_parameters** is provided. This function transfers the parameter values from the internal structures of the DLLs into a structure of the type SPCdata (see spcm\_def.h) which has to be defined by the user. The structure is common for all SPC and DPC module types, therefore some fields are not used for DPC modules. The parameter values in this structure are described below.

unsigned short base_adr	base I/O address on PCI bus
short init	set to initialisation result code
float cfd_limit_low	= CFD_TH1 threshold of CFD1 -510 ..0 mV
float cfd_limit_high	= CFD_TH2 threshold of CFD2 -510 ..0 mV
float cfd_zc_level	= CFD_TH3 threshold of CFD3 -510 ..0 mV
float cfd_holdoff	= CFD_TH4 threshold of CFD4 -510 ..0 mV
float sync_zc_level	= CFD_ZC1 Zero Cross level of CFD1 -96 ..96 mV
float sync_holdoff	= CFD_ZC2 Zero Cross level of CFD2 -96 ..96 mV
float sync_threshold	= CFD_ZC3 Zero Cross level of CFD3 -96 ..96 mV
float tac_range	DPC range in TCSPC and Multiscaler mode, 0.16461 .. 1e7 ns
short sync_freq_div	1,2,4
short tac_gain	not used for DPC230
float tac_offset	TDC offset in TCSPC and Multiscaler mode -100 .. 100%
float tac_limit_low	not used for DPC230
float tac_limit_high	= CFD_ZC4 Zero Cross level of CFD4 -96 ..96 mV
short adc_resolution	no of points of decay curve in TCSPC and Multiscaler mode 0,2,4,6,8,10,12,14 bits
short ext_latch_delay	not used for DPC230
float collect_time	0.0001 .. 100000s , default 2.0s
float display_time	not used for DPC230
float repeat_time	not used for DPC230
short stop_on_time	1 (stop) or 0 (no stop)
short stop_on_ovfl	not used for DPC230
short dither_range	not used for DPC230
short count_incr	not used for DPC230
short mem_bank	bit 1 - DPC 1 active, bit 2 - DPC 2 active, default 6 ( both TDCs active)
short dead_time_comp	not used for DPC230
unsigned short scan_control	not used for DPC230
short routing_mode	DPC230 bits 0-7 - control bits
float tac_enable_hold	macro time clock in ps, default 82.305 ps
short pci_card_no	module no on PCI bus ( 0-7)
unsigned short mode;	module's operation mode , default 8
	6 - TCSPC FIFO
	7 - TCSPC FIFO Image mode
	8 - Absolute Time FIFO mode
	9 - Absolute Time FIFO Image mode
unsigned long scan_size_x;	not used for DPC230
unsigned long scan_size_y;	not used for DPC230
unsigned long scan_rout_x;	not used for DPC230
unsigned long scan_rout_y;	not used for DPC230
unsigned long scan_flyback;	not used for DPC230
unsigned long scan_borders;	not used for DPC230
unsigned short scan_polarity;	not used for DPC230
unsigned short pixel_clock;	source of pixel clock in Image modes
	0 - internal, 1 - external, default 0
unsigned short line_compression;	not used for DPC230
unsigned short trigger;	external trigger condition -
	bits 1 & 0 mean : 00 - ( value 0 ) none(default),

	01 - ( value 1 ) active low, 10 - ( value 2 ) active high
float pixel_time;	not used for DPC230
unsigned long ext_pixclk_div;	not used for DPC230
float rate_count_time;	rate counting time in sec default 1.0 sec 0.0 - don't count rate outside the measurement
short macro_time_clk;	not used for DPC230
short add_select;	not used for DPC230
short test_eep	0: EEPROM is not read and not tested 1: EEPROM is read and tested for correct checksum
short adc_zoom;	not used for DPC230
unsigned long img_size_x;	not used for DPC230
unsigned long img_size_y;	not used for DPC230
unsigned long img_rout_x;	not used for DPC230
unsigned long img_rout_y;	not used for DPC230
short xy_gain;	not used for DPC230
short master_clock;	not used for DPC230
short adc_sample_delay;	not used for DPC230
short detector_type;	type of active inputs : bit 1 - TDC1, bit 2 - TDC2, bit value 0 , CFD inputs active, bit value 1 , TTL inputs active
short x_axis_type;	not used for DPC230
unsigned short chan_enable;	enable(1)/disable(0) input channels bits 0-7 - en/disable TTL channel 0-7 in TDC1 bits 8-9 - en/disable CFD channel 0-1 in TDC1 bits 12-19 - en/disable TTL channel 0-7 in TDC2 bits 20-21 - en/disable CFD channel 0-1 in TDC2
unsigned short chan_slope;	active slope of input channels 1 - rising, 0 - falling edge active bits 0-7 - slope of TTL channel 0-7 in TDC1 bits 8-9 - slope of CFD channel 0-1 in TDC1 bits 12-19 - slope of TTL channel 0-7 in TDC2 bits 20-21 - slope of CFD channel 0-1 in TDC2
unsigned long chan_spec_no;	channel numbers of special inputs, default 0x8813 bits 0-4 - reference chan. no ( TCSPC and Multiscaler modes) default = 19, value: 0-1 CFD chan. 0-1 of TDC1, 2-9 TTL chan. 0-7 of TDC1 10-11 CFD chan. 0-1 of TDC2, 12-19 TTL chan. 0-7 of TDC2 bits 8-10 - frame clock TTL chan. no ( imaging modes ) 0-7, default 0 bits 11-13 - line clock TTL chan. no ( imaging modes ) 0-7, default 1 bits 14-16 - pixel clock TTL chan. no ( imaging modes ) 0-7, default 2 bit 17 - TDC no for pixel, line, frame clocks ( imaging modes ) 0 = TDC1, 1 = TDC2, default 0 bits 18-31 - not used

To send the complete parameter set back to the DLLs and to the DPC module (e.g. after changing parameter values) the function **SPC\_set\_parameters** is used. This function checks and - if required - recalculates all parameter values due to cross dependencies and hardware restrictions. Therefore, it is recommended to read the parameter values after calling **SPC\_set\_parameters** by **SPC\_get\_parameters**.

Parameters set can be saved to ini\_file using the function **SPC\_save\_parameters\_to\_inifile**. **SPC\_read\_parameters\_from\_inifile** enables reading back saved parameters from ini\_file and then with **SPC\_set\_parameters** send it to the DPC module.

Single parameter values can be transferred to or from the DLL and module level by the functions **SPC\_set\_parameter** and **SPC\_get\_parameter**. To identify the desired parameter, the parameter identification par\_id is used. For the parameter identification keywords are defined in spcm\_def.h.

## Memory Configuration

The module has two independent FIFO buffers. Each of them can contain up to 4 million events. The streams of collected photons are written to the FIFO buffers in parallel. A `SPC_configure_memory` function call is not required.

## Memory Read Functions

Reading the memory of the DPC module is accomplished by the function **SPC\_read\_fifo**. There is no need to fill (write to) FIFO buffers. **SPC\_read\_fifo** delivers stream of events collected in one TDC FIFO buffer. The function must be called for both TDC (if both are active) to read data from all active input channels. The data contain unsorted photon entries and additional TDC control events in a **raw** format.

User should save the raw data from both TDCs to separate files and then use **SPC\_convert\_dpc\_raw\_data** function (in a way described in `use_dpc.c` file) to convert the files to a result file in **.spc** format (described in DPC Manual). **.spc** format is easy to use and understand in comparison to a raw data.

Extracting photons information from the FIFO data is done by the functions **SPC\_init\_phot\_stream** and **SPC\_get\_photon**.

During the measurement user should only read the raw data (by **SPC\_read\_fifo**) to avoid FIFO overruns and to increase max possible photons rate. Converting the data to **.spc** format and extracting photons information is a time consuming task and should be done after the measurement.

## Standard Measurements

DPC operation modes are described in DPC Manual.

The most important measurement functions are listed below.

**SPC\_test\_state** sets a state variable according to the current state of the measurement. The function is used to control the measurement loop. The status bits delivered by the function and important for the DPC module are listed below (see also `SPCM_DEF.H`).

<code>SPC_ARMED1</code>	<code>0x80</code>	measurement in progress in TDC 1
<code>SPC_ARMED2</code>	<code>0x40</code>	measurement in progress in TDC 2
<code>SPC_MEASURE</code>	<code>0x80</code>	image measurement active, no wait for trigger or 1 <sup>st</sup> frame pulse
<code>SPC_FEMPTY1</code>	<code>0x100</code>	FIFO empty in TDC 1
<code>SPC_FEMPTY2</code>	<code>0x200</code>	FIFO empty in TDC 2
<code>SPC_FOVL1</code>	<code>0x400</code>	FIFO overflow in TDC 1, data lost
<code>SPC_FOVL2</code>	<code>0x800</code>	FIFO overflow in TDC 2, data lost
<code>SPC_CTIM_OVER1</code>	<code>0x8</code>	collection timer of TDC 1 expired
<code>SPC_CTIM_OVER2</code>	<code>0x20</code>	collection timer of TDC 2 expired
<code>SPC_TIME_OVER</code>	<code>0x4</code>	measurement stopped on expiration of collection timer
<code>SPC_WAIT_FR</code>	<code>0x2000</code>	image measurement waits for frame signal to stop
<code>SPC_WAIT_TRG</code>	<code>0x1000</code>	wait for trigger

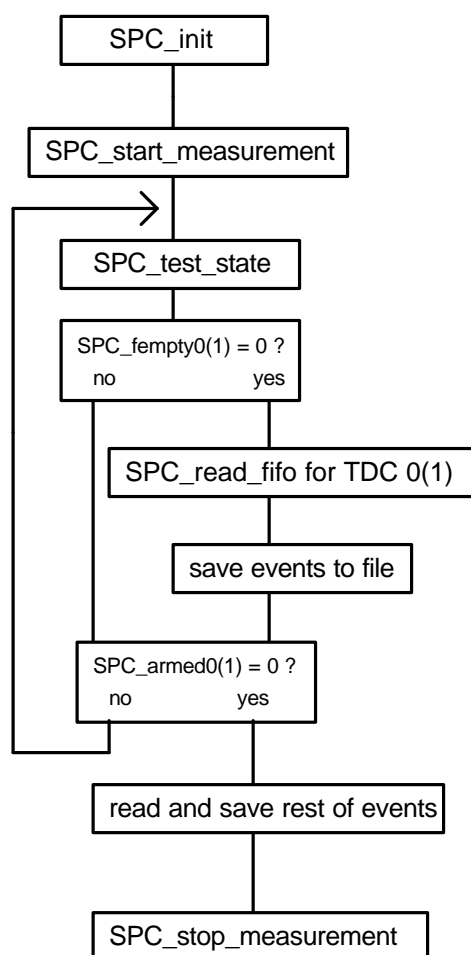
**SPC\_start\_measurement** starts the measurement in active TDCs with the parameters set before by the **SPC\_init**, **SPC\_set\_parameters** or **SPC\_set\_parameter** functions. When the measurement is started by **SPC\_start\_measurement**, also the TDCs collection timers are started. In the standard mode, i.e. when intensity-versus-time functions are recorded in one or more detector channels, the measurement stops when the specified stop condition appears (collection time expired, or stop by **SPC\_stop\_measurement**).

**SPC\_stop\_measurement** is used to stop the measurement by a software command.

For not imaging modes the measurement is stopped immediately in both TDCs.

For imaging modes real stop happens when next frame pulse appears (to ensure that whole frames are recorded). In this time period **SPC\_test\_state** will show the flag **SPC\_WAIT\_FR**. Another call to **SPC\_stop\_measurement** while waiting for the frame pulse will stop the measurement immediately.

A simple measurement sequence is shown in the block diagram below.



At the beginning, the measurement parameters are read from an initialisation file and send to the DPC module by **SPC\_init**. Additional parameter changes can be done before starting the measurement.



When the measurement has been started by `SPC_start_measurement` events can be read from TDCs FIFO buffers and saved to a file. The measurement runs until a stop condition (specified in the measurement parameters) is reached. Normally it is done after specified collection time when `Stop_on_time` parameter is set. Otherwise the measurement can be stopped by `SPC_stop_measurement` function, for example after reading specified amount of events. In this case the call of `SPC_test_state` returns `SPC_armed0(1) = 0` indicating that the measurement has been stopped and the rest of data can be read from the module memory. Finally `SPC_stop_measurement` must be called to perform some necessary DLL actions.

See also `use_dpc.c` file for other measurement examples.

## Count Rates

The count rates of the two TDCs of the DPC-230 are read by the **`SPC_read_rates`** function. Both rates are the total rates for all active channels of the TDCs.

Important: In contrast to the BH SPC modules the TDC chips have no counters to determine the count rates directly. The count rates have therefore to be determined by the SPCM software from the incoming photon data stream.

The results are stored into a structure of the following type – the same which is used for SPC modules:

<code>float sync_rate</code>	for DPC-230 - total photons rate in DPC1 in counts/s
<code>float cfd_rate</code>	for DPC-230 - total photons rate in DPC2 in counts/s
<code>float tac_rate</code>	for DPC-230 - not used
<code>float adc_rate</code>	for DPC-230 - not used

Integration time of rate values is equal normally 1sec and can be changed according to the parameter `RATE_COUNT_TIME`

To get correct results the **`SPC_clear_rates`** function must be called before the first call of `SPC_read_rates`

## On-Board Timers

The DPC module is equipped with Collection timer which is used to control the measurement.

The desired collection time interval is loaded with `SPC_init` or with a call of the functions `SPC_set_parameters` or `SPC_set_parameter`. The control of the timer is managed by the `SPC_start_measurement` function so that no explicit load/start/stop operations are required.

When the programmed collection time has expired, the measurement is stopped automatically if stop\_on\_time has been set (system parameters). The status can be read by the function SPC\_test\_state (see also 'Measurement Functions' and spcm\_def.h).

The residual collection time to the end of the measurement can be determined by the function **SPC\_get\_actual\_coltime**.

The time from the start of a measurement is returned by the function **SPC\_get\_time\_from\_start**.

## Error Handling

Each SPC DLL function returns an error status. Return values  $\geq 0$  indicate error free execution. A value  $< 0$  indicates that an error occurred during execution. The meaning of a particular error code can be found in spcm\_def.h file and can be read using **SPC\_get\_error\_string**. We recommend checking the return value after each function call.

## Using DLL functions in LabView environment

Each DLL function can be called in LabView program by using 'Call Library' function node. If you select Configure from the shortcut menu of the node, you see a Call Library Function dialog box from which you can specify the library name or path, function name, calling conventions, parameters, and return value for the node.

You should pay special attention to choosing correct parameter types using following conversion rules:

Type in C programs	Type in LabView
char	signed 8-bit integer, byte ( I8)
unsigned char	unsigned 8-bit integer, unsigned byte ( U8)
short	signed 16-bit integer, word ( I16)
unsigned short	unsigned 16-bit integer, unsigned word ( U16)
long, int	signed 32-bit integer, long ( I32)
unsigned long, int	unsigned 32-bit integer, unsigned long ( U32)
float	4-byte single, single precision ( SGL)
double	8-byte double, double precision ( DBL)
char *	C string pointer
float *	Pointer to Value ( Numeric, 4-byte single)

For structures defined in include file spcm\_def.h user should build in LabView a proper cluster. The cluster must contain the same fields in the same order as the C structure.

If a pointer to a structure is a function parameter, you connect to the node the proper cluster and define parameter type as 'Adapt to Type' (with data format = 'Handles by Value').

Connecting clusters with the contents which do not exactly correspond to the C structure fields can cause the program crash.

Problems appear if the **structure and the corresponding cluster contain string fields** - due to the fact that LabView sends to the DLL handles to LabView string instead of the C string pointers for strings inside the cluster.

In such case special version of the DLL function must be used which is prepared especially for use in LabView. Such functions have ‘\_LV’ letters after ‘SPC’ (for example SPC\_LV\_get\_eeeprom\_data), and if found in spcm\_def.h file they should be used in ‘Call Library’ function node instead of the standard function.

Another solution is to write extra C code to transform these data types, create .lsb file and use it in 'Code Interface' node (CIN) instead of 'Call Library'.

Experienced LabView and C users can prepare such CINs for every external code.

## Description of the SPC DLL Functions

### Initialisation functions:

```
-----  
short CVICDECL SPC_init (char * ini_file);  
-----
```

#### Input parameters:

- \* ini\_file: pointer to a string containing the name of the initialisation file in use (including file name and extension)

#### Return value:

0      no errors,      <0      error code

#### Description:

Before a measurement is started the measurement parameter values must be written into the internal structures of the DLL functions (not directly visible from the user program) and sent to the control registers of the DPC module(s). This is accomplished by the function **SPC\_init**. The function

- checks whether DLL is correctly registered ( looks for a BH license number and verifies it)
- reads the parameter values from the specified file ini\_file
- checks and recalculates the parameters depending on hardware restrictions of the DPC module(s)
- sends the parameter values to the internal structures of the DLL
- sends the parameter values to the DPC control registers
- performs a hardware test of the DPC module(s)

The DPC module, which will be initialised, is defined by 'pci\_bus\_no' and 'pci\_card\_no' parameter from ini\_file.

'pci\_bus\_no' defines which PCI bus with DPC modules will be initialised:

- value 0 – 255 defines specific bus number (from the range: 0 to number of PCI busses with DPC modules) ( if 'pci\_bus\_no' is greater than number of PCI busses with DPC modules, it is rounded to the number of busses –1 )
- value –1 means that the function will try to initialise DPC modules on all PCI busses

'pci\_card\_no' defines the number of DPC module on PCI bus to be initialised:

- value 0 – 7 defines one specific module ( if 'pci\_card\_no' is greater than number of DPC modules on PCI bus, it is rounded to the number of modules –1 )
- value –1 means that the function will try to initialise all DPC modules on PCI bus

The module will be initialised, but only when it is not in use (locked) by other application.

After successful initialisation the module is locked to prevent that other application can access it. The user should check initialisation status of all modules he wants to use by calling SPC\_get\_init\_status function.

If, for some reasons, the module which was locked must be initialised, it can be done using the function SPC\_set\_mode with the parameter 'force\_use' = 1.

The initialisation file is an ASCII file with a structure shown in the table below. We recommend either to use the file spcm.ini or to start with spcm.ini and introduce the desired changes.

```
; SPCM DLL initialisation file for DPC230 module
; DPC parameters have to be included in .ini file only when parameter
; value is different from default.
; for SPC modules use file spcm.ini instead of this one

[spc_base]
simulation = 0                ; 0 - hardware mode(default) ,
                             ; >0 - simulation mode (see spcm_def.h for possible values)
pci_bus_no = -1              ; PCI bus on which DPC modules will be looking for
                             ; 0 - 255, default -1 ( all PCI busses will be scanned)
pci_card_no = -1             ; number of the DPC module on PCI bus
                             ; 0 - 7, default -1 (all modules on PCI bus)

[spc_module]                 ; DPC hardware parameters
cfld_limit_low = -30.0       ; = CFD_TH1 threshold of CFD1 -510 ..0 mV, default -30
cfld_limit_high = -30.0      ; = CFD_TH2 threshold of CFD2 -510 ..0 mV, default -30
cfld_zc_level = -30.0        ; = CFD_TH3 threshold of CFD3 -510 ..0 mV, default -30
cfld_holdoff = -30.0         ; = CFD_TH4 threshold of CFD4 -510 ..0 mV, default -30

sync_zc_level = 0.0          ; = CFD_ZC1 Zero Cross Level of CFD1 -96 ..96 mV, default 0
sync_holdoff = 0.0           ; = CFD_ZC2 Zero Cross Level of CFD2 -96 ..96 mV, default 0
sync_threshold = 0.0         ; = CFD_ZC3 Zero Cross Level of CFD3 -96 ..96 mV, default 0
tac_limit_high = 0.0         ; = CFD_ZC4 Zero Cross Level of CFD4 -96 ..96 mV, default 0

mem_bank = 6                 ; bit 1 - DPC 1 active, bit 2 - DPC 2 active,
                             ; default 6 - both TDCs active
detector_type = 0            ; type of active inputs : bit 1 - TDC1, bit 2 - TDC2,
                             ; bit value 0 , CFD inputs active,
                             ; bit value 1 , TTL inputs active
                             ; default 0 - both TDCs have CFD inputs active

chan_enable = 0x3ff3ff       ; enable(1)/disable(0) input channels
                             ; bits 0-7 - en/disable TTL channel 0-7 in TDC1
                             ; bits 8-9 - en/disable CFD channel 0-1 in TDC1
                             ; bits 12-19 - en/disable TTL channel 0-7 in TDC2
                             ; bits 20-21 - en/disable CFD channel 0-1 in TDC2
                             ; default 0x3ff3ff - all inputs enabled
chan_slope = 0               ; active slope of input channels
                             ; 1 - rising, 0 - falling edge active
                             ; bits 0-7 - slope of TTL channel 0-7 in TDC1
                             ; bits 8-9 - slope of CFD channel 0-1 in TDC1
                             ; bits 12-19 - slope of TTL channel 0-7 in TDC2
                             ; bits 20-21 - slope of CFD channel 0-1 in TDC2
                             ; default 0 - all inputs falling edge
mode = 8                     ; module's operation mode , default 8
                             ; 6 - TCSPC FIFO
                             ; 7 - TCSPC FIFO Image mode
                             ; 8 - Absolute Time FIFO mode
                             ; 9 - Absolute Time FIFO Image mode
rate_count_time = 1.0        ; rate counting time in sec default 1.0 sec
                             ; 0.0 - don't count rate outside the measurement
collect_time = 2.0           ; 0.0001 .. 100000s , default 2.0 s
stop_on_time = 1             ; 0,1 , default 1
sync_freq_div = 1            ; 1,2,4 default 1 in TCSPC modes

trigger = 0                  ; external trigger condition
                             ; bits 1 & 0 mean : 00 - ( value 0 ) none(default),
                             ; 01 - ( value 1 ) active low,
```

```

;          10 - ( value 2 ) active high

pixel_clock = 0          ; source of pixel clock in Image modes
                        ; 0 - internal, 1 - external, default 0

chan_spec_no = 0x8813    ; channel numbers of special inputs
                        ; bits 0-4 - reference chan. no ( TCSPC and Multiscaler modes)
                        ;      default = 19, value:
                        ;      0-1 CFD chan. 0-1 of TDC1, 2-9 TTL chan. 0-7 of TDC1
                        ;      10-11 CFD chan. 0-1 of TDC2, 12-19 TTL chan. 0-7 of TDC2
                        ; bits 8-10 - frame clock TTL chan. no ( imaging modes ) 0-7, default 0
                        ; bits 11-13 - line clock TTL chan. no ( imaging modes ) 0-7, default 1
                        ; bits 14-16 - pixel clock TTL chan. no ( imaging modes ) 0-7, default 2
                        ; bit 17 - TDC no for pixel, line, frame clocks ( imaging modes )
                        ;      0 = TDC1, 1 = TDC2, default 0
                        ; bits 18-31 - not used

```

---

```
short CVICDECL SPC_get_init_status(short mod_no);
```

---

Input parameters:

mod\_no                    0 .. 7, DPC module number

Return value: initialisation result code of the DPC module 'mod\_no'

Description:

The procedure returns the initialisation result code set by the function SPC\_init. The possible values are shown below (see also spcm\_def.h):

INIT_OK	0	no error
INIT_NOT_DONE	-1	init not done
INIT_WRONG_EEP_CHKSUM	-2	wrong EEPROM checksum
INIT_WRONG_MOD_ID	-3	wrong module identification code
INIT_HARD_TEST_ERR	-4	hardware test failed
INIT_CANT_OPEN_PCI_CARD	-5	cannot open PCI card
INIT_MOD_IN_USE	-6	module in use (locked) - cannot initialise
INIT_WINDRV_R_VER	-7	incorrect WinDriver version
INIT_SPC_WRONG_LICENSE	-8	corrupted license key
INIT_SPC_FIRMWARE_VER	-9	incorrect firmware version of DPC module
INIT_SPC_NO_LICENSE	-10	license key not read from registry
INIT_SPC_LICENSE_NOT_VALID	-11	license is not valid for SPCM DLL
INIT_SPC_LICENSE_DATE_EXP	-12	license date expired
INIT_XILINX_ERR	-1xx	Xilinx chip configuration error - where xx = Xilinx error code

---

```
short CVICDECL SPC_get_module_info(short mod_no, SPCModInfo * mod_info);
```

---

Input parameters:

mod\_no                    0 .. 7, DPC module number

\*mod\_info                pointer to result structure (type SPCModInfo)

Return value: 0 no errors, <0 error code (see spcm\_def.h)

## Description:

After calling the SPC\_init function (see above) the SPCModInfo internal structures for all 8 modules are filled. This function transfers the contents of the internal structure of the DLL into a structure of the type SPCModInfo (see spcm\_def.h) which has to be defined by the user. The parameters included in this structure are described below.

short module_type	DPC module type (see spcm_def.h)
short bus_number	PCI bus number of the module
short slot_number	slot number on PCI bus 'bus_number' occupied by the module
short in_use	-1 used and locked by other application, 0 - not used, 1 - in use
short init	set to initialisation result code
unsigned short base_adr	base I/O address on PCI bus

---

```
short CVICDECL SPC_test_id(short mod_no) ;
```

---

## Input parameters:

mod\_no            0 .. 7, SPC module number

Return value: on success - module type, on error <0 (error code)

The procedure can be used to check whether a DPC module is present and which type of the module it is. It is a low level procedure that is called also during the initialisation in SPC\_init. The procedure returns a module type value of module 'mod\_no'. Possible module type values are defined in spcm\_def.h file.

The x0x and x3x versions are not distinguished by the id but by the EEPROM data and the function SPC\_init. SPC\_test\_id will return the correct values only if SPC\_init has been called.

```
/* supported module types - returned value from SPC_test_id */
#define M_SPC600            600            PCI version of 400
#define M_SPC630            630            PCI version of 430
#define M_SPC700            700            PCI version of 500
#define M_SPC730            730            PCI version of 530
#define M_SPC130            130            PCI special version of 630
#define M_SPC830            830            version of 730 with large memory, Fifo mode
#define M_SPC140            140            130 with large memory, Fifo mode, Scan modes
#define M_SPC930            930            830 with Camera mode
#define M_SPC150            150            140 with Fifo mode, Scan modes, Fifo Imaging, Cont. Flow
#define M_DPC230            230            DPC-230
#define M_SPC131            131            130 with with extended memory = SPC-130-EM
```

---

```
short CVICDECL SPC_set_mode(short mode, short force_use, int *in_use);
```

---

## Input parameters:

mode            mode of DLL operation  
force\_use       force using the module if they are locked ( in use)  
\*in\_use        pointer to the table with information which module must be used

Return value: on success - DLL mode, on error <0 (error code)

The procedure is used to change the mode of the DLL operation between the hardware mode and the simulation mode. It is also used to switch the DLL to the simulation mode if hardware errors occur during the initialisation.

Table 'in\_use' should contain entries for all 8 modules:

0 – means that the module will be unlocked and not used longer

1 – means that the module will be initialised and locked

When the Hardware Mode is requested for each of 8 possible modules:

-if 'in\_use' entry = 1 : the proper module is locked and initialised (if it wasn't) with the initial parameters set (from ini\_file) but only when it was not locked by another application or when 'force\_use' = 1.

-if 'in\_use' entry = 0 : the proper module is unlocked and cannot be used further.

When one of the simulation modes is requested for each of 8 possible modules:

-if 'in\_use' entry = 1 : the proper module is initialised (if it wasn't) with the initial parameters set (from ini\_file).

-if 'in\_use' entry = 0 : the proper module is unlocked and cannot be used further.

Errors during the module initialisation can cause that the module is excluded from use.

Use the function SPC\_get\_init\_status and/or SPC\_get\_module\_info to check which modules are correctly initialised and can be use further.

Use the function SPC\_get\_mode to check which mode is actually set. Possible 'mode' values are defined in the spcm\_def.h file.

---

```
short CVICDECL SPC_get_mode(void);
```

---

Input parameters: none

Return value: DLL operation mode

The procedure returns the current DLL operation mode. Possible 'mode' values are defined in the spcm\_def.h file:

```
#define SPC_HARD          0          /* hardware mode */
#define SPC_SIMUL600      600        /* simulation mode of SPC600 module */
#define SPC_SIMUL630      630        /* simulation mode of SPC630 module */
#define SPC_SIMUL700      700        /* simulation mode of SPC700 module */
#define SPC_SIMUL730      730        /* simulation mode of SPC730 module */
#define SPC_SIMUL130      130        /* simulation mode of SPC130 module */
#define SPC_SIMUL830      830        /* simulation mode of SPC830 module */
#define SPC_SIMUL140      140        /* simulation mode of SPC140 module */
#define SPC_SIMUL930      930        /* simulation mode of SPC930 module */
#define SPC_SIMUL150      150        /* simulation mode of SPC150 module */
#define DPC_SIMUL230      230        /* simulation mode of DPC230 module */
#define SPC_SIMUL131      131        /* simulation mode of SPC131 (= SPC-130-EM) module */
```



## Setup functions:

```
-----  
short CVICDECL SPC_get_parameters(short mod_no, SPCdata * data);  
-----
```

## Input parameters:

mod\_no                    0... 7, DPC module number  
\*data                    pointer to result structure (type SPCdata)

Return value: 0 no errors, <0 error code (see spcm\_def.h)

## Description:

After calling the SPC\_init function (see above) the measurement parameters from the initialisation file are present in the module and in the internal data structures of the DLLs. To give the user access to the parameters, the function **SPC\_get\_parameters** is provided. This function transfers the parameter values from the internal DLL structures of the module 'mod\_no' into a structure of the type SPCdata (see spcm\_def.h) which has to be defined by the user. The structure is common for all SPC and DPC module types, therefore some fields are not used for DPC modules. The parameter values in this structure are described below.

unsigned short base_adr	base I/O address on PCI bus
short init	set to initialisation result code
float cfd_limit_low	= CFD_TH1 threshold of CFD1 -510 ..0 mV
float cfd_limit_high	= CFD_TH2 threshold of CFD2 -510 ..0 mV
float cfd_zc_level	= CFD_TH3 threshold of CFD3 -510 ..0 mV
float cfd_holdoff	= CFD_TH4 threshold of CFD4 -510 ..0 mV
float sync_zc_level	= CFD_ZC1 Zero Cross level of CFD1 -96 ..96 mV
float sync_holdoff	= CFD_ZC2 Zero Cross level of CFD2 -96 ..96 mV
float sync_threshold	= CFD_ZC3 Zero Cross level of CFD3 -96 ..96 mV
float tac_range	DPC range in TCSPC and Multiscaler mode, 0.16461 .. 1e7 ns
short sync_freq_div	1,2,4
short tac_gain	not used for DPC230
float tac_offset	TDC offset in TCSPC and Multiscaler mode -100 .. 100%
float tac_limit_low	not used for DPC230
float tac_limit_high	= CFD_ZC4 Zero Cross level of CFD4 -96 ..96 mV
short adc_resolution	no of points of decay curve in TCSPC and Multiscaler mode 0,2,4,6,8,10,12,14 bits
short ext_latch_delay	not used for DPC230
float collect_time	0.0001 .. 100000s , default 2.0s
float display_time	not used for DPC230
float repeat_time	not used for DPC230
short stop_on_time	1 (stop) or 0 (no stop)
short stop_on_ovfl	not used for DPC230
short dither_range	not used for DPC230
short count_incr	not used for DPC230
short mem_bank	bit 1 - DPC 1 active, bit 2 - DPC 2 active, default 6 ( both TDCs active)
short dead_time_comp	not used for DPC230
unsigned short scan_control	not used for DPC230
short routing_mode	DPC230 bits 0-7 - control bits
float tac_enable_hold	macro time clock in ps, default 82.305 ps
short pci_card_no	module no on PCI bus ( 0-7)
unsigned short mode;	module's operation mode , default 8 6 - TCSPC FIFO 7 - TCSPC FIFO Image mode 8 - Absolute Time FIFO mode 9 - Absolute Time FIFO Image mode
unsigned long scan_size_x;	not used for DPC230
unsigned long scan_size_y;	not used for DPC230
unsigned long scan_rout_x;	not used for DPC230
unsigned long scan_rout_y;	not used for DPC230
unsigned long scan_flyback;	not used for DPC230

unsigned long scan_borders;	not used for DPC230
unsigned short scan_polarity;	not used for DPC230
unsigned short pixel_clock;	source of pixel clock in Image modes 0 - internal, 1 - external, default 0
unsigned short line_compression;	not used for DPC230
unsigned short trigger;	external trigger condition - bits 1 & 0 mean : 00 - ( value 0 ) none(default), 01 - ( value 1 ) active low, 10 - ( value 2 ) active high
float pixel_time;	not used for DPC230
unsigned long ext_pixclk_div;	not used for DPC230
float rate_count_time;	rate counting time in sec default 1.0 sec 0.0 - don't count rate outside the measurement
short macro_time_clk;	not used for DPC230
short add_select;	not used for DPC230
short test_eep	0: EEPROM is not read and not tested 1: EEPROM is read and tested for correct checksum
short adc_zoom;	not used for DPC230
unsigned long img_size_x;	not used for DPC230
unsigned long img_size_y;	not used for DPC230
unsigned long img_rout_x;	not used for DPC230
unsigned long img_rout_y;	not used for DPC230
short xy_gain;	not used for DPC230
short master_clock;	not used for DPC230
short adc_sample_delay;	not used for DPC230
short detector_type;	type of active inputs : bit 1 - TDC1, bit 2 - TDC2, bit value 0 , CFD inputs active, bit value 1 , TTL inputs active
short x_axis_type;	not used for DPC230
unsigned short chan_enable;	enable(1)/disable(0) input channels bits 0-7 - en/disable TTL channel 0-7 in TDC1 bits 8-9 - en/disable CFD channel 0-1 in TDC1 bits 12-19 - en/disable TTL channel 0-7 in TDC2 bits 20-21 - en/disable CFD channel 0-1 in TDC2
unsigned short chan_enable;	active slope of input channels 1 - rising, 0 - falling edge active bits 0-7 - slope of TTL channel 0-7 in TDC1 bits 8-9 - slope of CFD channel 0-1 in TDC1 bits 12-19 - slope of TTL channel 0-7 in TDC2 bits 20-21 - slope of CFD channel 0-1 in TDC2
unsigned long chan_spec_no;	channel numbers of special inputs, default 0x8813 bits 0-4 - reference chan. no ( TCSPC and Multiscaler modes) default = 19, value: 0-1 CFD chan. 0-1 of TDC1, 2-9 TTL chan. 0-7 of TDC1 10-11 CFD chan. 0-1 of TDC2, 12-19 TTL chan. 0-7 of TDC2 bits 8-10 - frame clock TTL chan. no ( imaging modes ) 0-7, default 0 bits 11-13 - line clock TTL chan. no ( imaging modes ) 0-7, default 1 bits 14-16 - pixel clock TTL chan. no ( imaging modes ) 0-7, default 2 bit 17 - TDC no for pixel, line, frame clocks ( imaging modes ) 0 = TDC1, 1 = TDC2, default 0 bits 18-31 - not used

---

```
short CVICDECL SPC_set_parameters(short mod_no, SPCdata *data);
```

---

Input parameters:

mod_no	0... 7, DPC module number
*data	pointer to result structure (type SPCdata)

Return value: 0 no errors, <0 error code (see spcm\_def.h)

#### Description:

The procedure sends all parameters from the 'SPCdata' structure to the internal DLL structures of the module 'mod\_no' and to the control registers of the DPC module 'mod\_no'.

The new parameter values are recalculated according to the parameter limits, hardware restriction and the DPC module type. Furthermore, cross dependencies between different parameters are taken into account to ensure the correct hardware operation. It is recommended to read back the parameters after setting it to get their real values after recalculation.

If an error occurs at a particular parameter, the procedure does not set the rest of the parameters and returns with an error code.

---

```
short CVICDECL SPC_get_parameter(short mod_no, short par_id, float * value);
```

---

#### Input parameters:

mod_no	0... 7, DPC module number
par_id	parameter identification number (see spcm_def.h)
*value	pointer to the parameter value

#### Return value:

0      no errors,      <0      error code

The procedure loads 'value' with the actual value of the requested parameter from the internal DLL structures of the module 'mod\_no'. The par\_id values are defined in spcm\_def.h file as SPC\_PARAMETERS\_KEYWORDS.

---

```
short CVICDECL SPC_set_parameter(short mod_no, short par_id, float value);
```

---

#### Input parameters:

mod_no	0... 7, DPC module number, -1 all used modules
par_id	parameter identification number
value	new parameter value

#### Return value:

0      no errors,      <0      error code

The procedure sets the specified hardware parameter. The value of the specified parameter is transferred to the internal DLL structures of the module 'mod\_no' and to the DPC module 'mod\_no'.

If 'mod\_no' = -1, parameter will be changed for all DPC modules which are actually in use.

The new parameter value is recalculated according to the parameter limits, hardware restrictions and DPC module type. Furthermore, cross dependencies between different parameters are taken into account to ensure the correct hardware operation. It is recommended to read back the parameters after setting it to get their real values after recalculation.

The par\_id values are defined in spcm\_def.h file as SPC\_PARAMETERS\_KEYWORDS.

---

```
short CVICDECL SPC_get_eeeprom_data( short mod_no, SPC_EEP_Data *eep_data);
```

---

Input parameters:

mod_no	0... 7, DPC module number
*eep_data	pointer to result structure

Return value: 0: no errors, <0: error code

The structure "eep\_data" is filled with the contents of EEPROM of DPC module 'mod\_no'. The EEPROM contains production data of the module. The structure "SPC\_EEP\_Data" is defined in the file spcm\_def.h.

Normally, the EEPROM data need not be read explicitly because the EEPROM is read during SPC\_init and the module type information and the adjust values are taken into account when the DPC module registers are loaded.

---

```
short CVICDECL SPC_write_eeeprom_data (short mod_no , unsigned short write_enable,  
                                     SPC_EEP_Data *eep_data);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
write_enable	write enable value (known by B&H)
*eep_data	pointer to a structure which will be sent to EEPROM

Return value: 0: no errors, <0: error code

The function is used to write data to the EEPROM of a DPC module 'mod\_no' by the manufacturer. To prevent corruption of the adjust data writing to the EEPROM can be executed only when correct 'write\_enable' value is used.

---

```
short CVICDECL SPC_read_parameters_from_inifile ( SPCdata *data, char *inifile);
```

---

Input parameters:

\*data            pointer to result structure (type SPCdata)  
 \*infile:        pointer to a string containing the name of the initialisation file (including  
                  file name and extension)

Return value:    0 no errors, <0 error code (see spcm\_def.h)

#### Description:

The procedure reads parameters from the file 'infile' and transfers them to the 'SPCdata' structure 'data'.

The 'infile' file is an ASCII file with a structure shown in SPC\_init description. We recommend using either the original .ini files or the files created using function SPC\_save\_parameters\_to\_infile.

If a particular parameter is not present in .ini file or cannot be read, the appropriate field in SPCdata 'data' structure is set to the parameter's default value.

Use SPC\_set\_parameters to send result parameters set to the DPC module.

```
-----
short CVICDECL SPC_save_parameters_to_infile ( SPCdata *data, char *dest_infile,
                                              char *source_infile, int with_comments);
-----
```

#### Input parameters:

\*data            pointer to result structure (type SPCdata)  
 \*dest\_infile:   pointer to a string containing the name of the destination file  
 \*source\_infile: pointer to a string containing the name of the source ini file, can be NULL  
 with\_comments   0 or 1 says whether comments from source\_infile will be copied to  
                  dest\_infile

Return value:    0 no errors, <0 error code (see spcm\_def.h)

#### Description:

The parameters set from the 'SPCdata' structure 'data' is saved to the section [spc\_module] in dest\_infile file. [spc\_base] section and initial comment lines are copied to dest\_infile from the source\_infile file.

If the parameter 'source\_infile' is equal NULL, ini\_file used in SPC\_init function call is used as the source file for dest\_infile.

Additionally when 'with\_comments' parameter is equal 1, comment lines for the particular parameters are taken from the source file and saved to dest\_infile together with the parameter value.

The 'dest\_infile' and 'source\_infile' files are ASCII files with a structure shown in SPC\_init description.

Use SPC\_read\_parameters\_from\_infile to read back the parameters set from the file and then SPC\_set\_parameters to send it to the DPC module.

## Status functions:

---

```
short CVICDECL SPC_test_state(short mod_no, short *state);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
*state	pointer to result variable

Return value: 0: no errors, <0: error code

SPC\_test\_state sets a state variable according to the current state of the measurement on DPC module 'mod\_no'. The function is used to control the measurement loop. The status bits delivered by the function and important for the DPC module are listed below (see also SPCM\_DEF.H).

SPC_ARMED1	0x80	measurement in progress in TDC 1
SPC_ARMED2	0x40	measurement in progress in TDC 2
SPC_MEASURE	0x80	image measurement active, no wait for trigger or 1 <sup>st</sup> frame pulse
SPC_FEMPTY1	0x100	FIFO empty in TDC 1
SPC_FEMPTY2	0x200	FIFO empty in TDC 2
SPC_FOVL1	0x400	FIFO overflow in TDC 1, data lost
SPC_FOVL2	0x800	FIFO overflow in TDC 2, data lost
SPC_CTIM_OVER1	0x8	collection timer of TDC 1 expired
SPC_CTIM_OVER2	0x20	collection timer of TDC 2 expired
SPC_TIME_OVER	0x4	measurement stopped on expiration of collection timer
SPC_WAIT_FR	0x2000	image measurement waits for frame signal to stop
SPC_WAIT_TRG	0x1000	wait for trigger

---

```
short CVICDECL SPC_get_sync_state(short mod_no, short *sync_state);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
*sync_state	pointer to result variable

Return value: 0: no errors, <0: error code

In the relative timing modes (multichannel scaler or TCSPC) reference pulses are recorded in one channel of the DPC-230. The times of the reference pulses are recorded together with the

photon times, and relative times between the photons and the reference pulses are calculated. The presence of the signal in a reference channel can be tested by the procedure.

Reference channel is defined by setting the parameter CHAN\_SPEC\_NO.

The procedure sets "sync\_state" according to the reference signal presence on the DPC module 'mod\_no'.

- 0: Reference signal not detected
- 1: Reference signal detected

---

```
short CVICDECL SPC_get_time_from_start(short mod_no, float *time);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
*time	pointer to result variable

Return value: 0: no errors, <0: error code

The procedure reads the DPC collection timer and calculates the time from the start of the measurement for the DPC module 'mod\_no'. It should be called during the measurement, because the timer starts to run after starting the measurement.

The procedure can be used to test the progress of the measurement.

---

```
short CVICDECL SPC_get_break_time(short mod_no, float *time);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
*time	pointer to result variable

Return value: 0: no errors, <0: error code

The procedure calculates for the DPC module 'mod\_no' the time from the start of the measurement to the moment of a measurement interruption by a user break (SPC\_stop\_measurement). The procedure can be used to find out the moment of measurement interrupt.

---

```
short CVICDECL SPC_get_actual_coltime(short mod_no, float *time);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
--------	---------------------------

\*time                      pointer to result variable

Return value: 0: no errors, <0: error code

The procedure reads the collection timer and calculates the actual collection time value for the DPC module 'mod\_no'. During the measurement this value decreases from the specified collection time to 0.

---

```
short CVICDECL SPC_read_rates(short mod_no, rate_values *rates);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
* rates	pointer to result rates structure

Return value:

0 - OK, -SPC\_RATES\_NOT\_RDY - rate values not ready yet, < 0: error code

The procedure reads the rate counts for the DPC module 'mod\_no', calculates the rate values and writes the results to the 'rates' structure.

The results are stored into a structure of the following type – the same which is used for SPC modules:

float sync_rate	for DPC-230 - total photons rate in DPC1 in counts/s
float cfd_rate	for DPC-230 - total photons rate in DPC2 in counts/s
float tac_rate	for DPC-230 - not used
float adc_rate	for DPC-230 - not used

Integration time of rate values is equal normally 1sec and can be changed according to the parameter RATE\_COUNT\_TIME

The procedure can be called at any time after an initial call to the SPC\_clear\_rates function. If the rate values are ready (after 1sec of integration time), the procedure fills 'rates', starts a new integration cycle and returns 0, otherwise it returns -SPC\_RATES\_NOT\_RDY.

---

```
short CVICDECL SPC_clear_rates(short mod_no);
```

---

Input parameters:

mod_no	0 .. 7, DPC module number
--------	---------------------------

Return value: 0: no errors, <0: error code



#### Description:

The procedure clears all rate counters for the DPC module 'mod\_no'.

To get correct rate values the procedure must be called once before the first call of the SPC\_read\_rates function. SPC\_clear\_rates starts a new rate integration cycle.

---

```
short CVICDECL SPC_get_scan_clk_state (short mod_no, short *scan_state);
```

---

#### Input parameters:

mod_no	0 .. 7, DPC module number
*scan_state	pointer to result variable

Return value: 0: no errors, <0: error code

The procedure sets "scan\_state" according to the presence of the scanning clocks on the DPC module 'mod\_no'.

Scan\_state value is valid only when the module works in one of imaging modes (FIFO\_TCSPC\_IMG or FIFO\_ABS\_IMG) (setting parameter MODE using SPC\_set\_parameter procedure). Otherwise the procedure returns error code -SPC\_BAD\_FUNC.

In imaging modes some input channels are reserved for scan clocks (pixel, line, frame). Scan clocks channels can be defined by setting the parameter CHAN\_SPEC\_NO.

The presence of the signals in scan clocks channels is detected and "scan\_state" is set accordingly.

Scan\_state bits should be interpreted as follows:

Bit mask value (hex):	1 – External Pixel Clock present
	2 – Line Clock present
	4 – Frame Clock present

---

```
short CVICDECL SPC_get_fifo_usage (short mod_no, float *usage_degree);
```

---

#### Input parameters:

mod_no	0 .. 15, DPC module and TDC number
* usage_degree	pointer to result variable

Return value: 0: no errors, <0: error code

The procedure sets "usage\_degree" with the value in the range from 0 to 1, which tells how occupied is FIFO memory of one of the TDC on the DPC module.

mod\_no values 0 .. 7 means TDC 1 of module 0 .. 7

mod\_no values 8 .. 15 means TDC 2 of module 0 .. 7

FIFO memory usage is set to 0 at the start of the measurement (in SPC\_start\_measurement) and after reading data from FIFO (SPC\_read\_fifo).

## Measurement control functions:

---

```
short CVICDECL SPC_start_measurement(short mod_no);
```

---

Input parameters:

mod\_no            0 .. 7, DPC module number

Return value: 0: no errors, <0: error code

The procedure is used to start the measurement on the DPC module 'mod\_no'.

Before a measurement is started DPC parameters must be set (SPC\_init or SPC\_set\_parameter(s)).

The procedure clears Macro time and FIFO buffers in active TDCs and then active TDCs are armed i.e. the photon collection is started.

---

```
short CVICDECL SPC_stop_measurement(short mod_no);
```

---

Input parameters:

mod\_no            0 .. 7, DPC module number

Return value: 0: no errors, <0: error code

The procedure is used to terminate a running measurement on the DPC module 'mod\_no'. The procedure action is different for different measurement modes.

For not imaging modes the measurement is stopped immediately in both TDCs.

For imaging modes real stop happens when next frame pulse appears (to ensure that whole frames are recorded). In this time period SPC\_test\_state will show the flag SPC\_WAIT\_FR. Another call to **SPC\_stop\_measurement** while waiting for the frame pulse will stop the measurement immediately.

## DPC memory transfer functions:

---

```
short CVICDECL SPC_read_fifo (short mod_no, unsigned long * count, unsigned short *data);
```

---

Input parameters:

mod_no	0 .. 15, DPC module and TDC number
*count	pointer to variable which: - on input contains required number of 16-bit words - on output will be filled with number of 16-bit words written to the buffer 'data'
*data	pointer to data buffer which will be filled

Return value:

0      no errors,      <0      error code

The procedure reads data from the FIFO memory of the specified TDC and DPC module.

mod\_no values 0 .. 7 means TDC 1 of module 0 .. 7

mod\_no values 8 .. 15 means TDC 2 of module 0 .. 7

SPC\_read\_fifo function reads 32-bits frames from the FIFO memory and writes them to the buffer 'data' until the FIFO is empty or 'Count' number of 16-bit words was already written.

The 'Count' variable is filled on exit with the number of 16-bit words written to the buffer. Please make sure that the buffer 'data' be allocated with enough memory for the expected number of frames (at least 'Count' 16-bit words).

## Other functions:

---

```
short CVICDECL SPC_get_error_string(short error_id, char * dest_string, short max_length);
```

---

Input parameters:

error_id	SPC DLL error id (0 – number of SPC errors-1) (see spcm_def.h file)
*dest_string	pointer to destination string
max_length	max number of characters which can be copied to 'dest_string'

Return value: 0: no errors, <0: error code

The procedure copies to 'dest\_string' the string which contains the explanation of the SPC DLL error with id equal 'error\_id'. Up to 'max\_length' characters will be copied.

Possible 'error\_id' values are defined in the spcm\_def.h file.

---

```
short CVICDECL SPC_init_phot_stream (short fifo_type, char * spc_file, short files_to_use,  
                                     short stream_type, short what_to_read );
```

---

Input parameters:

fifo_type	8 (FIFO_D230) for DPC module, other values are reserved for different SPC module types
* spc_file	file path of the 1 <sup>st</sup> spc file
files_to_use	number of subsequent spc files to use, 1..999 or –1 for all files
stream_type	bit 0 = 1- stream of BH .spc files ( 1st entry in each file contains MT clock, flags) bit 0 = 0 - no special meaning of the first entry in the file bit 1 = 1 –stream with raw data from TDC1 bit 2 = 1 –stream with raw data from TDC2 bit 3 = 1 –stream with raw data from TDC with active TTL inputs bit 8 = 1 –stream with DPC module data bit 9 = 1 - stream created in imaging mode bit 10 = 1 - stream contains raw data
what_to_read	defines which entries will be extracted bit 0 = 1 read valid photons,

bit 1 = 1 read invalid photons – no meaning for DPC module,  
bit 2 = 1 read pixel clock events, bit 3 = 1 read line clock events,  
bit 4 = 1 read frame clock events,  
bit 5 = 1 read markers 3 - no meaning for DPC module

Return value:  $\geq 0$ : stream handle, no errors,  $< 0$ : error code

The procedure is needed to initiate the process of extracting photons from a stream of .spc files created during FIFO measurement.

If the files were created using BH measurement software, 1<sup>st</sup> entry in each file contains Macro Time clock resolution. In such case bit 0 of 'stream\_type' parameter should be set to 1, otherwise if the 1<sup>st</sup> entry have no special meaning (just photon frame) set it to 0. Set bit 9 of 'stream\_type' if the file was created in one of imaging modes. Bit 8 must also be set for DPC data.

If the file(s) contains raw data (just read using SPC\_read\_fifo without conversion to DPC .spc format) bits 1,2,3 define which TDC and which inputs were active. This is important to calculate correct channel number (1 ... 20) while extracting photons from the stream.

Subsequent files created in BH software during one measurement have 3 digits file number in file name part of the path (for example xxx000.spc, xxx001.spc and so on). Such files can be treated together during extracting photons (they contain the same measurement) as a stream of files. When all photons from the 1<sup>st</sup> file will be extracted, the 2<sup>nd</sup> one will be opened during extraction and so on. The first file in the stream is given by 'spc\_file' parameter and 'files\_to\_use' parameter tells how many files belong to the stream (-1 means the procedure will evaluate number of files in the stream and use it as 'files\_to\_use' value).

'fifo\_type' parameter defines the format of the photons data in the stream. It depends mainly on the SPC/DPC module type which was used during the measurement. Possible 'fifo\_type' values are defined in the spcm\_def.h file. For DPC data value 8 (FIFO\_D230) should be used.

'what\_to\_read' parameter defines which entries will be extracted from the stream.

In most cases only bit 0 will be set (valid photons). For files created in imaging modes (bit 9 set in 'stream\_type') – pixel, line, frame events can also be extracted (bits 2-5) separately (CHAN\_SPEC\_NO parameter defines which channels are treated as the scan clock channels).

If the stream is successfully initialised, the procedure creates internal DLL PhotStreamInfo structure and returns the handle to the stream (positive value). Use this handle as an input parameter to the other extraction functions (SPC\_close\_phot\_stream, SPC\_get\_phot\_stream\_info, SPC\_get\_photon).

Max 8 streams can be initialised by the SPCM DLL.

Use SPC\_get\_phot\_stream\_info to get the current state of the stream and SPC\_get\_photon to extract subsequent photons from the stream.

After extracting photons stream should be closed using SPC\_close\_phot\_stream function.

See use\_dpc.c file for the extraction example.

```

-----
short          CVICDECL          SPC_get_phot_stream_info          (short          stream_hndl,
                                                                    PhotStreamInfo * stream_info );
-----

```

Input parameters:

stream\_hndl    handle of the initialised photons stream  
stream\_info    pointer to the stream info structure

Return value: 0: no errors, <0: error code

The procedure fills 'stream\_info' structure with the contents of DLL internal structure of the stream defined by handle 'stream\_hndl'. Procedure returns error, if 'stream\_hndl' is not the handle of the stream opened using SPC\_init\_phot\_stream function.

PhotStreamInfo structure is defined in the spcm\_def.h file.

```

-----
short CVICDECL SPC_get_photon (short stream_hndl, PhotInfo * phot_info );
-----

```

Input parameters:

stream\_hndl    handle of the initialised photons stream  
phot\_info       pointer to the photon info structure

Return value: 0: no errors, <0: error code

The procedure can be used in a loop to extract subsequent photons from the opened photons stream defined by handle 'stream\_hndl'.

The procedure fills 'phot\_info' structure with the information of the photon extracted from the current stream position. After extracting the procedure updates internal stream structures. If needed, it opens and read data from the next stream file. Use SPC\_get\_phot\_stream\_info function to get current stream state.

Procedure returns error, if 'stream\_hndl' is not the handle of the stream opened using SPC\_init\_phot\_stream function.

PhotInfo structure is defined in the spcm\_def.h file.

---

```
short CVICDECL SPC_close_phot_stream (short stream_hndl );
```

---

Input parameters:

stream_hndl	handle of the initialised photons stream
phot_info	pointer to the photon info structure

Return value: 0: no errors, <0: error code

The procedure is used to close the opened photons stream defined by handle 'stream\_hndl' after extraction of the photons.

The procedure frees all stream's memory and finally invalidates the handle 'stream\_hndl'.

Procedure returns error, if 'stream\_hndl' is not the handle of the stream opened using SPC\_init\_phot\_stream function.

---

```
short CVICDECL SPC_convert_dpc_raw_data ( short tdc1_stream_hndl,  
                                         short tdc2_stream_hndl, short init,  
                                         char * spc_file, int max_per_call );
```

---

Input parameters:

tdc1_stream_hndl	handle of the initialised stream of photons read from TDC1
tdc2_stream_hndl	handle of the initialised stream of photons read from TDC2
init	1 for 1 <sup>st</sup> call, 0 for subsequent calls
spc_file	file name of the destination .spc file
max_per_call	maximum number of events read from input streams in one call

Return value: 0: conversion finished, no errors, > 0 estimated rest to do in range 1000...1, <0: error code

The procedure is used in a loop to convert events from the opened photons streams of both TDC defined by handle 'tdc1(2)\_stream\_hndl'. One of the input stream handles can be equal NULL – it means that events from corresponding TDC are not used for conversion.

To get input stream handles use the procedure SPC\_init\_phot\_stream.

To avoid blocking the computer the procedure reads and converts in one call up to 'max\_per\_call' events from each stream. First call must be done with 'init' = 1 – this call initialises conversion process. Subsequent calls, up to the end of conversion, must be done with 'init' = 0.

Converted photon entries are written to the destination 'spc\_file'.

If error occurs the procedure returns error code < 0.



If no error, the procedure returns estimated progress value (rest to do) of the conversion process starting from 1000 down to 0. Value 0 means that all events from the opened input streams were analyzed and conversion was successfully finished.

Normally the input streams contain raw data read during the measurement from both TDCs using SPC\_read\_fifo procedure.

If the input streams contain data from both TDCs already converted to .spc format, the procedure will combine them into one .spc file sorted by macro time value.

See use\_dpc.c file for the conversion example.

See DPC manual for .spc format description.

```
-----  
short CVICDECL SPC_get_start_offset (      short mod_no,  
                                           short bank, unsigned long *ticks);  
-----
```

Input parameters:

mod_no	0 .. 7, DPC module number
bank	0 .. 1, TDC number
*ticks	pointer to value which will be filled with start offset ticks

Return value: 0: no errors, <0: error code

It is a low level procedure and not intended to normal use.

The procedure is used to get start offset of the 1<sup>st</sup> photon recorded in fifo memory of TDC's number 'bank' on DPC module 'mod\_no'. It must be called after starting the measurement ( SPC\_start\_measurement).

The procedure returns SPC\_RATES\_NOT\_RDY error, if start offset is not ready yet ( nothing was written to the DPC fifo).

Start offset is used to calculate correct time scale of the photons. It is included as a 2<sup>nd</sup> frame in .spc raw data files.

If error occurs the procedure returns error code < 0.

See use\_dpc.c file for the .spc files conversion example.

See DPC manual for .spc format description.

```
-----  
short CVICDECL SPC_close(void);  
-----
```

Input parameters: none

Return value: 0: no errors, <0: error code

It is a low level procedure and not intended to normal use.

The procedure frees buffers allocated via DLL and set the DLL state as before SPC\_init call.

SPC\_init is the only procedure which can be called after SPC\_close.

=====