Direct commands for Copenhagen CCD3 controllers (to be continued):

General format:

The character input buffer of the controller is a 20 char linear buffer. It is reset upon receiption of a '@' or a '?' character, and the content is forwarded to a command interpreter when a CR or LF character is received.

All commands and requests to the controller are in general following the same rules:

@xmpl n m<cr> is the command xmpl with the arguments n and m, and
?xmpl n<cr> is the corresponding request

In both cases the controller will reply with:

!xmpl n m and maybe some text

Examples:
@time 60000 will set the wanted integration time to 60000 msecs
and the controller will reply with !time 60000.

@vbha 0 23.5 will set the channel 0 ha-voltage (usually the OD) to 23.5volts, and the controller will reply !vbha 0 23.500

Note 1: Commands are in lower case! (090905PNø Both lo and up case should work)
Note 2: Some commands will take a few seconds to execute before the controller reply. Especially if the timing and readout is changed, the controller need to recalculate all the clock-waveforms accordingly. These commands are marked with a T.

Commands can be put in functional groups to support exposure control, readout format, timing- and bias- setup.

Exposure control (all times in msecs):

Command	Request	Reply	Action	
@sint	-	!sint	Start integration	
@time n	?time	!time%8d	Initial integration time in msecs (n>1)	
@timr n	?timr	!timr%8d	Residual exposure time in msecs (n>1)	
-	?tima	!tima%8d	Actual elapsed time in msecs	
@timw n	-	!timw%8d	new total wanted time in msecs (n>1)	
@sdly n	?sdly	!sdly %8d	Shutter delay in msecs (n>1)	
-	?stat	!stat %5d	status[31..16] : all zeroes status[15..08] : status from ctrl-sequencer status[07..00] : status from ctrl-program [0] : sequencer start/stop [1] : - [2] : shutter enable [3] : reset sequencer [8] : sequencer prompts for a start timing [9] : sequencer prompts for a PSU-sync [14,12]=0 idle [14,12]=1 integrating [14,12]=2 readout [14,12]=3 clear [14,12]=4 shutter delay	
@imod n,m	?imod n	!imod %1d %1d	Integration mode: n=0 => shutter n=1 => clear before exposure n=2 => readout after exposure m=0 => off; m=1 => on;	
@brek		!brek	Hard break of integration or readout. Aborts integration and/or readout without any saving and closes shutter. If the integration is to be terminated with a normal saving use the timr or timw commands.	

Readout format control:

Command	Request	Reply	Action	
@fres	-	!fres	Format reset : xtot and ytot to hardprogrammed values xsiz=xtot; ysix=ytot (no windowing) xbeg=ybeg=xbin=ybin=1 (no binning)	
@xtot n	?xtot	!xtot%5d	Total x size (for engineering only)	
@ytot n	?ytot	!ytot%5d	Total y size (for engineering only)	
@xsiz n	?xsiz	!xsiz%5d	x size for window	
@ysiz n	?ysiz	!ysiz%5d	y size for window	
@xbeg n	?xbeg	!xbeg%5d	x coordinate of lower left corner of window (First pixel is 1)	
@ybeg n	?ybeg	!ybeg%5d	y coordinate of lower left corner of window (First pixel is 1)	
@xbin n	?xbin	!xbin=%4d, Tpix=%4d => %4dkpix/s	x binning Recalculates: xsiz = (xsiz*xbin_old) div xbin_new;	T
@ybin n	?ybin	!ybin%4d	y binning Recalculates: ysiz = (ysiz*ybin_old) div ybin_new;	
@read n	?read	!read %1d	Readout direction; 0:Left; 1:Right; 2: Dual	T

Note: For the moment windowing is only implemented in read 0 mode (left readout)

Readout timing control:

Command	Request	Reply	Action	
@tsam n	?tsam	!tsam %4d,Tpix=%4d => %4dkpix/s	Clamp and sample times in clocks	T
@tspw n	?tspw	!tspw %4d,Tpix=%4d => %4dkpix/s	Serial pulse width in clocks	T
@tsol n	?tsol	!tsol %4d,Tpix=%4d => %4dkpix/s	Serial pulse overlap in clocks	T
@tsnd n	?tsnd	!tsnd %4d,Tpix=%4d => %4dkpix/s	Serial neutral delay in clocks	T
@tstr n	?tstr	!tstr %4d,Tpix=%4d => %4dkpix/s	Serial rise/fall times in clocks	T
@tres	-	!tres %4d, Tpix=%4d => %4dkpix/s	Reset all timing	T

Gain and offset control:

Command	Request	Reply	Action
@gain n m	?gain n	!gain %2d %7.3f	Individual Digital gain m in channel n
@zero n m	?zero n	!zero %2d %8d	Digital zero m in channel n
@offs n m	?offs n	!offs %2d %7.0f	Analog offset m in channel n
@cdsg n	?cdsg	!cdsg %8d	Fundamental cds-gain (n is integer)

Bias voltage control:

Command	Request	Reply	Action
@vbha n m	?vbha n	!vbha %2d %7.3f	Set HA high voltage channel n to m volts 5.0<=m<=24.0; Usually used for OD *1
@vbhb n m	?vbhb n	!vbhb %2d %7.3f	Set HB high voltage channel n to m volts 5.0<=m<=24.0; Usually used for RD *1
@vbhc n m	?vbhc n	!vbhc %2d %7.3f	Set HC high voltage channel n to m volts 5.0<=m<=24.0; *1
@vbla n m	?vbla n	!vbla %2d %7.3f	Set LA low voltage channel n to m volts -4.0<=m<=+4.0; Usually used for OG1 *1
@vblb n m	?vblb n	!vblb %2d %7.3f	Set LB low voltage channel n to m volts -4.0<=m<=+4.0; Usually used for OG2 *1
@vbod n m	?vbod n	!vbha %2d %7.3f	Same as vbha (for backward compatibility)
@vbrd n m	?vbrd n	!vbhb %2d %7.3f	Same as vbhb (for backward compatibility)
@vbdx n m	?vbdx n	!vbhc %2d %7.3f	Same as vbhc (for backward compatibility)
@vbog n m	?vbog n	!vbla %2d %7.3f	Same as vbla (for backward compatibility)
@vbgx n m	?vbgx n	!vblb %2d %7.3f	Same as vblb (for backward compatibility)

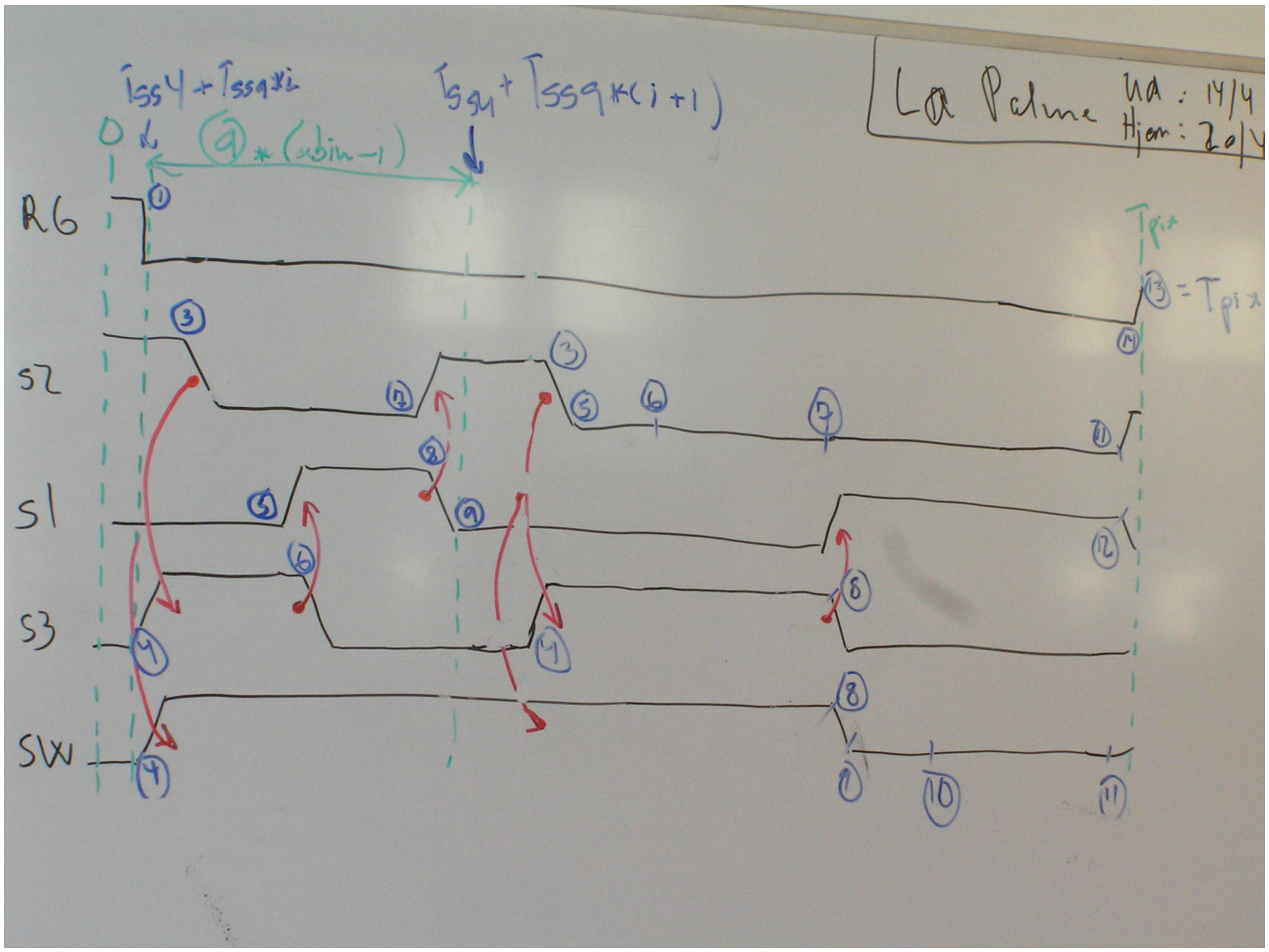
Misc. commands:

Command	Request	Reply	Action
@rest	-	!rest	Reset OptoRing
-	?pixc	!pixc %8d %8d	Pixel counter (for test purpose) new_pixcnt,(new_pixcnt-old_pixcnt)
	?temp n		

Additional usefull information

Why some command takes time

Some commands change parameters that alters the pixeltiming. These commands will automatically call routines that recalculates all neccesary waveform-tables.



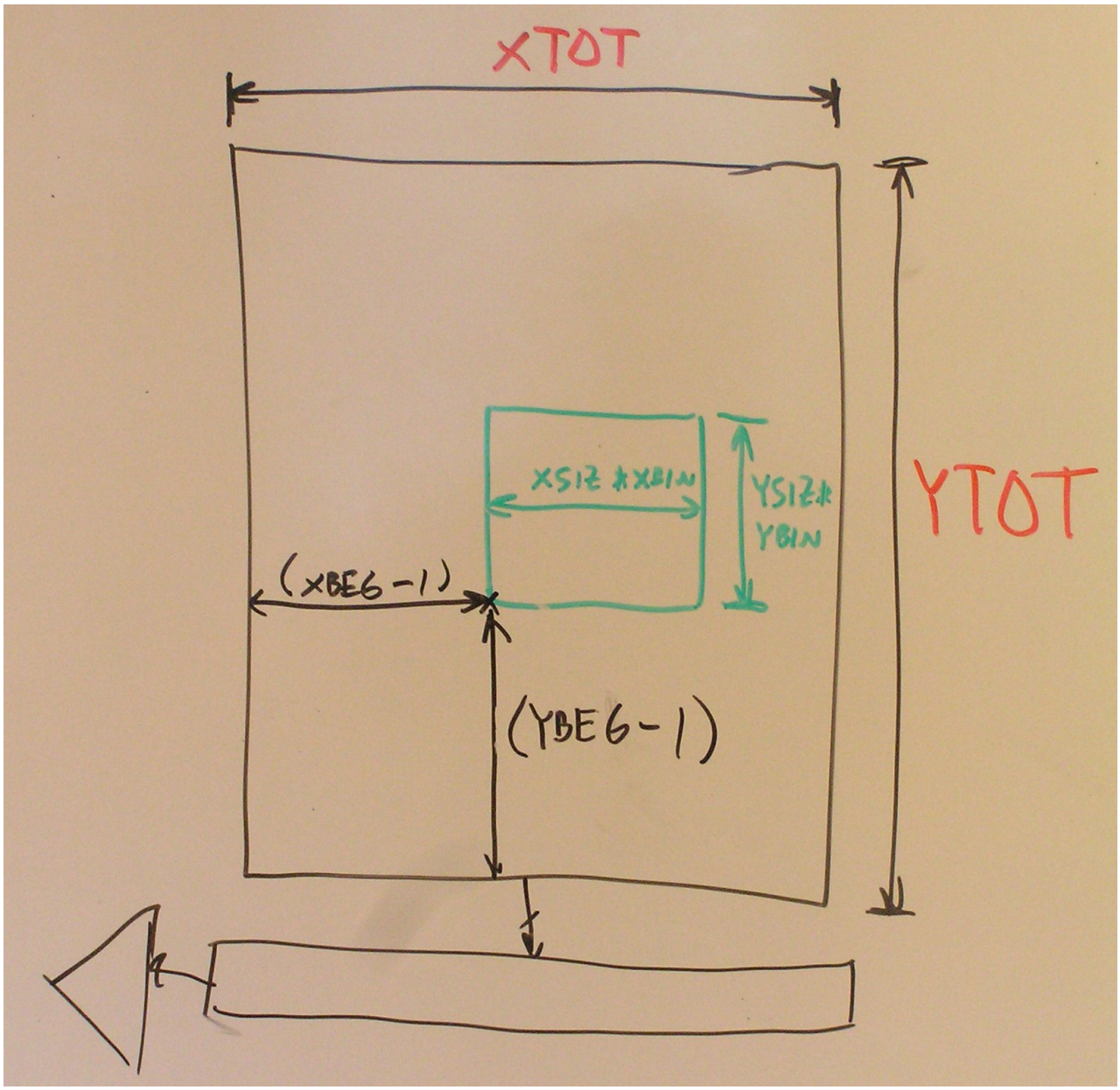
Definitions of serial clock timing parameters:

```
 /*
  *    S_pw:     serial pulse width
  *    S_ol:     serial overlap
  *    S_tr:     serial rise time
  *
  *    RG_pw:    RG pulse width
  *    RG_tr:    RG rise time
  *
  *    Tnd:      noise deay
  *    Tsam:     sample time
  */
      {
      Tp1   = RG_pw - RG_tr;
```

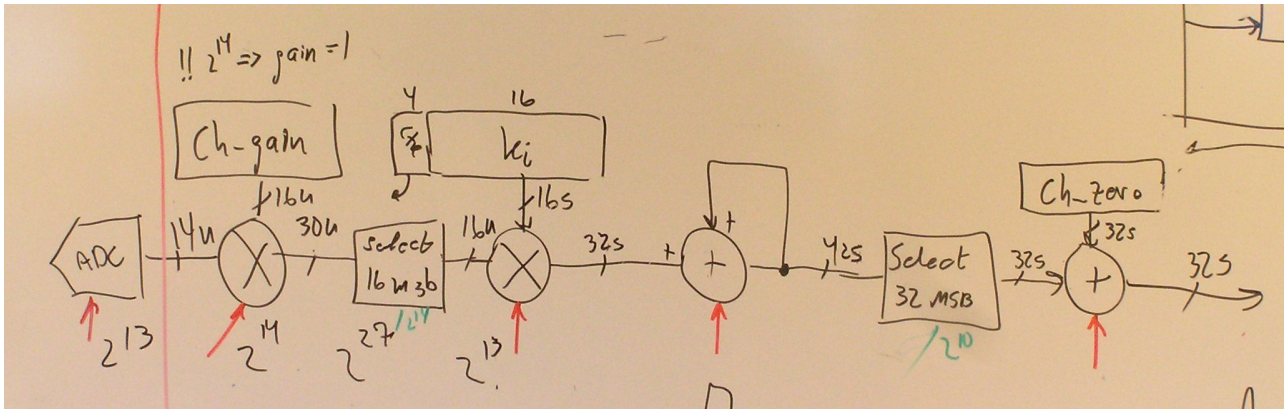
```
      Tp2  = Tp1 + RG_tr;
      Tp3  = S_pw - S_ol - S_tr;    // Fundamental
      Tp4  = Tp3 - S_ol;            // Derived from T3
      Tp5  = Tp3 + S_tr;            // Derived from T3
      Tp6  = Tp5 + Tnd;             // noisy delay
      Tp7  = Tp6 + Tsam;
      Tp8  = Tp7 + S_ol;
      Tp9  = Tp8 + S_tr;
      Tp10 = Tp9 + Tnd;
      Tp11 = Tp10 + Tsam;
      Tp12 = Tp11 + S_ol;
      Tp13 = Tp12 + S_tr;          // pixlength
      Tp14 = Tp13 - RG_tr - 1;
 //
      Tss1 = RG_pw - RG_tr;
      Tss2 = Tss1 + RG_tr;
      Tss3 = S_pw - S_ol - S_tr;   // Fundamental
      Tss4 = Tss3 - S_ol;          // Derived from T3
      Tss5 = Tss3 + S_pw;
      Tss6 = Tss5 + S_ol;
      Tss7 = Tss5 + S_pw;
      Tss8 = Tss7 + S_ol;
      Tss9 = Tss8 + S_tr;           // Tss9 =  3*S_pw = sswlength
      Tss10 = Tss9 - RG_tr - 1;
//
      pixlength = Tp13;
      sswlength = Tss9;

//*****************************************************************
```

Definitions for windowing:



A little on the digital signal chain:



Known SW bugs:

1) 20 character input buffer to command interpreter will overflow if more than 20 characters are input without a CR or LF.

2) Some commands or requests will reply without the '!' sign. sint,xbin

3) Commands vbod, vbrd, vbdx, vbog and vbgx are old names of vbha, vbhb, vbhc, vbla and vblb. They work, but the '!'-reply will carry the new names. Advise: Do not use the old names.

4) Imod is right now only controlling the shutter, but is described as it should be, ie. also controlling the pre-clear and post-readout.

5) reset sequencer cmdbit 3 not connected!!