DXP Timing Applications

This document provides details of the standard timing mode applications implemented in the range of DXP processors.

Mapping Applications

The DXP supports several mapping applications, including variants of both full spectrum mapping as well as mapping using regions of interest or single channel analyzer regions.

SCA Definition:

The number of SCAs is specified with the DSP parameter `NUMSCA`, which can range from 0 to 16. For SCA *n* (where *n* runs from 0 to 15), the bin limits are specified using the parameters `SCAnLO` and `SCAnHI`; all output counts that fall in the specified range of MCA bins (inclusive) are included in the SCA total.

Summary of DSP parameters used for SCA definition:

`NUMSCA` : Total number of SCAs defined (16 maximum)

`SCAnLO` : Lower bin limit of SCA n ($0 \leq n \leq 15$)

`SCAnHI` : Upper bin limit of SCA n ($0 \leq n \leq 15$)

Note: starting with DSP code version 1.08, the standard DSP code variant will include the parameters needed to define up to 16 SCA's (ROI's); the standard code will sum the defined regions at the end of the run into a buffer named SCADATA in data memory (described by DSP parameters SCADSTART and SCADLEN). Two words (32 bits) are used to store the integral of each defined SCA region, low word first, starting with the first SCA region (SCA0).

MultiSCA or MultiMCA Mapping:

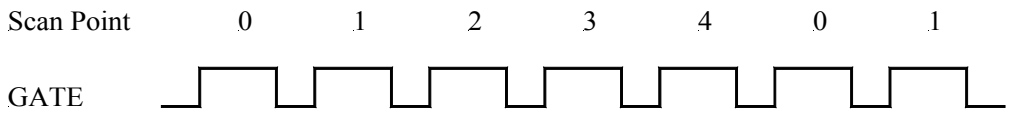
In mapping or scanning applications, the DXP records SCA or MCA data from many points, with minimal time needed to switch from one point to the next. Many scan points can be stored in onboard memory; the exact number depends on what memory is used (internal DSP memory or added external memory) and on the data format (word size for the SCA totals or MCA bins).

The scanning operation is the same for all variants. The `GATE` signal is used to signal the transition from one pixel to the next; the `GATE` interrupt must be enabled by setting bit 1 of the Timing Control Register (TCR); see the DXP User's manual. In general, the `GATE` signal should be asserted (TTL high) while taking data and deasserted between pixels. Note that if the IgnoreGATE bit is set in the Global Control Register (GCR), bringing the GATE signal low will not inhibit datataking (but will trigger the interrupt to switch points). The `GATEINTPOL` bit (bit 12) in the TCR selects which edge generates the GATE interrupt: `GATEINTPOL`=0 selects the falling edge, while `GATEINTPOL`=1 selects the rising edge.

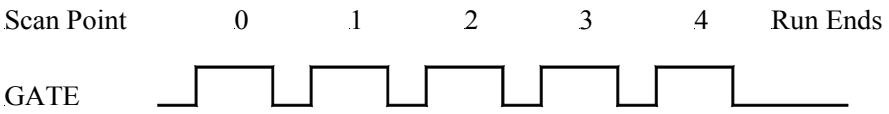
There are two basic modes for scanning. If MULTIMODE is set to 0, the user specifies a fixed number of points NUMPOINTS; after scanning through that number of points, the processor either jumps back to point 0 (if SINGLEPASS is set to 0) or stops taking data (if SINGLEPASS is set to 1). If MULTIMODE is set to 1, then the value of the SYNC input is used to define when to jump back to point zero: if SYNC is asserted during the transition, the first scan point is set active.

The different scanning scenarios are depicted pictorially below.

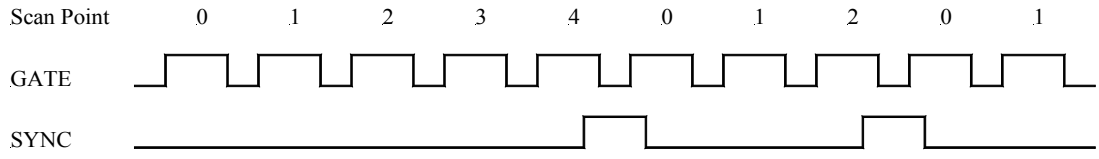
MULTIMODE=0, SINGLEPASS=0, NUMPOINTS=5



MULTIMODE=0, SINGLEPASS=1, NUMPOINTS=5



MULTIMODE=1



The maximum number of scan points is set by the amount of available memory. The scan point will not advance beyond the maximum value; if you attempt to scan past the maximum number of data points, all the extra data will be combined with the data from the last scan point and the DSP parameter SCANERROR will incremented by 1.

Summary of DSP parameters used to control scanning:

MULTIMODE: Selects scanning mode.

0: Fixed number of points

1: SYNC signal identifies point 0

NUMPOINTS: For MULTIMODE=0, the user sets this parameter to specify the desired number of scan points. For MULTIMODE=1, this parameter indicates the actual number of scan points based on the GATE and SYNC inputs.

SINGLEPASS: For MULTIMODE=0, indicates whether to stop the run after scanning through NUMPOINTS. For MULTIMODE=1, this parameter is not used.

MAXPOINTS: Maximum number of scan points (calculated by the DSP based on the amount of available memory and NUMSCA).

SCANERROR: Indicates that the number of scan points exceeded the maximum.

0: No error

≥1: MAXPOINTS exceeded; the value of SCANERROR indicates the number of extra points combined with the last valid scan point.

Mapping Data Formats

Single point SCA acquisition: this applies to either the standard firmware (which sums the SCA regions at the end of the run) or a special version of the MultiSCA firmware that stores only one point and updates the SCA totals in real time. In both cases, the SCA data is stored in the SCADATA buffer in DSP data memory, addressed using the DSP parameters SCADSTART and SCADLEN. Currently, this buffer is 32 words long, and holds SCA totals for up to 16 SCA's, at 2 words/SCA. The buffer is defined as follows:

Word 0:	Low word, SCA 0 total
Word 1:	High word, SCA0
Word 2:	Low word, SCA1
Word 3:	High word, SCA1
Etc.	
Word 31:	High word, SCA15

In the future, the buffer may expand to support more than 16 SCA's.

MultiSCA Mapping, Internal Memory: In this variant, the SCA mapping data are stored in DSP program memory, in the same buffer used to store the spectrum for MCA data acquisition. The word size in DSP program memory is 24 bits; one word is used to store each SCA total as well as each statistics word. The granularity of the livetime and realtime measurements is 400 ns per bit; the 24 bit word allows pixel times of up to only 6.7 seconds before rolling over. For each scan point, four statistics words are stored, so the record size for a single scan point is SCALEN = 4 + NUMSCA words. The length of the buffer is 12 kWords (12288 words), so the maximum number of scan points that can be stored is (12288/(4+NUMSCA)). For example, if NUMSCA=8, 1024 points can be stored. The SCA data is stored in the SPECTRUM buffer in program memory; the DSP parameter SPECTSTART points to the beginning of that buffer, while SPECTLEN is the length of the buffer.

The data record for a single scan point is organized as follows:

Word 0:	Livetime (400 ns units)
Word 1:	Realtime (400 ns units)
Word 2:	Input counts
Word 3:	Output counts
Word 4:	SCA 0 counts
Word 5:	SCA 1 counts
Etc.	

Length of single scan point: `SCALEN` = 4 + `NUMSCA` 24-bit words

Total length of scan record = `NUMPOINTS` * `SCALEN` words, starting at `SPECTSTART` in program memory.

MultiSCA Mapping, Compact External Memory (2 bytes/SCA): In this variant, the SCA mapping data are stored in optional external memory (up to 4 MB on the Saturn, 1 MB on the DXP-2X). The memory is organized in 16-bit words; 2 words are used for each statistics value, and 1 word is used for each defined SCA. The granularity of the livetime and realtime measurements is 400 ns per bit; the 32 bits allocated for the time statistics allow pixel times of up to 1718 seconds before rolling over. For each scan point, four statistics values are stored, so the record size for a single scan point is `SCALEN` = 4*2 + `NUMSCA 16-bit words`. For the DXP-2X, there is 1 MB of external memory (if installed), so the maximum number of scan points that can be stored is (524288/(8+`NUMSCA`)). For example, if `NUMSCA`=8, 32768 points can be stored. For the Saturn, up to four times more external memory is available.

The data record for a single scan point is organized as follows (in terms of 16-bit words):

Words 0 - 1:	Livetime (400 ns units), always low word first
Words 2 - 3:	Realtime (400 ns units)
Words 4 - 5:	Input counts
Words 6 - 7:	Output counts
Word 8:	SCA 0 counts
Words 9:	SCA 1 counts
Etc.	

The external data must be read through the use of special runs in the DSP.

Length of single scan point: SCALEN = 8 + NUMSCA 16-bit words

Total length of scan record = NUMPOINTS * SCALEN words, starting at the base of external memory (external address = 0).

MultiSCA Mapping, Standard External Memory (4 bytes/SCA): In this variant, the SCA mapping data are stored in optional external memory (up to 4 MB on the Saturn, 1 MB on the DXP-2X). The memory is organized in 16-bit words; 2 words are used for each statistics value as well as for each defined SCA region. For each scan point, four statistics values are stored, so the record size for a single scan point is SCALEN = 2*(4+NUMSCA) 16-bit words. For the DXP-2X, there is 1 MB of external memory (if installed), so the maximum number of scan points that can be stored is (524288/(8+2*NUMSCA)). For example, if NUMSCA=8, 21845 points can be stored. For the Saturn, up to four times more external memory is available.

The data record for a single scan point is organized as follows (16-bit words):

Words 0 - 1:	Livetime (400 ns units), always low word first
Words 2 - 3:	Realtime (400 ns units)
Words 4 - 5:	Input counts
Words 6 - 7:	Output counts
Words 8 - 9:	SCA 0 counts
Words 10 - 11:	SCA 1 counts
Etc.	

The external data must be read through the use of special runs in the DSP.

Length of single scan point: SCALEN = 8 + 2*NUMSCA 16-bit words

Total length of scan record = NUMPOINTS * SCALEN words, starting at the base of external memory (external address = 0).

MultiMCA Mapping, Compact External Memory (2 bytes/SCA), large spectrum: In this variant, the MCA mapping data are stored in optional external memory (up to 4 MB on the Saturn, 1 MB on the DXP-2X). The memory is organized in 16-bit words; 2 words are used for each statistics value, and 1 word is used for each MCA bin. The granularity of the livetime and realtime measurements is 400 ns per bit; the 32 bits allocated for the time statistics allow pixel times of up to 1718 seconds before rolling over. This variant supports large spectra (8K maximum record size – up to 8188 MCA bins); to accomplish this, the spectrum is built directly into the external memory. This slows the processing slightly compared to using internal memory, but allows very quick switching between

scan points. For each point, four statistics values are stored, so the record size for a single scan point is RECLEN = 4*2 + MCALEN 16-bit words. This record length is forced to fit evenly into a 16 kB external memory page; this implies that MCALEN is set equal to a power of 2 minus 4. The largest value of MCALEN is 8188. For the DXP-2X, there is 1 MB of external memory (if installed), so the maximum number of scan points that can be stored is (524288/RECLEN) . For example, if RECLEN=8192, 64 spectra can be stored. For the Saturn, four times more external memory is available.

The data record for a single scan point is organized as follows (in terms of 16-bit words):

Words 0 - 1:	Livetime (400 ns units), always low word first
Words 2 - 3:	Realtime (400 ns units)
Words 4 - 5:	Input counts
Words 6 - 7:	Output counts
Word 8:	MCA bin 0
Words 9:	MCA bin 1
Etc.	

The external data must be read through the use of special runs in the DSP.

Length of single scan point: RECLEN = 8 + MCALEN 16-bit words

Total length of scan record = NUMPOINTS * RECLEN words, starting at the base of external memory (external address = 0).