Intel® Open Source HD Graphics and Intel Iris™ Graphics

Programmer's Reference Manual

For the 2014-2015 Intel Core™ Processors, Celeron™ Processors and Pentium™ Processors based on the "Broadwell" Platform

Volume 6: Command Stream Programming

May 2015, Revision 1.0

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Table of Contents

Graphics Command Formats **1**
Command Header 2
Memory Interface Commands 5
2D Commands 7
3D Commands 9
VEBOX Commands 13
MFX Commands 14
Scheduling **16**
Execlists 16
Context Descriptor Format 18
Logical Ring Context Format 19
Context Status 20
RINGBUF — Ring Buffer Registers 23
Virtual Memory Control **24**
Render Engine Command Streamer (RCS) **25**
Batch Buffer Privilege Register 25
Mode Registers 26
Logical Context Support 27
Context Save Registers 28
MI Commands for Render Engine 29
User Mode Privileged Commands 30
Watchdog Timer Registers 33
Interrupt Control Registers **34**
Hardware-Detected Error Bit Definitions (for EIR EMR ESR) 35
Blitter Engine Command Streamer (BCS) **36**
Watchdog Timer Registers 37
Hardware-Detected Error Bit Definitions (for EIR EMR ESR) 37
Logical Context Support 38
Mode Registers 39
MI Commands for Blitter Engine 40
User Mode Privileged Commands 43
Video Command Streamer (VCS) **45**

Watchdog Timer Registers 45
VCS Hardware - Detected Error Bit Definitions (for EIR EMR ESR) 46
Logical Context Support 46
Mode Registers 47
Registers in Media Engine 48
GFX Pending TLB Cycles Information Registers 48
Memory Interface Commands for Video Codec Engine 49
User Mode Privileged Commands 50
Video Enhancement Engine Command Interface 52
VECS_RINGBUF — Ring Buffer Registers 52
Watchdog Timer Registers 52
Logical Context Support 53
Mode Registers 54
MI Commands for Video Enhancement Engine 55
User Mode Privileged Commands 56
Preemption 57
Ring Buffer Scheduling 57
ExecList Scheduling 58
Command Streamer (CS) ALU Programming 59

Graphics Command Formats

This section describes the general format of the graphics device commands.

Graphics commands are defined with various formats. The first DWord of all commands is called the *header* DWord. The header contains the only field common to all commands, the *client* field that determines the device unit that processes the command data. The Command Parser examines the client field of each command to condition the further processing of the command and route the command data accordingly.

Graphics commands vary in length, though are always multiples of DWords. The length of a command is either:

- Implied by the client/opcode
- Fixed by the client/opcode yet included in a header field (so the Command Parser explicitly knows how much data to copy/process)
- Variable, with a field in the header indicating the total length of the command

Note that command *sequences* require QWord alignment and padding to QWord length to be placed in Ring and Batch Buffers.

The following subsections provide a brief overview of the graphics commands by client type provides a diagram of the formats of the header DWords for all commands. Following that is a list of command mnemonics by client type.

Command Header

Render Command Header Format

Bits					
TYPE	**31:29**	**28:24**	**23**	**22**	**21:0**
Memory Interface (MI)	000	Opcode 00h – NOP 0Xh – Single DWord Commands 1Xh – Two+ DWord Commands 2Xh – Store Data Commands 3Xh – Ring/Batch Buffer Cmds		Identification No./DWord Count Command Dependent Data 5:0 – DWord Count 5:0 – DWord Count 5:0 – DWord Count	
Reserved	001, 010	Opcode – 11111	23:19 Sub Opcode 00h – 01h	18:16 Reserved	15:0 DWord Count

Bits						
TYPE	**31:29**	**28:27**	**26:24**	**23:16**	**15:8**	**7:0**
Common	011	00	Opcode – 000	Sub Opcode	Data	DWord Count
Common (NP)[1]	011	00	Opcode – 001	Sub Opcode	Data	DWord Count
Reserved	011	00	Opcode – 010 – 111			
Single Dword Command	011	01	Opcode – 000 – 001	Sub Opcode		N/A
Reserved	011	01	Opcode – 010 – 111			
Media State	011	10	Opcode – 000	Sub Opcode		Dword Count
Media Object	011	10	Opcode – 001 – 010	Sub Opcode	Dword Count	
Reserved	011	10	Opcode – 011 – 111			
3DState	011	11	Opcode – 000	Sub Opcode	Data	DWord Count
3DState (NP)[1]	011	11	Opcode – 001	Sub Opcode	Data	DWord Count
PIPE_Control	011	11	Opcode – 010		Data	DWord Count
3DPrimitive	011	11	Opcode – 011		Data	DWord Count
Reserved	011	11	Opcode – 100 – 111			
Reserved	100	XX				
Reserved	101	XX				
Reserved	110	XX				

Notes:

[1]The qualifier "NP" indicates that the state variable is non-pipelined and the render pipe is flushed before such a state variable is updated. The other state variables are pipelined (default).

Video Command Header Format

Bits						
TYPE	**31:29**	**28:24**		**23**	**22**	**21:0**
Memory Interface (MI)	000	Opcode 00h – NOP 0Xh – Single DWord Commands 1Xh – Reserved 2Xh – Store Data Commands 3Xh – Ring/Batch Buffer Cmds			Identification No./DWord Count Command Dependent Data 5:0 – DWord Count 5:0 – DWord Count 5:0 – DWord Count	
TYPE	**31:29**	**28:27**	**26:24**	**23:16**		**15:0**
Reserved	011	00	XXX	XX		
MFX Single DW	011	01	000	Opcode: 0h		0
Reserved	011	01	1XX			
Reserved	011	10	0XX			
AVC State	011	10	100	Opcode: 0h – 4h		DWord Count
AVC Object	011	10	100	Opcode: 8h		DWord Count
VC1 State	011	10	101	Opcode: 0h – 4h		DWord Count
VC1 Object	011	10	101	Opcode: 8h		DWord Count
Reserved	011	10	11X			
Reserved	011	11	XXX			
TYPE	**31:29**	**28:27**	**26:24**	**23:21**	**20:16**	**15:0**
MFX Common	011	10	000	000	subopcode	DWord Count
Reserved	011	10	000	001-111	subopcode	DWord Count
AVC Common	011	10	001	000	subopcode	DWord Count
AVC Dec	011	10	001	001	subopcode	DWord Count
AVC Enc	011	10	001	010	subopcode	DWord Count
Reserved	011	10	001	011-111	subopcode	DWord Count
Reserved (for VC1 Common)	011	10	010	000	subopcode	DWord Count
VC1 Dec	011	10	010	001	subopcode	DWord Count
Reserved (for VC1 Enc)	011	10	010	010	subopcode	DWord Count
Reserved	011	10	010	011-111	subopcode	DWord Count
Reserved (MPEG2 Common)	011	10	011	000	subopcode	DWord Count
MPEG2 Dec	011	10	011	001	subopcode	DWord Count
Reserved (for MPEG2 Enc)	011	10	011	010	subopcode	DWord Count
Reserved	011	10	011	011-111	subopcode	DWord Count
Reserved	011	10	100-111	XXX		

Video Enhancement Command Header Format

Bits					
TYPE	**31:29**	**28:24**	**23**	**22**	**21:0**
Memory Interface (MI)	000	Opcode 00h – NOP 0Xh – Single DWord Commands 1Xh – Two+ DWord Commands 2Xh – Store Data Commands 3Xh – Ring/Batch Buffer Cmds		Identification No./DWord Count Command Dependent Data 5:0 – DWord Count 5:0 – DWord Count 5:0 – DWord Count	
Reserved	001, 010				

TYPE	31:29	28:27	26:24	23:21	20:16	15:12	11:0
VEBOX (Parallel Video Pipe)	011	10: Pipeline 00: Reserved 01: Reserved 11: Reserved	Command Opcode – 100	Sub Opcode A	Sub Opcode B	Reserved	Dword Count

Blitter Command Header Format

Bits					
TYPE	**31:29**	**28:24**	**23**	**22**	**21:0**
Memory Interface (MI)	000	Opcode 00h – NOP 0Xh – Single DWord Commands 1Xh – Two+ DWord Commands 2Xh – Store Data Commands 3Xh – Ring/Batch Buffer Cmds		Identification No./DWord Count Command Dependent Data 5:0 – DWord Count 5:0 – DWord Count 5:0 – DWord Count	
Reserved	001, 011				

TYPE	31:29	28:22	21:9	8:0
Blitter (2D)	010	Command Opcode	Command Dependent Data	Dword Count

Memory Interface Commands

Memory Interface (MI) commands are basically those commands which do not require processing by the 2D or 3D Rendering/Mapping engines. The functions performed by these commands include:

- Control of the command stream (e.g., Batch Buffer commands, breakpoints, ARB On/Off, etc.)
- Hardware synchronization (e.g., flush, wait-for-event)
- Software synchronization (e.g., Store DWORD, report head)
- Graphics buffer definition (e.g., Display buffer, Overlay buffer)
- Miscellaneous functions

All of the following commands are defined in *Memory Interface Commands*.

Memory Interface Commands for RCP

Opcode (28:23)	Command	Pipes
1 DWord		
00h	MI_NOOP	All
01h	MI_SET_PREDICATE	Render
02h	MI_USER_INTERRUPT	All
03h	MI_WAIT_FOR_EVENT	All
05h	MI_ARB_CHECK	All
06h	MI_RS_CONTROL	Render
07h	MI_REPORT_HEAD	All
08h	MI_ARB_ON_OFF	All except Blitter
09h	MI_URB_ATOMIC_ALLOC	Render
0Ah	MI_BATCH_BUFFER_END	All
0Bh	MI_SUSPEND_FLUSH	All
0Ch	MI_PREDICATE	Render
0Dh	MI_TOPOLOGY_FILTER	Render
0Fh	MI_RS_CONTEXT	Render
2+ DWord		
10h	Reserved	
14h	MI_DISPLAY_FLIP	Render and Blitter
15h	Reserved	
16h	MI_SEMAPHORE_MBOX	All
17h	Reserved	
18h	MI_SET_CONTEXT	Render
19h	MI_URB_CLEAR	Render
1Ah	MI_MATH	All

Opcode (28:23)	Command	Pipes
1 DWord		
1Bh	MI_SEMAPHORE_SIGNAL	All
1Ch	MI_SEMAPHORE_WAIT	All
1Eh-1Fh	Reserved	
Store Data		
20h	MI_STORE_DATA_IMM	All
21h	MI_STORE_DATA_INDEX	All
22h	MI_LOAD_REGISTER_IMM	All
23h	MI_UPDATE_GTT	All
24h	MI_STORE_REGISTER_MEM	All
26h	MI_FLUSH_DW	All except Render
27h	MI_CLFLUSH	Render
29h	MI_LOAD_REGISTER_MEM	All
2Ah	MI_LOAD_REGISTER_REG	All
2Bh	MI_RS_STORE_DATA_IMM	Render
2Ch	MI_LOAD_URB_MEM	Render
2Dh	MI_STORE_URB_MEM	Render
2Eh	MI_MEM_TO_MEM	All
2Fh	MI_ATOMIC	All
Ring/Batch Buffer		
30h	Reserved	
31h	MI_BATCH_BUFFER_START	Render
32h-35h	Reserved	
36h	MI_CONDITIONAL_BATCH_BUFFER_END	All
37h-38h	Reserved	
39h-3Fh	Reserved	

2D Commands

The 2D commands include various flavors of BLT operations, along with commands to set up BLT engine state without actually performing a BLT. Most commands are of fixed length, though there are a few commands that include a variable amount of "inline" data at the end of the command.

All the following commands are defined in *Blitter Instructions*.

2D Command Map

Opcode (28:22)	Command
00h	Reserved
01h	XY_SETUP_BLT
02h	Reserved
03h	XY_SETUP_CLIP_BLT
04h-10h	Reserved
11h	XY_SETUP_MONO_PATTERN_SL_BLT
12h-23h	Reserved
24h	XY_PIXEL_BLT
25h	XY_SCANLINES_BLT
26h	XY_TEXT_BLT
27h-30h	Reserved
31h	XY_TEXT_IMMEDIATE_BLT
32h-3Fh	Reserved
40h	COLOR_BLT
41h-42h	Reserved
43h	SRC_COPY_BLT
44h-4Fh	Reserved
50h	XY_COLOR_BLT
51h	XY_PAT_BLT
52h	XY_MONO_PAT_BLT
53h	XY_SRC_COPY_BLT
54h	XY_MONO_SRC_COPY_BLT
55h	XY_FULL_BLT
56h	XY_FULL_MONO_SRC_BLT
57h	XY_FULL_MONO_PATTERN_BLT
58h	XY_FULL_MONO_PATTERN_MONO_SRC_BLT
59h	XY_MONO_PAT_FIXED_BLT
5Ah-70h	Reserved

Opcode (28:22)	Command
71h	XY_MONO_SRC_COPY_IMMEDIATE_BLT
72h	XY_PAT_BLT_IMMEDIATE
73h	XY_SRC_COPY_CHROMA_BLT
74h	XY_FULL_IMMEDIATE_PATTERN_BLT
75h	XY_FULL_MONO_SRC_IMMEDIATE_PATTERN_BLT
76h	XY_PAT_CHROMA_BLT
77h	XY_PAT_CHROMA_BLT_IMMEDIATE
78h-7Fh	Reserved

3D Commands

The 3D commands are used to program the graphics pipelines for 3D operations.

Refer to the *3D* chapter for a description of the 3D state and primitive commands and the *Media* chapter for a description of the media-related state and object commands.

For all commands listed in **3D Command Map**, the Pipeline Type (bits 28:27) is 3h, indicating the 3D Pipeline.

3D Command Map

Opcode Bits 26:24	Sub Opcode Bits 23:16	Command	Definition Chapter
0h	03h	Reserved	
0h	04h	3DSTATE_CLEAR_PARAMS	3D Pipeline
0h	05h	3DSTATE_DEPTH_BUFFER	3D Pipeline
0h	06h	3DSTATE_STENCIL_BUFFER	3D Pipeline
0h	07h	3DSTATE_HIER_DEPTH_BUFFER	3D Pipeline
0h	08h	3DSTATE_VERTEX_BUFFERS	Vertex Fetch
0h	09h	3DSTATE_VERTEX_ELEMENTS	Vertex Fetch
0h	0Ah	3DSTATE_INDEX_BUFFER	Vertex Fetch
0h	0Bh	3DSTATE_VF_STATISTICS	Vertex Fetch
0h	0Ch	Reserved	
0h	0Dh	3DSTATE_VIEWPORT_STATE_POINTERS	3D Pipeline
0h	0Eh	3DSTATE_CC_STATE_POINTERS	3D Pipeline
0h	10h	3DSTATE_VS	Vertex Shader
0h	11h	3DSTATE_GS	Geometry Shader
0h	12h	3DSTATE_CLIP	Clipper
0h	13h	3DSTATE_SF	Strips & Fans
0h	14h	3DSTATE_WM	Windower
0h	15h	3DSTATE_CONSTANT_VS	Vertex Shader
0h	16h	3DSTATE_CONSTANT_GS	Geometry Shader
0h	17h	3DSTATE_CONSTANT_PS	Windower
0h	18h	3DSTATE_SAMPLE_MASK	Windower
0h	19h	3DSTATE_CONSTANT_HS	Hull Shader
0h	1Ah	3DSTATE_CONSTANT_DS	Domain Shader
0h	1Bh	3DSTATE_HS	Hull Shader
0h	1Ch	3DSTATE_TE	Tesselator
0h	1Dh	3DSTATE_DS	Domain Shader
0h	1Eh	3DSTATE_STREAMOUT	HW Streamout

Opcode Bits 26:24	Sub Opcode Bits 23:16	Command	Definition Chapter
0h	1Fh	3DSTATE_SBE	Setup
0h	20h	3DSTATE_PS	Pixel Shader
0h	21h	3DSTATE_VIEWPORT_STATE_POINTERS_SF_CLIP	Strips & Fans
0h	22h	Reserved	
0h	23h	3DSTATE_VIEWPORT_STATE_POINTERS_CC	Windower
0h	24h	3DSTATE_BLEND_STATE_POINTERS	Pixel Shader
0h	25h	3DSTATE_DEPTH_STENCIL_STATE_POINTERS	Pixel Shader
0h	26h	3DSTATE_BINDING_TABLE_POINTERS_VS	Vertex Shader
0h	27h	3DSTATE_BINDING_TABLE_POINTERS_HS	Hull Shader
0h	28h	3DSTATE_BINDING_TABLE_POINTERS_DS	Domain Shader
0h	29h	3DSTATE_BINDING_TABLE_POINTERS_GS	Geometry Shader
0h	2Ah	3DSTATE_BINDING_TABLE_POINTERS_PS	Pixel Shader
0h	2Bh	3DSTATE_SAMPLER_STATE_POINTERS_VS	Vertex Shader
0h	2Ch	3DSTATE_SAMPLER_STATE_POINTERS_HS	Hull Shader
0h	2Dh	3DSTATE_SAMPLER_STATE_POINTERS_DS	Domain Shader
0h	2Eh	3DSTATE_SAMPLER_STATE_POINTERS_GS	Geometry Shader
0h	2Fh	Reserved	
0h	30h	3DSTATE_URB_VS	Vertex Shader
0h	31h	3DSTATE_URB_HS	Hull Shader
0h	32h	3DSTATE_URB_DS	Domain Shader
0h	33h	3DSTATE_URB_GS	Geometry Shader
0h	34h	3DSTATE_GATHER_CONSTANT_VS	Vertex Shader
0h	35h	3DSTATE_GATHER_CONSTANT_GS	Geometry Shader
0h	36h	3DSTATE_GATHER_CONSTANT_HS	Hull Shader
0h	37h	3DSTATE_GATHER_CONSTANT_DS	Domain Shader
0h	38h	3DSTATE_GATHER_CONSTANT_PS	Pixel Shader
0h	39h	3DSTATE_DX9_CONSTANTF_VS	Vertex Shader
0h	3Ah	3DSTATE_DX9_CONSTANTF_PS	Pixel Shader
0h	3Bh	3DSTATE_DX9_CONSTANTI_VS	Vertex Shader
0h	3Ch	3DSTATE_DX9_CONSTANTI_PS	Pixel Shader
0h	3Dh	3DSTATE_DX9_CONSTANTB_VS	Vertex Shader
0h	3Eh	3DSTATE_DX9_CONSTANTB_PS	Pixel Shader
0h	3Fh	3DSTATE_DX9_LOCAL_VALID_VS	Vertex Shader
0h	40h	3DSTATE_DX9_LOCAL_VALID_PS	Pixel Shader
0h	41h	3DSTATE_DX9_GENERATE_ACTIVE_VS	Vertex Shader
0h	42h	3DSTATE_DX9_GENERATE_ACTIVE_PS	Pixel Shader

Opcode Bits 26:24	Sub Opcode Bits 23:16	Command	Definition Chapter
0h	43h	3DSTATE_BINDING_TABLE_EDIT_VS	Vertex Shader
0h	44h	3DSTATE_BINDING_TABLE_EDIT_GS	Geometry Shader
0h	45h	3DSTATE_BINDING_TABLE_EDIT_HS	Hull Shader
0h	46h	3DSTATE_BINDING_TABLE_EDIT_DS	Domain Shader
0h	47h	3DSTATE_BINDING_TABLE_EDIT_PS	Pixel Shader
0h	48h	3DSTATE_VF_HASHING	Vertex Fetch
0h	49h	3DSTATE_VF_INSTANCING	Vertex Fetch
0h	4Ah	3DSTATE_VF_SGVS	Vertex Fetch
0h	4Bh	3DSTATE_VF_TOPOLOGY	Vertex Fetch
0h	4Ch	3DSTATE_WM_CHROMA_KEY	Windower
0h	4Dh	3DSTATE_PS_BLEND	Windower
0h	4Eh	3DSTATE_WM_DEPTH_STENCIL	Windower
0h	4Fh	3DSTATE_PS_EXTRA	Windower
0h	50h	3DSTATE_RASTER	Strips & Fans
0h	51h	3DSTATE_SBE_SWIZ	Strips & Fans
0h	52h	3DSTATE_WM_HZ_OP	Windower
0h	53h	3DSTATE_INT (internally generated state)	3D Pipeline
0h	56h-FFh	Reserved	
1h	00h	3DSTATE_DRAWING_RECTANGLE	Strips & Fans
1h	02h	3DSTATE_SAMPLER_PALETTE_LOAD0	Sampling Engine
1h	03h	Reserved	
1h	04h	3DSTATE_CHROMA_KEY	Sampling Engine
1h	05h	Reserved	
1h	06h	3DSTATE_POLY_STIPPLE_OFFSET	Windower
1h	07h	3DSTATE_POLY_STIPPLE_PATTERN	Windower
1h	08h	3DSTATE_LINE_STIPPLE	Windower
1h	0Ah	3DSTATE_AA_LINE_PARAMS	Windower
1h	0Bh	3DSTATE_GS_SVB_INDEX	Geometry Shader
1h	0Ch	3DSTATE_SAMPLER_PALETTE_LOAD1	Sampling Engine
1h	0Dh	3DSTATE_MULTISAMPLE	Windower
1h	0Eh	3DSTATE_STENCIL_BUFFER	Windower
1h	0Fh	3DSTATE_HIER_DEPTH_BUFFER	Windower
1h	10h	3DSTATE_CLEAR_PARAMS	Windower
1h	11h	3DSTATE_MONOFILTER_SIZE	Sampling Engine
1h	12h	3DSTATE_PUSH_CONSTANT_ALLOC_VS	Vertex Shader
1h	13h	3DSTATE_PUSH_CONSTANT_ALLOC_HS	Hull Shader

Opcode Bits 26:24	Sub Opcode Bits 23:16	Command	Definition Chapter
1h	14h	3DSTATE_PUSH_CONSTANT_ALLOC_DS	Domain Shader
1h	15h	3DSTATE_PUSH_CONSTANT_ALLOC_GS	Geometry Shader
1h	16h	3DSTATE_PUSH_CONSTANT_ALLOC_PS	Pixel Shader
1h	17h	3DSTATE_SO_DECL_LIST	HW Streamout
1h	18h	3DSTATE_SO_BUFFER	HW Streamout
1h	19h	3DSTATE_BINDING_TABLE_POOL_ALLOC	Resource Streamer
1h	1Ah	3DSTATE_GATHER_POOL_ALLOC	Resource Streamer
1h	1Bh	3DSTATE_DX9_CONSTANT_BUFFER_POOL_ALLOC	Resource Streamer
1h	1Ch	3DSTATE_SAMPLE_PATTERN	Windower
1h	1Dh	3DSTATE_URB_CLEAR	3D Pipeline
1h	1Eh-FFh	Reserved	
2h	00h	PIPE_CONTROL	3D Pipeline
2h	01h-FFh	Reserved	
3h	00h	3DPRIMITIVE	Vertex Fetch
3h	01h-FFh	Reserved	
4h-7h	00h-FFh	Reserved	

Pipeline Type (28:27)	Opcode	Sub Opcode	Command	Definition Chapter
Common (pipelined)	**Bits 26:24**	**Bits 23:16**		
0h	0h	03h	STATE_PREFETCH	Graphics Processing Engine
0h	0h	04h-FFh	Reserved	
Common (non-pipelined)	**Bits 26:24**	**Bits 23:16**		
0h	1h	00h	Reserved	N/A
0h	1h	01h	STATE_BASE_ADDRESS	Graphics Processing Engine
0h	1h	02h	STATE_SIP	Graphics Processing Engine
0h	1h	03h	SWTESS BASE ADDRESS	3D Pipeline
0h	1h	04h	GPGPU CSR BASE ADDRESS	Graphics Processing Engine
0h	1h	04h–FFh	Reserved	N/A
Reserved	**Bits 26:24**	**Bits 23:16**		
0h	2h–7h	XX	Reserved	N/A

VEBOX Commands

The VEBOX commands are used to program the Video Enhancement engine attached to the Video Enhancement Command Parser.

VEBOX Command Map

Pipeline Type (28:27)	Opcode (26:24)	SubopA (23:21)	SubopB (20:16)	Command
2h	4h	0h	0h	VEBOX_SURFACE_STATE
2h	4h	0h	2h	VEBOX_STATE

MFX Commands

The MFX (MFD for decode and MFC for encode) commands are used to program the multi-format codec engine attached to the Video Codec Command Parser. See the *MFD* and *MFC* chapters for a description of these commands.

MFX state commands support direct state model and indirect state model. Recommended usage of indirect state model is provided here (as a software usage guideline).

Pipeline Type (28:27)	Opcode (26:24)	SubopA (23:21)	SubopB (20:16)	Command	Chapter	Recommended Indirect State Pointer Map	Interruptable?
MFX Common (State)							
2h	0h	0h	0h	MFX_PIPE_MODE_SELECT	MFX	IMAGE	N/A
2h	0h	0h	1h	MFX_SURFACE_STATE	MFX	IMAGE	N/A
2h	0h	0h	2h	MFX_PIPE_BUF_ADDR_STATE	MFX	IMAGE	N/A
2h	0h	0h	3h	MFX_IND_OBJ_BASE_ADDR_STATE	MFX	IMAGE	N/A
2h	0h	0h	4h	MFX_BSP_BUF_BASE_ADDR_STATE	MFX	IMAGE	N/A
2h	0h	0h	6h	MFX_ STATE_POINTER	MFX	IMAGE	N/A
2h	0h	0h	7-8h	Reserved	N/A	N/A	N/A
MFX Common (Object)							
2h	0h	1h	9h	MFD_ IT_OBJECT	MFX	N/A	Yes
2h	0h	0h	4-1Fh	Reserved	N/A	N/A	N/A
AVC Common (State)							
2h	1h	0h	0h	MFX_AVC_IMG_STATE	MFX	IMAGE	N/A
2h	1h	0h	1h	MFX_AVC_QM_STATE	MFX	IMAGE	N/A
2h	1h	0h	2h	MFX_AVC_DIRECTMODE_STATE	MFX	SLICE	N/A
2h	1h	0h	3h	MFX_AVC_SLICE_STATE	MFX	SLICE	N/A
2h	1h	0h	4h	MFX_AVC_REF_IDX_STATE	MFX	SLICE	N/A
2h	1h	0h	5h	MFX_AVC_WEIGHTOFFSET_STATE	MFX	SLICE	N/A
2h	1h	0h	6-1Fh	Reserved	N/A	N/A	N/A
AVC Dec							
2h	1h	1h	0-7h	Reserved	N/A	N/A	N/A
2h	1h	1h	8h	MFD_AVC_BSD_OBJECT	MFX	N/A	No
2h	1h	1h	9-1Fh	Reserved	N/A	N/A	N/A
AVC Enc							
2h	1h	2h	0-1h	Reserved	N/A	N/A	N/A
2h	1h	2h	2h	MFC_AVC_FQM_STATE	MFX	IMAGE	N/A
2h	1h	2h	3-7h	Reserved	N/A	N/A	N/A
2h	1h	2h	8h	MFC_AVC_PAK_INSERT_OBJECT	MFX	N/A	N/A

Pipeline Type (28:27)	Opcode (26:24)	SubopA (23:21)	SubopB (20:16)	Command	Chapter	Recommended Indirect State Pointer Map	Interruptable?
2h	1h	2h	9h	MFC_AVC_PAK_OBJECT	MFX	N/A	Yes
2h	1h	2h	A-1Fh	Reserved	N/A	N/A	N/A
2h	1h	2h	0-1Fh	Reserved	N/A	N/A	N/A
VC1 Common							
2h	2h	0h	0h	MFX_VC1_PIC_STATE	MFX	IMAGE	N/A
2h	2h	0h	1h	MFX_VC1_PRED_PIPE_STATE	MFX	IMAGE	N/A
2h	2h	0h	2h	MFX_VC1_DIRECTMODE_STATE	MFX	SLICE	N/A
2h	2h	0h	2-1Fh	Reserved	N/A	N/A	N/A
VC1 Dec							
2h	2h	1h	0-7h	Reserved	N/A	N/A	N/A
2h	2h	1h	8h	MFD_VC1_BSD_OBJECT	MFX	N/A	Yes
2h	2h	1h	9-1Fh	Reserved	N/A	N/A	N/A
VC1 Enc							
2h	2h	2h	0-1Fh	Reserved	N/A	N/A	N/A
MPEG2 Common							
2h	3h	0h	0h	MFX_MPEG2_PIC_STATE	MFX	IMAGE	N/A
2h	3h	0h	1h	MFX_MPEG2_QM_STATE	MFX	IMAGE	N/A
2h	3h	0h	2-1Fh	Reserved	N/A	N/A	N/A
MPEG2 Dec							
2h	3h	1h	1-7h	Reserved	N/A	N/A	N/A
2h	3h	1h	8h	MFD_MPEG2_BSD_OBJECT	MFX	N/A	Yes
2h	3h	1h	9-1Fh	Reserved	N/A	N/A	N/A
MPEG2 Enc							
2h	3h	2h	0-1Fh	Reserved	N/A	N/A	N/A
The Rest							
2h	4-5h, 7h	x	x	Reserved	N/A	N/A	N/A

Scheduling

Content for this topic is currently under development.

Execlists

Execlists are the method by which new contexts are submitted for execution. Note that this mechanism cannot be used when the **Execlist Enable** bit in the corresponding engines MODE register is not set, i.e GFX_MODE register for Render Engine, BLT_MODE register for Blitter Engine, VCS_MODE register for Video Engine, or VECS_MODE register for Video Enhancement Engine. If this bit is not set in the engine's MODE register, writing to the registers in this section is UNDEFINED.

Broadwell implements 2 execlists. Each execlist can have up to 2 context descriptors in it, each describing a context to run. SW assembles an execlist by writing each of the context descriptor elements to the Execlist Submit Port register. Writing the final DWord triggers the submission. It is the responsibility of SW to keep track of when an empty execlist entry is available to receive a new execlist submitted via the Submit Port. Submitting a new execlist when there is already a pending execlist (in addition to the current execlist) is UNDEFINED. In general, the interrupt indicating that the pending execlist has become the current execlist should always be observed before a new pending execlist is submitted. This includes the case where the ring is idle and the very first execlist is submitted; it should not be assumed that this execlist becomes the current list instantaneously.

The submission of a new execlist (known as a preemption request) is interpreted as a request to switch execlists as soon as possible. This is the only trigger for a execlist switch. Within an execlist, a switch from one element (context) to the next can be triggered for several reasons, all of which are synchronous to what the running context itself is doing. Once a context is switched out, the relevant context state and context descriptor doesn't exist in HW, only way the context can be brought back in to HW is by SW resubmitting the context through Execlist Submit Port.

SW must ensure the contexts submitted to both the context descriptors in the execlist are different; i.e SW must not submit the same context descriptor to both the elements of the execlist.

The following are Execlist Registers:

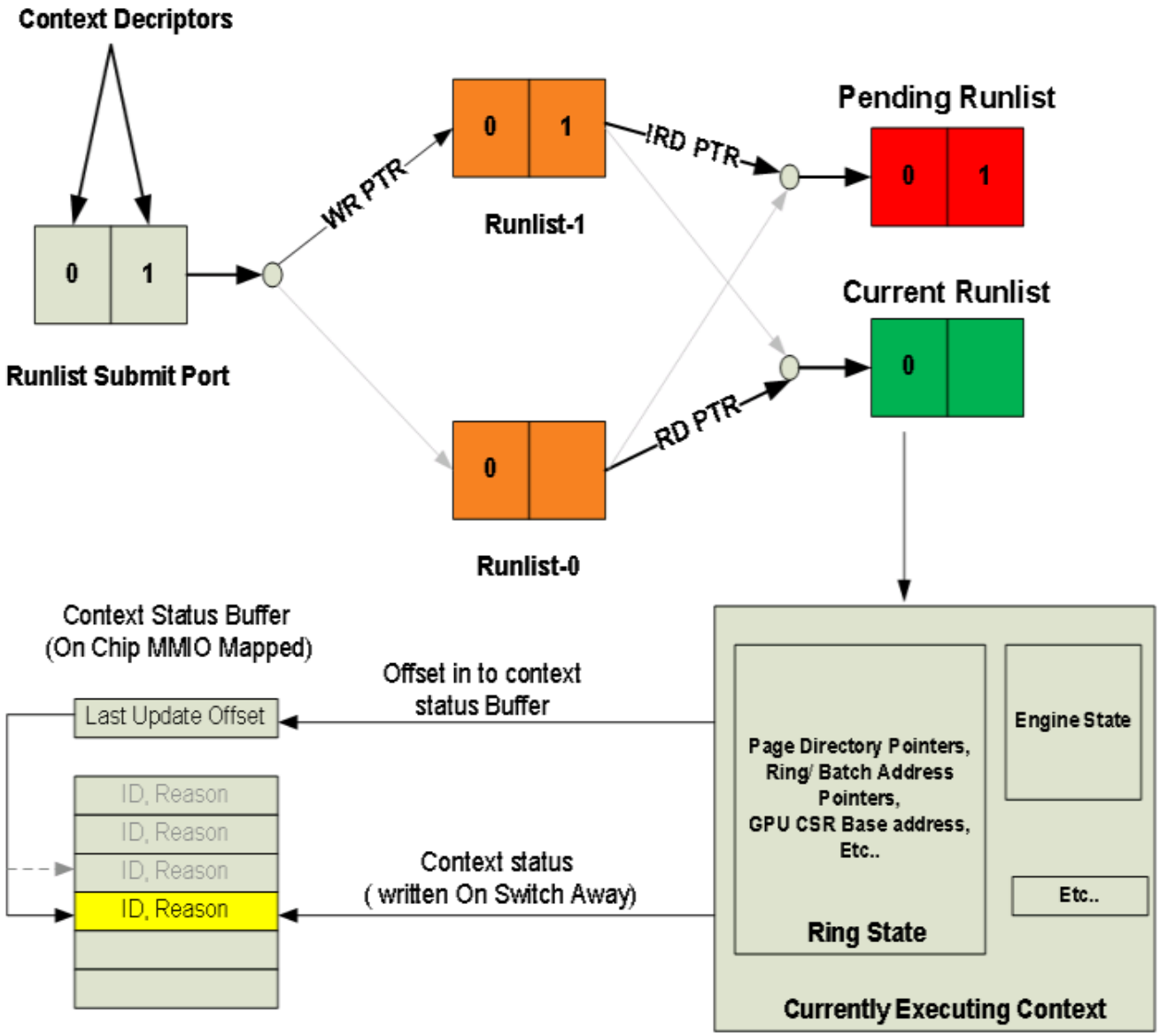
EXECLIST_SUBMITPORT - Execlist Submit Port Register

EXECLIST0_CONTENTS - Execlist 0 Contents Register

EXECLIST1_CONTENTS - Execlist 1 Contents Register

EXECLIST_STATUS - Execlist Status Register

Execlist Structure



Before submitting a context for the first time, the context image must be properly initialized. Proper initialization includes the ring context registers (ring location, head/tail pointers, etc.) and the page directory.

Render CS Only: Render state need not be initialized; the **Render Context Restore Inhibit** bit in the Context/Save image in memory should be set to prevent restoring garbage render context. See the Logical Ring Context Format section for details.

Context Descriptor Format Structure

Context Descriptor Format

Context Descriptor Format

Before submitting a context for the first time, the context image must be properly initialized. Proper initialization includes the ring context registers (ring location, head/tail pointers, etc.) and the page directory.

Render CS Only: Render state need not be initialized; the **Render Context Restore Inhibit** bit in the Context/Save image in memory should be set to prevent restoring garbage render context. See the Logical Ring Context Format section for details.

Programming Note on Context ID field in the Context Descriptor

This section describes the current usage by SW.

General Layout:

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Eng. ID				**SW Counter**					**HW Use**		**SW Context ID**																					

Eng. ID = Engine ID (a software defined enum to identify RCS, BCS etc..)

SW Counter = Submission Counter. (SW generates an unique counter value on every submission to ensure GroupID + PASID is unique to avoid ambiguity.)

Bit 20 = Is Proxy submission. If Set to true, SW Context ID[19:0] = LRCA [31:20], else it is an index into the Context Pool.

Logical Ring Context Format

When execlists are enabled, the Context Image for the each engine (Render, Video, Blitter, Video Enhancement) consists of Per-Process HW Status Page, Ring Context and Engine Context:

- Per-Process HW Status Page (4K)
- Ring Context (Ring Buffer Control Registers, Page Directory Pointers ..etc)
- Engine Context (PipelineState, Non-pipelineState, Statistics)

When execlists are disabled, the context image doesn't consist the Per-Process HW status page.

The detailed format of the Blitter/Video/VideoEnhancement logical ring context is documented in the "GPU Overview" volume, "Memory Data Formats" chapter.

The detailed format of the Render logical Ring and Engine Context including their size is mentioned in section "Graphics PRM: 3D-Media-GPGPU Engine > Render Command Memory Interface > Render Engine Logical Context Data > Register/State Context" for each product.

Context Status

A context switch interrupt will be sent anytime a context switch or execlist change occurs (including the execlist change without context switch scenario described in the ELSP -- Execlist Submit Port Register section). A status QW for the context that was just switched away from will be written to the Context Status Buffer in the Global Hardware Status Page. A copy of the Context Status Buffer is also maintained ON CHIP inside the command streamer, which is MMIO mapped and can be read/written using MMIO access.

Context Status Buffer in Global Hardware Status Page is exercised when IA based scheduling is done. The status contains the context ID and the reason for the context switch. Note that since there will have been no running contexts when the very first (after reset) execlist is submitted or when HW is idle, the Context ID in the first Context Status Qword will be UNDEFINED, this is indicated by setting IDLE to ACTIVE bit in the context status.

Format of Context Status QWord

Bits	Description
63:32	**Context ID**
31:28	Reserved
27:24	Reserved
23:20	Reserved
19:16	Reserved
15	**Lite Restore.** This bit is only valid only when Preempted bit is set. When set, this bit indicates a given context got preempted with the same context resulting in Lite Restore in HW.
14:12	**Display Plane.** This indicates the display plane for which Wait on Scnaline/V-Blank/Sync Flip has been executed leading to context switch. This field is only valid when one of the “Wait on Scanline” or “Wait on Vblnak” or “Wait on sync Flip” is set. 000b: Display Plane-A 001b: Display Plane-B 010b: Display Plane-C 011b: Display Plane Sprite-A 100b: Display Plane Sprite-B 101b: Display Plane Sprite-C
11	**Semaphore Wait Mode** 0: Signal Mode 1: Poll Mode This field is valid and must be looked at only when the "Wait on Semaphore" field is set.
10	Reserved
9	Reserved
8	**Wait on Scanline** has resulted in context switch. This may be cleared during context exit if the condition is met. If none of the bits specifying why we exit and ring is not complete, then scheduler should reschedule the context when possible.

Bits	Description
7	**Wait on Semaphore** has resulted in context switch. This may be cleared during context exit if the condition is met. If none of the bits specifying why we exit and ring is not complete, then scheduler should reschedule the context when possible.
6	**Wait on V-Blank** has resulted in context switch. This may be cleared during context exit if the condition is met. If none of the bits specifying why we exit and ring is not complete, then scheduler should reschedule the context when possible.
5	**Wait on Sync Flip** has resulted in context switch. This may be cleared during context exit if the condition is met. If none of the bits specifying why we exit and ring is not complete, then scheduler should reschedule the context when possible.
5	**Wait on Sync Flip** has resulted in context switch.
4	**Context Complete** Element is completely processed (Head eqv to Tail) and resulted in a context switch.
3	**ACTIVE to IDLE** following this context switch there is no active element available in HW to execute.
2	**Element Switch.** Context Switch happened from first element in the current execlist to the second element of the same execlist.
1	**Preempted.** Submission of a new execlist has resulted in context switch. The switch is from element in current execlist to element in pending execlist.
0	**IDLE to ACTIVE.** Execlist Submitted when HW is IDLE. When this bit is set rest of the fields in CSQ are not valid.

Context Status should be inferred as described in the tables below. In the two tables below only one of the context switch types will be set and it's quite possible multiple context switch reasons are set. A "Y" in a cell indicates the possibility of the context switch type for the corresponding context switch reason.

Inference of Context Status

Ctx Switch Type Ctx Switch Reason	IDLE to Active	Preempted/ Execlist Switch	**Element Switch	ACTIVE to IDLE
Context Complete	X	Y	Y	Y
Wait on Sync Flip	X	Y	Y	Y
Wait on V-Blank	X	Y	Y	Y
Wait on ScanLine	X	Y	Y	Y
Wait on Semaphore	X	Y	Y	Y
High Priority Context	Y	Y	X	Y

** This field is not valid when High Priority Context field is set and HW must force it to '0'.

When SW services a context switch interrupt, it should read the Context Status Buffer beginning where it left off reading the last time it serviced a context switch interrupt. It should read up to the **Context Status Buffer Write Pointer,** which is recorded in the Context Status Buffer Pointer register. At the end of the context switch interrupt processing SW will update the **Context Status Buffer Read Pointer** with the write buffer pointer value. The status QWs can be examined to determine which contexts were switched out between context interrupt service intervals, and why.

Number of Context Status Entries

Number of Status Entries
6 (QW) Entries

Status QWords are written to the Context Status Buffer at incrementing locations. The Context Status Buffer has a limited size (see Table Number of Context Status Entries) and simply wraps around to the beginning when the end is reached. Normally the number of status updates that can occur without SW intervening to submit a new execlist (and presumably reading any new status) is the number of execlists times the maximum number of context elements per execlist. Also note that there is no predictable relationship between a context's position in an execlist and the position of its corresponding status QWord in the Context Status Buffer.

The Context Status Buffer fits into a single cacheline so that the whole buffer is read from memory at once if the driver performs a cacheable read.

Format of the Context Status Buffer

QW	Description
7	**Last Written Status Offset.** The lower byte of this QWord is written on every context switch with the (pre-increment) value of the b>Context Status Buffer Write Pointer. The lower 3 bits increment for every status QWord write; bits[7:3] are reserved and must be '0'. The lowest 3 bits indicate which of the Context Status QWords was just written. The rest of the bits [63:8] are reserved.
6	Reserved: MBZ
5:0	**Context Status QWords.** A circular buffer of context status QWs. As each context is switched away from, its status is written here at ascending QWs as indicated by the **Last Written Status Offset**. Once QW 5 has been written, the pointer wraps around so that the next status will be written at QW0. Format = ContextStatusDW

The following are Context Status Registers:

CTXT_ST_PTR - Context Status Buffer Pointer Register

CTXT_ST_BUF - Context Status Buffer Contents

RINGBUF — Ring Buffer Registers

See the “Device Programming Environment” chapter for detailed information on these registers.

RING_BUFFER_TAIL - Ring Buffer Tail

RING_BUFFER_HEAD - Ring Buffer Head

RING_BUFFER_START - Ring Buffer Start

RING_BUFFER_CTL - Ring Buffer Control

UHPTR - Pending Head Pointer Register

Virtual Memory Control

Per-Process GTT (PPGTT) is setup for an engine (Render, Blitter, Video and Video Enhancement) by programming corresponding Page Directory Pointer (PDP) registers listed below. Refer “Graphics Translation Tables” in “Memory Overview” for more details on Per-Process page table entries and related translations.

Render Engine Command Streamer (RCS)

The RCS (Render Command Streamer) unit primarily serves as the software programming interface between the O/S driver and the Render Engine. It is responsible for fetching, decoding, and dispatching of data packets (3D/Media Commands with the header DWord removed) to the front end interface module of Render Engine.

Logic Functions Included
• MMIO register programming interface. • DMA action for fetching of ring data from memory. • Management of the Head pointer for the Ring Buffer. • Decode of ring data and sending it to the appropriate destination: 3D (Vertex Fetch Unit) & GPGPU. • Handling of user interrupts. • Flushing the 3D and GPGPU Engine. • Handle NOP.
• DMA action for fetching of execlists from memory. • Handling of ring context switch interrupt.

The register programming bus is a DWord interface bus that is driven by the configuration master. The RCS unit only claims memory mapped I/O cycles that are targeted to its range of 0x2000 to 0x27FF. The Gx and MFX Engines use semaphore to synchronize their operations.

RCS operates completely independent of the MFx CS.

The simple sequence of events is as follows: a ring (say PRB0) is programmed by a memory-mapped register write cycle. The DMA inside RCS is kicked off. The DMA fetches commands from memory based on the starting address and head pointer. The DMA requests cache lines from memory (one cacheline CL at a time). There is guaranteed space in the DMA FIFO (8 CL deep) for data coming back from memory. The DMA control logic has copies of the head pointer and the tail pointer. The DMA increments the head pointer after making requests for ring commands. Once the DMA copy of the head pointer becomes equal to the tail pointer, the DMA stops requesting.

The parser starts executing once the DMA FIFO has valid commands. All the commands have a header DWord packet. Based on the encoding in the header packet, the command may be targeted towards Vertex Fetch Unit or GPPGU engine or the command parser. After execution of every command, the actual head pointer is updated. The ring is considered empty when the head pointer becomes equal to the tail pointer.

Batch Buffer Privilege Register

FORCE_TO_NONPRIV - FORCE_TO_NONPRIV

Mode Registers

The following are the Mode Registers:

INSTPM - Instruction Parser Mode Register

EXCC - Execute Condition Code Register

NOPID - NOP Identification Register

CSPREEMPT - CSPREEMPT

RCS_CTXID_PREEMPTION_HINT - RCS Context Preemption Hint

RCS_PREEMPTION_HINT - RCS_PREEMPTION_HINT

RCS_PREEMPTION_HINT_UDW - RCS_PREEMPTION_HINT_UDW

RS_PRE_HINT - RS Preemption Hint

RS_PREEMPTION_HINT_UDW - RS Preemption Hint UDW

IDLEDLY - Idle Switch Delay

SEMA_WAIT_POLL - Semaphore Polling Interval on Wait

CS_RESET_CTRL - CS Reset Control Register

HWS_PGA - Hardware Status Page Address Register

Hardware Status Page Layout

Logical Context Support

The following are the Logical Context Support Registers:

BB_ADDR - Batch Buffer Head Pointer Register

BB_ADDR_UDW - Batch Buffer Upper Head Pointer Register

RCS_BB_STATE - RCS Batch Buffer State Register

CTXT_SR_CTL - Context Save/Restore Control Register

CCID - Current Context Register]

CXT_SIZE - Context Sizes

RS_CXT_OFFSET - Resource Streamer Context Offset

URB_CXT_OFFSET - URB Context Offset

CXT_EL_OFFSET - Exec-List Context Offset

SYNC_FLIP_STATUS - Wait For Event and Display Flip Flags Register

SYNC_FLIP_STATUS_1 - Wait For Event and Display Flip Flags Register 1

WAIT_FOR_RC6_EXIT - Control Register for Power Management

SBB_ADDR - Second Level Batch Buffer Head Pointer Register

SBB_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Register

SBB_STATE - Second Level Batch Buffer State Register

PS_INVOCATION_COUNT_SLICE0 - PS Invocation Count for Slice0

PS_INVOCATION_COUNT_SLICE1 - PS Invocation Count for Slice1

PS_INVOCATION_COUNT_SLICE2 - PS Invocation Count for Slice2

PS_DEPTH_COUNT_SLICE0 - PS Depth Count for Slice0

PS_DEPTH_COUNT_SLICE1 - PS Depth Count for Slice1

PS_DEPTH_COUNT_SLICE2 - PS Depth Count for Slice2

DISPLAY_MESSAGE_FORWARD_STATUS - Display Message Forward Status Register

R_PWR_CLK_STATE - Render Power Clock State Register

Context Save Registers

The following are the Context Save Registers:

BB_PREEMPT_ADDR - Batch Buffer Head Pointer Preemption Register

BB_PREEMPT_ADDR_UDW - Batch Buffer Upper Head Pointer Preemption Register

RING_BUFFER_HEAD_PREEMPT_REG - RING_BUFFER_HEAD_PREEMPT_REG

BB_START_ADDR - Batch Buffer Start Head Pointer Register

BB_START_ADDR_UDW - Batch Buffer Start Head Pointer Register for Upper DWord

BB_ADDR_DIFF - Batch Address Difference Register

BB_OFFSET - Batch Offset Register

SBB_PREEMPT_ADDR - Second Level Batch Buffer Head Pointer Preemption Register

SBB_PREEMPT_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Preemption Register

BB_PER_CTX_PTR - Batch Buffer Per Context Pointer

TDL_CONTEXT_SAVE - Context Save Request to TDL

MI Commands for Render Engine

This chapter describes the formats of the “Memory Interface” commands, including brief descriptions of their use. The functions performed by these commands are discussed fully in the *Memory Interface Functions* Device Programming Environment chapter.

This chapter describes MI Commands for the original graphics processing engine. The term “for Rendering Engine” in the title has been added to differentiate this chapter from a similar one describing the MI commands for the Media Decode Engine.

The commands detailed in this chapter are used across products within the Gen4+ family. However, slight changes may be present in some commands (i.e., for features added or removed), or some commands may be removed entirely. Refer to the *Preface* chapter for product specific summary.

MI_NOOP

MI_ARB_CHECK

MI_ARB_ON_OFF

MI_BATCH_BUFFER_START

MI_CONDITIONAL_BATCH_BUFFER_END

MI_DISPLAY_FLIP

MI_DISPLAY_FLIP

MI_LOAD_SCAN_LINES_EXCL

MI_LOAD_SCAN_LINES_INCL

MI_CLFLUSH

MI_MATH

MI_REPORT_HEAD

MI_STORE_DATA_IMM

MI_STORE_DATA_INDEX

MI_ATOMIC

MI_COPY_MEM_MEM

MI_LOAD_REGISTER_IMM

MI_LOAD_REGISTER_REG

MI_LOAD_REGISTER_MEM

MI_STORE_REGISTER_MEM

MI_SUSPEND_FLUSH

MI_UPDATE_GTT

MI_USER_INTERRUPT

MI_WAIT_FOR_EVENT

MI_SEMAPHORE_SIGNAL

MI_SEMAPHORE_WAIT

User Mode Privileged Commands

A subset of the commands are privileged. These commands may be issued only from a privileged batch buffer or directly from a ring buffer. Batch buffers in GGTT memory are privileged and batch buffers in PPGTT memory are non-privileged. On parsing privileged command from a non-privileged batch buffer, a Command Privilege Violation Error is flagged and the command is dropped. Command Privilege Violation Error is logged in Error identity register of command streamer which gets propagated as "Command Parser Master Error" interrupt to SW. Privilege access violation checks in HW can be disabled by setting "Privilege Check Disable" bit in GFX_MODE register. When privilege access checks are disabled HW will execute the Privilege command as expected.

User Mode Privileged Commands

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_UPDATE_GTT	Command is converted to NOOP.
MI_STORE_DATA_IMM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_STORE_DATA_INDEX	Command is converted to NOOP.
MI_STORE_REGISTER_MEM	Register read is always performed. Memory update is dropped if **Use Global GTT** is enabled.
MI_BATCH_BUFFER_START	Command when executed from a batch buffer can set its "Privileged" level to its parent batch buffer or lower. Chained or Second level batch buffer can be "Privileged" only if the parent or the initial batch buffer is "Privileged". This is HW enforced.
MI_LOAD_REGISTER_IMM	Command is converted to NOOP if the register accessed is privileged.
MI_LOAD_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled. Command is converted to NOOP, if the register accessed is privileged.
MI_LOAD_REGISTER_REG	Register write to a **Privileged Register** will be discarded.
MI_REPORT_PERF_COUNT	Command is converted to NOOP if **Use Global GTT** is enabled If a privilege access violation occurs, the Report ID field in the report generated by the next legitimate MI_REPORT_PERF_COUNT may be corrupted.
PIPE_CONTROL	Still send flush down, Post-Sync Operation is NOOP if **Use Global GTT** or Use "Store Data Index" is enabled. Post-Sync Operation LRI to **Privileged Register** is discarded. **Programming Note** **Context:** User Mode Privileged Commands Command Privilege Violation error will not be set in a predictable fashion on a Privilege Access Violation from a PIPE_CONTROL command.
MI_SET_CONTEXT	Command is converted to NOOP.
MI_ATOMIC	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_COPY_MEM_MEM	Command is converted to NOOP if **Use Global GTT** is used for source or destination address.

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_SEMAPHORE_WAIT	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_ARB_ON_OFF	Command is converted to NOOP.
MI_DISPLAY_FLIP	Command is converted to NOOP.
MI_CONDITIONAL_BATCH_BUFFER_END	Command is converted to NOOP if **Use Global GTT** is enabled.

Parsing one of the commands in the table above from a non-privileged batch buffer will flag an error and convert the command to a NOOP.

The table below lists the non-privileged registers that can be written to from a non-privileged batch buffer executed from Render Command Streamer.

User Mode Non-Privileged Registers

MMIO Name	MMIO Offset	SIZE in DWords
NOPID	0x2094	1
MI_PREDICATE_RESULT_2	0x23BC	1
INSTPM	0x20C0	1
IA_VERTICES_COUNT	0x2310	2
IA_PRIMITIVES_COUNT	0x2318	2
VS_INVOCATION_COUNT	0x2320	2
HS_INVOCATION_COUNT	0x2300	2
DS_INVOCATION_COUNT	0x2308	2
GS_INVOCATION_COUNT	0x2328	2
GS_PRIMITIVES_COUNT	0x2330	2
CL_INVOCATION_COUNT	0x2338	2
CL_PRIMITIVES_COUNT	0x2340	2
PS_INVOCATION_COUNT_0	0x22C8	2
PS_DEPTH_COUNT _0	0x22D8	2
GPUGPU_DISPATCHDIMX	0x2500	1
GPUGPU_DISPATCHDIMY	0x2504	1
GPUGPU_DISPATCHDIMZ	0x2508	1
MI_PREDICATE_SRC0	0x2400	1
MI_PREDICATE_SRC0	0x2404	1
MI_PREDICATE_SRC1	0x2408	1
MI_PREDICATE_SRC1	0x240C	1
MI_PREDICATE_DATA	0x2410	1
MI_PREDICATE_DATA	0x2414	1
MI_PRED_RESULT	0x2418	1
3DPRIM_END_OFFSET	0x2420	1

MMIO Name	MMIO Offset	SIZE in DWords
3DPRIM_START_VERTEX	0x2430	1
3DPRIM_VERTEX_COUNT	0x2434	1
3DPRIM_INSTANCE_COUNT	0x2438	1
3DPRIM_START_INSTANCE	0x243C	1
3DPRIM_BASE_VERTEX	0x2440	1
GPGPU_THREADS_DISPATCHED	0x2290	2
PS_INVOCATION_COUNT_1	0x22F0	2
PS_DEPTH_COUNT _1	0x22F8	2
BB_OFFSET	0x2158	1
MI_PREDICATE_RESULT_1	0x241C	1
CS_GPR (1-16)	0x2600	32
PS_INVOCATION_COUNT_2	0x2448	2
PS_DEPTH_COUNT_2	0x2450	2
Cache_Mode_0	0x7000	1
Cache_Mode_1	0x7004	1
GT_MODE	0x7008	1
L3_Config	0x7034	1
TD_CTL	0xE400	1
TD_CTL2	0xE404	1
SO_NUM_PRIMS_WRITTEN0	0x5200	2
SO_NUM_PRIMS_WRITTEN1	0x5208	2
SO_NUM_PRIMS_WRITTEN2	0x5210	2
SO_NUM_PRIMS_WRITTEN3	0x5218	2
SO_PRIM_STORAGE_NEEDED0	0x5240	2
SO_PRIM_STORAGE_NEEDED1	0x5248	2
SO_PRIM_STORAGE_NEEDED2	0x5250	2
SO_PRIM_STORAGE_NEEDED3	0x5258	2
SO_WRITE_OFFSET0	0x5280	1
SO_WRITE_OFFSET1	0x5284	1
SO_WRITE_OFFSET2	0x5288	1
SO_WRITE_OFFSET3	0x528C	1
PERF_CNT_1_DW0	0x91b8	1
PERF_CNT_1_DW1	0x91bc	1
PERF_CNT_2_DW0	0x91c0	1
PERF_CNT_2_DW1	0x91c4	1

Watchdog Timer Registers

These registers together implement a watchdog timer. Writing ones to the control register enables the counter, and writing zeros disables the counter. The second register is programmed with a threshold value which, when reached, signals an interrupt that then resets the counter to 0. Program the threshold value before enabling the counter or extremely frequent interrupts may result.

Note: The counter itself is not observable. It increments with the main render clock.
Programming Notes: When watch dog timer is enabled, HW does not trigger any kind of idle sequences. SW must enable and disable watch dog timer for any given workload within the same command buffer dispatch. SW must disable watch dog timer around semaphore waits and wait for events commands so that HW can trigger appropriate idle sequence for power savings.

PR_CTR - Render Watchdog Counter

PR_CTR_THRSH - Render Watchdog Counter Threshold

Interrupt Control Registers

The Interrupt Control Registers described in this section all share the same bit definition. The bit definition is as follows:

Bit Definition for Interrupt Control Registers - Render

Bit Definition for Interrupt Control Registers - Blitter

Bit Definition for Interrupt Control Registers Media#1 (VDBOX1)

Bit Definition for Interrupt Control Registers Media#2 (VDBOX2)

Bit Definition for Interrupt Control Registers- Video Enhancement (VDBOX)

The following table specifies the settings of interrupt bits stored upon a "Hardware Status Write" due to ISR changes:

Bit	Interrupt Bit	ISR Bit Reporting Via Hardware Status Write (When Unmasked Via HWSTAM)
9	Reserved	
8	**Context Switch Interrupt.** Set when a context switch has just occurred.	Not supported to be unmasked.
7	Reserved	
6	**Media Decode Pipeline Counter Exceeded Notify Interrupt.** The counter threshold for the execution of the media pipeline is exceeded. Driver needs to attempt hang recovery.	Not supported to be unmasked. Only for Media Pipe.
5	**L3 Parity interrupt**	Only for Render Pipe
4	**Flush Notify Enable**	0
3	**Master Error**	Set when error occurs, cleared when error cleared.
2	Reserved	
0	**User Interrupt**	0

RCS_HWSTAM - Render Hardware Status Mask Register

RCS_IMR - Render Interrupt Mask Register

VCS_HWSTAM - VCS Hardware Status Mask Register

VCS_IMR - VCS Interrupt Mask Register

BCS_HWSTAM - BCS Hardware Status Mask Register

BCS_IMR - BCS Interrupt Mask Register

VECS_HWSTAM - VECS Hardware Status Mask Register

VECS_IMR - VECS Interrupt Mask Register

Hardware-Detected Error Bit Definitions (for EIR EMR ESR)

This section defines the Hardware-Detected Error bit definitions and ordering that is common to the EIR, EMR, and ESR registers. The EMR selects which error conditions (bits) in the ESR are reported in the EIR. Any bit set in the EIR will cause the Master Error bit in the ISR to be set. EIR bits will remain set until the appropriate bit(s) in the EIR is cleared by writing the appropriate EIR bits with 1 (except for the unrecoverable bits described below).

The following structures describe the Hardware-Detected Error bits:

RCS Hardware-Detected Error Bit Definitions Structure

BCS Hardware-Detected Error Bit Definitions Structure

VCS Hardware-Detected Error Bit Definitions Structure

VECS Hardware-Detected Error Bit Definitions Structure

The following are the EIR, EMR, and ESR registers:

RCS_EIR - Error Identity Register

RCS_EMR - Error Mask Register

RCS_ESR - Error Status Register

BCS_EIR - BCS Error Identity Register

BCS_EMR - BCS Error Mask Register

BCS_ESR - BCS Error Status Register

VCS_EIR - VCS Error Identity Register

VCS_EMR - VCS Error Mask Register

VCS_ESR - VCS Error Status Register

VECS_EIR - VECS Error Identity Register

VECS_EMR - VECS Error Mask Register

VECS_ESR - VECS Error Status Register

Blitter Engine Command Streamer (BCS)

The BCS (Blitter Command Streamer) unit primarily serves as the software programming interface between the O/S driver and the Blitter Engine. It is responsible for fetching, decoding, and dispatching of data packets (Blitter Commands) to the front end interface module of Blitter Engine.

Logic Functions Included
• MMIO register programming interface. • DMA action for fetching of ring data from memory. • Management of the Head pointer for the Ring Buffer. • Decode of ring data and sending it to the blit engine. • Handling of user interrupts. • Flushing the Blitter Engine. • Handle NOP. • DMA action for fetching of execlists from memory. • Handling of ring context switch interrupt.

The register programming bus is a DWord interface bus that is driven by the configuration master. The BCS unit only claims memory mapped I/O cycles that are targeted to its range of 0x22000 to 0x224FF. The Blitter, Render and Media Engines use semaphore to synchronize their operations.

BCS operates completely independent of the other render and media command streams.

The simple sequence of events is as follows: a ring (say PRB0) is programmed by a memory-mapped register write cycle. The DMA inside BCS is kicked off. The DMA fetches commands from memory based on the starting address and head pointer. The DMA requests cache lines from memory (one cacheline CL at a time). There is guaranteed space in the DMA FIFO (8 CL deep) for data coming back from memory. The DMA control logic has copies of the head pointer and the tail pointer. The DMA increments the head pointer after making requests for ring commands. Once the DMA copy of the head pointer becomes equal to the tail pointer, the DMA stops requesting.

The parser starts executing once the DMA FIFO has valid commands. All the commands have a header DWord packet. Based on the encoding in the header packet, the command may be targeted towards Blitter Engine or the command parser. After execution of every command, the actual head pointer is updated. The ring is considered empty when the head pointer becomes equal to the tail pointer.

Watchdog Timer Registers

These are the Watchdog Timer registers:

BCS_CNTR - BCS Counter for the Blitter Engine

BCS_CTR_THRSH - BCS Watchdog Counter Threshold

Hardware-Detected Error Bit Definitions (for EIR EMR ESR)

This section defines the Hardware-Detected Error bit definitions and ordering that are common to the EIR, EMR, and ESR registers. The EMR selects which error conditions (bits) in the ESR are reported in the EIR. Any bit set in the EIR causes the Master Error bit in the ISR to be set. EIR bits remain set until the appropriate bits in the EIR are cleared by writing the appropriate EIR bits with 1 (except for the unrecoverable bits described below).

The following structure describes the Hardware-Detected Error bits:

BCS Hardware-Detected Error Bit Definitions Structure

The following are the EIR, EMR, and ESR registers:

BCS_EIR - BCS Error Identity Register

BCS_EMR - BCS Error Mask Register

BCS_ESR - BCS Error Status Register

Logical Context Support

The following are the Logical Context Support Registers:

BB_ADDR - Batch Buffer Head Pointer Register

BB_ADDR_UDW - Batch Buffer Upper Head Pointer Register

SBB_ADDR - Second Level Batch Buffer Head Pointer Register

SBB_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Register

CTXT_SR_CTL - Context Save/Restore Control Register

BCS_SYNC_FLIP_STATUS - BCS Wait for event and Display flip flags Register

SYNC_FLIP_STATUS - Wait For Event and Display Flip Flags Register

SYNC_FLIP_STATUS_1 - Wait For Event and Display Flip Flags Register 1

DISPLAY_MESSAGE_FORWARD_STATUS - Display Message Forward Status Register

BB_ADDR_DIFF - Batch Address Difference Register

BB_OFFSET - Batch Offset Register

RING_BUFFER_HEAD_PREEMPT_REG - RING_BUFFER_HEAD_PREEMPT_REG

BB_PREEMPT_ADDR - Batch Buffer Head Pointer Preemption Register

BB_PREEMPT_ADDR_UDW - Batch Buffer Upper Head Pointer Preemption Register

SBB_PREEMPT_ADDR - Second Level Batch Buffer Head Pointer Preemption Register

SBB_PREEMPT_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Preemption Register

MI_PREDICATE_RESULT_1 - Predicate Rendering Data Result 1

MI_PREDICATE_RESULT_2 - Predicate Rendering Data Result 2

INDIRECT_CTX - Indirect Context Pointer

INDIRECT_CTX_OFFSET - Indirect Context Offset Pointer

BB_PER_CTX_PTR - Batch Buffer Per Context Pointer

Mode Registers

The following are Mode Registers:

BCS_CXT_SIZE - BCS Context Sizes

BCS_MI_MODE - BCS Mode Register for Software Interface

BLT_MODE - Blitter Mode Register

BCS_INSTPM - BCS Instruction Parser Mode Register

Programming Note	
Context:	Mode Registers in Blitter Engine Command Streamer

- The BCS_INSTPM register is used to control the operation of the BCS Instruction Parser. Certain classes of instructions can be disabled (ignored) – often useful for detecting performance bottlenecks. Also, "Synchronizing Flush" operations can be initiated – useful for ensuring the completion (vs. only parsing) of rendering instructions.
- All Reserved bits are implemented.

BCS_EXCC - BCS Execute Condition Code Register

BCS_IDLEDLY - BCS Idle Switch Delay

BCS_SEMA_WAIT_POLL - BCS Semaphore Polling Interval on Wait

BCS_RESET_CTRL - BCS Reset Control Register

BCS_PREEMPTION_HINT - BCS_PREEMPTION_HINT

BCS_PREEMPTION_HINT_UDW - BCS_PREEMPTION_HINT_UDW

BCS_CTXID_PREEMPTION_HINT - BCS Context ID Preemption Hint

HWS_PGA - Hardware Status Page Address Register

Hardware Status Page Layout

MI Commands for Blitter Engine

This chapter describes the formats of the "Memory Interface" commands, including brief descriptions of their use. The functions performed by these commands are discussed fully in the *Memory Interface Functions* Device Programming Environment chapter.

This chapter describes MI Commands for the blitter graphics processing engine. The term "for Blitter Engine" in the title has been added to differentiate this chapter from a similar one describing the MI commands for the Media Decode Engine and the Rendering Engine.

The commands detailed in this chapter are used across products. However, slight changes may be present in some commands (i.e., for features added or removed), or some commands may be removed entirely. Refer to the *Preface* chapter for product specific summary.

MI_NOOP

MI_ARB_CHECK

MI_ARB_ON_OFF

MI_BATCH_BUFFER_START

A subset of the commands are privileged. These commands may be issued only from a privileged batch buffer or directly from a ring. Batch buffers in GGTT memory are privileged and batch buffers in PPGTT memory are non-privileged. On parsing privileged command from a non-privileged batch buffer, a Command Privilege Violation Error is flagged and the command is dropped. Command Privilege Violation Error is logged in Error identity register of command streamer which gets propagated as "Command Parser Master Error" interrupt to SW. Privilege access violation checks in HW can be disabled by setting "Privilege Check Disable" bit in BLT_MODE register. When privilege access checks are disabled HW executes privileged commands as expected.

User Mode Privileged Commands

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_UPDATE_GTT	Command is converted to NOOP.
MI_STORE_DATA_IMM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_STORE_DATA_INDEX	Command is converted to NOOP.
MI_STORE_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_BATCH_BUFFER_START	Command when executed from a batch buffer can set its "Privileged" level to its parent batch buffer or lower. Chained or Second level batch buffer can be "Privileged" only if the parent or the initial batch buffer is "Privileged". This is HW enforced.
MI_LOAD_REGISTER_IMM	Command is converted to NOOP if the register accessed is privileged.
MI_LOAD_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled. Register write to a **Privileged Register** is discarded.
MI_LOAD_REGISTER_REG	Register write to a **Privileged Register** is discarded.
MI_ATOMIC	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_COPY_MEM_MEM	Command is converted to NOOP if **Use Global GTT** is used for source or destination address.
MI_SEMAPHORE_WAIT	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_SEMAPHORE_SIGNAL	Command is converted to NOOP.
MI_ARB_ON_OFF	Command is converted to NOOP.
MI_DISPLAY_FLIP	Command is converted to NOOP.
MI_FLUSH_DW	Command is converted to NOOP if **Use Global GTT** or Use "Store Data Index" is enabled.
MI_CONDITIONAL_BATCH_BUFFER_END	Command is converted to NOOP if **Use Global GTT** is enabled.

Parsing one of the commands in the table above from a non-privileged batch buffer flags an error and converts the command to a NOOP.

The following table lists the non-privileged registers that can be written to from a non-secure batch buffer executed from Render Command Streamer.

User Mode Non-Privileged Registers

MMIO Name	MMIO Offset	Size in DWords
BCS_GPR	22600h	32
BCS_SWCTRL	22200h	32

MI_BATCH_BUFFER_END

MI_CONDITIONAL_BATCH_BUFFER_END

MI_DISPLAY_FLIP

MI_LOAD_SCAN_LINES_EXCL

MI_LOAD_SCAN_LINES_INCL

MI_FLUSH_DW

MI_MATH

MI_REPORT_HEAD

MI_STORE_DATA_IMM

MI_STORE_DATA_INDEX

MI_ATOMIC

MI_COPY_MEM_MEM

MI_LOAD_REGISTER_IMM

MI_LOAD_REGISTER_REG

MI_LOAD_REGISTER_MEM

MI_STORE_REGISTER_MEM

MI_SUSPEND_FLUSH

MI_UPDATE_GTT

MI_USER_INTERRUPT

MI_WAIT_FOR_EVENT

MI_SEMAPHORE_SIGNAL

MI_SEMAPHORE_WAIT

User Mode Privileged Commands

A subset of the commands are privileged. These commands may be issued only from a privileged batch buffer or directly from a ring buffer. Batch buffers in GGTT memory are privileged and batch buffers in PPGTT memory are non-privileged. On parsing a privileged command from a non-privileged batch buffer, a Command Privilege Violation Error is flagged and the command is dropped. Command Privilege Violation Error is logged in Error identity register of command streamer which gets propagated as "Command Parser Master Error" interrupt to SW. Privilege access violation checks in HW can be disabled by setting "Privilege Check Disable" bit in BLT_MODE register. When privilege access checks are disabled HW executes privileged commands as expected.

User Mode Privileged Commands

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_UPDATE_GTT	Command is converted to NOOP.
MI_STORE_DATA_IMM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_STORE_DATA_INDEX	Command is converted to NOOP.
MI_STORE_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_BATCH_BUFFER_START	Command when executed from a batch buffer can set its "Privileged" level to its parent batch buffer or lower. Chained or Second level batch buffer can be "Privileged" only if the parent or the initial batch buffer is "Privileged". This is HW enforced.
MI_LOAD_REGISTER_IMM	Command is converted to NOOP if the register accessed is privileged.
MI_LOAD_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled. Register write to a **Privileged Register** is discarded.
MI_LOAD_REGISTER_REG	Register write to a **Privileged Register** is discarded.
MI_ATOMIC	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_COPY_MEM_MEM	Command is converted to NOOP if **Use Global GTT** is used for source or destination address.
MI_SEMAPHORE_WAIT	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_SEMAPHORE_SIGNAL	Command is converted to NOOP.
MI_ARB_ON_OFF	Command is converted to NOOP.
MI_DISPLAY_FLIP	Command is converted to NOOP.
MI_FLUSH_DW	Still send flush down, Post-Sync Operation is converted to NOOP if **Use Global GTT** or Use "Store Data Index" is enabled.
MI_CONDITIONAL_BATCH_BUFFER_END	Command is converted to NOOP if **Use Global GTT** is enabled.

Parsing one of the commands in the table above from a non-privileged batch buffer will flag an error and convert the command to a NOOP.

The following table lists the non-privileged registers that can be written to from a non-privileged batch buffer executed from Blitter Command Streamer.

User Mode Non-Privileged Registers

MMIO Name	MMIO Offset	Size in DWords
BCS_GPR	22600h	32
BCS_SWCTRL	22200h	32

Video Command Streamer (VCS)

The VCS (Video Command Streamer) unit primarily serves as the software programming interface between the O/S driver and the MFD Engine. It is responsible for fetching, decoding, and dispatching of data packets (Media Commands with the header DWord removed) to the front end interface module of MFX Engine.

Its logic functions include:

- MMIO register programming interface
- DMA action for fetching of execlists and ring data from memory
- Management of the Head pointer for the Ring Buffer
- Decode of ring data and sending it to the appropriate destination: AVC, VC1, or MPEG2 engine
- Handling of user interrupts
- Handling of ring context switch interrupt
- Flushing the MFX Engine
- Handle NOP

The register programming (RM) bus is a DWord interface bus that is driven by the Gx Command Streamer. The VCS unit only claims memory mapped I/O cycles that are targeted to its range of 0x4000 to 0x4FFFF. The Gx and MFX Engines use semaphore to synchronize their operations.

VCS operates completely independent of the Gx CS.

The simple sequence of events is as follows: a ring (say PRB0) is programmed by a memory-mapped register write cycle. The DMA inside VCS is kicked off. The DMA fetches commands from memory based on the starting address and head pointer. The DMA requests cache lines from memory (one cacheline CL at a time). There is guaranteed space in the DMA FIFO (16 CL deep) for data coming back from memory. The DMA control logic has copies of the head pointer and the tail pointer. The DMA increments the head pointer after making requests for ring commands. Once the DMA copy of the head pointer becomes equal to the tail pointer, the DMA stops requesting.

The parser starts executing once the DMA FIFO has valid commands. All the commands have a header DWord packet. Based on the encoding in the header packet, the command may be targeted towards AVC/VC1/MPEG2 engine or the command parser. After execution of every command, the actual head pointer is updated. The ring is considered empty when the head pointer becomes equal to the tail pointer.

Watchdog Timer Registers

The following registers are defined as Watchdog Timer registers:

VCS_CNTR - VCS Counter for the bit stream decode engine

VCS_THRSH - VCS Threshold for the counter of bit stream decode engine

VCS Hardware - Detected Error Bit Definitions (for EIR EMR ESR)

This section defines the Hardware-Detected Error bit definitions and ordering that are common to the EIR, EMR, and ESR registers. The EMR selects which error conditions (bits) in the ESR are reported in the EIR. Any bit set in the EIR causes the Master Error bit in the ISR to be set. EIR bits remain set until the appropriate bits in the EIR are cleared by writing the appropriate EIR bits with 1 (except for the unrecoverable bits described below).

The following links describe the Hardware-Detected Error bits.

VCS Hardware-Detected Error Bit Definitions

VCS_EIR - VCS Error Identity Register

VCS_EMR - VCS Error Mask Register

VCS_ESR - VCS Error Status Register

Logical Context Support

This section contains the registers for Logical Context Support.

BB_STATE - Batch Buffer State Register

CTXT_SR_CTL - Context Save/Restore Control Register

BB_ADDR_DIFF - Batch Address Difference Register

BB_ADDR - Batch Buffer Head Pointer Register

SBB_ADDR - Second Level Batch Buffer Head Pointer Register

SBB_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Register

BB_OFFSET - Batch Offset Register

RING_BUFFER_HEAD_PREEMPT_REG - RING_BUFFER_HEAD_PREEMPT_REG

BB_PREEMPT_ADDR - Batch Buffer Head Pointer Preemption Register

BB_PREEMPT_ADDR_UDW - Batch Buffer Upper Head Pointer Preemption Register

SBB_PREEMPT_ADDR - Second Level Batch Buffer Head Pointer Preemption Register

SBB_PREEMPT_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Preemption Register

MI_PREDICATE_RESULT_1 - Predicate Rendering Data Result 1

MI_PREDICATE_RESULT_2 - Predicate Rendering Data Result 2

DISPLAY_MESSAGE_FORWARD_STATUS - Display Message Forward Status Register

FORCE_TO_NONPRIV - FORCE_TO_NONPRIV

INDIRECT_CTX - Indirect Context Pointer

INDIRECT_CTX_OFFSET - Indirect Context Offset Pointer

BB_PER_CTX_PTR - Batch Buffer Per Context Pointer

Mode Registers

The following are Mode Registers:

VCS_CXT_SIZE - VCS Context Sizes

VCS_MI_MODE - VCS Mode Register for Software Interface

MFX_MODE - Video Mode Register

VCS_INSTPM - VCS Instruction Parser Mode Register

VCS_IDLEDLY - VCS Idle Switch Delay

VCS_RESET_CTRL - VCS Reset Control Register

VCS_CTXID_PREEMPTION_HINT - VCS Context ID Preemption Hint

VCS_PREEMPTION_HINT - VCS_PREEMPTION_HINT

VCS_PREEMPTION_HINT_UDW

VCS_SEMA_WAIT_POLL - VCS Semaphore Polling Interval on Wait

HWS_PGA - Hardware Status Page Address Register

Hardware Status Page Layout

Registers in Media Engine

This topic describes the memory-mapped registers associated with the Memory Interface, including brief descriptions of their use. The functions performed by some of these registers are discussed in more detail in the Memory Interface Functions, Memory Interface Instructions, and Programming Environment chapters.

The registers detailed in this chapter are used across multiple projects and are extentions to previous projects. However, slight changes may be present in some registers (i.e., for features added or removed), or some registers may be removed entirely. These changes are clearly marked within this section.

GFX Pending TLB Cycles Information Registers

The following registers contain information about cycles that did not complete their TLB translation.

Information is organized as 64 entries, where each entry has a valid and ready bit, collapsed into separate registers.

VCS_TIMESTAMP - VCS Reported Timestamp Count

VCS_CTX_TIMESTAMP - VCS Context Timestamp Count

Memory Interface Commands for Video Codec Engine

This chapter describes the formats of the “Memory Interface” commands, including brief descriptions of their use. The functions performed by these commands are discussed fully in the *Memory Interface Functions* Device Programming Environment chapter.

This chapter describes MI Commands for the Video Codec Engine.
The commands detailed in this chapter are used across the later products within the Gen family. However, slight changes may be present in some commands (i.e., for features added or removed), or some commands may be removed entirely. Refer to the *Preface* chapter for details.

MI_ARB_CHECK

MI_BATCH_BUFFER_END

MI_CONDITIONAL_BATCH_BUFFER_END

MI_BATCH_BUFFER_START

MI_FLUSH_DW

MI_LOAD_REGISTER_IMM

MI_COPY_MEM_MEM

MI_LOAD_REGISTER_REG

MI_MATH

MI_NOOP

MI_REPORT_HEAD

MI_SEMAPHORE_SIGNAL

MI_SEMAPHORE_WAIT

MI_STORE_REGISTER_MEM

MI_STORE_DATA_IMM

MI_STORE_DATA_INDEX

MI_SUSPEND_FLUSH

MI_USER_INTERRUPT

MI_UPDATE_GTT

MI_LOAD_REGISTER_MEM

MI_ATOMIC

User Mode Privileged Commands

A subset of the commands are privileged. These commands may be issued only from a privileged batch buffer or directly from a ring. Batch buffers in GGTT memory are privileged and batch buffers in PPGTT memory are non-privileged. On parsing privileged command from a non-privileged batch buffer, a Command Privilege Violation Error is flagged and the command is dropped. Command Privilege Violation Error is logged in Error identity register of command streamer which gets propagated as "Command Parser Master Error" interrupt to SW. Privilege access violation checks in HW can be disabled by setting "Privilege Check Disable" bit in MFX_MODE register. When privilege access checks are disabled HW will execute the Privilege command as expected.

User Mode Privileged Commands

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_UPDATE_GTT	Command is converted to NOOP.
MI_STORE_DATA_IMM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_STORE_DATA_INDEX	Command is converted to NOOP.
MI_STORE_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_BATCH_BUFFER_START	Command when executed from a batch buffer can set its "Privileged" level to its parent batch buffer or lower. Chained or Second level batch buffer can be "Privileged" only if the parent or the initial batch buffer is "Privileged". This is HW enforced.
MI_LOAD_REGISTER_IMM	Command is converted to NOOP if the register accessed is privileged.
MI_LOAD_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled Register write to a **Privileged Register** will be discarded.
MI_LOAD_REGISTER_REG	Register write to a **Privileged Register** will be discarded.
MI_ATOMIC	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_COPY_MEM_MEM	Command is converted to NOOP if **Use Global GTT** is used for source or destination address.
MI_SEMAPHORE_SIGNAL	Command is converted to NOOP.
MI_SEMAPHORE_WAIT	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_ARB_ON_OFF	Command is converted to NOOP.
MI_FLUSH_DW	Still send flush down, Post-Sync Operation is converted to NOOP if **Use Global GTT** or Use "Store Data Index" is enabled.
MI_CONDITIONAL_BATCH_BUFFER_END	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_SEMAPHORE_SIGNAL	Command is converted to NOOP.

Parsing one of the commands in the table above from a non-privileged batch buffer flags an error and converts the command to a NOOP.

The following table lists the non-privileged registers that can be written to from a non-secure batch buffer executed from Video Command Streamer.

User Mode Non-Privileged Registers

MMIO Name	MMIO Offset	Size in DWords
VCS_GPR	12600h	32
VCS_GPR (2nd VCS)	1C600h	32
MFC_VDBOX1	12800h	64
MFC_VDBOX2	1C800h	64

Video Enhancement Engine Command Interface

The following topics describe the Video Enhancement Engine Command Interface.

VECS_RINGBUF — Ring Buffer Registers

The following are Ring Buffer Registers:

RING_BUFFER_TAIL - Ring Buffer Tail

RING_BUFFER_HEAD - Ring Buffer Head

RING_BUFFER_START - Ring Buffer Start

RING_BUFFER_CTL - Ring Buffer Control

UHPTR - Pending Head Pointer Register

Watchdog Timer Registers

The following are Watchdog Timer Registers:

VECS_CNTR - VECS Counter for the Video Enhancement Engine

VECS_CTR_THRSH - VECS Threshold for the Counter of Video Enhancement Engine

Logical Context Support

The following are Logical Context Support Registers:

BB_ADDR - Batch Buffer Head Pointer Register

BB_ADDR_UDW - Batch Buffer Upper Head Pointer Register

SBB_ADDR - Second Level Batch Buffer Head Pointer Register

SBB_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Register

BB_STATE - Batch Buffer State Register

CTXT_SR_CTL - Context Save/Restore Control Register

VECS_TIMESTAMP - VECS Reported Timestamp Count

VECS_CTX_TIMESTAMP - VECS Context Timestamp Count

BB_ADDR_DIFF - Batch Address Difference Register

BB_OFFSET - Batch Offset Register

RING_BUFFER_HEAD_PREEMPT_REG - RING_BUFFER_HEAD_PREEMPT_REG

BB_PREEMPT_ADDR - Batch Buffer Head Pointer Preemption Register

BB_PREEMPT_ADDR_UDW - Batch Buffer Upper Head Pointer Preemption Register

SBB_PREEMPT_ADDR - Second Level Batch Buffer Head Pointer Preemption Register

SBB_PREEMPT_ADDR_UDW - Second Level Batch Buffer Upper Head Pointer Preemption Register

MI_PREDICATE_RESULT_1 - Predicate Rendering Data Result 1

MI_PREDICATE_RESULT_2 - Predicate Rendering Data Result 2

DISPLAY_MESSAGE_FORWARD_STATUS - Display Message Forward Status Register

FORCE_TO_NONPRIV - FORCE_TO_NONPRIV

INDIRECT_CTX - Indirect Context Pointer

INDIRECT_CTX_OFFSET - Indirect Context Offset Pointer

BB_PER_CTX_PTR - Batch Buffer Per Context Pointer

Mode Registers

The following are Mode Registers:

VECS_MI_MODE — VECS Mode Register for Software Interface

VEBOX_MODE - Video Mode Register

VECS_INSTPM—VECS Instruction Parser Mode Register

HWS_PGA - Hardware Status Page Address Register

Hardware Status Page Layout

VECS_RESET_CTRL - VECS Reset Control Register

VECS_PREEMPTION_HINT

VECS_PREEMPTION_HINT_UDW

VECS_CTXID_PREEMPTION_HINT - VECS Context ID Preemption Hint

VECS_SEMA_WAIT_POLL - VECS Semaphore Polling Interval on Wait

MI Commands for Video Enhancement Engine

This chapter describes the formats of the "Memory Interface" commands, including brief descriptions of their use. The functions performed by these commands are discussed fully in the *Memory Interface Functions* Device Programming Environment chapter.

This chapter describes MI Commands for the Video Codec Engine.

The commands detailed in this chapter are used across the later products within the Gen family. However, slight changes may be present in some commands (i.e., for features added or removed), or some commands may be removed entirely. Refer to the *Preface* chapter for details.

MI_ARB_CHECK

MI_BATCH_BUFFER_END

MI_CONDITIONAL_BATCH_BUFFER_END

MI_BATCH_BUFFER_START

MI_FLUSH_DW

MI_LOAD_REGISTER_IMM

MI_LOAD_REGISTER_REG

MI_MATH

MI_NOOP

MI_REPORT_HEAD

MI_SEMAPHORE_SIGNAL

MI_SEMAPHORE_WAIT

MI_ATOMIC

MI_STORE_REGISTER_MEM

MI_STORE_DATA_IMM

MI_STORE_DATA_INDEX

MI_SUSPEND_FLUSH

MI_USER_INTERRUPT

MI_UPDATE_GTT

MI_COPY_MEM_MEM

MI_LOAD_REGISTER_MEM

User Mode Privileged Commands

A subset of the commands are privileged. These commands may be issued only from a privileged batch buffer or directly from a ring. Batch buffers in GGTT memory are privileged and batch buffers in PPGTT memory are non-privileged. On parsing a privileged command from a non-privileged batch buffer, a Command Privilege Violation Error is flagged and the command is dropped. A Command Privilege Violation Error is logged in the Error identity register of the command streamer which gets propagated as "Command Parser Master Error" interrupt to SW. Privilege access violation checks in HW can be disabled by setting "Privilege Check Disable" bit in VEBOX_MODE register. When privilege access checks are disabled HW executes privileged commands as expected.

User Mode Privileged Commands

User Mode Privileged Command	Function in Non-Privileged Batch Buffers
MI_UPDATE_GTT	Command is converted to NOOP.
MI_STORE_DATA_IMM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_STORE_DATA_INDEX	Command is converted to NOOP.
MI_STORE_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_BATCH_BUFFER_START	Command when executed from a batch buffer can set its "Privileged" level to its parent batch buffer or lower. Chained or Second level batch buffer can be "Privileged" only if the parent or the initial batch buffer is "Privileged". This is HW enforced.
MI_LOAD_REGISTER_IMM	Command is converted to NOOP if the register accessed is privileged.
MI_LOAD_REGISTER_MEM	Command is converted to NOOP if **Use Global GTT** is enabled. Register write to a **Privileged Register** will be discarded.
MI_LOAD_REGISTER_REG	Register write to a **Privileged Register** will be discarded.
MI_ATOMIC	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_COPY_MEM_MEM	Command is converted to NOOP if **Use Global GTT** is used for source or destination address.
MI_SEMAPHORE_SIGNAL	Command is converted to NOOP.
MI_SEMAPHORE_WAIT	Command is converted to NOOP if **Use Global GTT** is enabled.
MI_ARB_ON_OFF	Command is converted to NOOP.
MI_FLUSH_DW	Still send flush down, Post-Sync Operation is converted to NOOP if **Use Global GTT** or Use "Store Data Index" is enabled.
MI_CONDITIONAL_BATCH_BUFFER_END	Command is converted to NOOP if **Use Global GTT** is enabled.

Parsing one of the commands in the table above from a non-privileged batch buffer will flag an error and convert the command to a NOOP.

The table below lists the non-privileged registers that can be written to from a non-secure batch buffer executed from the Render Command Streamer.

User Mode Non-Privileged Registers

MMIO Name	MMIO Offset	Size in DWords
VECS_GPR	1A600h	32

Preemption

Preemption is a means by which HW is instructed to stop executing an ongoing workload and switch to the new workload submitted. Preemption flows are different based on the mode of scheduling.

Ring Buffer Scheduling

In Ring Buffer mode of scheduling SW triggers preemption by programming UHPTR (Updated Head Pointer Register) register with a valid head pointer. UHPTR contains head pointer and head pointer valid bit; the head pointer is valid only when the head pointer valid bit is set.

HW triggers preemption on a preemptable command on detecting Head Pointer Valid bit asserted in the UHPTR register. Following preemption HW updates its current head pointer with the Head Pointer from the UHPTR and starts execution; i.e all the commands from current head pointer to the updated head pointer are skipped by HW. HW samples the head pointer and the batch buffer address on preemption and updates them to the RING_BUFFER_HEAD_PREEMPT_REG and BB_PREEMPT_ADDR respectively. RING_BUFFER_HEAD_PREEMPT_REG and BB_PREEMPT_ADDR provide the graphics memory address of the preemptable command on which last preemption has occurred. HW resets the head pointer valid bit in UHPTR upon completion of preemption.

Programming Notes:

Preemption is not supported for Media Workloads. Hence preemption can be achieved only on Command Buffer boundaries. Media Command Buffers must be bracketed with MI_ARB_OFF and MI_ARB_ON commands to avoid preemption of media command buffers.

Example:

```
 Ring Buffer
…
MI_ARB_ON_OFF     // OFF
MI_BATCH_START    // Media Workload
MI_ARB_ON_OFF     // ON
MI_ARB_CHK        // Preemptable command outside media command buffer.
…
End Ring Buffer
```

The following tables list the Preemptable Commands in the Ring Buffer mode of scheduling:

Engine (below)	Preemptable Commands				
	MI_ARB_CHECK	3DPRIMITIVE	GPGPU_WALKER	PIPE_CONTROL ***	MEDIA STATE FLUSH
Render	AP	Object Level (if enabled *)	Mid-Thread (if enabled **)	PIPESEL-GPGPU MODE	PIPESEL-GPGPU MODE
Blitter	AP	N/A	N/A	N/A	N/A
Media	AP	N/A	N/A	N/A	N/A
VideoEnhancement	AP	N/A	N/A	N/A	N/A

AP: Allow preemption on UHPTR valid and arbitration enabled. Arbitration can be enabled/disabled using MI_ARB_ON_OFF command.

ExecList Scheduling

In ExecList mode of scheduling SW triggers preemption by submitting a new pending execlist to ELSP (ExecList Submit Port). HW triggers preemption on a preemptable command on detecting the availability of the new pending execlist, following preemption context switch happens to the newly submitted execlist. As part of the context switch preempted context state is saved to the preempted context LRCA, context state contains the details such that on resubmission of the preempted context HW can resume execution from the point where it was preempted.

Example:

```
 Ring Buffer

MI_ARB_ON_OFF   // OFF
MI_BATCH_START  // Media Workload
MI_ARB_ON_OFF   // ON
MI_ARB_CHK      // Preemptable command outside media command buffer.
```

The following tables list the Preemptable Commands in ExecList mode of scheduling:

Engine (below)	Preemptable Commands							
	MI_ARB_CHECK	Element Boundary	Semaphore Wait	Wait for Event	3DPRIMITIVE	GPGPU_WALKER	PIPE_CONTROL ***	MEDIA STATE FLUSH
Render	AP	AP	Unsuccessful & AP	Unsuccessful & AP	Object Level (if enabled *)	Mid-Thread (if enabled **)	PIPESEL-GPGPU MODE	PIPESEL-GPGPU MODE
Blitter	AP	AP	Unsuccessful & AP	Unsuccessful & AP	N/A	N/A	N/A	N/A
Media	AP	AP	Unsuccessful & AP	N/A	N/A	N/A	N/A	N/A
Video Enhancement	AP	AP	Unsuccessful & AP	N/A	N/A	N/A	N/A	N/A

Table Notes:

AP - Allow Preemption if arbitration is enabled.
* 0x229c bit 11 determines whether the level of preemption is command or object level.
** 0x20E4 bits 2:1 determine the level of preemption for GPGPU workloads.
*** MI_ATOMIC and MI_SEMAPHORE_SIGNAL commands with Post Sync Op bit set are treated as PIPE_CONTROL command with Post Sync Operation as Atomics or Semaphore Signal.
**** Any Header with the value [31:29] = "011", [28:27] = "00" OR "11" and [26:24] = "001". Refer to Graphics Command Formats.

Command Streamer (CS) ALU Programming

The command streamer implements a rudimentary Arithmetic Logic Unit (ALU) which supports basic arithmetic (Addition and Subtraction) and logical operations (AND, OR, XOR) on two 64-bit operands.

The ALU has two 64-bit registers at the input, SRCA and SRCB, to which source operands are loaded. The ALU result is written to a 64-bit accumulator. The Zero Flag and Carry Flag are assigned based on the accumulator output.

See the ALU Programming section in the Render Engine Command Streamer, for a description of the ALU programming model. That model is the same for all command streamers that support ALU programming, but each command streamer uses different address offsets for the registers used. The following subsections describe the ALU registers in the Blitter command streamer.

CS ALU Programming and Design