IIDC 1394-based Digital Camera Specification
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Digital Camera Sub Working Group (DC-SWG)

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Abstract: The purpose of this document is to act as a design guide for digital camera makers that wish to use IEEE 1394 as the camera-to-PC interconnect. Adherence to the design specifications contained herein do not guarantee, but will promote interoperability for this class of device. The camera registers, fields within those registers, video formats, modes of operation, and controls for each are specified. Area has been left for growth. To make application for additional specification, contact the 1394 Trade Association Instrumentation and Industrial Control Working Group, Digital Camera Sub Working Group (II-WG DC-SWG).
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Introduction

The 1394TA II-WG DC-SWG was formed with the following charter:

- Investigate command set specific to 1394 based digital camera device.

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TABLE OF CONTENTS

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1. Digital camera control command register

Base address for all digital camera command registers is:

Bus_ID, Node_ID , FFFF Fxxx xxxx (initial units space)

This address is contained in the configuration ROM in the camera unit directory.
The following sections define the entire camera CSR registers. The offset field in each of the tables is the byte offset from the above base address.

1.1 Camera initialize register

Offset	Name	Field	Bit	Description
000h	INITIALIZE	Initialize	[0]	If you assert this bit,, Camera will re-set to initial (factory setting value) state.
		-	[1..31]	Reserved (All zero)

0-7	8-15	16-23	24-31
i	Reserved		

Initial values	Zeros
Read values	Zeros
Write effect	If '0' no effect If '1' set initial state (Factory setting)

1.2 Inquiry register for video format/mode/frame rate

Each bit in the inquiry fields specifies the availability of a given feature. A value of '1' indicates that the corresponding feature is implemented; a value of '0' indicates that the corresponding feature is not implemented.
The following sections define the inquiry registers.

1.2.1 Inquiry register for video format

Offset	Name	Field	Bit	Description
100h	V_FORMAT_INQ	Format_0	[0]	VGA non-compressed format. (Maximum 640x480)
		Format_1	[1]	Super VGA non-compressed format (1)
		Format_2	[2]	Super VGA non-compressed format (2)
		Format_x	[3..5]	Reserved for other format.
		Format_6	[6]	Still Image Format
		Format_7	[7]	Partial Image Size Format
		-	[8..31]	Reserved. (All zero)

0-7	8-15	16-23	24-31
Format	Reserved		

Initial values	System dependent.
Read values	System dependent. Same value to Initial value.
Write effect	Ignored.

1.2.2 Inquiry register for video mode

Offset	Name	Field	Bit	Description
180h	V_MODE_INQ_0 (Format_0)	Mode_0	[0]	160 X 120 YUV(4:4:4) Mode (24bit/pixel)
		Mode_1	[1]	320 X 240 YUV(4:2:2) Mode (16bit/pixel)
		Mode_2	[2]	640 X 480 YUV(4:1:1) Mode (12bit/pixel)
		Mode_3	[3]	640 X 480 YUV(4:2:2) Mode (16bit/pixel)
		Mode_4	[4]	640 X 480 RGB Mode (24bit/pixel)
		Mode_5	[5]	640 X 480 Y (Mono) Mode (8bit/pixel)
		Mode_6	[6]	640 X 480 Y (Mono16) Mode (16bit/pixel)
		Mode_x	[7]	Reserved for another Mode
		-	[8..31]	Reserved. (All zero)
184h	V_MODE_INQ_1 (Format_1)	Mode_0	[0]	800 X 600 YUV(4:2:2) Mode (16bit/pixel)
		Mode_1	[1]	800 X 600 RGB Mode (24bit/pixel)
		Mode_2	[2]	800 X 600 Y (Mono) Mode (8bit/pixel)
		Mode_3	[3]	1024 X 768 YUV(4:2:2) Mode (16bit/pixel)
		Mode_4	[4]	1024 X 768 RGB Mode (24bit/pixel)
		Mode_5	[5]	1024 X 768 Y (Mono) Mode (8bit/pixel)
		Mode_6	[6]	800 X 600 Y (Mono16) Mode (16bit/pixel)
		Mode_7	[7]	1024 X 768 Y (Mono16) Mode (16bit/pixel)
		-	[8..31]	Reserved. (All zero)
188h	V_MODE_INQ_2 (Format_2)	Mode_0	[0]	1280 X 960 YUV(4:2:2) Mode (16bit/pixel)
		Mode_1	[1]	1280 X 960 RGB Mode (24bit/pixel)
		Mode_2	[2]	1280 X 960 Y (Mono) Mode (8bit/pixel)
		Mode_3	[3]	1600 X 1200 YUV(4:2:2) Mode (16bit/pixel)
		Mode_4	[4]	1600 X 1200 RGB Mode (24bit/pixel)
		Mode_5	[5]	1600 X 1200 Y (Mono) Mode (8bit/pixel)
		Mode_6	[6]	1280 X 960 Y (Mono16) Mode (16bit/pixel)
		Mode_7	[7]	1600X 1200 Y (Mono16) Mode (16bit/pixel)
		-	[8..31]	Reserved. (All zero)
18Ch : 197h	Reserved for other V_MODE_INQ_x for Format_x.			
198h	V_MODE_INQ_6 (Format_6)	Mode_0	[0]	Exif format
		Mode_x	[1..7]	Reserved for another Mode
		-	[8..31]	Reserved. (All zero)
19Ch	V_MODE_INQ_7 (Format_7)	Mode_0	[0]	Format_7 Mode_0
		Mode_1	[1]	Format_7 Mode_1
		Mode_2	[2]	Format_7 Mode_2
		Mode_3	[3]	Format_7 Mode_3
		Mode_4	[4]	Format_7 Mode_4
		Mode_5	[5]	Format_7 Mode_5
		Mode_6	[6]	Format_7 Mode_6
		Mode_7	[7]	Format_7 Mode_7
		-	[8..31]	Reserved. (All zero)

0-7	8-15	16-23	24-31
V_MODE_INQ	Reserved		

Initial values	System dependent
Read values	System dependent. Same value to Initial value
Write effect	Ignored

1.2.3 Inquiry register for video frame rate and base address of the Video Mode CSR for the Partial Image Size Format

Offset	Name	Field	Bit	Description
200h	V_RATE_INQ_0_0 (Format_0,Mode_0)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
204h	V_RATE_INQ_0_1 (Format_0,Mode_1)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
208h	V_RATE_INQ_0_2 (Format_0,Mode_2)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
20Ch	V_RATE_INQ_0_3 (Format_0,Mode_3)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
210h	V_RATE_INQ_0_4 (Format_0,Mode_4)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
214h	V_RATE_INQ_0_5 (Format_0,Mode_5)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_5	[5]	60fps
		FrameRate_x	[6..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
218h	V_RATE_INQ_0_6 (Format_0,Mode_6)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
21Ch : 21Fh	Reserved V_RATE_INQ_0_x (for other Mode_x of Format_0)			

220h	V_RATE_INQ_1_0 (Format_1,Mode_0)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
224h	V_RATE_INQ_1_1 (Format_1,Mode_1)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_x	[4..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
228h	V_RATE_INQ_1_2 (Format_1,Mode_2)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	Reserved
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_5	[5]	60fps
		FrameRate_x	[6..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
22Ch	V_RATE_INQ_1_3 (Format_1,Mode_3)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_x	[4..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
230h	V_RATE_INQ_1_4 (Format_1,Mode_4)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
234h	V_RATE_INQ_1_5 (Format_1,Mode_5)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
238h	V_RATE_INQ_1_6 (Format_1,Mode_6)	FrameRate_0	[0]	Reserved
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_4	[4]	30fps
		FrameRate_x	[5..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
23Ch	V_RATE_INQ_1_7 (Format_1,Mode_7)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_x	[4..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)

240h	V_RATE_INQ_2_0 (Format_2,Mode_0)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
244h	V_RATE_INQ_2_1 (Format_2,Mode_1)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
248h	V_RATE_INQ_2_2 (Format_2,Mode_2)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_x	[4..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
24Ch	V_RATE_INQ_2_3 (Format_2,Mode_3)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
250h	V_RATE_INQ_2_4 (Format_2,Mode_4)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_x	[2..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
254h	V_RATE_INQ_2_5 (Format_2,Mode_5)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_3	[3]	15fps
		FrameRate_x	[4..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
258h	V_RATE_INQ_2_6 (Format_2,Mode_6)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)
25Ch	V_RATE_INQ_2_7 (Format_2,Mode_7)	FrameRate_0	[0]	1.875fps
		FrameRate_1	[1]	3.75fps
		FrameRate_2	[2]	7.5fps
		FrameRate_x	[3..7]	Reserved for another frame rate
		-	[8..31]	Reserved (All zero)

260h : 2BFh	Reserved V_RATE_INQ_y_x (for other Format_y,Mode_x)			
2C0h	V_REV_INQ_6_0 (Format_6,Mode_0)	revision_0	[0]	Exif format revision 2.0
		revision_x	[1..7]	Reserved for other revision
		-	[8..31]	Reserved (All zero)
2C4h : 2DFh	Reserved V_REV_INQ_6_x (for other Mode_x of Format_6)			
2E0h	V_CSR_INQ_7_0	Mode_0	[0..31]	CSR quadlet offset for Format_7 Mode_0
2E4h	V_CSR_INQ_7_1	Mode_1	[0..31]	CSR quadlet offset for Format_7 Mode_1
2E8h	V_CSR_INQ_7_2	Mode_2	[0..31]	CSR quadlet offset for Format_7 Mode_2
2ECh	V_CSR_INQ_7_3	Mode_3	[0..31]	CSR quadlet offset for Format_7 Mode_3
2F0h	V_CSR_INQ_7_4	Mode_4	[0..31]	CSR quadlet offset for Format_7 Mode_4
2F4h	V_CSR_INQ_7_5	Mode_5	[0..31]	CSR quadlet offset for Format_7 Mode_5
2F8h	V_CSR_INQ_7_6	Mode_6	[0..31]	CSR quadlet offset for Format_7 Mode_6
2FCh	V_CSR_INQ_7_7	Mode_7	[0..31]	CSR quadlet offset for Format_7 Mode_7

For Format_0, Format_1, Format_2:

0-7	8-15	16-23	24-31
FrameRate	Reserved		

For Format_6:

0-7	8-15	16-23	24-31
revision	Reserved		

For Format_7 (Partial Image Size Format):

0-7	8-15	16-23	24-31
Base address of the Video Mode CSR (quadlet offset)			

"Base address of the Video Mode CSR" is the quadlet offset from the base address of initial register space.

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.3 Inquiry register for basic function

The entire field except "Memory_Channel" is bit assignment for inquiry.
(0:Not available 1:Available)

Offset	Name	Field	Bit	Description
400h	BASIC_FUNC_INQ	Advanced_Feature_Inq	[0]	Inquiry for advanced feature. (Vendor Unique)
		Vmode_Error_Status_Inq	[1]	Inquiry for existence of Vmode_Error_Status register
		Feature_Control_Error_Status_Inq	[2]	Inquiry for existence of Feature_Control_Error_Status register
			[3..15]	Reserved
		Cam_Power_Cntl	[16]	Camera process power ON/OFF capability
			[17..18]	Reserved
		One_Shot_Inq	[19]	One shot transmission capability
		Multi_Shot_Inq	[20]	Multi shot transmission capability
			[21..27]	Reserved
		Memory_Channel	[28..31]	Maximum memory channel number (N) Memory channel no 0 = Factory setting memory 1 = Memory Ch 1 2 = Memory Ch 2 : N= Memory Ch N If 0000, user memory is not available.

0-7				8-15	16-23				24-31	
a	v	f	Reserved		c	r	o	m	Reserved	mem

"Advanced Feature" is vendor unique features. Vendor shall prepare CSR's for these additional features and write base address of these CSR's at 480h as a quadlet offset value from the base address of initial register space.

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.4 Inquiry register for feature presence

The following registers show presence of the features. Each bit is corresponding to the feature. The camera which supports multiple video formats and video modes might change presence of feature.

The entire field is a bit assignment for inquiry. (0:Not available 1:Available)

Offset	Name	Field	Bit	Description
404h	Feature_Hi_Inq	Brightness	[0]	Brightness Control
		Auto Exposure	[1]	Auto Exposure Control
		Sharpness	[2]	Sharpness Control
		White_Balance	[3]	White Balance Control
		Hue	[4]	Hue Control
		Saturation	[5]	Saturation Control
		Gamma	[6]	Gamma Control
		Shutter	[7]	Shutter Speed Control
		Gain	[8]	Gain Control
		Iris	[9]	IRIS Control
		Focus	[10]	Focus Control
		Temperature	[11]	Temperature Control
		Trigger	[12]	Trigger Control
			[13..31]	Reserved
408h	Feature_Lo_Inq	Zoom	[0]	Zoom Control
		Pan	[1]	PAN Control
		Tilt	[2]	TILT Control
		Optical Filter	[3]	Optical Filter Control
			[4..15]	Reserved
		Capture_Size	[16]	Capture image size for Format_6
		Capture_Quality	[17]	Capture image quality for Format_6
			[18..31]	Reserved
40Ch : 47Fh	Reserved			
480h	Advanced_Feature_ Inq	Advanced_Feature _Quadlet_Offset	[0 .. 31]	Quadlet offset of the advanced feature CSR's from the base address of initial register space. (Vendor unique)

offset	0-7	8-15	16-23	24-31
404h	b e s w h s g s g l f t t	Reserved		
408h	z p t o	Reserved	s q	Reserved
480h	Quadlet offset of the advanced feature CSR			

Initial values	System dependent
Read values	System dependent (Depending on video format and video mode)
Write effect	Ignored

1.5 Inquiry register for feature elements

The following registers show the presence of feature, modes, maximum value and minimum value for each feature.
The camera which supports multiple video formats and video modes might change this registers. It is strongly recommended to check this register every time when change the video format and/or video mode.
All the fields named xxx_Inq are bit assignments for inquiry. (0:Not available 1:Available)
(Definition and specification of each feature is described in Appendix A.)

Offset	Name	Field	Bit	Description
500h	BRIGHTNESS_INQ	Presence_Inq	[0]	Presence of this feature
		Abs_Control_Inq	[1]	Capability of control with absolute value
			[2]	Reserved
		One_Push_Inq	[3]	One push auto mode (Controlled automatically by camera only once)
		ReadOut_Inq	[4]	Capability of reading the value of this feature
		On/Off_Inq	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto mode (Controlled automatically by camera)
		Manual_Inq	[7]	Manual mode (Controlled by user)
		Min_Value	[8..19]	Minimum value for this feature control
		Max_Value	[20..31]	Maximum value for this feature control
504h	AUTO_EXPOSURE_INQ	Same definition to BRIGHTNESS_INQ		
508h	SHARPNESS_INQ	Same definition to BRIGHTNESS_INQ		
50Ch	WHITE_BAL_INQ	Same definition to BRIGHTNESS_INQ		
510h	HUE_INQ	Same definition to BRIGHTNESS_INQ		
514h	SATURATION_INQ	Same definition to BRIGHTNESS_INQ		
518h	GAMMA_INQ	Same definition to BRIGHTNESS_INQ		
51Ch	SHUTTER_INQ	Same definition to BRIGHTNESS_INQ		
520h	GAIN_INQ	Same definition to BRIGHTNESS_INQ		
524h	IRIS_INQ	Same definition to BRIGHTNESS_INQ		
528h	FOCUS_INQ	Same definition to BRIGHTNESS_INQ		
52Ch	TEMPERATURE_INQ	Same definition to BRIGHTNESS_INQ		
530h	TRIGGER_INQ	Presence_Inq	[0]	Presence of this feature
		Abs_Control_Inq	[1]	Capability of control with absolute value
			[2..3]	Reserved
		ReadOut_Inq	[4]	Capability of reading the value of this feature
		On/Off_Inq	[5]	Capability of switching this feature ON and OFF
		Polarity_Inq	[6]	Capability of changing polarity of the trigger input
			[7..15]	Reserved
		Trigger_Mode0_Inq	[16]	Presence of Trigger Mode 0
		Trigger_Mode1_Inq	[17]	Presence of Trigger Mode 1
		Trigger_Mode2_Inq	[18]	Presence of Trigger Mode 2
		Trigger_Mode3_Inq	[19]	Presence of Trigger Mode 3
			[20 ..31]	Reserved
534h : 57Ch	Reserved for other FEATURE_HI_INQ			

580h	ZOOM_INQ	Presence_Inq	[0]	Presence of this feature
		Abs_Control_Inq	[1]	Capability of control with absolute value
			[2]	Reserved
		One_Push_Inq	[3]	One push auto mode (Controlled automatically by camera only once)
		ReadOut_Inq	[4]	Capability of reading the value of this feature
		On/Off_Inq	[5]	Capability of switching this feature ON and OFF
		Auto_Inq	[6]	Auto mode (Controlled automatically by camera)
		Manual_Inq	[7]	Manual mode (Controlled by user)
		Min_Value	[8..19]	Minimum value for this feature control
		Max_Value	[20..31]	Max value for this feature control
584h	PAN_INQ	Same definition to ZOOM_INQ		
588h	TILT_INQ	Same definition to ZOOM_INQ		
58Ch	OPTICAL_FILTER_INQ	Same definition to ZOOM_INQ		
590h : 5BCh	Reserved for other FEATURE_LO_INQ			
5C0h	CAPTURE_SIZE_INQ	Same definition to ZOOM_INQ		
5C4h	CAPTURE_QUALITY_INQ	Same definition to ZOOM_INQ		
5C8h : 5FCh	Reserved for other FEATURE_LO_INQ			

For TRIGGER_INQ

offset	0-7	8-15	16-23	24-31
530h	p a r R o r	Reserved	0 1 2 3	Reserved

For others

offset	0-7	8-15	16-23	24-31
5xxh	p a r O R o A m	Min_Value		Max_Value

Initial values	System dependent
Read values	System dependent (Depend on video format and video mode)
Write effect	Ignored

1.6 Status and control registers for camera

Offset	Name	Bit	Description
600h	Cur_V_Frm_Rate / Revision	[0..2]	Current frame rate or revision for Format_6 FrameRate_0 .. FrameRate_7 / revision_0 .. revision_7
		[3..31]	Reserved
604h	Cur_V_Mode	[0..2]	Current video mode Mode_0 .. Mode_7
		[3..31]	Reserved
608h	Cur_V_Format	[0..2]	Current video format Format_0 .. Format_7
		[3..31]	Reserved
60Ch	ISO_Channel	[0..3]	Isochronous channel number for video data transmission (Except for Format_6)
		[4..5]	Reserved
	ISO_Speed	[6..7]	Isochronous transmit speed code. (Except for Format_6)
		[8..31]	Reserved
610h	Camera_Power	[0]	1 = power-up camera 0 = power-down camera.
		[1..31]	Reserved
614h	ISO_EN/ Continuous_Shot	[0]	Except for Format_6: 1 = start ISO transmission of video data 0 = stop ISO transmission of video data For Format_6: 1 = start continuous shot and save to storage device. 0 = stop continuous shot If storage device becomes full, self cleared.
		[1..31]	Reserved
618h	Memory_Save	[0]	1 = current status and modes are saved to Mem_Save_Ch (Self Cleared)
		[1..31]	Reserved
61Ch	One_Shot	[0]	Except for Format_6: 1 = only one frame of video data is transmitted (Self cleared after transmission) For Format_6: 1 = capture one image and save to storage device. (Self cleared) Ignored if ISO_EN = 1
	Multi_Shot	[1]	Except for Format_6: 1 = N frames of video data is transmitted (Self cleared after transmission) N is cycle number. See below. For Format_6: 1 = Capture N images and save to storage device (Self cleared) N is image number. See below. Ignored if ISO_EN = 1 or One_Shot = 1
		[2..15]	Reserved
	Count_Number	[16..31]	Count number for Multi shot function.
620h	Mem_Save_Ch	[0..3]	Write channel for Memory_Save command Must be >= 0001 (0 is factory settings, which cannot be overwritten) (See BASIC_FUNC_INQ)
		[4..31]	Reserved

624h	Cur_Mem_Ch	[0..3]	When read from, returns Current Memory Channel number When written to, loads status, modes, and values from the specified memory channel
		[4..31]	Reserved
628h	Vmode_Error_Status	[0]	Error status of combination of Video format, mode, frame rate and ISO_Speed setting. 0: no error 1: error This flag will be updated every time at one of the above setting is changed by writing new value. (Except for Format_6 and Format_7)
		[1..31]	Reserved

Initial values	System dependent.
Read values	Last update (Reserved bits are always zero)
Write effect	As indicated in table above

During ISO_EN = 1 or One_Shot = 1 or Multi_Shot =1, the register value which reflects the Isochronous packet format cannot change. Writing value should be ignored.

1.6.1 Storage Media CSR (only for Format_6)

Offset	Name	Field	Bit	Description
680h	Media_Status	Media_Presence	[0]	Presence of the Media. 1=presence (Read only)
		Write_Protect	[1]	1 = Write Protected, 0 = Writable
			[2..7]	Reserved
		Occupied_Rate	[8..15]	Percentage of occupied rate.(0x64=100d is full) (Read only)
			[16..31]	Reserved
684h	Number_Of_Images	Expected_Remain	[0..15]	Expected number of images can store If value is 0xffff, must ignore this field. (Read only)
		Number_Of_Images	[16..31]	Number of stored images. (Read only)
688h	Media_Initialize	Initialize_Keyword	[0 ..31]	If the value that is equal to 'Initialize_Keyword' is written, media will be initialized. Initialize_Keyword = 0x46726D74 = 'Frmt'
68Ch	Image_ID for_Delete	Image_ID	[0..15]	Image_ID value to delete one image.
			[16..31]	Reserved
690h	Delete_Image	Delete_Keyword	[0..31]	If the value that is equal to 'Delete_Keyword' is written, one image it's ID is equal to "Image_ID" in 68Ch register will be deleted. Initialize_Keyword = 0x 44656C74 = 'Delt'

1.6.2 Stored Image CSR (only for Format_6)

Offset	Name	Field	Bit	Description
6C0h	Image_Number	Image_Number	[0..15]	Select one of the stored images. "Image_Number" must be less than "Number_Of_Images" in 684h register.
			[16..31]	Reserved
6C4h	Image_Status	Write_Protect	[0]	1 = Write Protected, 0 = Writable
			[1..7]	Reserved
		Number_Of_Quality	[8..15]	This value shows number of image quality level in the selected image file. It must be more than Zero. See "Load_Image_Quality" register. (Read Only)
		Image_ID	[15..31]	ID number of selected image. This is unique value in the same storage media. (Read only)
6C8h	Image_Information_Address		[0 ..15]	Reserved
		Address_Hi	[16..31]	Direct base address of the Image Information data. Upper 16 bits. (Read only)
6CCh	Image_Information_Address	Address_Lo	[0..31]	Direct base address of the Image Information data. Lower 32 bits. (Read only)
6D0h	Bytes_Of_Image_Information	Total_Bytes	[0..31]	Total amount of bytes of Image information data. If this value is Zero, information data for selected image is not available.
6D4h	Thumbnail_Address		[0 ..15]	Reserved
		Address_Hi	[16..31]	Direct base address of the thumbnail image data. Upper 16 bits. (Read only)
6D8h	Thumbnail_Address	Address_Lo	[0..31]	Direct base address of the thumbnail image data. Lower 32 bits. (Read only)
6DCh	Bytes_Of_Thumbnail	Total_Bytes	[0..31]	Total amount of bytes of thumbnail image data. If this value is Zero, thumbnail image of the selected image is not available. (Read only)
6E0h	Load_Image_Quality	Image_Quality	[0..7]	Select image quality level. 0 = whole data of the selected image file. 1 = lowest quality image data 'Image_Quality' <= 'Number_Of_Quality' Bigger value means higher quality.
6E4h	Image_Address		[0 ..15]	Reserved
		Address_Hi	[16..31]	Direct base address of the image data. Upper 16 bits. (Read only)
6E8h	Image_Address	Address_Lo	[0..31]	Direct base address of the image data. Lower 32 bits. (Read only)
6ECh	Bytes_Of_Image	Total_Bytes	[0..31]	Total amount of bytes of the image data. If this value is Zero, image is not available.

1.7 Status and control register for feature

The user can control each feature through "Status and control register for feature". The controllable items are mode and value.

Mode:

Each CSR has three bits for mode control, ON_OFF, One_Push and A_M_Mode. Feature can have four states corresponding to the combination of mode control bits.

One_Push	ON_OFF	A_M_Mode	State
X	0	X	**Off state**. Feature will be fixed value state and uncontrollable.
X	1	1	**Auto control state**. Camera controls feature by itself continuously.
0	1	0	**Manual control state**. User can control feature by writing value to the value field.
1 (Self clear)	1	0	**One-Push action**. Camera controls feature by itself only once and return to Manual control state with adjusted value.

(X : don't care)

Value:

If ReadOut_Inq bit of the "Inquiry register for feature elements" is one, the value field is valid and can be used for controlling feature. The user can write control value to value field only at the Manual control state. At the other states, the user can only read the value. The camera always has to show the real setting value at the value field if ReadOut_Inq is one.

The camera which supports multiple video formats and video modes might change presence, capability mode, Min_Value and Max_Value of the feature. It is strongly recommended to check "Inquiry register for feature elements" register every time when you change the video format and/or video mode.

Offset	Name	Field	Bit	Description
800h	BRIGHTNESS	Presence_Inq	[0]	Presence of this feature 0:N/A 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the Value field 1: Control with value in the Absolute value CSR If this bit = 1, value in the Value field is ignored.
			[2-4]	Reserved
		One_Push	[5]	Write '1': begin to work (Self cleared after operation) Read: Value='1' in operation Value='0' not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode, Read: read a current mode 0: Manual, 1: Auto.
			[8-19]	Reserved.
		Value	[20-31]	Value. Write the value in Auto mode, this field is ignored. If "ReadOut" capability is not available, read value has no meaning
804h	AUTO_EXPOSURE	Same definition to BRIGHTNESS		
808h	SHARPNESS	Same definition to BRIGHTNESS		
80Ch	WHITE_BALANCE	Presence_Inq	[0]	Presence of this feature. 0:N/A 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the Value field 1: Control with value in the Absolute value CSR If this bit = 1, value in the Value field is ignored.
			[2-4]	Reserved.
		One_Push	[5]	Write '1': begin to work (Self cleared after operation) Read: Value='1' in operation Value='0' not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode, Read: read a current mode 0: Manual, 1: Auto.
		U_Value / B_Value	[8-19]	U Value / B_Value. Write the value in AUTO mode, this field is ignored. If "ReadOut" capability is not available, read value has no mean
		V_Value / R_Value	[20-31]	V Value / R_Value Write the value in AUTO mode, this field is ignored. If "ReadOut" capability is not available, read value has no mean
810h	HUE	Same definition to BRIGHTNESS		
814h	SATURATION	Same definition to BRIGHTNESS		
818h	GAMMA	Same definition to BRIGHTNESS		
81Ch	SHUTTER	Same definition to BRIGHTNESS		
820h	GAIN	Same definition to BRIGHTNESS		
824h	IRIS	Same definition to BRIGHTNESS		
828h	FOCUS	Same definition to BRIGHTNESS		

82Ch	TEMPERATURE	Presence_Inq	[0]	Presence of this feature. 0:N/A 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the Value field 1: Control with value in the Absolute value CSR If this bit = 1, value in the Value field is ignored.
			[2-4]	Reserved.
		One_Push	[5]	Write '1': begin to work (Self cleared after operation) Read: Value='1' in operation Value='0' not in operation If A_M_Mode =1, this bit is ignored.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		A_M_Mode	[7]	Write: set the mode, Read: read a current mode 0: Manual, 1: Auto.
		Target_ Temperature	[8-19]	Aimed value of the temperature. 10 times of the absolute temperature
		Temperature	[20-31]	Temperature at the present time. (Read only) 10 times of the absolute temperature
830h	TRIGGER_MODE	Presence_Inq	[0]	Presence of this feature. 0:N/A 1:Available
		Abs_Control	[1]	Absolute value control 0: Control with value in the Value field 1: Control with value in the Absolute value CSR If this bit = 1, value in the Value field is ignored.
			[2-5]	Reserved.
		ON_OFF	[6]	Write: ON or OFF this feature, Read: read a status 0: OFF, 1: ON If this bit =0, other fields will be read only.
		Trigger_Polarity	[7]	If Polarity_Inq is "1", Write to change polarity of the trigger input Read to get polarity of the trigger input. If Polarity_Inq is "0", Read only. (0: Low active input, 1: High active input)
			[8 – 11]	Reserved
		Trigger_Mode	[12-15]	Trigger mode. (Trigger_Mode_0 – 15)
			[16 – 19]	Reserved
		Parameter	[20-31]	Parameter for trigger function, if required. (Optional)
834h : 87Ch	Reserved for other FEATURE_HI			
880h	Zoom	Same definition to BRIGHTNESS		
884h	PAN	Same definition to BRIGHTNESS		
888h	TILT	Same definition to BRIGHTNESS		
88Ch	OPTICAL_FILTER	Same definition to BRIGHTNESS		
890h : 8BCh	Reserved for other FEATURE_LO			
8C0h	CAPTURE_SIZE	Same definition to BRIGHTNESS		
8C4h	CAPTURE_QUALITY	Same definition to BRIGHTNESS		
8C8h : 8FCh	Reserved for other FEATURE_LO			

For WHITE_BALANCE

offset	0-7						8-15	16-23	24-31
80Ch	p	a	r	o	o	a	U_Value / B_Value	V_Value / R_Value	

For TEMPERATURE

offset	0-7						8-15	16-23	24-31
82Ch	p	a	r	o	o	a	Target_Temperature	Temperature	

For TRIGGER_MODE

Offset	0-7					8-15		16-23	24-31
830h	p	a	r	o	p	r	T_Mode	r	Parameter

For others

Offset	0-7						8-15	16-23	24-31
8xxh	p	a	r	o	o	a	Reserved	Value	

Initial values	System dependent
Read values	Last update values
Write effect	Stored (bit [0] is read only)

1.7.1 Inquiry register for Absolute value CSR offset address

Offset	Name	Bit	Description
700h	ABS_CSR_HI_INQ_0	[0..31]	Quadlet offset of the Absolute value CSR for Brightness
704h	ABS_CSR_HI_INQ_1	[0..31]	Quadlet offset of the Absolute value CSR for Auto Exposure
708h	ABS_CSR_HI_INQ_2	[0..31]	Quadlet offset of the Absolute value CSR for Sharpness
70Ch	ABS_CSR_HI_INQ_3	[0..31]	Quadlet offset of the Absolute value CSR for White Balance
710h	ABS_CSR_HI_INQ_4	[0..31]	Quadlet offset of the Absolute value CSR for Hue
714h	ABS_CSR_HI_INQ_5	[0..31]	Quadlet offset of the Absolute value CSR for Saturation
718h	ABS_CSR_HI_INQ_6	[0..31]	Quadlet offset of the Absolute value CSR for Gamma
71Ch	ABS_CSR_HI_INQ_7	[0..31]	Quadlet offset of the Absolute value CSR for Shutter
720h	ABS_CSR_HI_INQ_8	[0..31]	Quadlet offset of the Absolute value CSR for Gain
724h	ABS_CSR_HI_INQ_9	[0..31]	Quadlet offset of the Absolute value CSR for Iris
728h	ABS_CSR_HI_INQ_10	[0..31]	Quadlet offset of the Absolute value CSR for Focus
72Ch	ABS_CSR_HI_INQ_11	[0..31]	Quadlet offset of the Absolute value CSR for Temperature
730h	ABS_CSR_HI_INQ_12	[0..31]	Quadlet offset of the Absolute value CSR for Trigger
734h : 77Fh	Reserved		
780h	ABS_CSR_LO_INQ_0	[0..31]	Quadlet offset of the Absolute value CSR for Zoom
784h	ABS_CSR_LO_INQ_1	[0..31]	Quadlet offset of the Absolute value CSR for Pan
788h	ABS_CSR_LO_INQ_2	[0..31]	Quadlet offset of the Absolute value CSR for Tilt
78Ch	ABS_CSR_LO_INQ_3	[0..31]	Quadlet offset of the Absolute value CSR for Optical Filter
790h : 7BFh	Reserved		
7C0h	ABS_CSR_LO_INQ_16	[0..31]	Quadlet offset of the Absolute value CSR for Capture Size
7C4h	ABS_CSR_LO_INQ_17	[0..31]	Quadlet offset of the Absolute value CSR for Capture Quality
7C8h : 7FFh	Reserved		

0-7	8-15	16-23	24-31
Base address of the Absolute value CSR (quadlet offset)			

"Base address of the Absolute value CSR" is the quadlet offset from the base address of initial register space.

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.7.2 Feature control error status register

Each field is an error or warning flag for the corresponding feature control register.
If bit = 1, mode and/or value of the feature control register has some error or warning. If bit = 0, no error or warning.
Each flag will be updated every time when corresponding feature control register is updated.

It is strongly recommended to check feature register if bit = 1.

Offset	Name	Field	Bit	Description
640h	Feature_Control_Error_Status_HI	Brightness	[0]	Brightness Control
		Auto Exposure	[1]	Auto Exposure Control
		Sharpness	[2]	Sharpness Control
		White_Balance	[3]	White Balance Control
		Hue	[4]	Hue Control
		Saturation	[5]	Saturation Control
		Gamma	[6]	Gamma Control
		Shutter	[7]	Shutter Speed Control
		Gain	[8]	Gain Control
		Iris	[9]	IRIS Control
		Focus	[10]	Focus Control
		Temperature	[11]	Temperature Control
		Trigger	[12]	Trigger Control
			[13..31]	Reserved
644h	Feature_Control_Error_Status_LO	Zoom	[0]	Zoom Control
		Pan	[1]	PAN Control
		Tilt	[2]	TILT Control
		Optical Filter	[3]	Optical Filter Control
			[4..15]	Reserved
		Capture_Size	[16]	Capture image size for Format_6
		Capture_Quality	[17]	Capture image quality for Format_6
			[18..31]	Reserved

Offset	0-7	8-15	16-23	24-31
640h	b e s w h s g s	g l f t t	Reserved	
644h	z p t o	Reserved	s q	Reserved

Initial values	All zero
Read values	Last update
Write effect	Ignored

1.8 Register map

Offset	Register
000h	<Camera initialize register> INITIALIZE
100h 180h	<Inquiry register for video format> V_FORMAT_INQ <Inquiry register for video mode> V_MODE_INQ_x
200h	<Inquiry register for video frame rate> V_RATE_INQ_y_x
300h	<Reserved>
400h	<Inquiry register for feature presence> BASIC_FUNC_INQ FEATURE_HI_INQ FEATURE_LO_INQ
500h	<Inquiry register for feature elements> xxxxxxxxxx_INQ
600h 640h 680h 6C0h	<Status and control register for camera> CAM_STA_CTRL <Feature control error status register> <Storage Media CSR> (Only for Format_6) <Stored Image CSR> (Only for Format_6)
700h	<Inquiry register for Absolute value CSR offset address>
800h	<Status and control register for feature> xxxxxxxxxxx

1.9 Video Mode CSR for Format_7

Base address for each video mode command and status registers is:

Bus_ID, Node_ID , FFFF Fxxx xxxx (initial units space)

This address is contained in the Format_7 section of the "1.2.3 Inquiry register for video frame rate and base address of the Video Mode CSR for the Partial Image Size Format". This register shall be prepared for each video mode that is Format_7, Mode_x.
The offset field in each of the following table is the byte offset from the above base address.

Offset	Name	Field	Bit	Description	
000h	MAX_IMAGE_SIZE_INQ	Hmax	[0..15]	Maximum Horizontal pixel number	
		Vmax	[16..31]	Maximum Vertical pixel number	
004h	UNIT_SIZE_INQ	Hunit	[0..15]	Horizontal unit pixel number	
		Vunit	[16..31]	Vertical unit pixel number	
008h	IMAGE_POSITION	Left	[0..15]	Left position of requested image region (pixels)	
		Top	[16..31]	Top position of requested image region (pixels)	
00Ch	IMAGE_SIZE	Width	[0..15]	Width of requested image region (pixels)	
		Height	[16..31]	Height of requested image region (pixels)	
010h	COLOR_CODING_ID	Coding_ID	[0..7]	Color coding ID from COLOR_CODING_INQ register	
		-	[8..31]	Reserved (All zero)	
014h	COLOR_CODING_INQ	Mono8	[0]	Y only. Y=8bits, non compressed	ID=0
		4:1:1 YUV8	[1]	4:1:1, Y=U=V= 8bits, non compressed	ID=1
		4:2:2 YUV8	[2]	4:2:2, Y=U=V=8bits, non compressed	ID=2
		4:4:4 YUV8	[3]	4:4:4, Y=U=V=8bits, non compressed	ID=3
		RGB8	[4]	R=G=B=8bits, non compressed	ID=4
		Mono16	[5]	Y only, Y=16bits, non compressed	ID=5
		RGB16	[6]	R=G=B=16bits, non compressed	ID=6
		-	[7..31]	Reserved (All zero)	ID=7-31
018h : 033h	COLOR_CODING_INQ	Reserved for other Color_Coding.			ID= 32-255
034h	PIXEL_NUMBER_INQ	PixelPerFrame	[0..31]	Pixel number per frame	
038h	TOTAL_BYTES_HI_INQ	BytePerFrameHi	[0..31]	Higher quadlet of total bytes of image data per frame	
03Ch	TOTAL_BYTES_LO_INQ	BytePerFrameLo	[0..31]	Lower quadlet of total bytes of image data per frame	
040h	PACKET_PARA_INQ	UnitBytePerPacket	[0..15]	Minimum bytes per packet	
		MaxBytePerPacket	[16..31]	Maximum bytes per packet	
044h	BYTE_PER_PACKET	BytePerPacket	[0..15]	Packet size	
		RecBytePerpacket	[16..31]	Recommended bytes per packet. If this value is zero, must ignore this field.	
048h	PACKET_PER_FRAME_INQ	PacketPerFrame	[0..31]	Number of Packets per frame.	
04Ch	UNIT_POSITION_INQ	Hposunit	[0..15]	Horizontal unit pixel number for position If read value of Hposunit is 0, Hposunit = Hunit for compatibility.	
		Vposunit	[16..31]	Vertical unit number for position If read value of Vposunit is 0, Vposunit = Vunit for compatibility.	
050h : 07Bh	Reserved				

07Ch	VALUE_SETTING	Presence	[0]	If this bit is one, "Setting_1" , "ErrorFlag_1" and "ErrorFlag_2" fields are valid. This bit is read only.
		Setting_1	[1]	If writing "1" to this bit, IMAGE_POSITION, IMAGE_SIZE, COLOR_CODING_ID and ISO_Speed register value will be reflected in PIXEL_NUMBER_INQ, TOTAL_BYTES_HI_INQ, TOTAL_BYTES_LO_INQ, PACKET_PARA_INQ and BYTE_PER_PACKET register. This bit is self cleared, must wait becoming "0" and also check ErrorFlag_1 is all zero before using value in the PIXEL_NUMBER_INQ, TOTAL_BYTES_HI_INQ, TOTAL_BYTES_LO_INQ, PACKET_PARA_INQ and BYTE_PER_PACKET register
			[2..7]	Reserved
		ErrorFlag_1	[8]	Combination of the values of IMAGE_POSITION, IMAGE_SIZE, COLOR_CODING_ID and ISO_Speed register is not acceptable. 1: error 0: no error This flag will be updated every time when Setting_1 bit returns to "0" from "1".
		ErrorFlag_2	[9]	BytePerPacket value is not acceptable. 1: error 0: no error
			[10..31]	Reserved (All zero)

During ISO_EN = 1 or One_Shot = 1 or Multi_Shot =1, register value which reflects to the Isochronous packet format cannot change. Writing value should be ignored.

1.9.1 MAX_IMAGE_SIZE_INQ register

This register is an inquiry register for maximum image size.

0-7	8-15	16-23	24-31
Hmax (pixels)		Vmax (pixels)	

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.9.2 UNIT_SIZE_INQ and UNIT_POSITION_INQ register

This register is an inquiry register for unit size.

Hmax = Hunit * n = Hposunit*n3 (n, n3 is integer)
Vmax = Vunit * m = Vposunit*m3 (m, m3 is integer)

If read value of Hposunit is 0, Hposunit = Hunit for compatibility with Rev 1.20.
If read value of Vposunit is 0, Vposunit = Vunit for compatibility with Rev 1.20.

UNIT_SIZE_INQ

0-7	8-15	16-23	24-31
Hunit (pixels)		Vunit (pixels)	

UNIT_POSITION_INQ

0-7	8-15	16-23	24-31
Hposunit (pixels)		Vposunit (pixels)	

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.9.3 IMAGE_POSITION and IMAGE_SIZE register

These registers determine an area of required data. All the data must be as follows:

Left = Hposunit * n1
Top = Vposunit * m1
Width = Hunit * n2
Height = Vunit * m2 (n1, n2, m1, m2 are integer)

Left + Width <= Hmax
Top + Height <= Vmax

0-7	8-15	16-23	24-31
Left		Top	

0-7	8-15	16-23	24-31
Width		Height	

Initial values	All Zero
Read values	Last update value
Write effect	Stored

1.9.4 COLOR_CODING_ID and COLOR_CODING_INQ registers

COLOR_CODING_INQ register describes available color-coding capability of the system. Each coding scheme has its own ID number. Required color-coding scheme must be set to COLOR_CODING_ID register as the ID number.

COLOR_CODING_ID register

0-7	8-15	16-23	24-31
Coding_ID	Reserved		

Initial values	All Zero
Read values	Last update value
Write effect	Stored

COLOR_CODING_INQ registers

0-7	8-15	16-23	24-31
Bit assignment is described in the table above			

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

1.9.5 PIXEL_NUMBER_INQ and TOTAL_BYTE_INQ registers

PIXEL_NUMBER_INQ register includes total pixel number of required image area.
TOTAL_BYTE_INQ register includes total data amount value of required image area as the bytes.

If Presence bit in the VALUE_SETTING register is zero, values of these registers will be updated by writing new value to IMAGE_POSITION, IMAGE_SIZE and COLOR_CODING_ID registers.
If Presence bit in the VALUE_SETTING register is one, values of these registers will be updated by writing one to the Setting_1 bit in the VALUE_SETTING register. If ErrorFlag_1 bit is zero after Setting_1 bit returns to zero, values of these registers are valid.

PIXEL_NUMBER_INQ register

0-7	8-15	16-23	24-31
PixelPerFrame			

Initial values	All Zero
Read values	Last update value
Write effect	Ignored

TOTAL_BYTE_HI_INQ and TOTAL_BYTE_LO_INQ registers

0-7	8-15	16-23	24-31
Higher part of BytePerFrame			
Lower part of BytePerFrame			

Initial values	All Zero
Read values	Last update value
Write effect	Ignored

1.9.6 PACKET_PARA_INQ and BYTE_PER_PACKET register

MaxBytePerPacket describes maximum packet size for one Isochronous packet.
UnitBytePerPacket is the unit for Isochronous packet size.
RecBytePerPacket describes recommended packet size for one Isochronous packet. If RecBytePerPacket is zero, you must ignore this field.

If Presence bit in the VALUE_SETTING register is zero, values of these fields will be updated by writing new value to IMAGE_POSITION, IMAGE_SIZE and COLOR_CODING_ID registers with the value of ISO_Speed register (60Ch [6..7]).
At first, ISO_Speed register must be written. Then IMAGE_POSITION, IMAGE_SIZE and COLOR_CODING_ID registers should be updated.

If Presence bit in the VALUE_SETTING register is one, values of these fields will be updated by writing one to the Setting_1 bit in the VALUE_SETTING register. If ErrorFlag_1 bit is zero after Setting_1 bit returns to zero, values of these fields are valid.

BytePerPacket value determines real packet size and transmission speed for one frame image. BytePerPacket value must keep the following condition.

BytePerPacket = UnitBytePerPacket * n (n is integer)
BytePerPacket <= MaxBytePerPacket

PACKET_PARA_INQ

0-7	8-15	16-23	24-31
UnitBytePerPacket		MaxBytePerPacket	

Initial values	All Zero
Read values	Last update value
Write effect	Ignored

BYTE_PER_PACKET

0-7	8-15	16-23	24-31
BytePerPacket		RecBytePerPacket	

For RecBytePerPacket field

Initial values	System dependent
Read values	Last update value
Write effect	Ignored

For BytePerPacket field

Initial values	All Zero
Read values	Last update value
Write effect	Stored

1.9.7 PACKET_PER_FRAME_INQ register

If BytePerPacket * n != BytePerFrame (n is integer), you must use padding. The PacketPerFrame value is a number of packets per one frame. This register will be updated after BytePerPacket is written.

Total number of bytes of transmission data per one frame = BytePerPacket * PacketPerFrame

Number of bytes of padding = BytePerPacket * PacketPerFrame - BytePerFrame

Receiver must ignore above padding data in the last packet of each frame.

0-7	8-15	16-23	24-31
PacketPerFrame			

Initial values	All Zero
Read values	Last update value
Write effect	Ignored

1.9.8 VALUE_SETTING register

If Presence bit is one, this register is available and valid.

Purpose of Setting_1 bit is for updating TOTAL_BYTES_HI_INQ, TOTAL_BYTES_LO_INQ, PACKET_PARA_INQ and BYTE_PER_PACKET register. If one of the value in the IMAGE_POSITION, IMAGE_SIZE, COLOR_CODING_ID and ISO_Speed register is changed, Setting_1 bit must be set "1".

ErrorFlag_1 field will be updated when Setting_1 bit returns to "0". If ErrorFlag_1 field is zero, values of TOTAL_BYTES_HI_INQ, TOTAL_BYTES_LO_INQ, PACKET_PARA_INQ and BYTE_PER_PACKET register are valid.

After BytePerPacket value is written, ErrorFlag_2 field will be updated. If ErrorFlag_2 field is zero, can start Isochronous transmission without any problem.

0-7			8-31		
p	s	Reserved	e	e	Reserved

For Presence

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

For Setting_1

Initial values	All zero
Read values	Last update value
Write effect	Stored and self clear

For ErrorFlag_1, ErrorFlag_2

Initial values	All zero
Read values	Last update value
Write effect	Ignored

1.10 CSRs Advanced Features

These CSRs are for vendor unique features. The vendor shall prepare CSRs for these additional features and write the base address of these CSRs at 480h as a quadlet offset value from the base address of initial register space.
The first two quadlets are "Access Control Register"(ACR). The user has to write "Feature_ID" to ACR to unlock "CSRs Advanced Features". Each model that implements "CSRs Advanced Features" must have "Feature_ID". "Feature_ID" is advanced feature set unique value and consists of 48bits.
The remaining structure of this area has to be determined by vendor.

The user can determine Time_Out value with the unlock operation. Time_Out value consists of 12 bits and the unit is millisecond. (Maximum 4.095 second)
If the user does not access "CSRs Advanced Features" within Time_Out value, the unlock operation will be canceled and ACR will return to its initial state. If the user access "CSRs Advanced Features" within Time_Out value, Time_out will be refreshed.
If the user node unlocks "CSRs Advanced Features" user node's Bus_ID and Node_ID value will be copied in the ACR. Then the other node cannot access nor unlock this CSR area. If bus reset occurs, ACR will be initialized.

Access Control Register

Write format

0-7	8-15	16-23	24-31
Feature_ID_Hi			
Feature_ID_Lo		0xf	Time_Out

Read format

0-7	8-15	16-23	24-31
Bus_ID+Node_ID		0xffff	
0xffffff			Time_Out

Initial values	All one (0xffffffffffffffff)
Read values	Last update value
Write effect	If the upper 48 bits of written value is equal to "Feature_ID", store source Bus_ID+Node_ID(16 bits) value to upper 16bits area. Also, Time_Out value and lower 12 bits value are stored. The other bits will be one. If upper 48 bits of written value is not equal to "Feature_ID", write action is ignored and all bits will be one.
Bus Reset	All one

Feature_ID

0-7	8-15	16-23	24-31	32-39	40-47
Company_ID			Advanced feature set unique value		

Each company has to manage lower 3 bytes value to keep advanced feature set uniqueness.

1.11 Absolute value CSR for Feature elements

Absolute value CSR is for absolute value control for each feature elements if available. Each CSR consists of three quadlet. Vendor shall prepare CSR and write base address of this CSR at "Inquiry register for Absolute value CSR offset address" as a quadlet offset value from the base address of initial register space.

Units of all elements are predefined. Please see appendix B for details.
All value must be IEEE/REAL*4 Floating-point format.

Offset	Name	Field	Bit	Description
000h	Absolute value	Min_Value	[0..31]	Minimum value for this feature control
004h		Max_Value	[0..31]	Maximum value for this feature control
008h		Value	[0..31]	Absolute control value

0-7	8-15	16-23	24-31
Floating-point value with IEEE/REAL*4 format			

IEEE/REAL*4 Floating-Point Value Notation:

Value = (-1)**S×1.mmmmmmmmmmmmmmmmmmmmmmmm×2**(exp-127)

Sign (S)	Exponent (exp)	Mantissa (m)
1bit	8bit	23bit

For Min_Value, Max_Value

Initial values	System dependent
Read values	System dependent (Same as initial value)
Write effect	Ignored

For Value

Initial values	System dependent
Read values	Real setting value
Write effect	Stored but adjusted to real setting value

2. Isochronous packet format

Every video format, mode and frame rate has different video data format.

2.1 Isochronous packet format for Format_0, Format_1 and Format_2

2.1.1 Video Isochronous packet structure

The following table shows the format of the first quadlet in the data field of each Isochronous data block.

0-7	8-15	16-23		24-31	
data_length		tg	channel	tCode	sy
header_CRC					
Video data payload					
data_CRC					

Isochronous Data Block Packet Format

Where the following fields are defined in the IEEE 1394 standard:

data_length : number of bytes in the data field

tg : (tag field) shall be set to zero

channel : isochronous channel number, as programmed in the iso_channel field of the cam_sta_ctrl register

tCode : (transaction code) shall be set to the isochronous data block packet tCode

sy : (synchronization value) shall be set to 0001h on the first isochronous data block of a frame, and shall be set to zero on all other isochronous data blocks

Video data payload: shall contain the digital video information, as defined in the following sections

2.1.2 Video mode comparison chart

Format_0

	Video Format	60fps	30fps	15fps	7.5fps	3.75fps
Mode_0	160x120 YUV(4:4:4) 24bit/pixel		1/2H 80p 60q	1/4H 40p 30q	1/8H 20p 15q	
Mode_1	320x240 YUV(4:2:2) 16bit/pixel		1H 320p 160q	1/2H 160p 80q	1/4H 80p 40q	1/8H 40p 20q
Mode_2	640x480 YUV(4:1:1) 12bit/pixel		2) 2H 1280p 480q	1H 640p 240q	1/2H 320p 120q	1/4H 160p 60q
Mode_3	640x480 YUV(4:2:2) 16bit/pixel		4) 2H 1280p 640q	2) 1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
Mode_4	640x480 RGB 24bit/pixel		4) 2H 1280p 960q	2) 1H 640p 480q	1/2H 320p 240q	1/4H 160p 120q
Mode_5	640x480 Y (Mono) 8bit/pixel	4) 4H 2560p 640q	2) 2H 1280p 320q	1H 640p 160q	1/2H 320p 80q	1/4H 160p 40q
Mode_6	640x480 Y (Mono16) 16bit/pixel		4) 2H 1280p 640q	2) 1H 640p 320q	1/2H 320p 160q	1/4H 160p 80q
Mode_7	Reserved					

Format_1

Mode	Video Format	60fps	30fps	15fps	7.5fps	3.75fps	1.875fps
Mode_0	800x600 YUV(4:2:2) 16bit/pixel		4) 5/2H 2000p 1000q	2) 5/4H 1000p 500q	5/8H 500p 250q	5/16H 250p 125q	
Mode_1	800x600 RGB 24bit/pixel			4) 5/4H 1000p 750q	2) 5/8H 500p 375q		
Mode_2	800x600 Y (Mono) 8bit/pixel	4) 5H 4000p 1000q	2) 5/2H 2000p 500q	5/4H 1000p 250q	5/8H 500p 125q		
Mode_3	1024x768 YUV(4:2:2) 16bit/pixel			4) 3/2H 1536p 768q	2) 3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q
Mode_4	1024x768 RGB 24bit/pixel				4) 3/4H 768p 576q	2) 3/8H 384p 288q	3/16H 192p 144q
Mode_5	1024x768 Y (Mono) 8bit/pixel		4) 3H 3072p 768q	2) 3/2H 1536p 384q	3/4H 768p 192q	3/8H 384p 96q	3/16H 192p 48q
Mode_6	800x600 Y (Mono16) 16bit/pixel		4) 5/2H 2000p 1000q	2) 5/4H 1000p 500q	5/8H 500p 250q	5/16H 250p 125q	
Mode_7	1024x768 Y (Mono16) 16bit/pixel			4) 3/2H 1536p 768q	2) 3/4H 768p 384q	3/8H 384p 192q	3/16H 192p 96q

Format_2

Mode	Video Format	60fps	30fps	15fps	7.5fps	3.75fps	1.875fps
Mode_0	1280x960 YUV(4:2:2) 16bit/pixel				4) 1H 1280p 640q	2) 1/2H 640p 320q	1/4H 320p 160q
Mode_1	1280x960 RGB 24bit/pixel				4) 1H 1280p 960q	2) 1/2H 640p 480q	1/4H 320p 240q
Mode_2	1280x960 Y (Mono) 8bit/pixel			4) 2H 2560p 640q	2) 1H 1280p 320q	1/2H 640p 160q	1/4H 320p 80q
Mode_3	1600x1200 YUV(4:2:2) 16bit/pixel				4) 5/4H 2000p 1000q	2) 5/8H 1000p 500q	5/16H 500p 250q
Mode_4	1600x1200 RGB 24bit/pixel					4) 5/8H 1000p 750q	2) 5/16H 500p 375q
Mode_5	1600x1200 Y (Mono) 8bit/pixel			4) 5/2H 4000p 1000q	2) 5/4H 2000p 500q	5/8H 1000p 250q	5/16H 500p 125q
Mode_6	1280x960 Y (Mono16) 16bit/pixel				4) 1H 1280p 640q	2) 1/2H 640p 320q	1/4H 320p 160q
Mode_7	1600x1200 Y (Mono16) 16bit/pixel				4) 5/4H 2000p 1000q	2) 5/8H 1000p 500q	5/16H 500p 250q

[---H : Line / Packet]
2) : required S200 data rate [---p : Pixel / Packet]
4) : required S400 data rate [---q : Quadlet / Packet]

2.1.3 Video data payload structure

Pn : Pixel number / packet

K : $Pn \times n$ (n = 0..N-1)

($Pn \times N$ = Total pixel number / frame.)

<YUV (4: 4: 4) format >

U-(K+0)	Y-(K+0)	V-(K+0)	U-(K+1)
Y-(K+1)	V-(K+1)	U-(K+2)	Y-(K+2)
V-(K+2)	U-(K+3)	Y-(K+3)	V-(K+3)
U-(K+Pn-4)	Y-(K+Pn-4)	V-(K+Pn-4)	U-(K+Pn-3)
Y-(K+Pn-3)	V-(K+Pn-3)	U-(K+Pn-2)	Y-(K+Pn-2)
V-(K+Pn-2)	U-(K+Pn-1)	Y-(K+Pn-1)	V-(K+Pn-1)

<YUV (4: 2: 2) format >

U-(K+0)	Y-(K+0)	V-(K+0)	Y-(K+1)
U-(K+2)	Y-(K+2)	V-(K+2)	Y-(K+3)
U-(K+4)	Y-(K+4)	V-(K+4)	Y-(K+5)
U-(K+Pn-6)	Y-(K+Pn-6)	V-(K+Pn-6)	Y-(K+Pn-5)
U-(K+Pn-4)	Y-(K+Pn-4)	V-(K+Pn-4)	Y-(K+Pn-3)
U-(K+Pn-2)	Y-(K+Pn-2)	V-(K+Pn-2)	Y-(K+Pn-1)

<YUV (4: 1: 1) format >

U-(K+0)	Y-(K+0)	Y-(K+1)	V-(K+0)
Y-(K+2)	Y-(K+3)	U-(K+4)	Y-(K+4)
Y-(K+5)	V-(K+4)	Y-(K+6)	Y-(K+7)
U-(K+Pn-8)	Y-(K+Pn-8)	Y-(K+Pn-7)	V-(K+Pn-8)
Y-(K+Pn-6)	Y-(K+Pn-5)	U-(K+Pn-4)	Y-(K+Pn-4)
Y-(K+Pn-3)	V-(K+Pn-4)	Y-(K+Pn-2)	Y-(K+Pn-1)

<RGB format >

R-(K+0)	G-(K+0)	B-(K+0)	R-(K+1)
G-(K+1)	B-(K+1)	R-(K+2)	G-(K+2)
B-(K+2)	R-(K+3)	G-(K+3)	B-(K+3)
R-(K+Pn-4)	G-(K+Pn-4)	B-(K+Pn-4)	R-(K+Pn-3)
G-(K+Pn-3)	B-(K+Pn-3)	R-(K+Pn-2)	G-(K+Pn-2)
B-(K+Pn-2)	R-(K+Pn-1)	G-(K+Pn-1)	B-(K+Pn-1)

<Y (Mono) format >

Y-(K+0)	Y-(K+1)	Y-(K+2)	Y-(K+3)
Y-(K+4)	Y-(K+5)	Y-(K+6)	Y-(K+7)
Y-(K+Pn-8)	Y-(K+Pn-7)	Y-(K+Pn-6)	Y-(K+Pn-5)
Y-(K+Pn-4)	Y-(K+Pn-3)	Y-(K+Pn-2)	Y-(K+Pn-1)

< Y (Mono16) format >

High byte	Low byte

Y-(K+0)	Y-(K+1)
Y-(K+2)	Y-(K+3)
Y-(K+Pn-4)	Y-(K+Pn-3)
Y-(K+Pn-2)	Y-(K+Pn-1)

2.1.4 Data structure

<Y, R, G, B>

Each component has 8bit data. The data type is "Unsigned Char".

	Signal level (Decimal)	Data (Hexadecimal)
Highest	255	0xFF
	254	0xFE
	:	:
	1	0x01
Lowest	0	0x00

<U, V>

Each component has 8bit data. The data type is "Straight Binary".

	Signal level (Decimal)	Data (Hexadecimal)
Highest (+)	127	0xFF
	126	0xFE
	:	:
	1	0x81
Lowest	0	0x80
	-1	0x7F
	:	:
	-127	0x01
Highest (-)	-128	0x00

< Y(Mono16) >

Y component has 16bit data. The data type is "Unsigned Short (big-endian)".

Y	Signal level (Decimal)	Data (Hexadecimal)
Highest	65535	0xFFFF
	65534	0xFFFE
	:	:
	1	0x0001
Lowest	0	0x0000

2.2 Isochronous packet format for Partial image size video format (Format_7)

2.2.1 Video Isochronous packet structure

The following table shows the format of the first quadlet in the data field of each Isochronous data block.

0-7	8-15	16-23		24-31	
data_length		tg	channel	tCode	sy
header_CRC					
Video data payload					
data_CRC					

Isochronous Data Block Packet Format

Where the following fields are defined in the IEEE 1394 standard:

data_length : number of bytes in the data field

tg : (tag field) shall be set to zero

channel : isochronous channel number, as programmed in the iso_channel field of the cam_sta_ctrl register

tCode : (transaction code) shall be set to the isochronous data block packet tCode

sy : (synchronization value) shall be set to 0001h on the first isochronous data block of a frame, and shall be set to zero on all other isochronous data blocks

Video data payload: shall contain the digital video information, as defined in the following sections

2.2.2 Video data payload structure

Pn : Pixel number / packet

K : $Pn \times n$ (n = 0..N-1)

($Pn \times N$ = Total pixel number / frame.)

< Mono8 format (color coding ID = 0) >

Y component has 8bit data.

Y-(K+0)	Y-(K+1)	Y-(K+2)	Y-(K+3)
Y-(K+4)	Y-(K+5)	Y-(K+6)	Y-(K+7)
Y-(K+Pn-8)	Y-(K+Pn-7)	Y-(K+Pn-6)	Y-(K+Pn-5)
Y-(K+Pn-4)	Y-(K+Pn-3)	Y-(K+Pn-2)	Y-(K+Pn-1)

< 4:1:1 YUV8 format (color coding ID = 1)>

Each component has 8bit data.

U-(K+0)	Y-(K+0)	Y-(K+1)	V-(K+0)
Y-(K+2)	Y-(K+3)	U-(K+4)	Y-(K+4)
Y-(K+5)	V-(K+4)	Y-(K+6)	Y-(K+7)
U-(K+Pn-8)	Y-(K+Pn-8)	Y-(K+Pn-7)	V-(K+Pn-8)
Y-(K+Pn-6)	Y-(K+Pn-5)	U-(K+Pn-4)	Y-(K+Pn-4)
Y-(K+Pn-3)	V-(K+Pn-4)	Y-(K+Pn-2)	Y-(K+Pn-1)

< 4:2:2 YUV8 format (color coding ID = 2) >

Each component has 8bit data.

U-(K+0)	Y-(K+0)	V-(K+0)	Y-(K+1)
U-(K+2)	Y-(K+2)	V-(K+2)	Y-(K+3)
U-(K+4)	Y-(K+4)	V-(K+4)	Y-(K+5)
U-(K+Pn-6)	Y-(K+Pn-6)	V-(K+Pn-6)	Y-(K+Pn-5)
U-(K+Pn-4)	Y-(K+Pn-4)	V-(K+Pn-4)	Y-(K+Pn-3)
U-(K+Pn-2)	Y-(K+Pn-2)	V-(K+Pn-2)	Y-(K+Pn-1)

< 4:4:4 YUV8 format (color coding ID = 3) >

Each component has 8bit data.

U-(K+0)	Y-(K+0)	V-(K+0)	U-(K+1)
Y-(K+1)	V-(K+1)	U-(K+2)	Y-(K+2)
V-(K+2)	U-(K+3)	Y-(K+3)	V-(K+3)
U-(K+Pn-4)	Y-(K+Pn-4)	V-(K+Pn-4)	U-(K+Pn-3)
Y-(K+Pn-3)	V-(K+Pn-3)	U-(K+Pn-2)	Y-(K+Pn-2)
V-(K+Pn-2)	U-(K+Pn-1)	Y-(K+Pn-1)	V-(K+Pn-1)

<RGB8 format (color coding ID = 4) >

Each component has 8bit data.

R-(K+0)	G-(K+0)	B-(K+0)	R-(K+1)
G-(K+1)	B-(K+1)	R-(K+2)	G-(K+2)
B-(K+2)	R-(K+3)	G-(K+3)	B-(K+3)
R-(K+Pn-4)	G-(K+Pn-4)	B-(K+Pn-4)	R-(K+Pn-3)
G-(K+Pn-3)	B-(K+Pn-3)	R-(K+Pn-2)	G-(K+Pn-2)
B-(K+Pn-2)	R-(K+Pn-1)	G-(K+Pn-1)	B-(K+Pn-1)

< Mono16 format (color coding ID = 5) >

Y component has 16bit data.

High byte	Low byte

Y-(K+0)	Y-(K+1)
Y-(K+2)	Y-(K+3)
Y-(K+Pn-4)	Y-(K+Pn-3)
Y-(K+Pn-2)	Y-(K+Pn-1)

< RGB16 format (color coding ID = 6) >

Each component has 16bit data.

High byte	Low byte

R-(K+0)	G-(K+0)
B-(K+0)	R-(K+1)
G-(K+1)	B-(K+1)
B-(K+Pn-2)	R-(K+Pn-1)
G-(K+Pn-1)	B-(K+Pn-1)

2.2.3 Data structure

< Mono8, RGB8 >

Each component (Y, R, G, B) has 8bit data. The data type is "Unsigned Char".

Y,R,G,B	Signal level (Decimal)	Data (Hexadecimal)
Highest	255	0xFF
	254	0xFE
	:	:
	1	0x01
Lowest	0	0x00

< YUV8 >

Each component (Y, U, V) has 8bit data. The Y component is the same as in the above table.
The data type is "Straight Binary" for U and V data.

U, V	Signal level (Decimal)	Data (Hexadecimal)
Highest (+)	127	0xFF
	126	0xFE
	:	:
	1	0x81
Lowest	0	0x80
	-1	0x7F
	:	:
	-127	0x01
Highest (-)	-128	0x00

< Mono16, RGB16 >

Each component (Y,R,G,B) has 16bit data. The data type is "Unsigned Short (big-endian)".

Y,R,G,B	Signal level (Decimal)	Data (Hexadecimal)
Highest	65535	0xFFFF
	65534	0xFFFE
	:	:
	1	0x0001
Lowest	0	0x0000

3. Serial bus management

This chapter describes the camera behavior on a given Serial Bus. (IEEE 1394 Digital Camera is in accordance with IEEE standard 1212-1991.)

3.1 Bus Management

The camera compliant with this specification is a peripheral for a personal computer or workstation. Another node on the IEEE 1394 bus, such as a computer, acts as the camera controller.
In order for the camera to perform any action, the camera controller must access the camera control registers, as described in this standard. A camera, which is compliant with this protocol standard, is a passive device. It initiates no actions of its own. The camera is neither Isochronous manager capable nor full bus manager capable. The camera is also not cycle master capable. The contents of the self_ID packet generated by the camera, and the contents of camera configuration ROM shall accurately reflect this level of capability.
In order for the camera to perform any action, it must be connected to other IEEE 1394 nodes. At a minimum, there must be a cycle master capable node and an Isochronous manager capable node. In addition, there must be some node that is running application software that implements the protocol described in this standard. Note that all of these capabilities could reside in a single node.
The camera controller is responsible for the following activities related to camera operation:

1) Force a cycle master capable node to be the root
2) Start cycle master operation
3) Initialize the camera control registers for a desired video mode, frame rate, etc.
4) Allocate Isochronous resources needed by the camera (Isochronous channel number and bandwidth, as needed for the selected video mode)
5) Program the Isochronous channel number and transmit speed into the camera control registers
6) Instruct the camera to start sourcing Isochronous video data

The camera continues sourcing Isochronous video data until the camera controller instructs the camera to stop. If a bus reset occurs during camera operation, the camera continues sourcing Isochronous data immediately after the bus reset.

3.2 Asynchronous Transfer Capabilities

The camera compliant with this specification shall be capable of sending and receiving the asynchronous packets with a payload of up to 32 quadlets. This protocol does not use any asynchronous transactions that exceed this limit.
If a node sends a request packet to the digital camera between the request and corresponding response subaction, the digital camera will acknowledge that packet with a "busy" acknowledge code.

3.3 Isochronous Transfer Capabilities

The camera compliant with this specification is capable of being an Isochronous talker. The camera is not capable of listening to a channel of Isochronous data.
The digital camera is capable of transmitting Isochronous data on channels 0 to 15 only, inclusive.

3.4 IEEE 1394 Specific Address Space

The camera compliant with this specification shall be compliant with the IEEE 1394 and IEEE 1212 standards.

The following sections define all CSR and ROM locations that the camera shall implement. All information in these sections is intended to comply with the IEEE 1394 standard. Where discrepancies arise, the IEEE 1394 standard shall prevail. All address-offset locations in these sections are with respect to a base address of:

FFFF F000 0000h

3.4.1 Implemented CSR's

The digital camera implements the following core CSR's, as required by the IEEE 1394 standard:

Offset	0-7	8-15	16-23	24-31
0000h	STATE_CLEAR			
0004h	STATE_SET			
0008h	NODE_IDS			
000Ch	RESET_START			
0010h				
0014h				
0018h	SPLIT_TIMEOUT_HI			
001Ch	SPLIT_TIMEOUT_LO			

Core CSR's

The digital camera implements the following IEEE 1394 Serial Bus dependent CSR's:

Offset	0-7	8-15	16-23	24-31
0200h	CYCLE_TIME			
0204h				
0208h				
020Ch				
0210h	BUSY_TIMEOUT			

Serial Bus Dependent CSR's

3.4.2 Configuration ROM

IEEE 1394 Digital Camera implements the Configuration ROM as defined in IEEE standard 1212-1991 and IEEE standard 1394-1995.

unit_sw_version = 0x000102 (for 1394 based Digital Camera specification version 1.30)

History:

- unit_sw_version = 0x000101 (for 1394 based Digital Camera specification version 1.20)
- unit_sw_version = 0x000100 (for 1394 based Digital Camera specification version 1.04)

	Offset	0-7	8-15	16-23	24-31
Bus Info Block	400h	04h	crc_length	rom_crc_value	
	404h	31h	33h	39h	34h
	408h	0 0 1 0 rsv	FFh	max_rec	rsv
	40Ch	node_vendor_id			chip_id_hi
	410h	chip_id_lo			
Root Directory	414h	0004h		CRC	
	418h	03h	module_vendor_ID		
	41Ch	0Ch	rsv	1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0	
	420h	8Dh	indirect_offset		
	424h	D1h	unit_directory offset		

Root Directory

	Offset	0-7	8-15	16-23	24-31
Node unique ID leaf	0000h	0002h		CRC	
	0004h	node_vendor_id			chip_id_hi
	0008h	chip_id_lo			

Node Unique ID leaf

	Offset	0-7	8-15	16-23	24-31
Unit Directory	0000h	0003h		CRC	
	0004h	12h	unit_spec_ID (=0x00A02D)		
	0008h	13h	unit_sw_version		
	000Ch	D4h	unit_dependent_directory offset		

Unit directory

	Offset	0-7	8-15	16-23	24-31
Unit Dependent Info	0000h	unit_dep_info_length		CRC	
	0004h	40h	command_regs_base		
	0008h	81h	vendor_name_leaf		
	000Ch	82h	model_name_leaf		

Unit Dependent Directory

Where:

command_regs_base is the quadlet offset from the base address of initial register space of the base address of the command registers defined in section 1 of this standard.

vendor_name_leaf specifies the number of quadlets from the address of the vendor_name_leaf entry to the address of the vendor_name leaf containing an ASCII representation of the vendor name of this node.

model_name_leaf specifies the number of quadlets from the address of the model_name_leaf entry to the address of the model_name leaf containing an ASCII representation of the model name of this node.

3.4.3 Format of Vendor Name and Model Name Leaves

The unit dependent directory may contain pointers to information leaves that contain the ASCII name of the vendor and model name for this node. The format of these leaves is shown in the following table:

	Offset	0-7	8-15	16-23	24-31
Name Leaf	0000h	leaf_length		CRC	
	0004h	00h	00 0000h		
	0008h	0000 0000h			
	000Ch	char_0	char_1	char_2	char_3
	0010h	char_4	char_5	char_6	char_7
	0014h	char_8	...		
	n+6h	...			char_n-3
	n+Ah	char_n-2	Char_n-1	NUL	NUL

Vendor Name/Model Name Leaves

A. Appendix A (Feature definition and specification)

A.1 Brightness Control

Black level of the picture.

Off state:
Brightness level will be fixed value.

Auto control state:
Camera controls brightness level automatically by itself continuously.

Manual control state:
Camera controls brightness level manually by writing value to value-field.

One-Push action:
Camera controls brightness level automatically by itself only once and returns to Manual mode with adjusted value.

A.2 Auto Exposure Control

This feature is similar to "Contrast control".

Off state:
Exposure will be controlled manually using "Gain", "Iris" and/or "Shutter" features.

Auto control state:
Camera controls reference level automatically by itself continuously

Manual control state:
Camera controls exposure level automatically, but user can change reference level by writing value to "Auto_Exposure" register.

One-Push action:
Camera controls reference level automatically by itself only once and returns to Manual control state with adjusted value.

A.3 Sharpness Control

Sharpness of the picture.

Off state:
Sharpness level will be fixed value.

Auto control state:
Camera controls sharpness level automatically by itself continuously.

Manual control state:
Camera controls sharpness level manually by writing value to value-field.

One-Push action:
Camera controls sharpness level automatically by itself only once and returns to Manual control state with adjusted value.

A.4 White Balance Control

Adjustment of the white color of the picture.

At the YUV video mode, controlled by U value and V value.
At the RGB video mode, controlled by B value and R value.

Off state:
White balance will be fixed value.

Auto control state:
Camera controls white balance automatically by itself continuously.

Manual control state:

Camera controls white balance manually by writing value to value-field.

One-Push action:

Camera controls white balance automatically by itself only once and returns to Manual control state with adjusted value.

A.5 Hue Control

Color phase of the picture.

Off state:

Hue will be fixed value.

Auto control state:

Camera controls hue automatically by itself continuously.

Manual control state:

Camera controls hue manually by writing value to value-field.

One-Push action:

Camera controls hue automatically by itself only once and returns to Manual control state with adjusted value.

A.6 Saturation Control

Color saturation of the picture.

Off state:

Saturation level will be fixed value.

Auto control state:

Camera controls saturation level automatically by itself continuously.

Manual control state:

Camera controls saturation level manually by writing value to value-field.

One-Push action:

Camera controls saturation level automatically by itself only once and returns to Manual control state with adjusted value.

A.7 Gamma Control

Define the function between incoming light level and output picture level.

$y = f(x)$

y : output picture level
x : incoming light level

Off state:

Gamma will be fixed value.

Auto control state:

Camera controls gamma automatically by itself continuously.

Manual control state:

Camera controls gamma manually by writing value to value-field.

One-Push action:

Camera controls gamma automatically by itself only once and returns to Manual control state with adjusted value.

A.8 Shutter Control

Integration time of the incoming light.

Off state:

Integration time will be fixed value.

Auto control state:

Camera controls integration time automatically by itself continuously.

Manual control state:

Camera controls integration time manually by writing value to value-field.

One-Push action:
Camera controls integration time automatically by itself only once and returns to Manual control state with adjusted value.

A.9 Gain Control

Camera circuit gain control.

Off state:
Gain level will be fixed value.

Auto control state:
Camera controls gain level automatically by itself continuously.

Manual control state:
Camera controls gain level manually by writing value to value-field.

One-Push action:
Camera controls gain level automatically by itself only once and returns to Manual control state with adjusted value.

A.10 Iris Control

Mechanical lens iris control.

Off state:
Iris will be fixed value.

Auto control state:
Camera controls iris automatically by itself continuously.

Manual control state:
Camera controls iris manually by writing value to value-field.

One-Push action:
Camera controls iris automatically by itself only once and returns to Manual control state with adjusted value.

A.11 Focus Control

Lens focus control.

Off state:
Focus will be fixed value.

Auto control state:
Camera controls focus automatically by itself continuously.

Manual control state:
Camera controls focus manually by writing value to value-field.

One-Push action:
Camera controls focus automatically by itself only once and returns to Manual control state with adjusted value.

A.12 Temperature Control

Getting temperature inside of the camera and/or controlling temperature.

Off state:
Camera stops temperature control.

Auto control state:
Camera controls temperature by itself aims to "Target_Temperature" continuously.
User can get temperature at the present time from "Temperature" value.

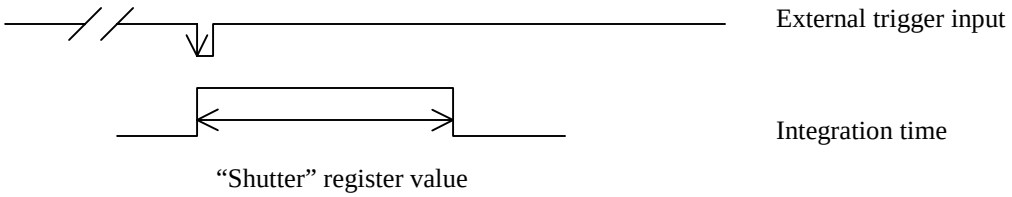
Manual control state:
In this mode, camera controls temperature by itself. But "Target_Temperature" value will be ignored. User can only get temperature at the present time from "Temperature" value.

One-Push action:
Camera controls temperature by itself aims to "Target_Temperature" value only once. User can get temperature at the present time from "Temperature" value.

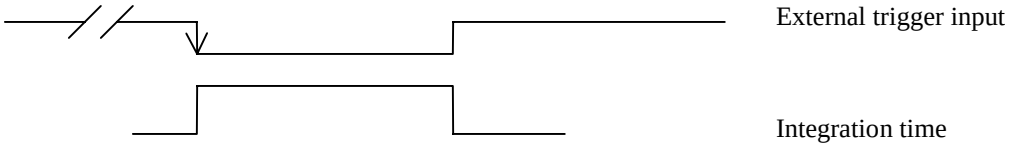
A.13 Trigger Control

If this feature is turned on, trigger function will work. If turned off, trigger input is ignored.
In the following explanation, trigger input is Low Active. (Trigger_Polarity = 0)

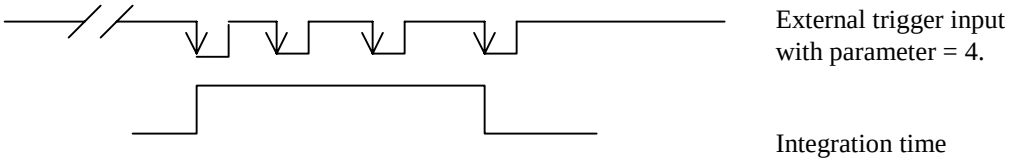
Trigger mode 0:
Camera starts integration of the incoming light from external trigger input falling edge. Integration time is described in "Shutter" register. No parameter is needed.



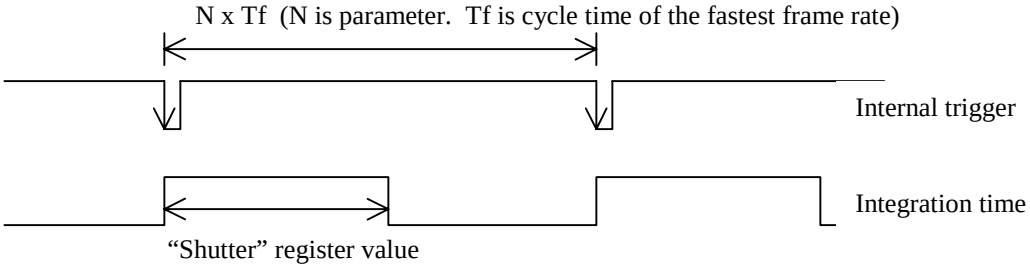
Trigger mode 1:
Camera starts integration of the incoming light from external trigger input falling edge. Integration time is equal to low state time of the external trigger input. No parameter is needed.



Trigger mode 2:
Camera starts integration of incoming light from first external trigger input falling edge. At the N-th (parameter) external trigger input falling edge, integration will be stopped.
Parameter is required and must be two or more. (N >= 2)



Trigger mode 3:
This is a internal trigger mode. Camera will issue trigger internally and cycle time is N times (parameter) of the cycle time of fastest frame rate. Integration time of incoming light is described in "Shutter" register.
Parameter is required and must be one or more. (N >= 1)



A.14 Zoom Control

Lens zoom control.

Off state:
Zoom will be fixed value.

Auto control state:
Camera controls zoom automatically by itself continuously.

Manual control state:
Camera controls zoom manually by writing value to value-field.

One-Push action:
Camera controls zoom automatically by itself only once and returns to Manual control state with adjusted value.

A.15 Pan Control

Camera pan control.

Off state:
Pan will be fixed value.

Auto control state:
Camera controls pan automatically by itself continuously.

Manual control state:
Camera controls pan manually by writing value to value-field.

One-Push action:
Camera controls pan automatically by itself only once and returns to Manual control state with adjusted value.

A.16 Tilt Control

Camera tilt control.

Off state:
Tilt will be fixed value.

Auto control state:
Camera controls tilt automatically by itself continuously.

Manual control state:
Camera controls tilt manually by writing value to value-field.

One-Push action:
Camera controls tilt automatically by itself only once and returns to Manual control state with adjusted value.

A.17 Optical filter Control

Changing optical filter of camera lens function.

Off state:
Optical filter will be fixed value.

Auto control state:
Camera controls optical filter automatically by itself continuously.

Manual control state:
Camera controls optical filter manually by writing value to value-field.

One-Push action:
Camera controls optical filter automatically by itself only once and returns to Manual control state with adjusted value.

B. Appendix B (Unit of value for Absolute value control)

The following tables describe unit of the value for absolute value control for each feature element.

Meaning of Value type:

Absolute: Value is absolute value.
Relative: Value is absolute value but reference point is system dependent.

B.1 Feature elements High

Feature element name	Function	Unit	Reference point	Value type
Brightness	Black level offset	%	----	Absolute
Auto Exposure	Auto Exposure	EV	0	Relative
White_Balance	White Balance	K	----	Absolute
Hue	Hue	deg	0	Relative
Saturation	Saturation	%	100	Relative
Shutter	Integration time	sec	----	Absolute
Gain	Circuit gain	dB	0	Relative
Iris	Iris	F	----	Absolute
Focus	Focus	m	----	Absolute
Trigger	External Trigger	times	----	Absolute

Definitions for other feature elements, which are not listed above, will be defined in the future.

B.2 Feature elements Low

Feature element	Function	Unit	Reference point	Type
Zoom	Zoom	power	1 (Wide end)	Relative
Pan	Pan	deg	0	Relative
Tilt	Tilt	deg	0	Relative

Definitions for other feature elements, which are not listed above, will be defined in the future.

EV: exposure value
K: kelvin
deg: degree
sec: second
dB: decibel
F: F number
m: meter

For the feature of "Hue", + means counterclockwise, - means clockwise on the vector scope.
For the feature of "Pan", + means turning to clockwise, - means turning to counterclockwise.
For the feature of "Tilt", + means turning to upward, - means turning to downward.