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IAS Module EEPROM and OTPM Standard



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APPLICATION NOTE

Background

ON Semiconductor provides the Imager Access System (IAS) family of modules offering standardized connectors and layout configuration, which are compatible with evaluation systems and reference designs offered by ON Semiconductor. The IAS modules also has standardized protocol to store module & driver related info in sensor OTPM or module EEPROM. This document describes the data structure and standard used to store the said information.

EEPROM & MEMORY MAP

EEPROM

For IAS EEPROM selection, it is recommended to use CAT24C64BAC4CTR EEPROM with 0xA8 write address (0xA9 as read address). This document uses a 64kbit EEPROM in the definition.

When selecting the EEPROM slave address for the IAS module, the I2C slave address (8-bit) below was avoided due to conflicts on the based boards (DEMO3 system).

- 0xA0
- 0xD2
- 0x72
- 0xAE

EEPROM Memory Map

Suppose the EEPROM has 8k addresses, from 0x0000 to 0x1FFF. The address range is divided into three sections. The address from 0x0000 to 0x000F (A0x0000 to A0x000F) are reserved for IAS EEPROM identifier (defined later in this document) as well as module serial number (if applicable). A0x0010 to A0x1FEF are allocated for record types, which contain the module & calibration information (if any). All record types should follow the exact structure defined in this document. A0x1FF0 to A0x1FFF are reserved for internal use.

Table 1.

Byte Address	Description
0x0000	IAS EEPROM identifier (16 bytes)
0x0005	
0x0006 0x000F	Module Serial Number (Optional, 10 characters in ASCII)
0x0010	Record types (8160 bytes)
0x1FEF	
0x1FF0	Reserved (16 bytes)
0x1FFF	

IAS EEPROM Identifier

A0x0000 to A0x0005 is defined to be the IAS Identifier, which will be programmed with the values 0x4F 0x4E 0x49 0x41 0x53 0x00. If those bytes don't have the identifier the EEPROM is considered to be un-formatted. If the bytes match those values then it is formatted.

Module Serial Number

When applicable, A0x0006 to A0x000F is defined to be the module serial number (in ASCII code format). Total 10 bytes has been allocated for the serial number.

EEPROM record type data structure

The record types start at A0x0010. Each record immediately follows the previous one as a simple list. There's no directory table.

Each record start with a 2-byte word (throughout this document, a word is 2 bytes) that has the validation info (high 8 bits) and the record type number (low 8 bit), followed by a 2-byte (1 word) record_type_length (in # of words), followed by the content of the record types. Each word is stored in big endian byte order. The record_type_length value does not count the length of validation info, record type number and record_type_length itself.

Each record type number should only have one incidence in the EEPROM. If a record type needs to be invalidated (and not replaced with the new value) for some reason, user can mark the validation info to 0xF0 and the record_type_length value should be kept.

OTPM

Some sensors has OTPM spaces allocated to store module calibration data as different record types. For the detailed structure of the sensor OTPM and space available for customer use. Refer to the OTPM Technical Note for related sensors.

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The content for each record types defined for IAS modules are identical. Record Type 0x11 (Auto-loaded LSC) is only applicable in OTPM.

EEPROM. "Number of Bytes Allocated" in Table 2. includes the validation info, record type number and length for EEPROM and header for OTPM. Within a Record Type, it is recommended to use value 0 for the undefined bits.

RECORD TYPES

Record types in use

Table 2 shows the all the defined record types. Refer to the IAS module data sheet for which record types are stored in

Table 2.

Record Type	Record Type Descriptor	Number of Bytes Allocated	Note
0x11	Auto-Loaded LSC (Illuminant 1)	236	OTPM only
0x30	IAS Product and Vendor info	28	
0x31	Auto-Focus Calibration Data (Macro)	12	
0x32	Auto-Focus Calibration Data (Infinity)	12	
0x34	Lens Shading table (Illuminant 1)	236	
0x35	Lens Shading table (Illuminant 2)	236	
0x36	Lens Shading Table (Illuminant 3)	236	
0x37	AWB Calibration Data (Illuminant 1)	12	
0x38	AWB Calibration Data (Illuminant 2)	12	
0x39	AWB Calibration Data (Illuminant 3)	12	
0x50 – 0x5F	User Data (can be specified by end user)		

RT (Record Type) 0x30 – Product and Vendor Info

A total 28 bytes is allocated for product and vendor information which describes the calibration data stored in

the EEPROM / OTPM. Table below shows a more detailed view of Product and Vendor Segment (RT 0x30).

Table 3.

OTPM Buffer Register	EEPROM Address	Bit	Description
N/A	Start of Record (SOR) + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
		[7:0]	Record Type Number: value = 0x30
N/A	SOR + 2	[15:0]	Record Type Length: value = 0x000C
0x3800	SOR + 4	15	0: This is not an IAS module 1: This is an IAS module
		[14:8]	Undefined
		[7]	0: No Module ID Stored 1: Module ID Stored
		[6:4]	Undefined
		[3]	0: No AWB Calibration Data Stored 1: AWB Calibration Data Stored
		[2]	0: No LSC Table Stored 1: LSC Table Stored.
		[1]	0: No AF Calibration Data Stored 1: AF Calibration Data Stored
		[0]	Undefined

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Table 3.

OTPM Buffer Register	EEPROM Address	Bit	Description
0x3802	SOR + 6	[15:8]	Module_ID (defined in IAS part #)
		[7:0]	IAS_ID (defined in IAS part #)
0x3804	SOR + 8	[15:8]	Module Revision (defined as part of IAS part #)
		[7:0]	Undefined
0x3806	SOR + 10	[15:0]	Description: Undefined
0x3808	SOR + 12	[15:8]	OTPM/EEPROM Revision.
		[7:0]	Undefined
0x380A	SOR + 14	[15:12]	Undefined
		[11:8]	Production month code(optional)
		[7:0]	Production date code (optional)
0x380C	SOR + 16	[15:8]	Undefined
		[7:0]	Production Year code (optional) Enter the (year – 2000). e.g. For year 2018, value = 0x12
0x380E	SOR + 18	[15:12]	Undefined
		[11]	0: No IR switch installed. 1: IR switch installed.
		[10:8]	Undefined
		[7:4]	IRCF type 0: Undefined 1. Absorptive 2. Reflective 3. Hybrid
		[3:0]	IRCF option 0: Undefined 1: No IRCF 2: Visible, 650 nm 3. Visible, 670 nm 4. Dual–band 650 nm, 850 nm 5. Dual–band 670 nm, 850 nm 6. Dual–band 650 nm, 940 nm 7. Dual–band 670 nm, 940 nm 8. IR only 850 9: IR only 940
0x3810	SOR + 20	[15:0]	Undefined
0x3812	SOR + 22	[15:0]	Undefined

Table 3.

OTPM Buffer Register	EEPROM Address	Bit	Description
0x3814	SOR + 24	[15:14]	Number of Illumination used for calibration stored. 00: Undefined 01: One Illumination used for calibration. 10: Two illuminations used for calibration. 11: three illuminations used for calibration.
		[13:12]	Undefined
		[11:8]	Illuminant 1; Type used for Shading calibration data stored in RT 0x34 and 0x37. 0: D65 1: D50 2: CWF 3: Illuminant A/Tungsten 4: TL84 5: Flash/Strobe 6–15: Undefined
		[7:6]	Type of Shading Calibration Data stored in RT0x34, 0x35, 0x36 0b00: No Calibration Data Stored. 0b01: In-sensor LSC Register Format 0b10: Generic Shading Data. 0b11: Undefined.
		[5]	0: No Auto Loaded LSC (0x11) stored in OTPM 1: Auto loaded LSC (RT 0x11) stored in OTPM
		[4:0]	Undefined
0x3816	SOR + 26	[15:8]	Undefined
		[7:4]	Illuminant 2 Used for RT 0x35 and 0x38 0: D65 1: D50 2: CWF 3: Illuminant A/Tungsten 4: TL84 5: Flash/Strobe 6–15: Undefined
		[3:0]	Illuminant 3 used for RT 0x36 and 0x39 0: D65 1: D50 2: CWF 3: Illuminant A/Tungsten 4: TL84 5: Flash/Strobe 6–15: Undefined

RT 0x31 & 0x32 – AF Calibration Data

A total 24 bytes are defined for the AF calibration data records (12 bytes for each RT). By default RT 0x31 is

intended to included AF calibration data for Macro position and RT 0x32 for infinity position. The table below includes more details about the Record Types.

Table 4.

Record Type	OTPM Buffer Register	EEPROM Address	Bit	Description
0x31	N/A	(Start of Record) SOR + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
			[7:0]	Record Type Number: value = 0x31
	N/A	SOR + 2	[15:0]	Record Type Length: value = 0x0004
	0x3800	SOR + 4	[15:10]	Undefined
			[9:0]	Calibration Data for Macro Position
	0x3802	SOR + 6	[15:0]	Undefined
	0x3804	SOR + 8	[15:0]	Undefined
0x3806	SOR + 10	[15:0]	Undefined	
0x32	N/A	SOR + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
			[7:0]	Record Type Number: value = 0x32
	N/A	SOR + 2	[15:0]	Record Type Length: value = 0x0004
	0x3800	SOR + 4	[15:10]	Undefined
			[9:0]	Calibration Data for Infinity Position
	0x3802	SOR + 6	[15:0]	Undefined
	0x3804	SOR + 8	[15:0]	Undefined
0x3806	SOR + 10	[15:0]	Undefined	

NOTE: When 8-bit VCM codes are used, they should be MSB shifted to bit 9 of 0x3800 (e.g., 0x3800[15:0] = 000000XXXXXXXX00).

RT 0x37 0x38 & 0x39 – AWB Calibration Data

12 bytes were allocated for each AWB calibration record type. One, two or all three of the Record Types may contain data, corresponding to the value programmed in the Illuminant information fields in the Product and Vendor record (record type 0x30).

AWB Calibration Procedure

For per-module calibration, only AWB white points need to be stored for each color temperature. This is done alongside the LSC calibration process.

For the generic white point calibration, take the center 1/8X x 1/8Y (see Figure below) of pixels from the RAW flat field image, calculate the average pixel level of R, Gr (Green red pixel), Gb (Green blue pixel), and B channels (minus black level), and store the average of R/Gr, B/Gb, and Gr/Gb ratios times 1024 in 16-bit integer format.

- R_ave = Red average – Black_pedestal
- B_ave = Blue average – Black_pedestal
- Gb_ave = Gb average – Black_pedestal
- Gr_ave = Gr average – Black_pedestal

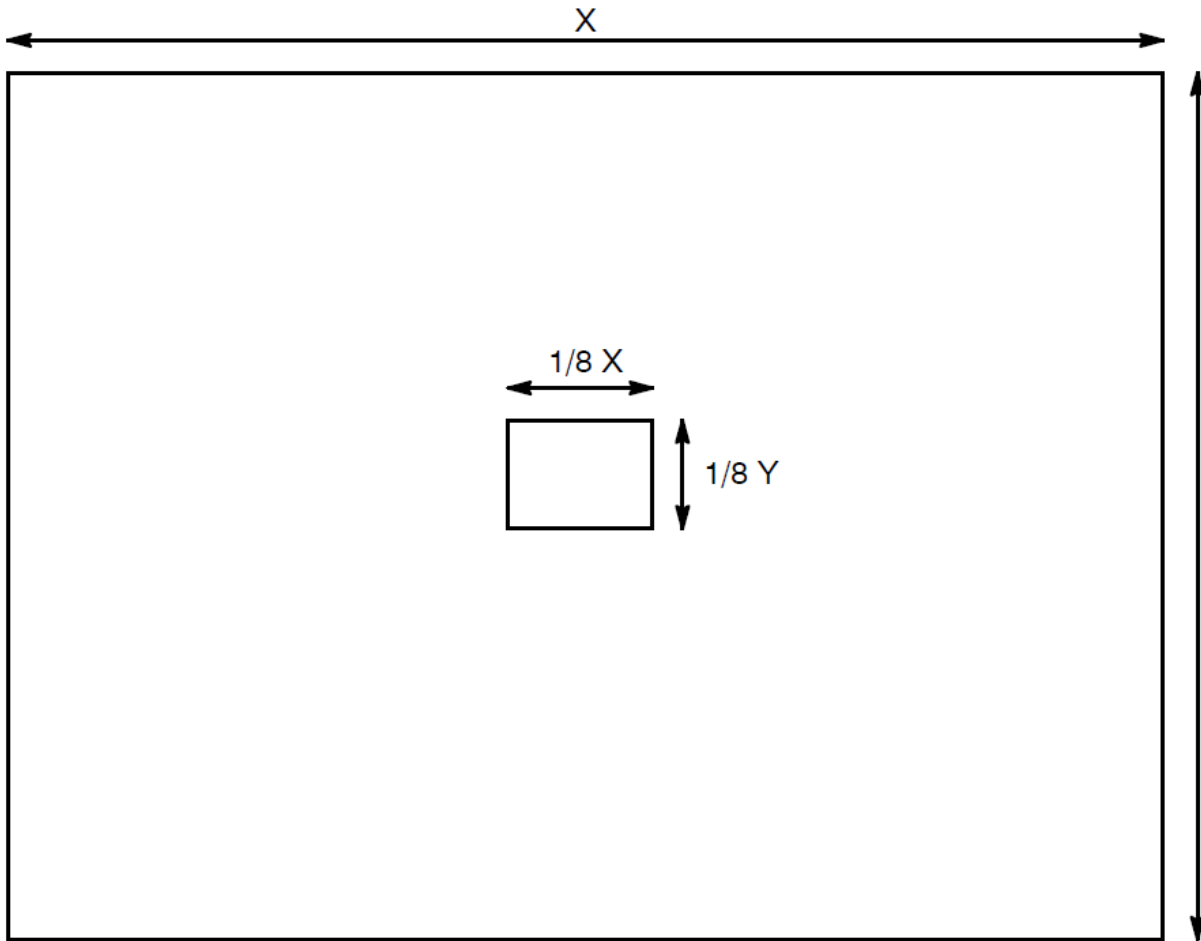


Figure 1.

Calculation Average Values for R/Gr, B/Gb and Gr/Gb

See table below for detailed calibration and description of each value.

Table 5.

Record Type	OTPM Buffer Register	EEPROM Address	Bits	Description
0x37 Illuminant 1	N/A	(Start of Record) SOR + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
			[7:0]	Record Type Number: value = 0x37
	N/A	SOR + 2	[15:0]	Record Type Length: value = 0x0004
	0x3800	SOR + 4	[15:0]	R/Gr = R_ave / Gr_ave * 1024
	0x3802	SOR + 6	[15:0]	B/Gb = B_ave / Gb_ave * 1024
	0x3804	SOR + 8	[15:0]	Gr/Gb = Gr_ave / Gb_ave * 1024
	0x3806	SOR + 10	[15:0]	value = 0xFFFF

Table 5.

Record Type	OTPM Buffer Register	EEPROM Address	Bits	Description
0x38 Illuminant 2	N/A	SOR + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
			[7:0]	Record Type Number: value = 0x38
	N/A	SOR + 2	[15:0]	Record Type Length: value = 0x0004
	0x3800	SOR + 4	[15:0]	R/Gr = R_ave / Gr_ave * 1024
	0x3802	SOR + 6	[15:0]	B/Gb = B_ave / Gb_ave * 1024
	0x3804	SOR + 8	[15:0]	Gr/Gb = Gr_ave / Gb_ave * 1024
	0x3806	SOR + 10	[15:0]	value = 0xFFFF
0x39 Illuminant 3	N/A	SOR + 0	[15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.
			[7:0]	Record Type Number: value = 0x39
	N/A	SOR + 2	[15:0]	Record Type Length: value = 0x0004
	0x3800	SOR + 4	[15:0]	R/Gr = R_ave / Gr_ave * 1024
	0x3802	SOR + 6	[15:0]	B/Gb = B_ave / Gb_ave * 1024
	0x3804	SOR + 8	[15:0]	Gr/Gb = Gr_ave / Gb_ave * 1024
	0x3806	SOR + 10	[15:0]	value = 0xFFFF

RT 0x11, 0x34 0x35 0x36 – Lens Shading Calibration

Each LSC Record Type are defined to have 236 bytes (assuming it is for in-sensor LSC register format is used). RT 0x11 (auto loaded LSC) only applies for OTPM as previously mentioned. Both RT 0x11 and RT0x34 are defined for Illuminant 1. If it is preferred for the LSC to be auto-loaded, use RT 0x11, otherwise use RT0x34.

For all Record Types defined for LSC (whether auto-loaded or not), the format of the content is the same.

The content can be generated using DevwareX’s LensCalib tool based on flat-field images.

Table below shows a mapping between the OTPM content in buffer registers, values in EEPROM and sensor register for LSC. For easier reference, each address/register was assigned an example value so that the correlation between the three can be more obvious. It is straight forward to generate the value for EEPROM based on what LensCalib tool has generated for OTPM.

Table 6.

OTPM		EEPROM		Sensor	
Buffer Register	Value	Address	Value	LSC Register Address	Value
N/A		SOR + 0 [15:8]	0x00: This is a valid Record Type. 0xF0: This record has been invalidated.	N/A	
N/A		SOR + 0 [7:0]	record type number 0x34, 0x35 or 0x36	N/A	
N/A		SOR + 2	record type Length; value = 0x74	N/A	
0x3800	0xF803	SOR + 4	0xF803	N/A	
0x3802	0xA300	SOR + 6	0xA300	N/A	
0x3804	0x0170	SOR + 8	0x0170	0x3600	0x0170
0x3806	0xBEEB	SOR + 10	0xBEEB	0x3602	0xBEEB
0x3808	0x1DB0	SOR + 12	0x1DB0	0x3604	0x1DB0
0x380A	0x050C	SOR + 14	0x050C	0x3606	0x050C
0x380C	0x3EAC	SOR + 16	0x3EAC	0x3608	0x3EAC
0x380E	0x00B0	SOR + 18	0x00B0	0x360a	0x00B0

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Table 6.

OTPM		EEPROM		Sensor	
Buffer Register	Value	Address	Value	LSC Register Address	Value
0x3810	0xA529	SOR + 20	0xA529	0x360c	0xA529
0x3812	0x56D0	SOR + 22	0x56D0	0x360e	0x56D0
0x3814	0x690A	SOR + 24	0x690A	0x3610	0x690A
0x3816	0x0DEE	SOR + 26	0x0DEE	0x3612	0x0DEE
0x3818	0x00F0	SOR + 28	0x00F0	0x3614	0x00F0
0x381A	0x8DEB	SOR + 30	0x8DEB	0x3616	0x8DEB
0x381C	0x620F	SOR + 32	0x620F	0x3618	0x620F
0x381E	0x252B	SOR + 34	0x252B	0x361a	0x252B
0x3820	0x2ECE	SOR + 36	0x2ECE	0x361c	0x2ECE
0x3822	0x0150	SOR + 38	0x0150	0x361e	0x0150
0x3824	0x94CB	SOR + 40	0x94CB	0x3620	0x94CB
0x3826	0x16D0	SOR + 42	0x16D0	0x3622	0x16D0
0x3828	0x498B	SOR + 44	0x498B	0x3624	0x498B
0x382A	0x41CC	SOR + 46	0x41CC	0x3626	0x41CC
0x382C	0xA320	SOR + 48	0xA320	N/A	
0x382E	0x020A	SOR + 50	0x020A	0x3640	0x020A
0x3830	0x400C	SOR + 52	0x400C	0x3642	0x400C
0x3832	0xE066	SOR + 54	0xE066	0x3644	0xE066
0x3834	0x976D	SOR + 56	0x976D	0x3646	0x976D
0x3836	0x216A	SOR + 58	0x216A	0x3648	0x216A
0x3838	0x4868	SOR + 60	0x4868	0x364a	0x4868
0x383A	0x520B	SOR + 62	0x520B	0x364c	0x520B
0x383C	0x82EA	SOR + 64	0x82EA	0x364e	0x82EA
0x383E	0xE36C	SOR + 66	0xE36C	0x3650	0xE36C
0x3840	0x398B	SOR + 68	0x398B	0x3652	0x398B
0x3842	0x25CB	SOR + 70	0x25CB	0x3654	0x25CB
0x3844	0x3BEB	SOR + 72	0x3BEB	0x3656	0x3BEB
0x3846	0x1DAC	SOR + 74	0x1DAC	0x3658	0x1DAC
0x3848	0xEE6B	SOR + 76	0xEE6B	0x365a	0xEE6B
0x384A	0xB16B	SOR + 78	0xB16B	0x365c	0xB16B
0x384C	0x34EA	SOR + 80	0x34EA	0x365e	0x34EA
0x384E	0x3B4C	SOR + 82	0x3B4C	0x3660	0x3B4C
0x3850	0xCC2A	SOR + 84	0xCC2A	0x3662	0xCC2A
0x3852	0xA58D	SOR + 86	0xA58D	0x3664	0xA58D
0x3854	0x14EC	SOR + 88	0x14EC	0x3666	0x14EC
0x3856	0xA340	SOR + 90	0xA340	N/A	
0x3858	0x1510	SOR + 92	0x1510	0x3680	0x1510
0x385A	0xF10B	SOR + 94	0xF10B	0x3682	0xF10B
0x385C	0xE727	SOR + 96	0xE727	0x3684	0xE727
0x385E	0x186B	SOR + 98	0x186B	0x3686	0x186B

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Table 6.

OTPM		EEPROM		Sensor	
Buffer Register	Value	Address	Value	LSC Register Address	Value
0x3860	0x3A4F	SOR + 100	0x3A4F	0x3688	0x3A4F
0x3862	0x42D0	SOR + 102	0x42D0	0x368a	0x42D0
0x3864	0xB36C	SOR + 104	0xB36C	0x368c	0xB36C
0x3866	0x21B0	SOR + 106	0x21B0	0x368e	0x21B0
0x3868	0x7ECC	SOR + 108	0x7ECC	0x3690	0x7ECC
0x386A	0x8810	SOR + 110	0x8810	0x3692	0x8810
0x386C	0x51AF	SOR + 112	0x51AF	0x3694	0x51AF
0x386E	0x354B	SOR + 114	0x354B	0x3696	0x354B
0x3870	0x344F	SOR + 116	0x344F	0x3698	0x344F
0x3872	0xA30E	SOR + 118	0xA30E	0x369a	0xA30E
0x3874	0x706C	SOR + 120	0x706C	0x369c	0x706C
0x3876	0x19F0	SOR + 122	0x19F0	0x369e	0x19F0
0x3878	0x972C	SOR + 124	0x972C	0x36a0	0x972C
0x387A	0x0C6D	SOR + 126	0x0C6D	0x36a2	0x0C6D
0x387C	0x1B2C	SOR + 128	0x1B2C	0x36a4	0x1B2C
0x387E	0x760E	SOR + 130	0x760E	0x36a6	0x760E
0x3880	0xA360	SOR + 132	0xA360		
0x3882	0xF4CB	SOR + 134	0xF4CB	0x36c0	0xF4CB
0x3884	0xE56D	SOR + 136	0xE56D	0x36c2	0xE56D
0x3886	0x210A	SOR + 138	0x210A	0x36c4	0x210A
0x3888	0x218F	SOR + 140	0x218F	0x36c6	0x218F
0x388A	0x03EE	SOR + 142	0x03EE	0x36c8	0x03EE
0x388C	0x384A	SOR + 144	0x384A	0x36ca	0x384A
0x388E	0x9C4D	SOR + 146	0x9C4D	0x36cc	0x9C4D
0x3890	0x32AC	SOR + 148	0x32AC	0x36ce	0x32AC
0x3892	0x286F	SOR + 150	0x286F	0x36d0	0x286F
0x3894	0x3A4C	SOR + 152	0x3A4C	0x36d2	0x3A4C
0x3896	0x10A9	SOR + 154	0x10A9	0x36d4	0x10A9
0x3898	0x9A6C	SOR + 156	0x9A6C	0x36d6	0x9A6C
0x389A	0xA26E	SOR + 158	0xA26E	0x36d8	0xA26E
0x389C	0x644D	SOR + 160	0x644D	0x36da	0x644D
0x389E	0x77EE	SOR + 162	0x77EE	0x36dc	0x77EE
BLOCK5	0x38A0	SOR + 164	0x38A0	0x36de	0xA46C
0x38A2	0xE4ED	SOR + 166	0xE4ED	0x36e0	0xE4ED
0x38A4	0x1E6D	SOR + 168	0x1E6D	0x36e2	0x1E6D
0x38A6	0x2A6F	SOR + 170	0x2A6F	0x36e4	0x2A6F
0x38A8	0x0ECA	SOR + 172	0x0ECA	0x36e6	0x0ECA
0x38AA	0xA380	SOR + 174	0xA380	N/A	
0x38AC	0xB74D	SOR + 176	0xB74D	0x3700	0xB74D
0x38AE	0x1A2D	SOR + 178	0x1A2D	0x3702	0x1A2D

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Table 6.

OTPM		EEPROM		Sensor	
Buffer Register	Value	Address	Value	LSC Register Address	Value
0x38B0	0x476F	SOR + 180	0x476F	0x3704	0x476F
0x38B2	0x82CE	SOR + 182	0x82CE	0x3706	0x82CE
0x38B4	0x96B0	SOR + 184	0x96B0	0x3708	0x96B0
0x38B6	0x4B0E	SOR + 186	0x4B0E	0x370a	0x4B0E
0x38B8	0x01AE	SOR + 188	0x01AE	0x370c	0x01AE
0x38BA	0x9DD0	SOR + 190	0x9DD0	0x370e	0x9DD0
0x38BC	0xE2CE	SOR + 192	0xE2CE	0x3710	0xE2CE
0x38BE	0x3DCD	SOR + 194	0x3DCD	0x3712	0x3DCD
0x38C0	0x008E	SOR + 196	0x008E	0x3714	0x008E
0x38C2	0xF86B	SOR + 198	0xF86B	0x3716	0xF86B
0x38C4	0x686D	SOR + 200	0x686D	0x3718	0x686D
0x38C6	0x142F	SOR + 202	0x142F	0x371a	0x142F
0x38C8	0x88F0	SOR + 204	0x88F0	0x371c	0x88F0
0x38CA	0xC56D	SOR + 206	0xC56D	0x371e	0xC56D
0x38CC	0x1B4D	SOR + 208	0x1B4D	0x3720	0x1B4D
0x38CE	0x786E	SOR + 210	0x786E	0x3722	0x786E
0x38D0	0xAA4E	SOR + 212	0xAA4E	0x3724	0xAA4E
0x38D2	0x958F	SOR + 214	0x958F	0x3726	0x958F
0x38D4	0x13C1	SOR + 216	0x13C1		
0x38D6	0x0648	SOR + 218	0x0648	0x3782	0x0648
0x38D8	0x04C8	SOR + 220	0x04C8	0x3784	0x04C8
0x38DA	0x23E0	SOR + 222	0x23E0	N/A	
0x38DC	0xE7C5	SOR + 224	0xE7C5	0x37C0	0xE7C5
0x38DE	0x0089	SOR + 226	0x0089	0x37C2	0x0089
0x38E0	0x84A7	SOR + 228	0x84A7	0x37C4	0x84A7
0x38E2	0x9AA8	SOR + 230	0x9AA8	0x37C6	0x9AA8
0x38E4	0xFFFF	SOR + 232	0xFFFF	N/A	

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