



TOREO-P650

Register Description

Version 1

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TOREO-P650 – Register Description

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1 Register Map

1.1 General Camera Registers

1.1.1 Camera Status

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0003	Status		R	Bit[3]: 1..Illumination-Board temperature sensor error Bit[4]: 1..Main-Board temperature sensor error Bit[5]: 1..Calibration data missing Bit[6]: 1..Factory Regmap was loaded Bit[9]: 1..Illumination board over-temperature Bit[11]: 1..Error condition reported by one of the LIMs Bit[13]: 1...Color Sensor Error Bit[14]: 1...Base board temperature sensor Error Bit[15]: 1...TIM/ToF Sensor Error
000E	FrameCounter		R	Frame Counter (increments on every captured frame)
001B	IlluminationBoardTemp		R	Temperature of LED-Board in 0,01[°C] (FFFF: Sensor not available).
001C	SensorTemp		R	Temperature of ToF-Sensor in 0,01[°C] (FFFF: Sensor not available).
010D	BaseboardTemp		R	Temperature of baseboard in 0,01[°C] (FFFF: Sensor not available).
0040	UpTimeLow		R	Lower 16 bit of uptime in [s]
0041	UpTimeHigh		R	Higher 16 bit of uptime in [s]
0046	ProcessorStatus		R	Bit[0:7] ... Temperature of the processor in °C (FF: Sensor not available) Bit[8:15] ... Processor speed in 10 MHz steps
0021	CalibStatus		R	Bit[11]: 1..No FPN Calibration data in NVM Bit[12]: 1..No FPPN Calibration data in NVM Bit[14]: 1..No Lens Calibration data in NVM

0118	CalibStatus2	R	Bit[0]: 1 ... No wiggling calibration data Bit[1]: 1 ... No geometric model parameters for 3D sensor Bit[2]: 1 ... No overlay calibration data (lenscalib V2) Bit[3]: 1 ... No geometric model parameters for RGB sensor 1 Bit[4]: 1 ... No geometric model parameters for RGB sensor 2
0580	RegmapStatus	R	Bit [0] ... Factory Regmap exists on device Bit [1] ... Factory Regmap is loaded Bit [2] ... User Regmap exists on device Bit [3] ... User Regmap is loaded Bit [4] ... Factory Reset was triggered at last boot

1.1.2 Camera Information

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0006	DeviceType	B650	R	Hardware specific identification Note: will be updated in future
0008	FirmwareInfo		R	Bit[0-5]: Non Functional Revision Bit[6-10]: Minor Revision Bit[11-15]: Major Revision
003D	BuildYearMonth		R	Build date/time Bit[14-4]: Year Bit[3-0]: Month
003E	BuildDayHour		R	Build date/time Bit[9-5]: Day Bit[4-0]: Hour
003F	BuildMinuteSecond		R	Build date/time Bit[11-6]: Minute Bit[5-0]: Second
000C	SerialNrLowWord		R	Lower 16bit of the 32bit Serial Number
000D	SerialNrHighWord		R	Higher 16bit of the 32bit Serial Number
0570	ArticleNrPart1		R	First part of the article number (###-****-*)
0571	ArticleNrPart2		R	Second part of the article number (***-####-*)
0572	DeviceRevisionMajor		R	Third part of the article number (***-****-#) Also: Major part of the revision number

0573	DeviceRevisionMinor	R	Bit[0-7]: ... nonfunctional part of the revision number Bit[8-15]: ... minor number of the revision number
0026	HorizontalFov	R	Horizontal field of view in 0,01[°]
0027	VerticalFov	R	Vertical field of view in 0,01[°]

1.1.3 Control

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0022	CmdEnablePasswd		R/W	Set a password for critical operations: 0x4877: Register map flash operations (register CmdExec 0x0033)
0033	CmdExec		R/W	0xC177.. Restart application

Executing the following commands must be preceded by writing 0x4877 into register CmdEnablePasswd (0x0022):

- 0xC2AE.. Clear UserRegMap in flash
- 0x9E20.. Load UserRegMap from flash
- 0x909A.. Load FactoryRegMap
- 0xDD9E.. Write UserRegMap to flash

0034	CmdExecResult		R	Result code of the operation initiated using CmdExec 1.. Success Other.. Error
00D0	IOstate0	0000	R/W	Bit[0] – Bit[9] ... reserved Bit[8]: ... state of OUT_0 (R/W) Bit[9]: ... state of OUT_1 (R/W) Bit[10] - Bit[15} ... reserved
0100	UserDefined0	0	R/W	For any purpose
0101	UserDefined1	0	R/W	For any purpose
0102	UserDefined2	0	R/W	For any purpose
0103	UserDefined3	0	R/W	For any purpose
0104	UserDefined4	0	R/W	For any purpose
0105	UserDefined5	0	R/W	For any purpose
0106	UserDefined6	0	R/W	For any purpose
0107	UserDefined7	0	R/W	For any purpose
0108	UserDefined8	0	R/W	For any purpose
0109	UserDefined9	0	R/W	For any purpose

1.2 Tof Imager Control

1.2.1 General

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0001	Mode0	0001	R/W	Bit[0]: 0..Manual Mode, 1.. Video Mode Bit[4]: 1..Manual Trigger (self-clearing bit)
0116	Accumulation	0001	R/W	Accumulation of frames (without dead time in between)
0005	IntegrationTime	01F4	R/W	Integration Time [μ s]
0009	ModulationFrequency	0FA0	R/W	Modulation frequency in multiples of 10kHz
000A	Framerate	0014	R/W	Framerate [Hz]
0120	NofSequ	1	R/W	Number of sequences that are recorded without wait time in between
0121	IntTimeSeq1	01F4	R/W	Integration time [μ s] to be used for capturing sequence 1 NOTE: Sequence 0 integration time is set via register IntegrationTime
0122	IntTimeSeq2	01F4	R/W	Integration time [μ s] to be used for capturing sequence 2
0123	IntTimeSeq3	01F4	R/W	Integration time to be used for capturing sequence 3
0128	ModFreqSeq1	0FA0	R/W	Modulation frequency in multiples of 10kHz NOTE: Sequence 0 modulation frequency is set via register ModulationFrequency
0129	ModFreqSeq2	0FA0	R/W	Modulation frequency to be used for capturing sequence 2 Register description: See ModFreqSeq1
012A	ModFreqSeq3	0FA0	R/W	Modulation frequency to be used for capturing sequence 3 Register description: See ModFreqSeq1
0574	NofPhases	0004	R/W	Number of phases to be captured

1.3 Color Sensor Control

1.3.1 General

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
05A0	ColorRoiStartX	0	R/W	First line of the region of interest. NOTE: ROI values get updated with writing ColorRoiEndY. NOTE2: ColorRoiEndX and ColorRoiEndY set to 0 means ROI is disabled. NOTE3: both sensor's resolutions have to be the same (ColorStreamParams and ColorStream2Params) NOTE4: ColorRoiStartX has to be even NOTE5: ColorRoiEndX has to be odd
05A1	ColorRoiStartY		R/W	Last line of the region of interest, NOTE: ROI values get updated with writing ColorRoiEndY. NOTE2: ColorRoiEndX and ColorRoiEndY set to 0 means ROI is disabled. NOTE3: both sensor's resolutions have to be the same (ColorStreamParams and ColorStream2Params) NOTE4: ColorRoiStartX has to be even NOTE5: ColorRoiEndX has to be odd
05A2	ColorRoiEndX	0	R/W	First column of the region of interest NOTE: ROI values get updated with writing ColorRoiEndY. NOTE2: ColorRoiEndX and ColorRoiEndY set to 0 means ROI is disabled. NOTE3: both sensor's resolutions have to be the same (ColorStreamParams and ColorStream2Params) NOTE4: ColorRoiStartX has to be even NOTE5: ColorRoiEndX has to be odd

05A3	ColorRoiEndY		R/W	<p>Last column of the region of interest.</p> <p>NOTE: ROI values get updated with writing ColorRoiEndY.</p> <p>NOTE2: ColorRoiEndX and ColorRoiEndY set to 0 means ROI is disabled.</p> <p>NOTE3: both sensor's resolutions have to be the same (ColorStreamParams and ColorStream2Params)</p> <p>NOTE4: ColorRoiStartX has to be even</p> <p>NOTE5: ColorRoiEndX has to be odd</p>
05A4	ColorImgProc	0000	R/W	<p>Bits[0..1]:</p> <p>0...No binning</p> <p>1...2x2 binning</p> <p>2...4x4 binning</p> <p>3...8x8 binning</p>
0170	OverlayConfig	0000	R/W	<p>Bit 0: 1...Mark 3D points without color assignment as "invalid" (X value 0x1)</p> <p>Bit 1: 1... Average all assigned color pixels</p> <p>0... color information is taken from the central pixel of the assigned color pixels</p> <p>Bit 2: 1... Fast mode activated</p> <p>0... Fast mode deactivated</p>
0171	OverlayVectorLengthTh reshold	200	R/W	<p>Threshold in millimeters compared to shortest vector length to a color sensor pixel from a 3D point that allows the assignment of a color sensor value</p>
0177	OverlayOverlapClearnes sLimit	10	R/W	<p>Clearness limit for assigning a color value to a ToF pixel [%]</p>

1.3.2 Sensor 1

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
00E0	ColorStreamParams		R/W	<p>Bit[1]: enable JPEG compression</p> <p>Bit[4..7]: Color sensor resolution</p> <p>2 ... VGA (640x480)</p> <p>7 ... 1080P (1920x1080)</p> <p>9 ... UHD 4K (3840x2160)</p> <p>10 ... (4192x3120)</p> <p>Bit[15]: enable grayscale mode</p>

00E1	ColorSensorControl		R/W	Bit[0]: 1 ... AEC/AGC enabled Bit[1]: 1 ... AWB enabled Bit[2]: 1 ... Frame sync activated Bit[3]: 1 ... Hdr enable
00E2	ColorSensorExposure		R/W	Exposure register value for color sensor [100 µs]
00E3	ColorSensorGain		R/W	Gain register value for color sensor [0.01%]
00E7	ColorSensorWhiteBalance		R/W	White balance temperature [K]
00E8	ColorSensorSharpness		R/W	Sharpness value
00E9	ColorSensorGamma		R/W	Gamma value
00EA	ColorSensorBrightness		R/W	Brightness value [0.1 %]
00EB	ColorSensorContrast		R/W	Contrast value [0.1 %]
00EC	ColorSensorSaturation		R/W	Saturation value [0.1 %]
00ED	ColorSensorHdrConfig		R/W	HDR config
00EE	ColorSensorCapturedFrames		R/W	Color sensor captured frame rate [0,1Hz]
00EF	ColorSensorFrameRate		R/W	Color sensor trigger frame rate [0,1Hz]
05A5	ColorJpegQuality	004B	R/W	JPEG Quality [%]

1.3.3 Sensor 2

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0590	ColorStream2Params		R/W	Bit[1]: enable JPEG compression Bit[4..7]: Color sensor resolution 2 ... VGA (640x480) 7 ... 1080P (1920x1080) 9 ... UHD 4K (3840x2160) 10 ... (4192x3120) Bit[15]: enable grayscale mode
0591	ColorSensor2Control		R/W	Bit[0]: 1 ... AEC/AGC enabled Bit[1]: 1 ... AWB enabled Bit[2]: 1 ... Frame sync activated Bit[3]: 1 ... Hdr enable
0592	ColorSensor2Exposure		R/W	Exposure register value for color sensor [100 µs]
0593	ColorSensor2Gain		R/W	Gain register value for color sensor [0.01 %]
0597	ColorSensor2WhiteBalance		R/W	White balance temperature [K]
0598	ColorSensor2Sharpness		R/W	Sharpness value

0599	ColorSensor2Gamma		R/W	Gamma value
059A	ColorSensor2Brightness		R/W	Brightness value [% * 10]
059B	ColorSensor2Contrast		R/W	Contrast value [% * 10]
059C	ColorSensor2Saturation		R/W	Saturation value [% * 10]
059D	ColorSensor2HdrConfig		R/W	HDR config
059E	ColorSensor2CapturedFps		R/W	Color sensor captured frame rate [0,1Hz]
05AD	Color2JpegQuality	004B	R/W	JPEG Quality [%]

1.4 Illumination Control

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0048	LIM1Status	0000	R/W	Status word of LIM #1 or external illumination. Bits[0..4]: Overcurrent on LED segments 0..4 Bit[5]: Watchdog enabled Bits[6..7]: Reserved Bits[8..12]: Open load on LED segments 0..4 Bit[14]: Temperature sensor error Bit[15]: Could not read status word (communication failure)
0049	Lim2Status	0000	R	Status word of LIM #2 (Bit description see register <i>Lim1Status</i>)
0292	TempDevConfig0	0000	R/W	Illumination control of LIM0: Bit[0]: 1 ... enable Power Bit[1]: 1 ... enable Segment 1 Bit[2]: 1 ... enable Segment 2 Bit[3-15]: reserved
0292	TempDevConfig1	0000	R/W	Illumination control of LIM1: Bit[0]: 1 ... enable Power Bit[1]: 1 ... enable Segment 1 Bit[2]: 1 ... enable Segment 2 Bit[3-15]: reserved

1.5 Image Processing

1.5.1 Processing Chain Configuration

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0004	ImageDataFormat	0	R/W	Bit[3:10]: 0 DistAmp Distance and Amplitude 1 DistAmpConf Distance, Amplitude and Confidence 2 DistAmpColor1Color2 Distance, Amplitude, Color1 and Color2 3 XYZ Pointcloud (xyz coordinates) 4 XYZAmp Pointcloud (xyz coordinates) and amplitude 5 XYZOverlay1Overlay2 Pointcloud (xyz coordinates) and color overlay 6 DistColor1Color2 Distance, Color1 and Color2 9 DistXYZ Distance and Pointcloud (xyz coordinates) 10 ZAmp Radial Distance (Z coordinate) and amplitude 12 Dist Distance 27 Amp Amplitude 255 UserDefined channels see registers 0x0620 – 0x0627
01E0	ImgProcConfig	28C0	R/W	Bit[0]: 1... enable Median filter Bit[1]: 1... enable Average Filer Bit[4]: 1... enable Sliding Frame Average Bit[6]: 1... enable wiggling compensation Bit[7]: 1... enable FPPN compensation Bit[10]: 1... enable FrameAverage Filter Bit[11]: 1... enable temperature compensation Bit[13]: 1... enable offsets via registers DistCalibOffsetX (0x00C1 onwards) Bit[14]: 1... enable phase symmetry check

01F0	ImgProcConfig3	0000	R/W	<p>Bit[0]: 1... enable Combine Mode (combine several sequences to one)</p> <p>Bit[3]: 1 ... enable Path length correction</p> <p>Bit[6]: 1 ... enable FPN</p> <p>Bit[7]: 1 ... enable Vernier</p> <p>Bit[11]: 1 ... enable Sensor saturation check</p> <p>Bit[12]: 1 ... mark dead pixels</p> <p>Bit[13]: 1 ... enable flying pixel filter</p>
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0620	ChannelData0	0000	R/W	<p>The registers ChannelData0 – ChannelData7 define the data delivered by the camera.</p> <p>If a channel ID is selected twice the camera sends it only ones.</p> <p>If no channel ID is selected the camera sends a Distance channel as default.</p> <p>If the camera is not able to send a specific channel ID the channel gets skipped.</p> <p>The order of the selected channel IDs does not matter.</p>
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Note: this register become active if register ImageDataFormat is set to 0x07FB

Channel data format:

- 0 .. Inactive
- 1 .. Distance
- 2 .. Amplitude
- 3 .. X coordinates
- 4 .. Y coordinates
- 5 .. Z coordinates
- 6 .. Confidence
- 9 .. Color0
- 10 .. Overlay0
- 11 .. Color1
- 12 .. Overlay1
- 13 .. Amplitude8

0621	ChannelData1	0000	R/W	See register 0x0620
0622	ChannelData2	0000	R/W	See register 0x0620
0623	ChannelData3	0000	R/W	See register 0x0620
0624	ChannelData4	0000	R/W	See register 0x0620
0625	ChannelData5	0000	R/W	See register 0x0620

0626	ChannelData6	0000	R/W	See register 0x0620
0627	ChannelData7	0000	R/W	See register 0x0620

1.5.2 Filter Configuration

1.5.2.1 Additive Offset (Global Offset)

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
00C1	DistOffset0	0000	R/W	An offset for distance values when operating at modulation frequency with index 0
00C2	DistOffset1	0000	R/W	An offset for distance values when operating at modulation frequency with index 1
00C3	DistOffset2	0000	R/W	An offset for distance values when operating at modulation frequency with index 2
00C4	DistOffset3	0000	R/W	An offset for distance values when operating at modulation frequency with index 3

1.5.2.2 Saturation and Low Amplitude Filter

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0010	ConfidenceThresLow	012C	R/W	Amplitude threshold for valid distance data
0011	ConfidenceThresHigh	3E80	R/W	Amplitude threshold for valid distance data

1.5.2.3 Flying Pixel Filter

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0199	FlyingPixelFilterThres	0050	R/W	Depth threshold value to detect flying Pixel [mm]
019A	FlyingPixelFilterConfig	0004	R/W	Bit[0-2]: Bad neighbor pixel threshold

1.5.2.4 Temporal Filters

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
01E5	FilterSlafConfig	0005	R/W	Bit[0-7]: ...Window size
01E7	FilterFrameAverageCon fig	0002	R/W	Bit[0-7]: ... Number of frames

1.5.2.5 Median Filter

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
01E1	FilterMedianConfig	0001	R/W	Bit[0-7]: ... Nr of Median Iterations

1.5.2.6 Average Filter

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
01E2	FilterAverageConfig	0100	R/W	Bit[0-7]: 0... 3x3 Pixel 1... 5x5 Pixel 2... 2x2 Pixel

1.5.2.7 Amplitude scaling

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
057B	AmpScaleMin	0000	R/W	Lower boundary for 16bit to 8bit Amplitude Scaling
057C	AmpScaleMax	FFFF	R/W	Upper boundary for 16bit to 8bit Amplitude Scaling

1.6 Interface Configuration

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
00FA	InterfaceConfig	0000	R/W	Data interface select 0 ... Stream data via Ethernet 2 ... Stream data over shared memory 65535 ... Stream disabled

1.6.1 Ethernet

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
0240	Eth0Config	0006	R/W	Bit[0]: 1.. Enable DHCP Bit[1]: 1.. Enable UDP streaming Bit[1]: 1.. UDP stream ignore CRC Bit[3]: 1.. Enable retransmission
0241	Eth0Mac2	ACDE	R/W	Low byte and byte 1 of MAC address
0242	Eth0Mac1	4801	R/W	Byte 2 and byte 3 of MAC address
0243	Eth0Mac0	0203	R/W	Byte 4 and high byte of MAC address
0244	Eth0Ip0	000A	R/W	Low word of IP address
0245	Eth0Ip1	C0A8	R/W	High word of IP address
0246	Eth0Snm0	FF00	R/W	Low word of subnet mask
0247	Eth0Snm1	FFFF	R/W	High word of subnet mask
0248	Eth0Gateway0	0000	R/W	Low word of gateway
0249	Eth0Gateway1	0000	R/W	High word of gateway
024D	Eth0UdpStreamIp0	E000	R/W	Low word of IP address for UDP stream
024D	Eth0UdpStreamIp1	E000	R/W	High word of IP address for UDP stream
024E	Eth0UdpStreamPort	2712	R/W	Port for UDP streaming
0259	Eth0UdpPacketSize	0578	R/W	Packet size for UDP data interface
025A	Eth0LinkSpeed	03E8	R	Link speed [Mbps]
025B	Eth0MtuSize	05DC	R/W	Eth0 MUT size (maximum transmission unit)

1.6.2 Shared memory

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
05C0	ShmVersion		R	Version of used shared memory protocol
05C1	ShmKey		R	Key to connect to shared memory
05C2	ShmSizeLowWord		R	Low word of the size of shared memory in bytes
05C3	ShmSizeHighWord		R	High word of the size of shared memory in bytes

2 Document Revision History

Version	Date	Document Revision
1	2022-01-25	Initial Draft
2	2023-02-23	<ul style="list-style-type: none"> - Updated register Status (0x0003) - Updated register ImageDataFormat (0x0004) - Added register SerialNrLowWord (0x000C) and SerialNrHighWord (0x000D) - Updated register CmdExec (0x0033) - Added register IOstate0 (0x00D0) - Updated register ColorStreamParams (0x00E0) and ColorStream2Params (0x0290) - Added register Accumulation (0x0116) - Added register OverlayConfig (0x0170) - Updated register ImgProcConfig (0x01e0) - Added register FilterAverageConfig (0x01e1) - Updated register ImgProcConfig3 (0x01f0) - Updated register TempDevConfig0 (0x0292) - Added register TempDevConfig1 (0x0296) - Added register Eth0MtuSize (0x25B) - Added registers ColorJpegQuality (0x05A5) and Color2JpegQuality (0x05AD)

Table 2-1: Revision history