



# TOREO-P650

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## 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..LED-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..LED board over-temperature Bit[11]: 1..Error condition reported by one of the LIMs 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).
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

<b>0580</b>	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
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## 1.1.2 Camera Information

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
<b>0006</b>	DeviceType	5046	R	Hardware specific identification Note: will be updated in future
<b>0008</b>	FirmwareInfo		R	Bit[0-5]: Non Functional Revision Bit[6-10]: Minor Revision Bit[11-15]: Major Revision
<b>003D</b>	BuildYearMonth		R	Build date/time Bit[14-4]: Year Bit[3-0]: Month
<b>003E</b>	BuildDayHour		R	Build date/time Bit[9-5]: Day Bit[4-0]: Hour
<b>003F</b>	BuildMinuteSecond		R	Build date/time Bit[11-6]: Minute Bit[5-0]: Second
<b>0570</b>	ArticleNrPart1		R	First part of the article number (###-****-*)
<b>0571</b>	ArticleNrPart2		R	Second part of the article number (***-####-*)
<b>0572</b>	DeviceRevisionMajor		R	Third part of the article number (***-****-#) Also: Major part of the revision number
<b>0573</b>	DeviceRevisionMinor		R	Bit[0-7]: ... nonfunctional part of the revision number Bit[8-15]: ... minor number of the revision number
<b>0026</b>	HorizontalFov		R	Horizontal field of view in 0,01[°]
<b>0027</b>	VerticalFov		R	Vertical field of view in 0,01[°]

### 1.1.3 Control

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
<b>0022</b>	CmdEnablePasswd		R/W	Set a password for critical operations: 0x4877: Register map flash operations (register CmdExec 0x0033)
<b>0033</b>	CmdExec		R/W	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
<b>0034</b>	CmdExecResult		R	Result code of the operation initiated using CmdExec 1.. Success Other.. Error
<b>0100</b>	UserDefined0	0	R/W	For any purpose
<b>0101</b>	UserDefined1	0	R/W	For any purpose
<b>0102</b>	UserDefined2	0	R/W	For any purpose
<b>0103</b>	UserDefined3	0	R/W	For any purpose
<b>0104</b>	UserDefined4	0	R/W	For any purpose
<b>0105</b>	UserDefined5	0	R/W	For any purpose
<b>0106</b>	UserDefined6	0	R/W	For any purpose
<b>0107</b>	UserDefined7	0	R/W	For any purpose
<b>0108</b>	UserDefined8	0	R/W	For any purpose
<b>0109</b>	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
<b>0001</b>	Mode0	0001	R/W	Bit[0]: 0..Manual Mode, 1.. Video Mode Bit[4]: 1..Manual Trigger (self-clearing bit)
<b>0005</b>	IntegrationTime	01F4	R/W	Integration Time [ $\mu$ s]

<b>0009</b>	ModulationFrequency	0FA0	R/W	Modulation frequency in multiples of 10kHz
<b>000A</b>	Framerate	0014	R/W	Framerate [Hz]
<b>0120</b>	NofSequ	1	R/W	Number of sequences that are recorded without wait time in between
<b>0121</b>	IntTimeSeq1	01F4	R/W	Integration time to be used for capturing sequence 1
NOTE: Sequence 0 integration time is set via register <b>IntegrationTime</b>				
<b>0122</b>	IntTimeSeq2	01F4	R/W	Integration time to be used for capturing sequence 2
<b>0123</b>	IntTimeSeq3	01F4	R/W	Integration time to be used for capturing sequence 3
<b>0128</b>	ModFreqSeq1	0FA0	R/W	Modulation frequency in multiples of 10kHz
NOTE: Sequence 0 modulation frequency is set via register <b>ModulationFrequency</b>				
<b>0129</b>	ModFreqSeq2	0FA0	R/W	Modulation frequency to be used for capturing sequence 2
Register description: See <b>ModFreqSeq1</b>				
<b>012A</b>	ModFreqSeq3	0FA0	R/W	Modulation frequency to be used for capturing sequence 3
Register description: See <b>ModFreqSeq1</b>				
<b>0574</b>	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
<b>05A0</b>	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.



<b>05A1</b>	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.
<b>05A2</b>	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.
<b>05A3</b>	ColorRoiEndY		R/W	Last 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.
<b>05A4</b>	ColorImgProc	0000	R/W	Bits[0..1]: 0...No binning 1...2x2 binning 2...4x4 binning 3...8x8 binning
<b>0171</b>	OverlayVectorLengthTh reshold	200	R/W	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
<b>0177</b>	OverlayOverlapClearnes sLimit	10	R/W	Clearness limit for assigning a color value to a ToF pixel [%]

### 1.3.2 Sensor 1

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

<b>00E1</b>	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 Bit[4]: 1 ... Disable color sensor
<b>00E2</b>	ColorSensorExposure	R/W	Exposure register value for color sensor [100 µs]
<b>00E3</b>	ColorSensorGain	R/W	Gain register value for color sensor [0.01%]
<b>00E7</b>	ColorSensorWhiteBalance	R/W	White balance temperature [K]
<b>00E8</b>	ColorSensorSharpness	R/W	Sharpness value
<b>00E9</b>	ColorSensorGamma	R/W	Gamma value
<b>00EA</b>	ColorSensorBrightness	R/W	Brightness value [0.1 %]
<b>00EB</b>	ColorSensorContrast	R/W	Contrast value [0.1 %]
<b>00EC</b>	ColorSensorSaturation	R/W	Saturation value [0.1 %]
<b>00ED</b>	ColorSensorHdrConfig	R/W	HDR config
<b>00EE</b>	ColorSensorCapturedFrames	R/W	Color sensor captured frame rate [0,1Hz]
<b>00EF</b>	ColorSensorFrameRate	R/W	Color sensor trigger frame rate [0,1Hz]

### 1.3.3 Sensor 2

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
<b>0590</b>	ColorStream2Params		R/W	Bit[4..7]: Color sensor resolution 2 ... VGA (640x480) 7 ... 1080P (1920x1080) 9 ... UHD 4K (3840x2160) 10 ... (4192x3120)
<b>0591</b>	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 Bit[4]: 1 ... Disable color sensor
<b>0592</b>	ColorSensor2Exposure		R/W	Exposure register value for color sensor [100 µs]
<b>0593</b>	ColorSensor2Gain		R/W	Gain register value for color sensor [0.01 %]
<b>0597</b>	ColorSensor2WhiteBalance		R/W	White balance temperature [K]
<b>0598</b>	ColorSensor2Sharpness		R/W	Sharpness value

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

## 1.4 Illumination Control

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
<b>0048</b>	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)
<b>0049</b>	Lim2Status	0000	R	Status word of LIM #2 (Bit description see register <b><i>Lim1Status</i></b> )
<b>0292</b>	TempDevConfig0	0000	R/W	Device specific configuration of temperature device 0 LIM: Bit[0]: 1 ... enable PEN Bit[1]: 1 ... enable LED Segment 1 Bit[2]: 1 ... enable LED 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
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<b>0004</b>	ImageDataFormat	0	R/W	<p>Bit[3:10]:</p> <p>0 DistAmp                  2 bytes depth-data / 2 bytes amp-data</p> <p>1 DistAmpConf                  2 bytes depth-data, 2 bytes amp-data, 1 byte confidence</p> <p>3 XYZ                  X/Y/Z coordinates (2 bytes in signed format for each coordinate)</p> <p>4 XYZAmp                  X/Y/Z coordinates and amp-data (2 bytes in signed format for each coordinate, 2 bytes unsigned for the amp value)</p> <p>5 XYZColor1Color2                  X/Y/Z coordinates and color Information for each pixel (2 bytes in signed format for XYZ, 2 bytes color information in YUV444) ... This is the mode used for 2D-3D overlay</p> <p>7 Phase0_90_180_270                  4 phases without image processing 4 times 2 bytes for 0°, 90°, 180° and 270°</p> <p>9 DistXYZ                  depth-data and X/Y/Z coordinates (2 byte unsigned for the depth value , 2 byte in signed format for each coordinate)</p> <p>10 ZAmp                  Optical axis coordinate and amp-data (2 bytes in signed format, 2 bytes unsigned for amp-data)</p> <p>12 Dist                  2 bytes depth-data</p> <p>13 RawdistAmp                  2 bytes raw depth data; 2 bytes amp data</p> <p>27 Amp                  2 bytes amp data</p> <p>255 UserDefined channels (see registers 0x0620 – 0x0627)</p>
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<b>01E0</b>	ImgProcConfig	28C0	R/W	Bit[0]: 1... enable Median filter 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
<b>01F0</b>	ImgProcConfig3	0000	R/W	Bit[0]: 1... enable Combine Mode (combine several sequences to one) Bit[3]: 1 ... enable Path length correction Bit[6]: 1 ... enable FPN Bit[7]: 1 ... enable Vernier Bit[12]: 1 ... mark dead pixels Bit[13]: 1 ... enable flying pixel filter

<b>0620</b>	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

<b>0621</b>	ChannelData1	0000	R/W	See register 0x0620
<b>0622</b>	ChannelData2	0000	R/W	See register 0x0620
<b>0623</b>	ChannelData3	0000	R/W	See register 0x0620
<b>0624</b>	ChannelData4	0000	R/W	See register 0x0620
<b>0625</b>	ChannelData5	0000	R/W	See register 0x0620
<b>0626</b>	ChannelData6	0000	R/W	See register 0x0620
<b>0627</b>	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
<b>00C1</b>	DistOffset0	0000	R/W	An offset for distance values when operating at modulation frequency with index 0
<b>00C2</b>	DistOffset1	0000	R/W	An offset for distance values when operating at modulation frequency with index 1
<b>00C3</b>	DistOffset2	0000	R/W	An offset for distance values when operating at modulation frequency with index 2
<b>00C4</b>	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
<b>0010</b>	ConfidenceThresLow	012C	R/W	Amplitude threshold for valid distance data
<b>0011</b>	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
<b>0199</b>	FlyingPixelFilterThres	0050	R/W	Depth threshold value to detect flying Pixel [mm]
<b>019A</b>	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
<b>01E5</b>	FilterSlafConfig	0005	R/W	Bit[0-7]: ...Window size
<b>01E7</b>	FilterFrameAverageConfig	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
<b>01E1</b>	FilterMedianConfig	0001	R/W	Bit[0-7]: ... Nr of Median Iterations

#### 1.5.2.6 Amplitude scaling

Addr (hex)	Register Name	Default Value (hex)	R/W	Description
<b>057B</b>	AmpScaleMin	0000	R/W	Lower boundary for 16bit to 8bit Amplitude Scaling
<b>057C</b>	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
<b>00FA</b>	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
<b>0240</b>	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
<b>0241</b>	Eth0Mac2	ACDE	R/W	Low byte and byte 1 of MAC address
<b>0242</b>	Eth0Mac1	4801	R/W	Byte 2 and byte 3 of MAC address
<b>0243</b>	Eth0Mac0	0203	R/W	Byte 4 and high byte of MAC address
<b>0244</b>	Eth0Ip0	000A	R/W	Low word of IP address
<b>0245</b>	Eth0Ip1	C0A8	R/W	High word of IP address
<b>0246</b>	Eth0Snm0	FF00	R/W	Low word of subnet mask
<b>0247</b>	Eth0Snm1	FFFF	R/W	High word of subnet mask
<b>0248</b>	Eth0Gateway0	0000	R/W	Low word of gateway
<b>0249</b>	Eth0Gateway1	0000	R/W	High word of gateway
<b>024D</b>	Eth0UdpStreamIp0	E000	R/W	Low word of IP address for UDP stream
<b>024D</b>	Eth0UdpStreamIp1	E000	R/W	High word of IP address for UDP stream
<b>024E</b>	Eth0UdpStreamPort	2712	R/W	Port for UDP streaming
<b>0259</b>	Eth0UdpPacketSize	0578	R/W	Packet size for UDP data interface
<b>025A</b>	Eth0LinkSpeed	03E8	R	Link speed [Mbps]

## 1.6.2 Shared memory

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

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Table 2-1: Revision history