Vision Stick™

FS-M2X4GMSL2 **USER GUIDE**

Revision History

Revision	Author	Release Date	Description of change
0.1	SJ	2025-10-17	Initial Release
0.2	SJ	2025-10-27	Added Connector locations diagram
0.3	SJ	2025-11-04	Added JTAG Adapter Card details
0.4	SJ	2025-11-11	Updated to match Rev 2 Pinout
0.5	ST	2025-12-10	Reviewed and updated in preparation for release
0.6	SJ	2025-12-13	Updated diagrams based on review feedback
0.7	ST	2025-12-15	Added introductory notes. Ready for draft document creation

Contents

Introduction

Thank you for purchasing the FS-M2X4GSML2 ("Vision Stick", "Device"). Before using the Device, be sure to carefully read this User Guide and fully understand how to correctly use the Device. Always keep this User Guide handy for reference.

SAFETY PRECAUTIONS, WARNINGS, AND DISCLAIMER

Observe and follow the precautions listed below to prevent injuries to you or other personnel or damage to property.

- **Before using the Device, read these safety precautions carefully to ensure proper use.**
- **These precautions contain serious safety instructions that must be followed.**
- **After reading through this manual, be sure to always keep it handy.**

The following conventions are used to indicate the possibility of injury/damage and classify precautions if the product is handled incorrectly.

	Indicates the possibility of death, injury, or damage to the unit and items connected to the device, if the product is handled incorrectly.

 WARNING

In the event of a failure, disconnect the power supply.
If the product is used as is, a fire or electric shock may occur. Disconnect the power supply immediately and contact our sales personnel for repair.

If an unpleasant smell or smoking occurs, disconnect the power supply.
If the product is used as is, a fire or electric shock may occur. Disconnect the power supply immediately. After verifying that no smoking is observed, contact our sales personnel for repair.

Do not disassemble, repair or modify the product.
Otherwise, a fire or electric shock may occur due to a short circuit or heat generation. For inspection, modification or repair, contact our sales personnel.

Do not touch a cooling fan.
As a cooling fan rotates in high speed, do not put your hand close to it. Otherwise, it may cause injury to persons. Never touch a rotating cooling fan.

Do not place the product on unstable locations.
Otherwise, it may drop or fall, resulting in injury to persons or failure.

If the product is dropped or damaged, do not use it as is.
Otherwise, a fire or electric shock may occur.

Do not touch the product with a metallic object.
Otherwise, a fire or electric shock may occur.

Do not place the product in dusty or humid locations or where water may splash.
Otherwise, a fire or electric shock may occur.

Do not get the product wet or touch it with a wet hand.
Otherwise, the product may break down or it may cause a fire, smoking or electric shock.

Do not touch a connector on the product.
Otherwise, the surface of a connector may be contaminated with sweat or skin oil, resulting in contact failure of a connector or it may cause a malfunction, fire or electric shock due to static electricity.

Do not use or place the product in the following locations.
- Locations that have condensing humidity
- Locations that are dusty
- Locations without appropriate airflow
- Locations exposed to oily smoke or steam
- Locations exposed to direct sunlight
- Locations close to heating equipment
- Locations without appropriate temperature control
- Locations close to water or chemicals
- Locations without appropriate Electrostatic Discharge (ESD) precautions

Otherwise, a fire, electric shock, accident or damage may occur due to a short circuit or heat generation.

Do not place heavy things on the product.
Otherwise, the product may be damaged.

DISCLAIMER

This Device is an evaluation unit intended for development of video data with computing systems. Only qualified personnel shall use this Device. Fidus Systems assumes no responsibility for any damages resulting from the use of this Device for purposes other than those stated.

Even if the Device is used properly, Fidus Systems assumes no responsibility for any damages caused by:

1. Earthquake, thunder, natural disaster or fire resulting from the use beyond our responsibility, acts by a third party or other accidents, the customer's willful or accidental misuse or use under other abnormal conditions.

2. Secondary impact arising from use of this unit or its unusable state (business interruption, injury, or others).

3. Use of this Device against the instructions given in this manual.

4. Malfunctions due to connection to other devices.

Fidus Systems assumes no responsibility or liability for:

1. Erasure or corruption of data arising from use of this Device.

2. Any consequences or other abnormalities arising from use of this Device, or,

3. Damage of this Device not due to our responsibility or failure due to modification.

This Device has been developed by assuming its use for research, testing or evaluation. It is not authorized for use in any system or application that requires high reliability or in which its use may impact safety.

Repair of this Device is carried out by replacing it on a chargeable basis (i.e., at the customer's expense), not repairing the faulty devices. However, non-chargeable replacement is offered for initial failure if such notification is received within two (2) weeks after delivery of the product.

Regarding associated software or FPGA code, i.e., the "Reference Design": Fidus Systems makes no guarantee of the quality or robustness of the Reference Design. Fidus is not required to support, maintain, or modify, the Reference Design beyond the initial release and the associated targeted tools and/or Operating System. The Reference Design is for reference and knowledge only and is not designed to be incorporated into any end product.

The specification of this Device is subject to change without prior notice.

The Device is subject to discontinuation without prior notice.

1.1 BACKGROUND

The FS-M2X4GMSL2 (Fidus Systems, M.2 w/ four (4) GMSL2 camera inputs) "Vision Stick" is designed to enable development, experimentation, and operation, in a variety of x86-based applications. Fundamentally, the Vision Stick is designed to enable a relatively low-cost, high value integration of GMSL2 cameras into the x86 ecosystem. An onboard AMD Artix UltraScale+ FPGA provides both Image Sensor Processing (ISP; mini-ISP from AMD) and bridging functionality (GMSL2-to-PCIe) enabling the x86 ingest. The Reference Design included enables Clients to modify or extend the functionality to their specific applications.

This solution is intended to help the Customer address needs in the following markets,

- **Industrial:** Enable the interfacing of various camera types to existing x86 industrial boards.
  i.e., Mini-ITX, Single Board Computer NUC's, mini PCs, etc.

- **Automotive:** Enable proof-of-concept and early development using generic AMD consumer and industrial boards

- **Security:** Multi-camera systems

- **General:** Research and development within various corporations, institutions, research entities, and others

The goal of this solution is to create a demonstration and developmental starting point for Client use and integration.

1.2 AUDIENCE

This document is targeted at the users of the Vision Stick.

1.3 SCOPE

This document describes how a user can operate the Vision Stick.

1.4 REFERENCE DOCUMENTS

Document Number	Description
ADI GMSL2 Specification	Analog Devices GMSL2 Channel Specification User Guide Revision 1.0, 10/23
PCI SIG Link	PCI Express M.2 Specification Rev 5.0, Version 1.0
TBD	AMD mini-ISP
Artix UltraScale+	AMD Artix UltraScale+ information

Description

The Fidus Vision Stick, M.2 compatible FPGA module is a high-performance development platform targeting GMSL-based camera operations, ISP, and other functions. The Device features a quad GMSL2 camera interface with Power-over-Coax capabilities, an M.2 PCIe interface, an SPI FLASH, and a programmable clock source. This board is ideal for GMSL camera operations, but can also be used for high-speed accelerator applications. The M.2 form factor and interface allows integration with various microprocessors and compute systems, as well as SSF and other expansion modules.

2.1 BOARD FEATURES

- FPGA: AMD Artix UltraScale+ (XCAU7P-2SBVC484I)
- FLASH: 128Mb QSPI
- CLOCK: 100MHz Fabric Clock
- PROGRAMMABLE CLOCKING: I2C controlled programmable clock (optional)
- GMSL: 4x GMSL2 Camera Input Interfaces
- POWER-OVER-COAX: Max 600mA per GMSL interface from dedicated connector
- M.2 INTERFACE: PCIe Gen3 x4
- FORM FACTOR: M.2 2280, M-Key
- VISUAL INDICATORS: 1x RGB

2.2 APPLICATIONS

- Up to 4x GMSL2 Cameras (5Mpix, 30fps)
- Industrial
- Automotive
- Security
- Various Edge Computing
- R&D

2.3 ARCHITECTURE

The following diagram depicts the high-level architecture of the Vision Stick.
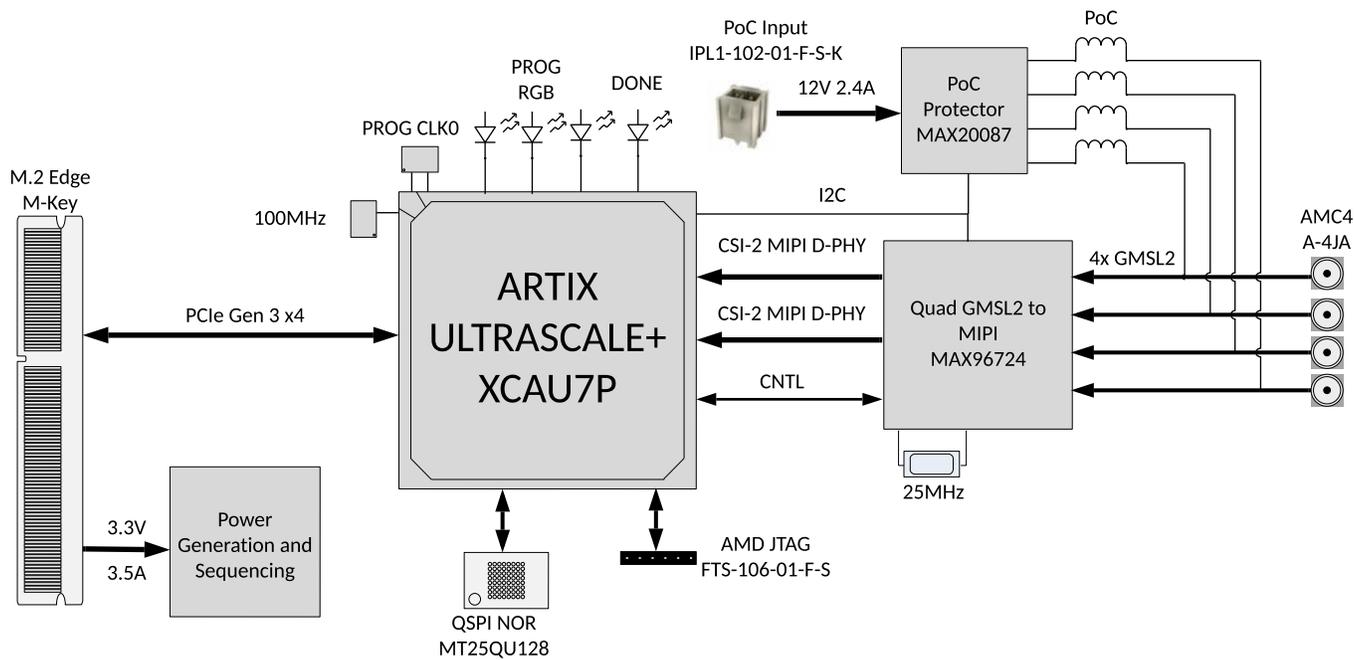
Usage

3.1 HARDWARE AND ACCESSORIES REQUIRED

- Fidus Vision Stick (PA-10956-01)

- Fidus JTAG Adapter Card (PA-100966-01)

- AMD Platform Cable USB II (HW-USB-II-G) or equivalent

  – Must support AMD's standard 2x7 JTAG connector

- Cables, AMC4-to-FAKRA

  – Tested with Amphenol, 150mm cable

- GMSL2 Camera(s)

  – Tested with and developed for Quanta HZKJ-1/2/3 (Sony IMX728)

  – Other cameras may be supported in the future. For more information, contact Fidus prior to ordering.

- Processor board that supports an M.2, 2280, M-Key, PCIe Gen3 x4 device

  – System airflow is recommended

3.2 CONNECTIVITY

The below diagram shows the connection points for the various interfaces on the Vision Stick.
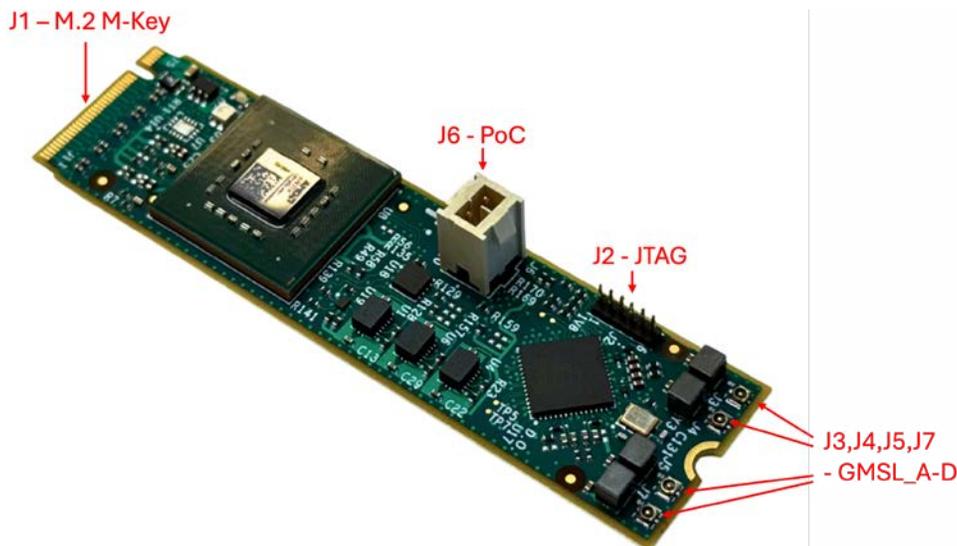
3.2.1 JTAG Connector

Due to size constraints, rather than placing the AMD standard 2x7 JTAG header onboard, the Vision Stick utilizes a 6-pin, 0.5mm pitch header (Samtec, FTS-106-01-F-S) for JTAG-based programming and debug of the FPGA and the non-volatile QSPI memory that stores the FPGA programming load.

Signal	Connector Pin	Description
1V8	J2.1	1.8V Power for Programmer
TDI	J2.2	JTAG Test Data In
TCK	J2.3	JTAG Test Clock
TMS	J2.4	JTAG Test Mode Select
GND	J2.5	Ground
TDO	J2.6	JTAG Test Data Out

3.2.1.1 JTAG Adapter Card

Due to the fine pitch of the JTAG connector (Samtec, FTS-106-01-F-S), Fidus offers a custom adapter card (PA-100966-01) to enable support for the AMD's standard 2x7 JTAG connector. The 2x7 JTAG connector is keyed, however, the onboard 6-pin connector is not keyed. Please ensure the orientation of the card is correct. Pin 1 of the adapter card connector J2 must be aligned and connected to pin 1 of J2 on the main PCB.

WARNING

Warning: Connecting the JTAG Adapter Card in reverse may result in damage to the Vision Stick and/or other connected devices.
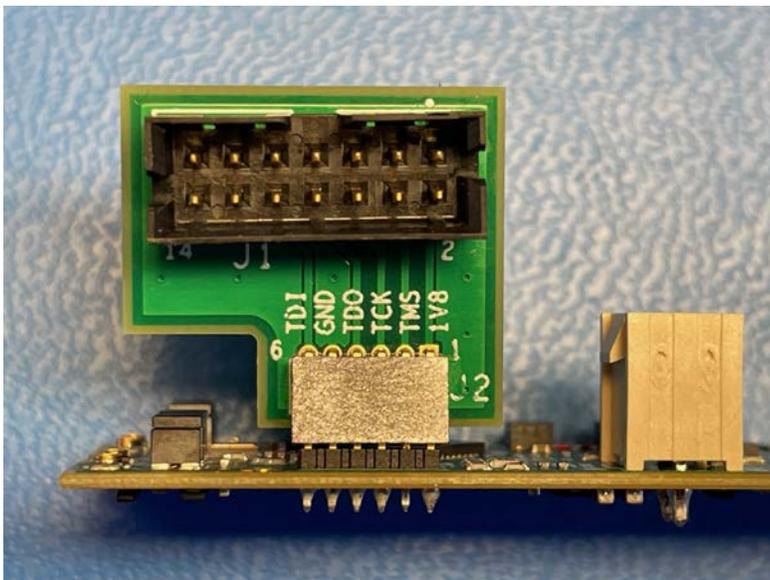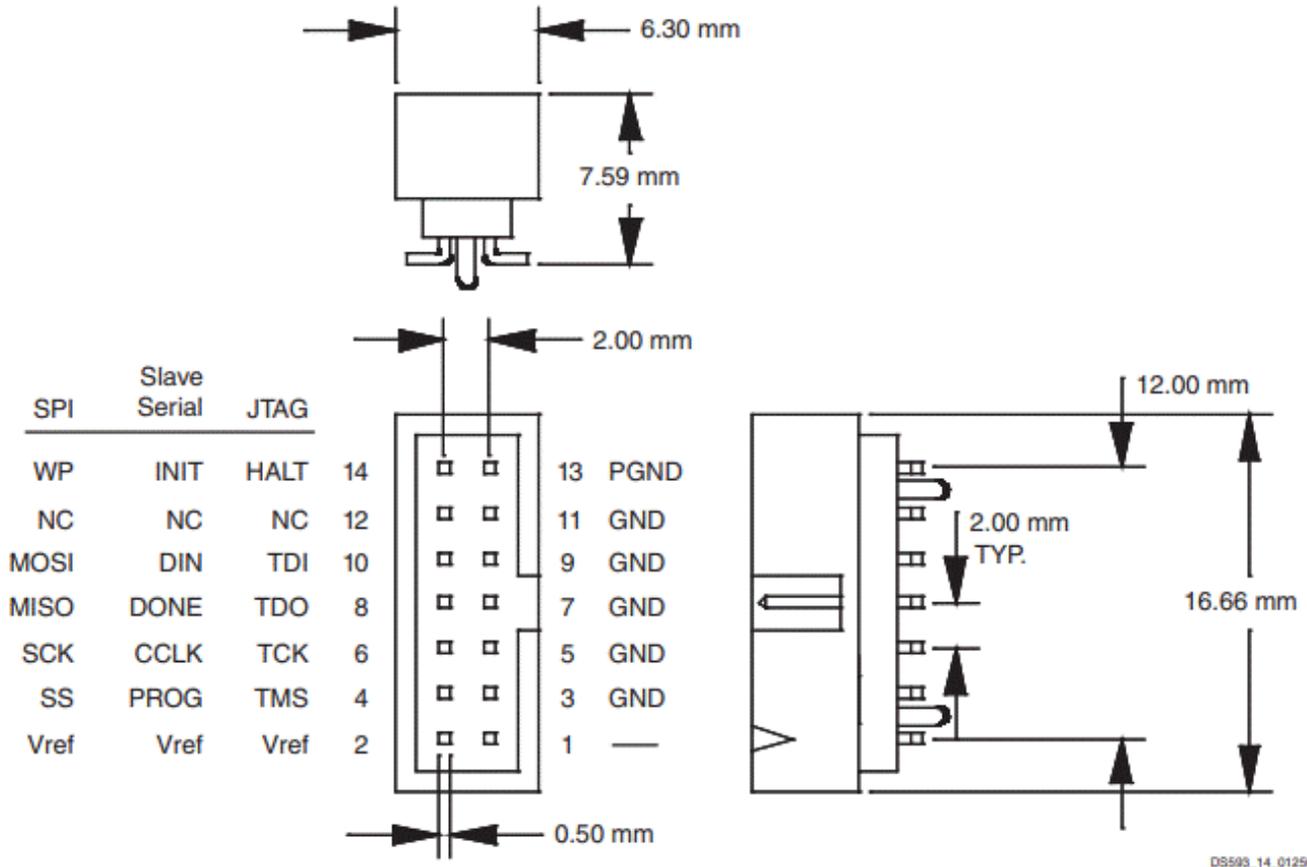
Figure 14: **Target Interface Connector Dimensions and Signal Assignments**

3.2.2 POWER-OVER-COAX INPUT POWER CONNECTOR

The 2-pin, keyed, dedicated input power connector (Samtec, IPL-102-01-F-S-K) allows the User to leverage power-over-coax functionality to power their selected camera using the appropriate (camera defined) voltage ranging from +3VDC to +16VDC.
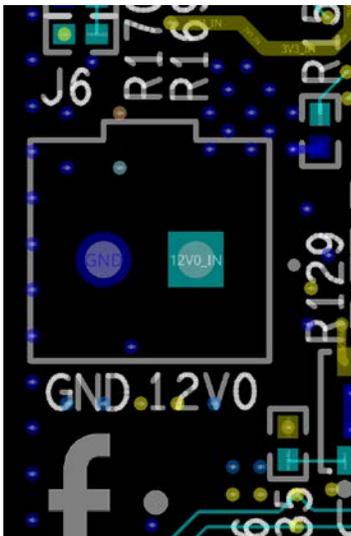
 WARNING

Warning

- Applying voltage outside of the specified range above may result in damage to the Vision Stick and/or other connected devices.

- Always ensure the correct polarity. Incorrect polarity may result in damage to the Vision Stick and/or other connected devices.

- It is the responsibility of the User to ensure that the power cable is of appropriate gauge to support their application.

Signal	Connector Pin	Description
12V0_IN	J6.1	Camera power input
GND	J6.2	Ground

3.2.3 GMSL CONNECTORS

Connectors J3, J4, J5 and J6 are the input connections and power-over-coax connections to the 4x GMSL cameras. (Amphenol, A-4JA). All connectors are equivalent, i.e., any combination of connector use is valid.

Signal	Connector Pin	Description
GMSL_A	J3.1	GMSL Input from and PoC to Camera A
GMSL_B	J4.1	GMSL Input from and PoC to Camera B
GMSL_C	J5.1	GMSL Input from and PoC to Camera C
GMSL_D	J7.1	GMSL Input from and PoC to Camera D

3.2.3 M.2 EDGE CONNECTOR

Connector J1 is the standard M.2 edge connector with the M-key. Detailed signals as well as FPGA connections are described below in Section 3.9

3.3 POWER

The Vision Stick is solely powered by the M.2 Connector. The cameras are solely powered by the power connector via power-over-coax. The M.2 standard inputs +3.3VDC @ 3.5A maximum. Being an FPGA-based device, the actual power requirements of the Vision Stick is dependent on the User's application.

WARNING

Warning: Do not allow your FPGA program to exceed the M.2 power limits and always monitor the Vision Stick FPGA temperature. As a small form factor device, even with the heatsink, the Vision stick is very limited in the amount of power it can safely dissipate. The User is responsible for ensure that the Vision Stick does not over-heat (the power at which this occurs will be based on the User's airflow).

3.4 FLASH

The Vision Stick has 128Mb of 1.8V QSPI FLASH for non-volatile program storage. This is the default boot device for the FPGA.

3.5 CLOCKING

The PCBA includes a 100MHz fabric clock and an optional dual-output programmable clock. The clocking architecture is depicted below.
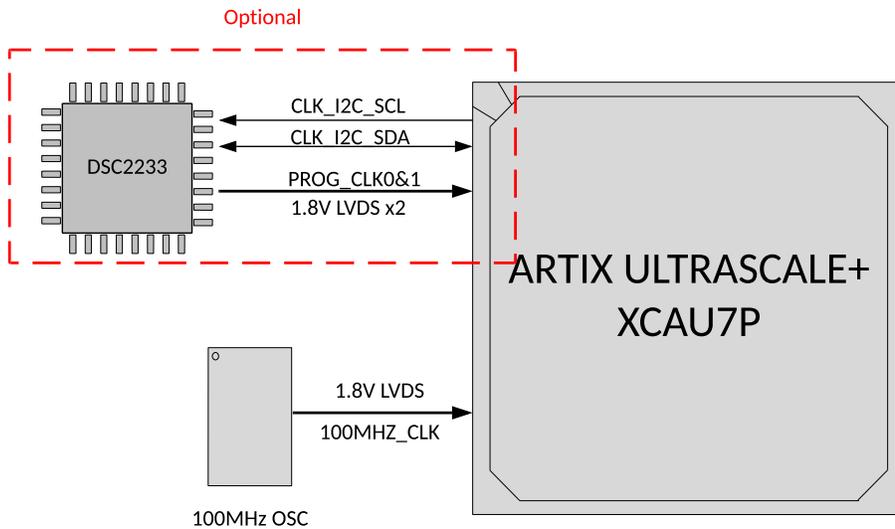
Note: The optional programmable clock is not populated unless variant Vision stick card is purchased

3.5.1 FABRIC CLOCK
The PCBA includes a 100MHz fabric clock.

Signal	FPGA Pin	Description
100MHZ_CLK_P	K16	1.8V LVDS, Positive
100MHZ_CLK_N	J17	1.8V LVDS, Negative

3.5.2 PROGRAMMABLE CLOCKING (OPTIONAL)
The PCBA includes a programmable dual output clock. Using an I2C interface, the output frequency can be set from 2.3 to 460MHz.

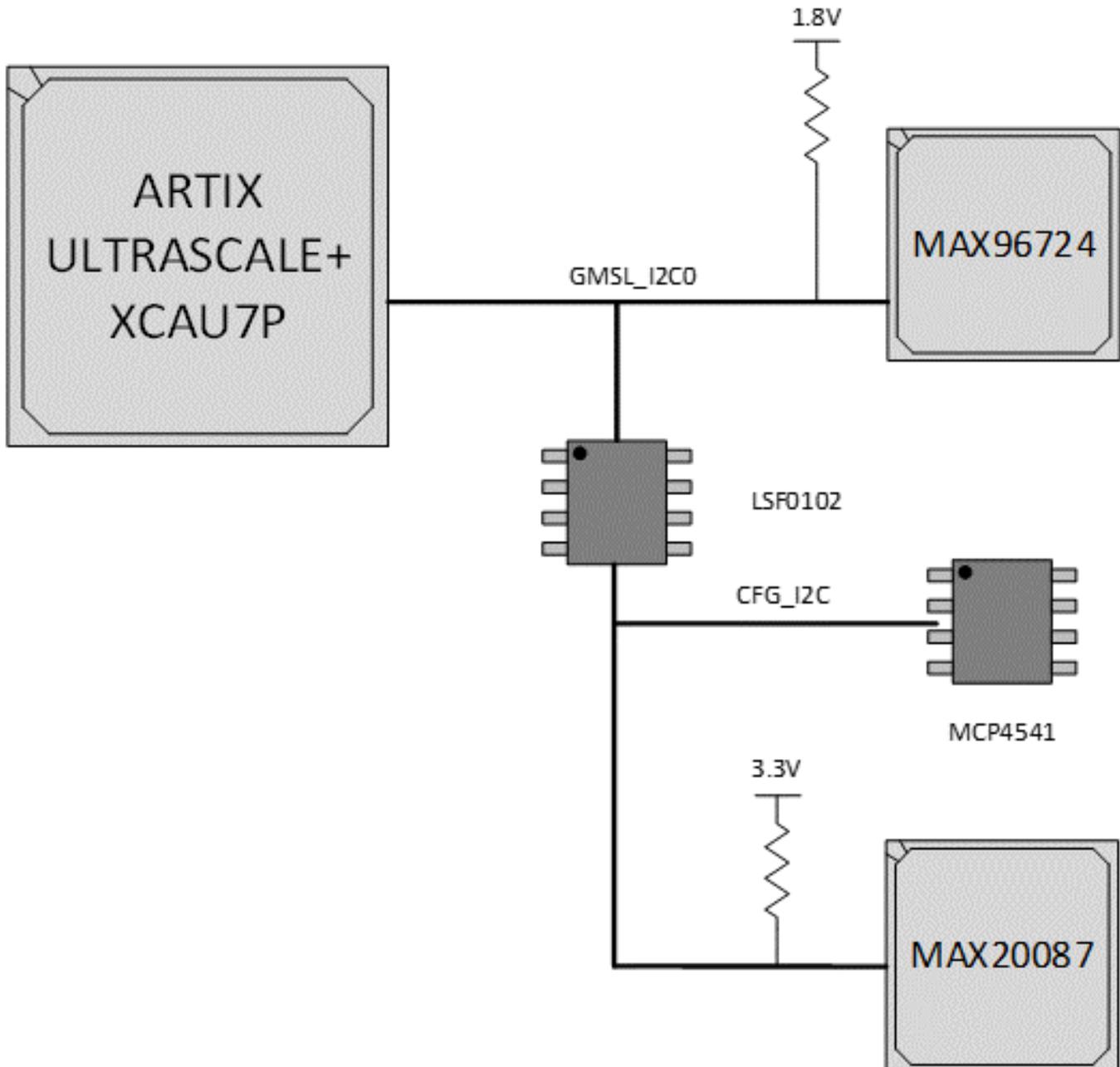| Signal	FPGA Pin	Description
PROG_CLK0_P	L20	LVDS Programmable Clock 0
PROG_CLK0_N	K20	
PROG_CLK1_P	M18	LVDS Programmable Clock 1
PROG_CLK1_N	M19	
CLK_I2C_SCL	AB9	I2C Clock
CLK_I2C_SDA	AB10	I2C Data

3.6 MIPI /GMSL INTERFACE

The GMSL interface allows cameras capable of GMSL2 signaling to communicate with the FPGA. However, since the FPGA does not natively support GMSL signaling, a GMSL2 to MIPI de-serializer is used. The device U17 ([ADI, MAX96724](#)) adapts the GMSL signaling to 2x 4-lane MIPI D-PHY interface. This de-serializer also includes an I2C bus for configuration and control as well as some GPIO signals. The MIPI interface is assigned to Bank 66 of the FPGA.

Signal	FPGA Pin	Description
MIPI_DB3_P	E13	MIPI Data Bus B Lane 3
MIPI_DB3_N	D13	
MIPI_DB2_P	F13	MIPI Data Bus B Lane 2
MIPI_DB2_N	E14	
MIPI_DB1_P	E15	MIPI Data Bus B Lane 1
MIPI_DB1_N	E16	
MIPI_DB0_P	C14	MIPI Data Bus B Lane 0
MIPI_DB0_N	C15	
MIPI_CLKB_P	B14	MIPI Data Bus B Clock
MIPI_CLKB_N	B15	
MIPI_DA3_P	C10	MIPI Data Bus A Lane 3
MIPI_DA3_N	B10	
MIPI_DA2_P	D11	MIPI Data Bus A Lane 2
MIPI_DA2_N	C11	
MIPI_DA1_P	E11	MIPI Data Bus A Lane 1
MIPI_DA1_N	D12	
MIPI_DA0_P	F11	MIPI Data Bus A Lane 0
MIPI_DA0_N	F12	
MIPI_CLKA_P	B12	MIPI Data Bus A Clock
MIPI_CLKA_N	A12	
MIPI_GPIO0	A3	MAX96724 GPIO0
MIPI_GPIO1	A2	MAX96724 GPIO1
MIPI_GPIO2	B3	MAX96724 GPIO2
MIPI_GPIO3	B2	MAX96724 GPIO3
MIPI_MFP4_LOCK	C4	MAX96724 Lock
MIPI_MFP5_ERR_B	B4	MAX96724 Error (Neg logic)
MIPI_FPGA_PWDN_B	C5	MAX96724 Power down (Neg logic)
GMSL_POC_EN	J1	MAX20087 Enable
GMSL_POC_INT_B	J2	MAX20087 Interrupt (Neg logic)

3.7 GMSL I2C INTERFACE

The GMSL/MIPI De-serializer (ADI, MAX96724), a Power-over-Coax Protection device (ADI, MAX20087), and a digital potentiometer (Microchip, MCP4541) that can be used to control the GMSL Mode are connected to an i2c interface mastered by the FPGA. A voltage translator (TI, LFS0102) is used to meet the signaling level needs of the different i2c devices.

3.7.1 FPGA PINS

Signal	FPGA Pin	Description
GMSL_SCL0	A5	GMSL I2C Clock
GMSL_SDA0	B5	GMSL I2C Data

3.7.2 I2C ADDRESS

Device	I2C Address	Description
ADI, MAX96724 (U17)	0x4E	GMSL2 De-serializer
ADI, MAX20087 (U20)	0x50/51	PoC Protection Switch
Microchip, MCP4541 (U18)	0x5C/5D	GMSL2 Potentiometer

The GMSL Mode on the GMSL2 De-serializer is configurable using the MCP4541, a 100kohm digital potentiometer. See below table for resistance settings required.

CFG1/MFP6 INPUT VOLTAGE (PERCENTAGE of V_{DDIO}) (NOTES a, b)			SUGGESTED RESISTOR VALUES (±1% TOLERANCE) (NOTE c)		MAPPED CONFIGURATION (NOTE d)				
MIN	TYP	MAX	R1 (Ω)	R2 (Ω)	CX/ STP	GMSL1/ GMSL2		MAX96724	MAX96724F/R
0.0%	0.0%	11.7%	OPEN	10000	COAX	GMSL2		6Gbps	3Gbps
16.9%	20.2%	23.6%	80600	20500	COAX	GMSL2		3Gbps	3Gbps
28.8%	32.1%	35.5%	68100	32400	COAX	GMSL1		HIM Disabled	HIM Disabled
40.7%	44.0%	47.9%	56200	44200	STP	GMSL2		6Gbps	3Gbps
52.6%	56.0%	59.3%	44200	56200	STP	GMSL2		3Gbps	3Gbps
64.5%	67.9%	71.2%	32400	68100	STP	GMSL1		HIM Enabled	HIM Enabled

3.8 POWER-OVER COAX (POC)

The Power-over-Coax interface takes an input voltage on connector J6 (IPL1-102-01-F-S-K) and outputs it on the GMSL outputs. The input voltage can range from 3 to 16V. As per the over-current protection device, each GMSL interface is designed to source up to 600mA at 85deg C. For a total of 2.4A at the input connector. The associated current and voltage protection device ADI, MAX20087 (U20) is connected to the i2c bus defined above.

⚠️ **WARNING**

Warning: Exceeding 2.4A and/or operating outside of the stated voltage range on the PoC system can result in damage to the Vision Stick and/or the other connected devices.

3.9 M.2 EDGE CONNECTOR

The M.2 M-Key edge connector provides power, an SMB interface, and a PCIe x4 link from the motherboard to the Vision Stick. The M.2 signaling is connected to the FPGA as per the table below.

M.2 Pin	Signal Name	FPGA Pin
55	M2_CLK_P	AA17
53	M2_CLK_N	AA18
49	M2_RX0_P	AA21
47	M2_RX0_N	AA22
43	M2_TX0_P	AB19
41	M2_TX0_N	AB20
37	M2_RX1_P	W21
35	M2_RX1_N	W22
31	M2_TX1_P	Y19
29	M2_TX1_N	Y20
25	M2_RX2_P	U21
23	M2_RX2_N	U22
19	M2_TX2_P	V19
17	M2_TX2_N	V20
13	M2_RX3_P	R21
11	M2_RX3_N	R22
7	M2_TX3_P	T19
5	M2_TX3_N	T20
50	M2_PERST_B	AB5
52	M2_CLKREQ_B	AB4
54	M2_WAKE_B	AB3
40	SMB_CLK	AB15
42	SMB_DATA	AB14

3.10 DONE LED

The Vision Stick includes a RED LED to indicate that programming of the FPGA is "DONE". Note: To save power, the circuit is designed such that the LED is lit by default and then turns off when FPGA programming has been successfully completed.
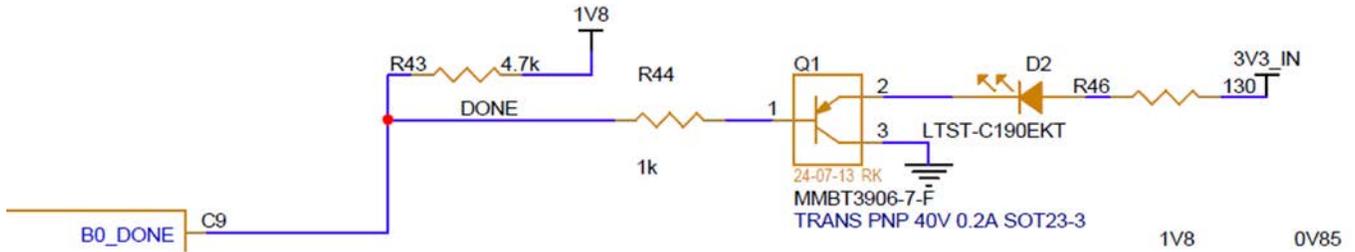
3.11 RGB LED

The Vision Stick includes a programmable tri-color (RGB) LED (Broadcom, ASMB-LTD3-0C3F3). In the standard configuration, the Green LED indicates the GMSL Lock status, the Red LED indicates GMSL ERROR status. The Blue LED is readily available for custom programming. That said, all LEDs can be used for User-defined custom purposes.

Mechanical

4.1 MECHANICAL DIMENSIONS

The Vision Stick is a M.2, 2280 form factor PCBA, 0.8 mm thick (nom), D8 height restriction, and M keying. Please refer to both the drawing below and for further information, the reference documentation.

4.2 THERMAL CONSIDERATIONS

The Vision Stick includes a passive heat-sink attached to the AMD Artix UltraScale+ (XCAU7P-2SBVC484I). If programmed with additional FPGA functionality, the heat load may reach damaging levels. The User is responsible for ensuring that their custom FPGA programming does not exceed temperature limits.

WARNING

Warning: Exceeding temperature limits may damage Vision Stick and/or other devices. As the User may choose to program the Vision Stick with their proprietary FPGA load or support various PoC cameras, the User is responsible for ensuring that the power consumption and operating temperatures are never exceeded.

Environment

Specification	By Design	Tested
Operating Temperature Range	-40 to +55C	Room Temperature (~23C)
Storage Temperature Range	-40 to +55C	N/A
Shock/Vibe	N/A	N/A

Note: All components are Industrial rated.

Reference Design

The included Reference Design demonstrates the use of Vision Stick to ingest up to four (4) cameras worth of video, apply an example image sensor processing, and then transfer this data over to the x86 based system for Display. The Reference Design consists of:

- A Linux-based GUI for control of the programmable devices and the display of the received video. Source and binary are available.

- An AMD Vivado (enter version) code base that enables the GUI functionality. Source and binary are available, but some may be obfuscated due to ownership rights.

Note 1: The Reference Design was demonstrated on a Beelink SER5 miniPC using Linux, featuring an AMD Ryzen Processor. The previously identified Quanta cameras were used.

Note 2: Future development work and demonstrations are being undertaken on the Sapphire Edge AI miniPC.

For our demonstration purposes, Fidus created the following mechanical "collar" to enable robust integration into these platforms.

Warranty

This device is intended for developmental use only. As such, the Warranty is limited to defects in craftsmanship upon initial delivery only.

 WARNING

Warning: This device was not designed for in-vehicle (e.g., in-car) use or any application where its use may impact Safety. Vision Stick and its related accessories are for developmental and demonstration purposes only. Use is at the sole responsibility, liability, and discretion of the end User.

Support

Please contact Fidus Systems for purchasing, pre-purchases questions, or any concerns regarding compatibility.

Contact: design@fidus.com

Appendix A

A.1 Acronyms	
BoM	Bill of Materials
CLK	Clock
CS	Chip Select
CSI(-2)	Camera Serial Interface. As in MIPI CSI-2.
EEPROM	Electrically Erasable Programmable Read-Only Memory
FPGA	Field-Programmable Gate Array
GB	Gigabyte
Gb	Gigabit
Gbps	Gigabit per second
GMSL	Gigabit Multimedia Serial Link. Where appropriate, GMSL2 and GMSL3 refer to the newer versions of the Specification.
GPI	General Purpose Input
GPIO	General Purpose Input/Output
GPO	General Purpose Output
JTAG	Joint Test Action Group (programming interface)
LED	Light Emitting Diode
Mbps	Megabits per second
MHz	Megahertz
MIPI	Mobile Industry Processor Interface
ms	Millisecond
NC	No Connection
PCB	Printed Circuit Board (bare)
PCBA	Printed Circuit Board Assembly
PCIe	Peripheral Component Interconnect Express
PoC	Power Over Coax
RAM	Random Access Memory
SoC	System-on-Chip

ABOUT FIDUS

Fidus Systems, founded in 2001, specializes in leading-edge electronic product development with offices in Ottawa and Waterloo, Ontario, and San Jose, California. Our hardware, software, FPGA, verification, wireless, mechanical, and signal integrity teams work to innovate, design, and deliver next-generation products for customers in emerging technology markets. Fueled by 20+ years' experience and creativity, along with our collaborative and process-driven approach, we turn complex challenges into well-designed solutions. And with over 400 customers and 4000+ completed projects, we have the expertise to be a seamless extension of your team, providing a clear focus and commitment to getting designs and prototypes to market faster. Once you start working with us, you'll trust us like one of your own. Our hallmark is transparency. Our guiding principle is first time right.

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innovate·design·deliver

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