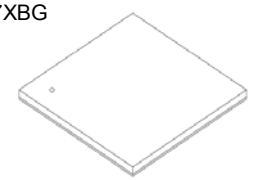
CMOS Digital Integrated Circuit Silicon Monolithic

TC358867XBG

Mobile Peripheral Devices

TC358867XBG



P-VFBGA80-0707-0.65-001
Weight: 76mg (Typ.)

Overview

TC358867XBG is a bridge device that enables video streaming from a Host (application or baseband processor) over MIPI® DSI or DPI link to drive DisplayPort™ display panels. TC358867XBG also supports audio streaming from the host via I2S interface to the Display panels. TC358867XBG provides a low power bridge solution to efficiently translate MIPI® DSI or DPI transfers to DisplayPort™ transfers. As the DisplayPort™ uses fewer wires compared to other existing display panel standards, it simplifies the LCD connectivity. The effect of using TC358867XBG is to enable existing baseband devices supporting DSI or DPI streaming to connect to new panels supporting DisplayPort™ interface and also to connect to existing panels over longer distance using DisplayPort™ adaptors at far-end.

Features

- Translates MIPI® DSI/DPI Link video stream from Host to DisplayPort™ Link data to external display devices.
- The inputs are driven by a DSI Host with 4-Data Lanes, upto1 Gbps/lane or DPI Host with 16/18/24 bit interface upto154 MHz parallel clock.
- (Optional) Supports HDCP Digital Content Protection version 1.3 (DisplayPort™ amendment Rev1.1).
- Embeds audio information from the I2S port into the DisplayPort™ data stream.
- The output Interface consists of a DisplayPort™ Tx with a 2-lane Main Link and AUX-Ch.
- Register Configuration**:** From DSI link or I²C interface.
- Interrupt to host to inform any error status or status needing attention from Host.
- Internal test pattern (color bar) generator for DP o/p testing without any video (DSI/DPI) i/p.
- Debug/Test Port**:** I²C Slave
- **DSI Receiver**
  - ✧ MIPI® DSI**:** v1.01 / MIPI® D-PHY**:** v0.90 Compliant.
  - ✧ Up to four (4) Data Lanes with Bi-direction support on Data Lane 0.
  - ✧ Maximum speed at 1 Gbps/lane.
  - ✧ Supports Burst as well as Non-Burst Mode Video Data.
    - Video data packets are limited to one row per Hsync period.
  - ✧ Supports video stream packets for video data transmission.
  - ✧ Supports generic long packets for accessing the chip's register set.
  - ✧ Video input data formats:
    - RGB-565, RGB-666 and RGB-888.
    - New DSI V1.02 Data Type Support**:** 16-bit YCbCr 422
  - ✧ Interlaced video mode is not supported.
- **DPI Receiver**
  - ✧ Up to 16 / 18 / 24 bit parallel data interface.
  - ✧ Maximum speed at 154 MPs (Mpixel per sec).
  - ✧ Video input data formats**:** RGB-565, RGB-666 and RGB-888.
  - ✧ Only Progressive mode supported.
- **I2S Audio Interface:** Supports one I2S port for audio streaming from the host to TC358867XBG.
  - ✧ Supports slave mode (BCLK, LRCLK & over-sampling clock input from Host).
  - ✧ Supports sampling frequencies of 32, 44.1, 48, 88.2, 96, 176.4 & 192 kHz.
  - ✧ Supports up to 2 audio channels.
  - ✧ Supports 16, 18, 20 or 24bits per sample.
  - ✧ Optionally inserts IEC60958 status bits and preamble bits per channel.
- **DisplayPort™ Interface:** Supports a DisplayPort™ link from TC358867XBG to display panels.
  - ✧ High speed serial bridge chip using VESA® DisplayPort™ 1.1a Standard.
  - ✧ Supports one dual-lane DisplayPort™ port for high bandwidth applications
  - ✧ Support 1.62 or 2.7 Gbps/lane data rate with voltage swings @0.4, 0.6, 0.8 or 1.2 V
  - ✧ Support of pre-emphasis levels of 0, 3.5dB and 6dB.

- ✧ Supports Audio related Secondary Data Packets.
- ✧ AUX channel supported at 1 Mbps.
- ✧ HPD support through GPIO based interrupts
- ✧ Enhanced mode supported for content protection.
- ✧ (Optional) Support HDCP encryption Version 1.3 with DisplayPort™ amendment Revision 1.1.
- ✧ Secure ASSR (Alternate Scrambler Seed Reset) support.
- ✧ Stream Policy Maker is assumed handled by the Host (software/firmware).
  - Start Link training in response to HPD & read final Link training status
  - Configure DP link for actual video streaming & start video streaming
- ✧ Link Policy maker is assumed shared between the Host and TC358867XBG chip.
  - In auto_correction = 0 mode, control link training
  - Initiate Display device capabilities read and configure TC358867XBG accordingly.
- ✧ Video timing generation as per panel requirement.
- ✧ SSCG with to 30 kHz modulation to reduce EMI.
- ✧ Built in PRBS7 Generator to test DisplayPort™ Link.

- **RGB Parallel Output Interface:**
  - ✧ RGB888 output (DisplayPort™ disabled) with only DSI input supported in this mode
  - ✧ PCLK max. = 100 MHz
  - ✧ Polarity control for PCLK, VSYNC, HSYNC & DE
- **I²C Interface:**
  - ✧ I²C slave interface for chip register set access enabled using a boot-strap option.
  - ✧ I²C compliant slave interface support for normal (100 kHz) and fast mode (400 kHz).
- **GPIO Interface:**
  - ✧ 2 bits of GPIO (shared with other digital logic).
  - ✧ Direction controllable by Host I²C accesses.
- **Clock Source:**
  - ✧ DisplayPort™ clock source is from an external clock input or clock from DSI interface (13, 26, 19.2 or 38.4 MHz) – generates all internal & output clocks to interfacing display devices.
  - ✧ Built-in PLLs generate high-speed DisplayPort™ link clock requiring no external components. These PLLs are part of the DisplayPort™ PHY.
- Clock and power management support to achieve low power states.
- **Possible modes of Operation:**
  - ✧ MODE S21**:** TC358867XBG uses DisplayPort™ Tx as single 2-lane DisplayPort™ link to interface to single DisplayPort™ display device. Video stream source is from MIPI® DSI Host.
  - ✧ MODE P21**:** TC358867XBG uses DisplayPort™ Tx as single 2-lane DisplayPort™ link to interface to single DisplayPort™ display device. Video stream source is from MIPI® DPI Host.
  - ✧ MODE S2P**:** TC358867XBG uses only Parallel output port and disables DisplayPort™ Tx to interface to single RGB display device. Video stream source is from MIPI® DSI Host.
- **Power supply inputs**
  - ✧ Core and MIPI® D-PHY**:** 1.2 V ± 0.06 V
  - ✧ Digital I/O**:** 1.8 V ± 0.09 V
  - ✧ DisplayPort™**:** 1.8 V ± 0.09 V
  - ✧ DisplayPort™**:** 1.2 V ± 0.06 V
- **Power Consumptions (Typical value based on estimations)**
  - ✧ Power-down mode (DSI-Rx in ULPS, DP PHY & PLLs disabled, clocks stopped)**:**
    - DSI Rx**:** 0.01 mW
    - DP PHY**:** 2.34 mW
    - PLL9**:** 0.01 mW
    - Core**:** 0.96 mW
    - Rest**:** 0.01 mW
  - ✧ Normal operation (1920 × 1080 resolution with DSI-Rx in 4-lane @925 Mbps per lane, DP PHY in dual lane link @2.7 Gbps per lane)**:**
    - DSI Rx**:** 21.79 mW
    - DP PHY**:** 142.70 mW
    - PLL9**:** 2.42 mW
    - Core**:** 87.64 mW
    - IOs**:** 1.68 mW
- **Package**
  - 0.65mm ball pitch, 80 balls, 7 × 7 mm BGA package

Table of contents

Table of Figures

List of Tables

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REFERENCES

1. MIPI® DSI, "MIPI® Alliance Specification for DSI Version 1.01.00 - 21 February 2008"
2. MIPI® DPI, “MIPI Alliance Standard for Display Pixel Interface (DPI-2) Version 2.00 – 15 September 2005”
3. MIPI® D-PHY, “DRAFT MIPI® Alliance Specification for D-PHY Version 0.91.00 – r0.01 14-March-2008"
4. VESA® DisplayPort™ Standard (Version 1, Revision 1A January 11, 2008)
5. VESA® embedded DisplayPort™ (eDP) Standard (Version 1.1 October 23, 2009)
6. Digital Content Protection LLC, HDCP (Version 1.3 with DisplayPort™ amendment Revision 1.1, Jan. 15 2010)
7. I^2C bus specification, version 2.1, January 2000, Philips Semiconductor
8. Draft CEA-861-C, A DTV Profile for Uncompressed High Speed Digital Interfaces (Doc. Number: CEA-861rCv9.pdf (PNXXX)) Date: 05/04/2005
9. DisplayPort™ PHY DFT Strategy Specification Rev 1.3

1. Overview

The DSI/DPI to DisplayPort™ converter (TC358867XBG) is a bridge device that enables video streaming from a Host (application or baseband processor) over MIPI® DSI or DPI link to drive DisplayPort™ display panels. TC358867XBG also supports audio streaming from the host via I2S interface to the Display panels. TC358867XBG provides a low power bridge solution to efficiently translate MIPI® DSI or DPI transfers to DisplayPort™ transfers. As the DisplayPort™ uses fewer wires compared to other existing display panel standards, it simplifies the LCD connectivity. The effect of using TC358867XBG is to enable existing baseband devices supporting DSI or DPI streaming to connect to new panels supporting DisplayPort™ interface and also to connect to existing panels over longer distance using DisplayPort™ adaptors at far-end.

The chip can be configured through the DSI link by sending write/read register commands through DSI Generic Long Write packets. It can also be configured through the I^2C Slave interface.

The DSI-RX receiver supports from 1 to 4-Lane configurations at bit rate up to 1 Gbps per lane. Host can transmit video in continuous video streaming mode. Host controls video timing by sending video frame and line sync events together with video pixel data; video data transmission can be burst or non-burst. Since the chip integrates only a small video buffer, Host still has to take care of transmitting pixel data at appropriate video line time in order to avoid buffer overflow (or underflow).

The DPI-Rx receiver supports 16, 18 or 24 bits parallel interface along with the required control signals for the Pixel clock and HSync/VSync/DE.

The TC358867XBG also supports content protection using HDCP copy protection(Optional).

The DisplayPort™ transmitter supports data throughput at 1.62 Gbps or 2.7 Gbps per lane of main link.

TC358867XBG supports three configuration modes. These modes mainly differ based on the source of input stream and output interface..

- Mode_S21**:** A system configuration where TC358867XBG may typically be used is shown in Figure 1.1. In this configuration, the TC358867XBG can support displays with resolution up to WUXGA (1920×1200) at 24bit, 60 fps or WUXGA (1920×1200) at 18bit, 60 fps. Video stream source is from DSI Host.

- Mode_P21**:** A system configuration where TC358867XBG may typically be used is shown in Figure 1.2. This is similar to the Mode_S21 except that the video stream source is from DPI Host. In this configuration, the TC358867XBG can support displays with resolution up to WUXGA (1920×1200) at 24bit, 60 fps.

- Mode_S2P**:** A system configuration where TC358867XBG may typically be used is shown in Figure 1.3. In this mode, DisplayPort™ output is not used and the chip rather behaves as a DSI to RGB convertor. In this system, TC358867XBG could be connected to a single display. In this configuration, the TC358867XBG can support displays with resolution up to WXGA (1280x800 or 1366x768). Maximum output PCLK is 100MHz. Video stream source is from DSI Host.

The chip supports power management to conserve power when its functions are not in use. Host manages the chip's power consumption modes by using ULPS messages over DSI link during DPI input mode.

The following figures show all these modes, where TC358867XBG, display panels and a Host are connected in target Reference system for mobile large display panel applications.

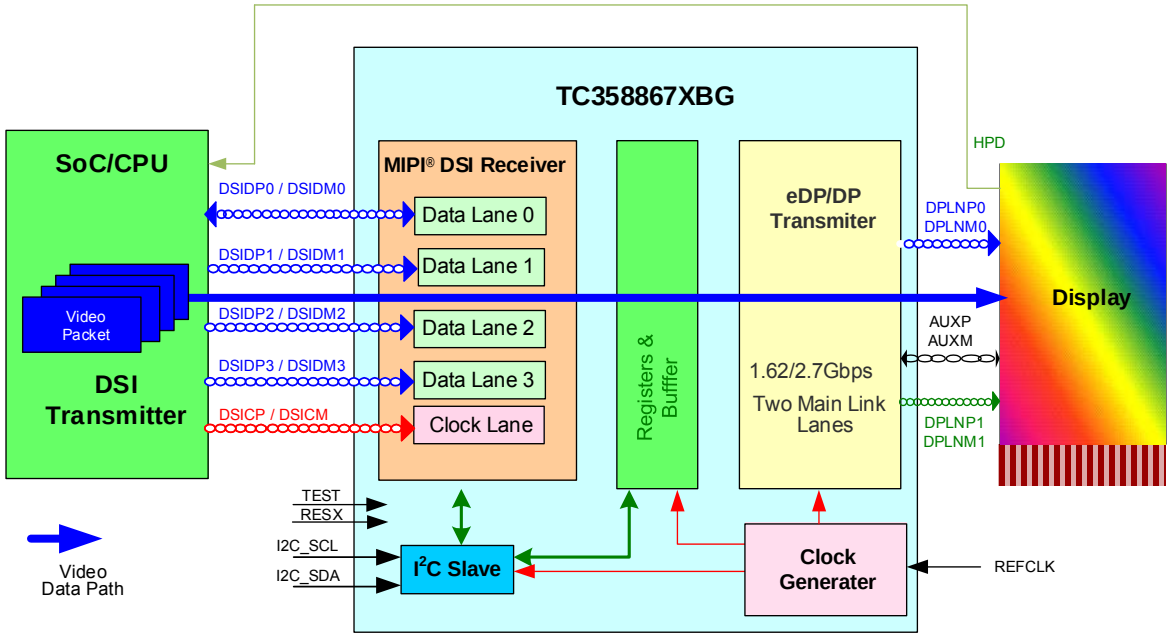


Figure 1.1 System Overview with TC358867XBG in MODE_S21 Configuration

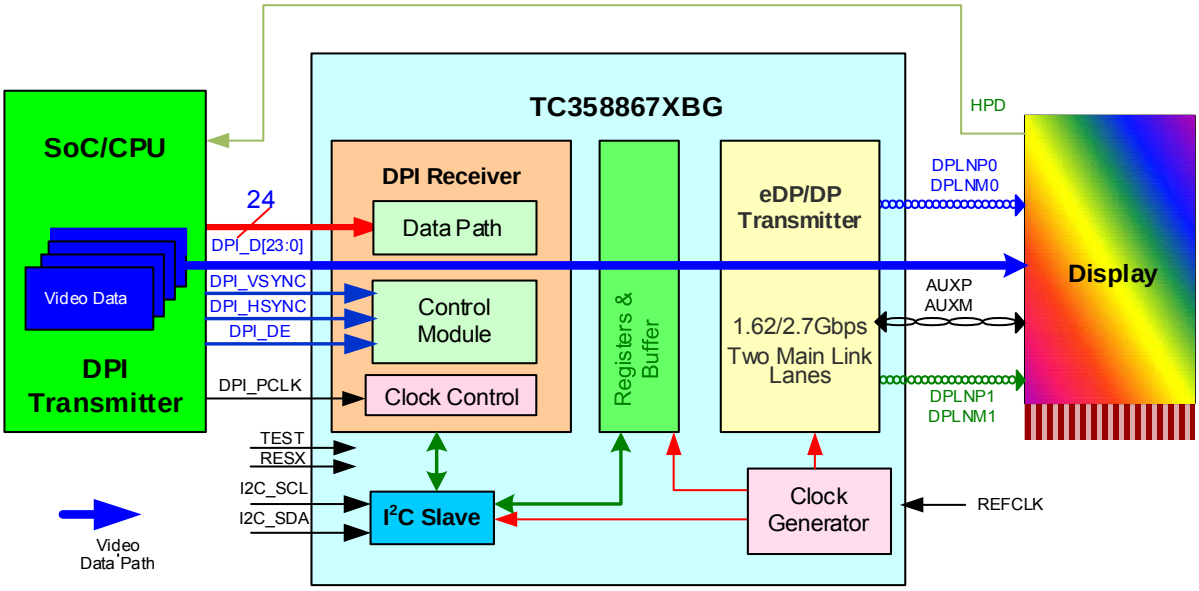


Figure 1.2 System Overview with TC358867XBG in MODE_P21 Configuration

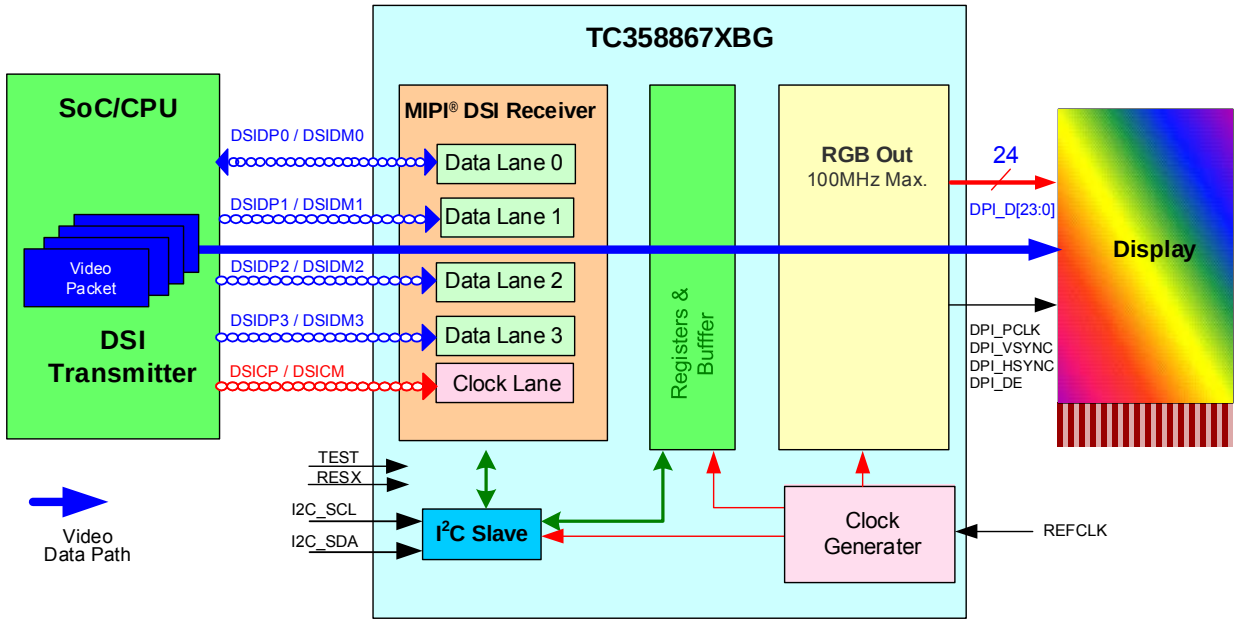


Figure 1.3 System Overview with TC358867XBG in MODE_S2P Configuration

2. Features

Below are the main features supported by TC358867XBG.

- Translates MIPI® DSI/DPI Link video stream from Host to DisplayPort™ Link data to external display devices.
- The inputs are driven by a DSI Host with 4-Data Lanes, upto1 Gbps/lane or DPI Host with 16/18/24 bit interface upto154 MHz parallel clock.
- (Optional) Supports HDCP Digital Content Protection version 1.3 (DisplayPort™ amendment Rev1.1).
- Embeds audio information from the I2S port into the DisplayPort™ data stream.
- The output Interface consists of a DisplayPort™ Tx with a 2-lane Main Link and AUX-Ch.
- Register Configuration**:** From DSI link or I^2C interface.
- Interrupt to host to inform any error status or status needing attention from Host.
- Internal test pattern (color bar) generator for DP o/p testing without any video (DSI/DPI) i/p.
- Debug/Test Port**:** I^2C Slave
- **DSI Receiver**
  - ✧ MIPI® DSI**:** v1.01 / MIPI® D-PHY**:** v0.90 Compliant.
  - ✧ Up to four (4) Data Lanes with Bi-direction support on Data Lane 0.
  - ✧ Maximum speed at 1 Gbps/lane.
  - ✧ Supports Burst as well as Non-Burst Mode Video Data.
    - Video data packets are limited to one row per Hsync period.
  - ✧ Supports video stream packets for video data transmission.
  - ✧ Supports generic long packets for accessing the chip's register set.
  - ✧ Video input data formats**:**
    - RGB-565, RGB-666 and RGB-888.
    - New DSI V1.02 Data Type Support**:** 16-bit YCbCr 422
  - ✧ Interlaced video mode is not supported.
- **DPI Receiver**
  - ✧ Up to 16 / 18 / 24 bit parallel data interface.
  - ✧ Maximum speed at 154 MPs (MPixel per sec).
  - ✧ Video input data formats**:** RGB-565, RGB-666 and RGB-888.
  - ✧ Only Progressive mode supported.
- **I2S Audio Interface:** Supports one I2S port for audio streaming from the host to TC358867XBG.
  - ✧ Supports slave mode (BCLK, LRCLK & over-sampling clock input from Host).
  - ✧ Supports sampling frequencies of 32, 44.1, 48, 88.2, 96, 176.4 & 192 kHz.
  - ✧ Supports up to 2 audio channels.
  - ✧ Supports 16, 18, 20 or 24 bits per sample.
  - ✧ Optionally inserts IEC60958 status bits and preamble bits per channel.
- **DisplayPort™ Interface:** Supports a DisplayPort™ link from TC358867XBG to display panels.
  - ✧ High speed serial bridge chip using VESA® DisplayPort™ 1.1a Standard.
  - ✧ Supports one dual-lane DisplayPort™ port for high bandwidth applications.
  - ✧ Support 1.62 or 2.7 Gbps/lane data rate with voltage swings @0.4, 0.6, 0.8 or 1.2 V.
  - ✧ Support of pre-emphasis levels of 0, 3.5 dB and 6 dB.
  - ✧ Supports Audio related Secondary Data Packets.
  - ✧ AUX channel supported at 1 Mbps.
  - ✧ HPD support through GPIO based interrupts
  - ✧ Enhanced mode supported for content protection.
  - ✧ (Optional) Support HDCP encryption Version 1.3 with DisplayPort™ amendment Revision 1.1.
  - ✧ Secure ASSR (Alternate Scrambler Seed Reset) support for embedded DisplayPort™ panels
  - ✧ Stream Policy Maker is assumed handled by the Host (software/firmware).
    - Start Link training in response to HPD & read final Link training status
    - Configure DP link for actual video streaming & start video streaming
  - ✧ Link Policy maker is assumed shared between the Host and TC358867XBG chip.
    - In auto_correction = 0 mode, control link training
    - Initiate Display device capabilities read and configure TC358867XBG accordingly.

- ✧ Video timing generation as per panel requirement.
- ✧ SSCG with to 30 kHz modulation to reduce EMI.
- ✧ Built in PRBS7 Generator to test DisplayPort™ Link.

- **RGB Parallel Output Interface:**
  - ✧ RGB888 output (DisplayPort™ disabled) with only DSI input supported in this mode
  - ✧ PCLK max. = 100 MHz
  - ✧ Polarity control for PCLK, VSYNC, HSYNC & DE
- **I²C Interface:**
  - ✧ I²C slave interface for chip register set access enabled using a boot-strap option.
  - ✧ I²C compliant slave interface support for normal (100 kHz) and fast mode (400 kHz).
- **GPIO Interface:**
  - ✧ 2 bits of GPIO (shared with other digital logic).
  - ✧ Direction controllable by Host I²C accesses.
- **Clock Source:**
  - ✧ DisplayPort™ clock source is from an external clock input or clock from DSI interface (13, 26, 19.2 or 38.4 MHz) – generates all internal & output clocks to interfacing display devices.
  - ✧ Built-in PLLs generate high-speed DisplayPort™ link clock requiring no external components. These PLLs are part of the DisplayPort™ PHY.
- Clock and power management support to achieve low power states.
- **Possible modes of Operation:**
  - ✧ MODE S21**:** TC358867XBG uses DisplayPort™ Tx as single 2-lane DisplayPort™ link to interface to single DisplayPort™ display device. Video stream source is from MIPI® DSI Host.
  - ✧ MODE P21**:** TC358867XBG uses DisplayPort™ Tx as single 2-lane DisplayPort™ link to interface to single DisplayPort™ display device. Video stream source is from MIPI® DPI Host.
  - ✧ MODE S2P**:** TC358867XBG uses only Parallel output port and disables DisplayPort™ Tx to interface to single RGB display device. Video stream source is from MIPI® DSI Host.
- **Power supply inputs**
  - ✧ Core and MIPI® D-PHY**:** 1.2 V ± 0.06 V
  - ✧ Digital I/O**:** 1.8 V ± 0.09 V
  - ✧ DisplayPort™**:** 1.8 V ± 0.09 V
  - ✧ DisplayPort™**:** 1.2 V ± 0.06 V
- **Power Consumptions (Typical value based on estimations)**
  - ✧ Power-down mode (DSI-Rx in ULPS, DP PHY & PLLs disabled, clocks stopped)**:**
    - DSI Rx**:** 0.01 mW
    - DP PHY**:** 2.34 mW
    - PLL9**:** 0.01 mW
    - Core**:** 0.96 mW
    - Rest**:** 0.01 mW
  - ✧ Normal operation (1920×1080 resolution with DSI-Rx in 4-lane @925 Mbps per lane, DP PHY in dual lane link @2.7 Gbps per lane)**:**
    - DSI Rx**:** 21.79 mW
    - DP PHY**:** 142.70 mW
    - PLL9**:** 2.42 mW
    - Core**:** 87.64 mW
    - IOs**:** 1.68 mW
- **Package**
  - 0.65mm ball pitch, 80 balls, 7 × 7 mm BGA package

Note: Attention about ESD. This product is weak against ESD. Please handle it carefully.

Table 2.1 TC358867XBG operational modes summary with panel size support information

Mode	Input Configuration		Register Access Method	Max Panel size example
	DSI input	DPI input		
S21	Active	X	DSI or I²C	WUXGA 18bpp @ 60fps WUXGA 24bpp @ 60fps
P21	X	Active	I²C	WUXGA 24bpp @ 60fps

Tables below provide an idea of different panel sizes that can be supported by using different data link lane configurations.

Table 2.2 Panel Size v/s Data link required by TC358867XBG in DSI input case

Frame Size			FPS	Pixel Clock (MHz)	RGB666				RGB888			
		With OverHead			Bit Rate (Gbps)	# DSI Data lanes	# DP Main links		Bit Rate (Gbps)	# DSI Data lanes	# DP Main links	
							1.62G	2.7G			1.62G	2.7G
XGA	1024×768	1184×790	60	56	1.01	2	1	1	1.34	2	2	1
WXGA+ / WSXGA	1440×900	1600×926	60	89	1.60	2	2	1	2.13	3	2	1
SXGA+	1400×1050	1560×1080	60	89	1.82	2	2	1	2.43	3	2	2
WSXGA+	1680×1050	1840×1080	60	119	2.15	3	2	1	2.86	3	–	2
UXGA	1600×1200	1760×1235	60	130	2.35	3	2	2	3.13	4	–	2
WUXGA	1920×1200	2080×1235	60	154	2.77	3	–	2	3.70	4	–	2

Table 2.3 Panel Size v/s Data link required by TC358867XBG in DPI input case

Frame Size			FPS	Pixel Clock (MHz)	DPI Support 154 MHz PCLK	RGB666			RGB888		
		With OverHead				Bit Rate (Gbps)	# DP Main links		Bit Rate (Gbps)	# DP Main links	
							1.62G	2.7G		1.62G	2.7G
XGA	1024×768	1184×790	60	56	Yes	1.01	1	1	1.34	2	1
WXGA+ / WSXGA	1440×900	1600×926	60	89	Yes	1.60	2	1	2.13	2	1
SXGA+	1400×1050	1560×1080	60	89	Yes	1.82	2	1	2.43	2	2
WSXGA+	1680×1050	1840×1080	60	119	Yes	2.15	2	1	2.86	–	2
UXGA	1600×1200	1760×1235	60	130	Yes	2.35	2	2	3.13	–	2
WUXGA	1920×1200	2080×1235	60	154	Yes	2.77	–	2	3.70	–	2

Note: These are the formats commonly used by displays. Support for other sizes is possible as long as they satisfy the maximum data rate constraints on the DSI and DisplayPort™ link interfaces.

Note: Throughout the rest of the document, "DP" is used to denote "DisplayPort™". Both these words have been used interchangeably and refer to the VESA® DisplayPort™ specification as mentioned in the references.

3. External Pins

3.1. TC358867XBG External Pins

TC358867XBG uses an 80ball package. Following table gives the signals of TC358867XBG and their function.

Table 3.1 TC358867XBG Functional Signal List for 80-ball Package

Group	Pin Name	I/O	Type	Function	Note
System: Reset, Clock, Mode select, Test (9)	RESX	I	Sch	System Reset – active Low 0: Reset 1: Normal operation	—
	REFCLK	I	Sch	13, 26, 19.2 or 38.4 MHz 50ps phase jitter p2p/ WC duty cycle 40-60%	—
	INT	O	N	Interrupt to Host – active High 0: No interrupt is generated 1: Interrupt is generated	4mA
	DISABLE_ASSR	I	N	ASSR control 0: Enable ASSR 1: Disable ASSR	—
	MODE[1:0]	I	N	Mode Selection pins MODE_0: 0: REFCLK is source of internal DP PLL 1: When REFCLK="0", DSI clock is source of internal DP PLL. When REFCLK="1", DPI PCLK is source of internal DP PLL. MODE_1: When MODE_0="1" & REFCLK="0" this pin will be effective. 0: DSI clock/2/7 is source of internal DP PLL. 1: DSI clock/2/9 is source of internal DP PLL.	—
	TEST	I	N	Test Pin - active high 0: Normal operation 1: Test mode	—
	TEST3	O	N	Test Pin, Open	—
	VPGM0	NA	—	eFUSE programming voltage. Connect to GND	—
DSI Rx (10)	DSICP	I	MIPI®-PHY	MIPI®-DSI Rx Clock Lane Pos.	—
	DSICM	I	MIPI®-PHY	MIPI®-DSI Rx Clock Lane Neg.	—
	DSIDP0	I/O	MIPI®-PHY	MIPI®-DSI Rx Data Lane Pos.	—
	DSIDM0	I/O	MIPI®-PHY	MIPI®-DSI Rx Data Lane Neg.	—
	DSIDP[3:1]	I	MIPI®-PHY	MIPI®-DSI Rx Data Lane Pos.	—
	DSIDM[3:1]	I	MIPI®-PHY	MIPI®-DSI Rx Data Lane Neg.	—
DP Out (8)	DPLNP[1:0]	O	DP-PHY	embedded DisplayPort™ Output Main Link Pos.	—
	DPLNM[1:0]	O	DP-PHY	embedded DisplayPort™ Output Main Link Neg.	—
	DPAUXP	I/O	DP-PHY	embedded DisplayPort™ Output AUX Channel Pos	—
	DPAUXM	I/O	DP-PHY	embedded DisplayPort™ Output AUX Channel Neg	—
	PREC_RES[1:0]	I	DP-PHY	Precision Resistance (3kΩ @ 1%) connection	—
DPI Tx/Rx (28)	DPI_PCLK	I/O	N	DPI Pixel Clock (max 154 MHz) (default: Input)	4mA
	DPI_VSYNC	I/O	N	DPI Vertical Sync (default: Input)	4mA
	DPI_HSYNC	I/O	N	DPI Horizontal Sync (default: Input)	4mA
	DPI_DE	I/O	N	DPI Data Enable (default: Input)	4mA
	DPI_D [23:0]	I/O	N	DPI Parallel Data (default: Input)	4mA
I²C (3)	I2C_SCL	OD	Sch	I²C Clock	—
	I2C_SDA	OD	Sch	I²C Data	4mA
	I2C_ADR_SEL	I	N	I²C Slave Address Select 0: Slave address=7'b1101_000 1: Slave address=7'b0001_111	—

I2S (4)	SD/I2S_OSCLK	I	N	I2S Over Sampling Clock	—
	I2S_BCLK	I	N	I2S Bit Clock (max 12.5 MHz)	—
	I2S_LRCLK	I	N	I2S sample clock (max 192 kHz)	—
	I2S_DATA	I	N	I2S Data	—
GPIO (2)	GPIO[1:0]	OD	5T-OD	GPIO or Test Control *Note1 GPIO[1:0] can be used for HPD support	4mA
POWER (10)	VDDC (1.2V)	NA	—	VDD for Internal Core (2)	—
	VDDS (1.8V)	NA	—	VDDS for IO Ring power supply (1)	—
	VDD_PLL18 (1.8V)	NA	—	VDD for DP PHY PLLs (1)	—
	VDD_DP18 (1.8V)	NA	—	VDD for DP PHY Main Channels (2)	—
	VDD_PLL912 (1.2V)	NA	—	VDD for PLL9 (1)	—
	VDD_DP12 (1.2V)	NA	—	VDD for DP PHY (2)	—
	VDD_DSI12 (1.2V)	NA	—	VDD for the MIPI® DSI PHY (1)	—
GROUND (6)	VSS	NA	—	Ground (Core, DSI, I/O) (3)	—
	VSS_DP	NA	—	Ground (DP) (3)	—

Note 1: Pins with multiplexed Functional mode functions.

N: Normal IO
PHY: Either DP analog front end or MIPI® D-PHY
Sch: Schmitt trigger input
OD: Open drain
5T-OD: 5 V tolerant bi-direction buffer with Open drain

3.2. TC358867XBG Ball Mapping

The mapping of TC358867XBG signals to the external pins is given in the following figure. (BGA array)

Top View

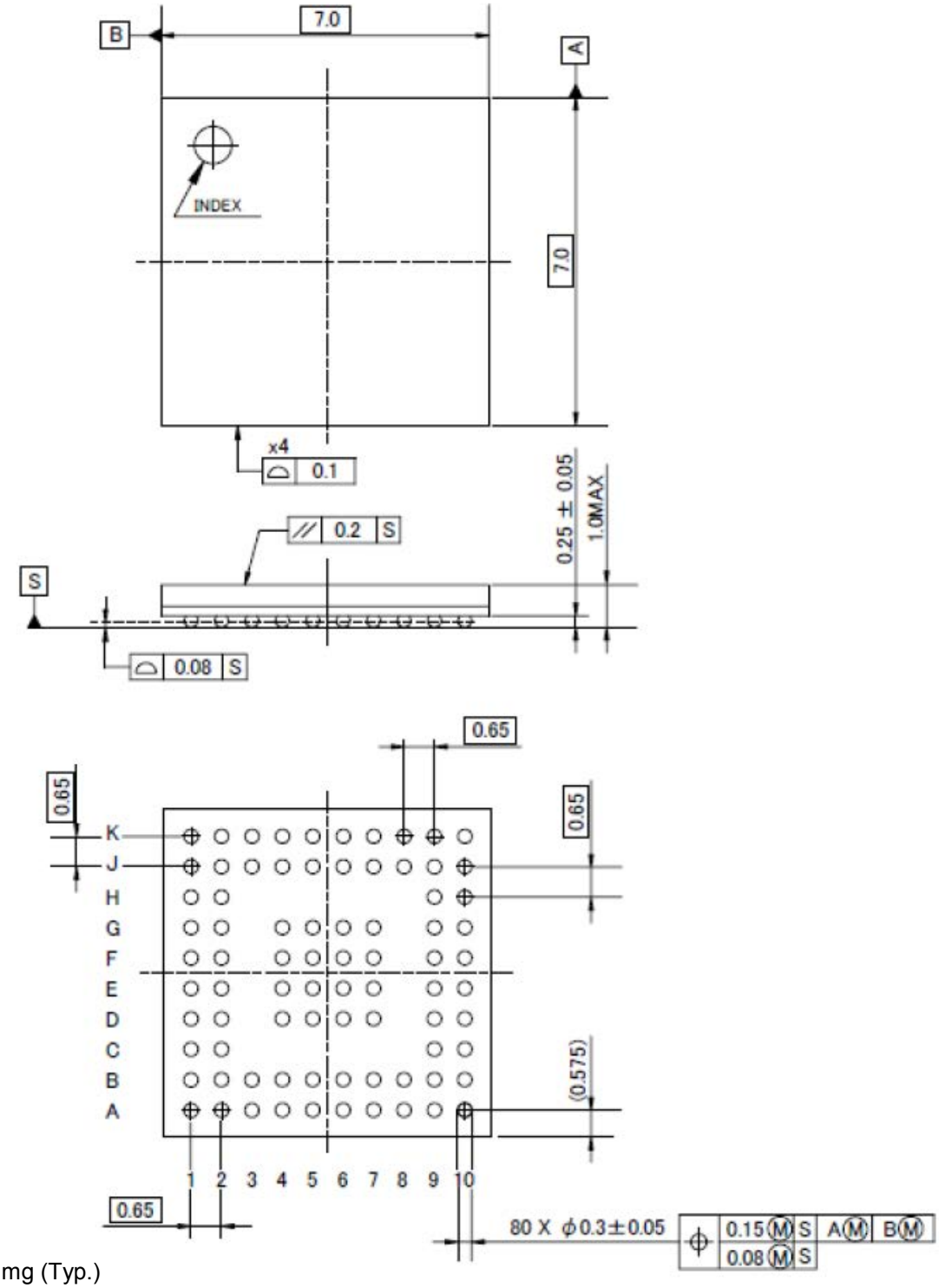
	1	2	3	4	5	6	7	8	9	10
A	INT	GPIO0	DPI_VSYNC	DPI_D0	VDDC	VDDC	DPI_D3	VDDS	I2C_SDA	I2C_SCL
B	DSIDM0	DSIDP0	DPI_DE	DPI_HSYNC	DPI_D1	DPI_D2	DPI_D4	DPI_D7	DPI_D5	DPI_D6
C	DSIDM1	DSIDP1							DPI_D9	DPI_D8
D	DSICM	DSICP		I2S_LRCLK	I2S_BCLK	SD/ I2S_OSCLK	I2S_DATA		DPI_D13	DPI_D14
E	VDD_DSI12	I2C_ADR_SEL		VSS	TEST3	VPGM0	DPI_D10		DPI_D16	DPI_D15
F	DSIDM2	DSIDP2		VSS	VSS	TEST	DPI_D11		DPI_D17	DPI_D18
G	DSIDM3	DSIDP3		VSS_DP	VSS_DP	VSS_DP	DPI_D12		DPI_D19	DPI_PCLK
H	PREC_RES0	DISABLE_ASSR							DPI_D20	DPI_D21
J	PREC_RES1	MODE1	DPLNP0	VDD_DP12	MODE0	DPLNP1	GPIO1	DPAUXP	RESX	DPI_D23
K	REFCLK	VDD_DP18	DPLNM0	VDD_DP12	VDD_PLL18	DPLNM1	VDD_DP18	DPAUXM	VDD_PLL912	DPI_D22

Figure 3.1 TC358867XBG 80-ball Layout

4. Package

The package for TC358867XBG is described in the figure below.

Unit: mm



Weight: 76 mg (Typ.)

Figure 4.1 80 ball TC358867XBG package

5. Electrical Characteristics

5.1. Absolute Maximum Ratings

VSS/VSS_DP= 0 V reference

VDD18 used for VDDS, VDD_DP18 and VDD_PLL18; VDD12 used for VDDC, VDD_DSI12, VDD_DP12 and VDD_PLL912.

Table 5.1 Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage (1.8 V)	VDD18	-0.3 to +3.5	V
Supply voltage (1.2 V)	VDD12	-0.3 to +2.0	V
Supply voltage (IO)	VDD18	-0.3 to +3.5	V
	VREF	-0.3 to +3.5	V
Input voltage	VIN	-0.3 to VDDS+0.3	V
Output voltage	VOUT	-0.3 to VDDS+0.3	V
Storage temperature	Tstg	-40 to +125	°C

5.2. Operating Condition

VSS/VSS_DP = 0 V reference

VDD18 used for VDDS, VDD_DP18 and VDD_PLL18; VDD12 used for VDDC, VDD_DSI12, VDD_DP12 and VDD_PLL912.

Table 5.2 Operating Condition

Parameter	Symbol	Min	Typ.	Max	Unit
Supply voltage (1.8 V)	VDD18	1.71	1.8	1.89	V
Supply voltage (1.2 V)	VDD12	1.14	1.2	1.26	V
Operating frequency (internal)	Fopr	—	—	200	MHz
Operating temperature	Ta	-20	—	+85	°C

5.3. DC Electrical Specification

VSS/VSS_DP = 0V reference

Table 5.3 DC Electrical Specification

Parameter	Symbol	Min	Typ.	Max	Unit
Input voltage High level CMOS input Note1	VIH	0.7 VDDS	—	VDDS	V
Input voltage Low level CMOS input Note1	VIL	0	—	0.3 VDDS	V
Input voltage High level CMOS Schmitt Trigger Note1	VIHS	0.7 VDDS	—	VDDS	V
Input voltage Low level CMOS Schmitt Trigger Note1	VILS	0	—	0.3 VDDS	V
Output voltage High level Note1, Note2	VOH	0.8 VDDS	—	VDDS	V
Output voltage Low level Note1, Note2	VOL	0	—	0.2 VDDS	V
Input leak current High level	IIH1 (Note3)	-10	—	10	μA
Input leak current Low level	IIL1 (Note4)	-10	—	10	μA
	IIL2 (Note5)	-200	—	-10	μA

Note1: VDDS within recommended operating condition.
Note2: Output current value is according to each IO buffer specification. Output voltage changes with output current value.
Note3: Normal pin, or Pull-up I/O pin applied VDDS supply voltage to input pin
Note4: Normal pin applied VSS (0 V) to input pin
Note5: Pull-up I/O pin applied VSS (0 V) to input pin

5.4. Power Consumption (Typical value based on estimation)

Typical power consumption as measured for the power-down modes and for normal operation are provided below:

- Power-down mode (DSI-Rx in ULPS, DP PHY & PLLs disabled, clocks stopped):
  - ✧ DSI Rx: 0.01 mW
  - ✧ DP PHY: 2.34 mW
  - ✧ PLL9: 0.01 mW
  - ✧ Core: 0.96 mW
  - ✧ Rest: 0.01 mW

- Normal operation (1920×1080 resolution with DSI-Rx in 4-lane @925 Mbps per lane, DP PHY in dual lane link @2.7 Gbps per lane):
  - ✧ DSI Rx: 21.79 mW
  - ✧ DP PHY: 142.70 mW
  - ✧ PLL9: 2.42 mW
  - ✧ Core: 87.64 mW
  - ✧ IOs: 1.68 mW

6. Revision History

Table 6.1 Revision History

Revision	Date	Description
0.1	2017-12-27	Newly released (Preliminary)
0.2	2018-01-25	“Overview”/“Feature” description is updated. Table 3-1 is modified and updated. Figure 3-1 is updated.
0.3	2018-02-20	Modified weight. Added descriptions of the last page.
1.0	2018-03-27	Deleted descriptions of the last page. Modified descriptions of the trademarks. Modified Figure 1.1, Figure 1.2 and Figure 1.3. Corrected typos. Modified descriptions in Features. Officially released.
1.1	2018-05-28	Modified Table 2.2 and Table 2.3.

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