CMOS Digital Integrated Circuit Silicon Monolithic

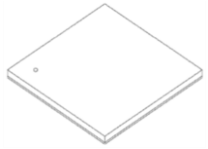
TC358768AXBG/TC358778XBG/TC9594XBG

Mobile Peripheral Devices

Overview

Parallel Port to MIPI® DSI® (TC358768AXBG/TC358778XBG/TC9594XBG) is a bridge device that converts RGB to DSI. All internal registers can access through I²C or SPI.

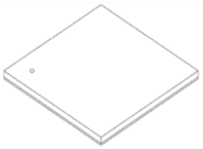
TC358768AXBG



P-VFBGA72-0404-0.40A3

Weight: 32 mg (typ.)

TC358778XBG/TC9594XBG



P-VFBGA80-0707-0.65-001

Weight: 68 mg (typ.)

Features

- DSI-TX Interface
  - MIPI DSI compliant
    Support DSI Video Mode data transfer.
    DCS℠ Command for panel register access.
  - Supports up to 1 Gbps per data lane.
  - Supports1, 2, 3 or 4 data lanes.
  - Supports RGB888/666/565 video data formats.
- RGB Interface
  - Supports RGB888/666/565 data formats.
  - Up to 166 MHz input clock.
  - Support VSYNC/HSYNC polarity option (default Low).
  - Support DE polarity option (default High).
- I²C/SPI Target Interface (Option to select either I²C or SPI interface)
  - I²C Interface (when CS = L)
    Support for normal (100 kHz), fast mode (400 kHz) and Special mode (1 MHz).
    Configure all TC358768AXBG/TC358778XBG/TC9594XBG internal registers.
    Writing to DCS registers will trigger DCS Command transmits over DSI.
  - SPI interface (when CS = H)
    SPI interface support for up to 25 MHz operation.
    Configure all TC358768AXBG/TC358778XBG/TC9594XBG internal registers.
    Writing to DCS registers will trigger DCS Command transmits over DSI.
- GPIO signals
  - 2 GPIO signals
    Two GPIO signals can be configured as SPI signals (SPI_SS and SPI_MISO).
    Or One GPIO signal can be configured as Interrupt output signal, INT.
- System
  - Clock and power management support to achieve low power states.
- Power supply inputs
  - Core and MIPI D-PHY℠: 1.2 V
  - I/O: 1.8 V or 3.3 V
- Typical Power Consumption
  - WXGA @60 fps: Pixel Clk: 74.25 MHz, DSIClk: 312 MHz → 66.7 mW
  - 1080P @60 fps: Pixel Clk: 148.5 MHz, DSIClk: 471 MHz → 91.5 mW
  - Power Down Condition is achieved by turning off clock sources: PCLK and REFCLK.

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REFERENCES

1. MIPI DSI, “mipi_DSI_specification_v01-02-00, June 28, 2010”
2. MIPI DCS “DRAFT mipi_DCS_specification_v01-02-00_r0-02, December 2008”
3. MIPI D-PHY, “mipi_D-PHY_specification_v01-00-00, May 14, 2009”
4. I^2C bus specification, version 2.1, January 2000, Philips Semiconductor

1. Overview

The Parallel Port to MIPI DSI (TC358768AXBG/TC358778XBG/TC9594XBG) is a bridge device that converts RGB to DSI. All internal registers can access through I^2C or SPI.

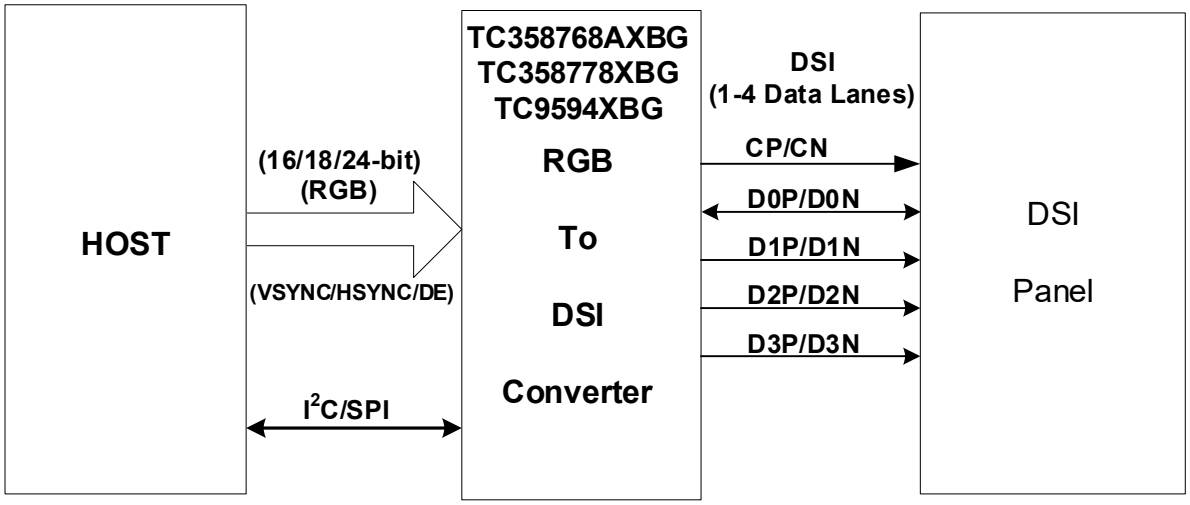


Figure 1.1 System Overview with TC358768AXBG/TC358778XBG/TC9594XBG in RGB to DSI-TX

2. Features

Below are the main features supported by TC358768AXBG/TC358778XBG/TC9594XBG.

- DSI-TX Interface
  - MIPI DSI compliant.
    Support DSI Video Mode data transfer.
    DCS Command for panel register access.
  - Supports up to 1 Gbps per data lane.
  - Supports1, 2, 3 or 4 data lanes.
  - Supports RGB888/666/565 video data formats.
- RGB Interface
  - Supports RGB888/666/565 data formats.
  - Up to 166 MHz input clock.
  - Support VSYNC/HSYNC polarity option (default Low).
  - Support DE polarity option (default High).
- I^2C/SPI Target Interface (Option to select either I^2C or SPI interface)
  - I^2C Interface (when CS = L)
    Support for normal (100 kHz), fast mode (400 kHz) and Special mode (1 MHz).
    Configure all TC358768AXBG/TC358778XBG/TC9594XBG internal registers.
    Writing to DCS registers will trigger DCS Command transmits over DSI.
  - SPI interface (when CS = H)
    SPI interface support for up to 25 MHz operation.
    Configure all TC358768AXBG/TC358778XBG/TC9594XBG internal registers.
    Writing to DCS registers will trigger DCS Command transmits over DSI.
- GPIO signals
  - 2 GPIO signals
    Two GPIO signals can be configured as SPI signals (SPI_SS and SPI_MISO).
    Or One GPIO signal can be configured as Interrupt output signal, INT.
- System
  - Clock and power management support to achieve low power states.
- Power supply inputs
  - Core and MIPI D-PHY: 1.2 V
  - I/O: 1.8 V or 3.3 V
- Typical Power Consumption
  - WXGA@60 fps: Pixel Clk: 74.25 MHz, DSIClk: 312 MHz → 66.7 mW
  - 1080P@60 fps: Pixel Clk: 148.5 MHz, DSIClk: 471 MHz → 91.5 mW

	VDDC	VDDIO	VDDMIPI	Total Power	
	1.2 V	3.3 V	1.2 V		
1080P Video	42.8 mA	0.4 mA	32.3 mA		
	51.4 mW	1.3 mW	38.8 mW	91.5	mW
WXGA Video	34.7 mA	0.2 mA	20.4 mA		
	41.7 mW	0.6 mW	24.4 mW	66.7	mW
Power Down w/o PCLK, REFCLK	0.07 mA	0.03 mA	0.01 mA		
	0.09 mW	0.08 mW	0.01 mW	0.18	mW

  - Power Down Condition is achieved by turning off clock sources: PCLK and REFCLK.

3. External Pins

3.1. TC358768AXBG pinout description

TC358768AXBG resides in BGA72 pin packages.
The following table gives the signals of TC358768AXBG and their function.

Table 3.1 TC358768AXBG Functional Signal List

Group	Pin Name	I/O	Type	Function	Note
System: Reset & Clock (4)	RESX	I	Sch	System reset input, active low	—
	REFCLK	I	N	Reference clock input (6 MHz to 40 MHz)	—
	MSEL	I	N	Mode Select 1'b0: Test mode 1'b1: Normal mode	—
	CS	I	N	Configuration Select - When CS = L, enable I²C interface - When CS = H, enable SPI interface	—
MIPI-DSI (10)	MIPI_CP	—	PHY	MIPI-DSI clock positive	—
	MIPI_CN	—	PHY	MIPI-DSI clock negative	—
	MIPI_D0P	—	PHY	MIPI-DSI Data 0 positive	—
	MIPI_D0N	—	PHY	MIPI-DSI Data 0 negative	—
	MIPI_D1P	—	PHY	MIPI-DSI Data 1 positive	—
	MIPI_D1N	—	PHY	MIPI-DSI Data 1 negative	—
	MIPI_D2P	—	PHY	MIPI-DSI Data 2 positive	—
	MIPI_D2N	—	PHY	MIPI-DSI Data 2 negative	—
	MIPI_D3P	—	PHY	MIPI-DSI Data 3 positive	—
	MIPI_D3N	—	PHY	MIPI-DSI Data 3 negative	—
I²C (2)	I2C_SCL	OD	Sch	I²C serial clock or SPI_SCLK	4 mA
	I2C_SDA	OD	Sch	I²C serial data or SPI_MOSI	4 mA
Parallel Port IF (28)	PD[23:0]	I	N	Parallel Port Input Data Note: PD[23:16] can be configure to be GPIO[10:3]	—
	VSYNC	I	N	Parallel port VSYNC signal	—
	HSYNC	I	N	Parallel port HSYNC signal	—
	DE	I	N	Parallel Port DE signal	—
	PCLK	I	N	Parallel Port Clock signal	—
GPIO (2)	GPIO[2:1]	I/O	N	GPIO[2:1] signals - (GPIO[1] option to become SPI_SSor INT signal) - (GPIO[2] option to become SPI_MISO signal)	4 mA
POWER (9)	VDDC (1.2 V)	NA	—	VDD for Internal Core (3)	—
	VDDIO (1.8 V or 3.3 V)	NA	—	VDDIO is for IO power supply (4)	—
	VDD_MIPI (1.2 V)	NA	—	VDD for the MIPI (2)	—
GROUND (17)	VSS	NA	—	Ground	—

3.2. TC358768AXBG BGA72 Pin Count Summary

Table 3.2 TC35

8768AXBG BGA 72 Pin Count Summary

Group Name	Pin Count	Note
SYSTEM	4	—
MIPI-DSI	10	—
I^2C IF	2	—
GPIO	2	—
Parallel Port IF	28	—
POWER	9	IO, MIPI and Core Power
GROUND	17	—
TOTAL	72	—

3.3. TC358778XBG/TC9594XBG pinout description

TC358778XBG/TC9594XBG resides in BGA80 pin packages.

The following table gives the signals of TC358778XBG/TC9594XBG and their function.

Table 3.3 TC358778XBG/TC9594XBG Functional Signal List

Group	Pin Name	I/O	Type	Function	Note
System: Reset & Clock (4)	RESX	I	Sch	System reset input, active low	—
	REFCLK	I	N	Reference clock input (6 MHz to 40 MHz)	—
	MSEL	I	N	Mode Select 1'b0: Test mode 1'b1: Normal mode	—
	CS	I	N	Configuration Select - When CS = L, enable I²C interface - When CS = H, enable SPI interface	—
MIPI-DSI (10)	MIPI_CP	—	PHY	MIPI-DSI clock positive	—
	MIPI_CN	—	PHY	MIPI-DSI clock negative	—
	MIPI_D0P	—	PHY	MIPI-DSI Data 0 positive	—
	MIPI_D0N	—	PHY	MIPI-DSI Data 0 negative	—
	MIPI_D1P	—	PHY	MIPI-DSI Data 1 positive	—
	MIPI_D1N	—	PHY	MIPI-DSI Data 1 negative	—
	MIPI_D2P	—	PHY	MIPI-DSI Data 2 positive	—
	MIPI_D2N	—	PHY	MIPI-DSI Data 2 negative	—
	MIPI_D3P	—	PHY	MIPI-DSI Data 3 positive	—
	MIPI_D3N	—	PHY	MIPI-DSI Data 3 negative	—
I²C IF (2)	I2C_SCL	OD	Sch	I²C serial clock or SPI_SCLK	4 mA
	I2C_SDA	OD	Sch	I²C serial data or SPI_MOSI	4 mA
Parallel Port IF (28)	PD[23:0]	I	N	Parallel Port Input Data Note: PD[23:16] can be configure to be GPIO[10:3]	—
	VSYNC	I	N	Parallel port VSYNC signal	—
	HSYNC	I	N	Parallel port HSYNC signal	—
	DE	I	N	Parallel Port DE signal	—
	PCLK	I	N	Parallel Port Clock signal	—
GPIO (2)	GPIO[2:1]	I/O	N	GPIO[2:1] signals - (GPIO[1] option to become SPI_SSor INT signal) - (GPIO[2] option to become SPI_MISO signal)	4 mA
POWER (9)	VDDC (1.2 V)	NA	—	VDD for Internal Core (3)	—
	VDDIO (1.8 V or 3.3 V)	NA	—	VDDIO is for IO power supply (4)	—
	VDD_MIPI (1.2 V)	NA	—	VDD for the MIPI (2)	—
GROUND (25)	VSS	NA	—	Ground	—

3.4. TC358778XBG/TC9594XBG BGA80 Pin Count Summary

Table 3.4 TC358778XBG/TC9594XBG BGA 80 Pin Count Summary

Group Name	Pin Count	Note
SYSTEM	4	—
MIPI-DSI	10	—
I^2C IF	2	—
GPIO	2	—
Parallel Port IF	28	—
POWER	9	IO, MIPI and Core Power
GROUND	25	—
TOTAL	80	—

3.5. TC358768AXBG Pin Layout

A1	A2	A3	A4	A5	A6	A7	A8	A9
VSS	PD17	PD19	PD21	PD23	GPIO2	I2C_SCL	MSEL	VSS
B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
VDDC	PD16	PD18	PD20	PD22	GPIO1	I2C_SDA	RESX	VDDIO
C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
PD15	PD14	VSS	VSS	VSS	VSS	VDD_MIPI	MIPI_D3P	MIPI_D3N
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
PD13	PD12	VSS				VSS	MIPI_D2P	MIPI_D2N
E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**
VSS	VSS	VDDC				VDD_MIPI	MIPI_CP	MIPI_CN
F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
VSS	VSS	VSS				VSS	MIPI_D1P	MIPI_D1N
G1	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**
PD11	PD10	VDDIO	VSS	VSS	VDDIO	VDDIO	MIPI_D0P	MIPI_D0N
H1	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**
VDDC	PD8	PD6	PD4	PD2	PD0	PCLK	DE	CS
J1	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	**J8**	**J9**
VSS	PD9	PD7	PD5	PD3	PD1	REFCLK	VSYNC	HSYNC

Figure 3.1 TC358768AXBG 72-Pin Layout (Top View)

3.6. TC358778XBG/TC9594XBG Pin Layout

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
VSS	PD17	PD19	PD21	PD23	GPIO2	VDDC	I2C_SCL	MSEL	VSS
B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
VDDC	PD16	PD18	PD20	PD22	GPIO1	VSS	I2C_SDA	RESX	VDDIO
C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
PD15	PD14							MIPI_D3P	MIPI_D3N
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
PD13	PD12		VSS	VSS	VSS	VSS		MIPI_D2P	MIPI_D2N
E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**
PD11	PD10		VSS	VSS	VSS	VSS		VSS	VDD_MIPI
F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
PD9	PD8		VSS	VSS	VSS	VSS		MIPI_CP	MIPI_CN
G1	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**
PD7	PD6		VSS	VSS	VSS	VSS		MIPI_D1P	MIPI_D1N
H1	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**
VDDIO	VSS							VSS	VDD_MIPI
J1	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	**J8**	**J9**	**J10**
PD4	PD2	PD0	VSS	VSS	PCLK	DE	CS	MIPI_D0P	MIPI_D0N
K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
PD5	PD3	PD1	VDDC	VDDIO	REFCLK	VSYNC	HSYNC	VDDIO	VSS

Figure 3.2 TC358778XBG/TC9594XBG 80-Pin Layout (Top View)

4. Package

4.1. TC358768AXBG Package

The packages for TC358768AXBG is described in the figure below.

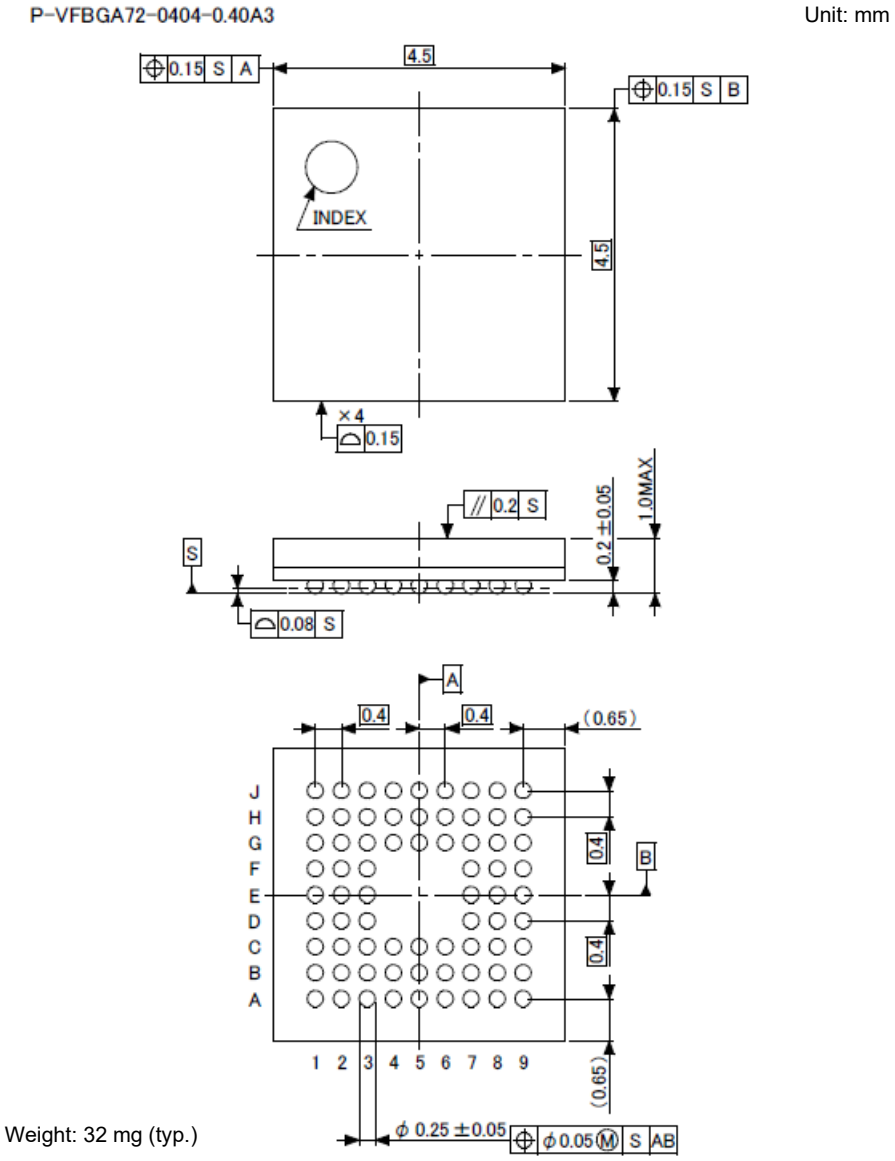


Figure 4.1 TC358768AXBG P-VFBGA72-0404-0.40A3 package

Table 4.1 TC358768AXBG P-VFBGA72-0404-0.40A3 Mechanical Dimension

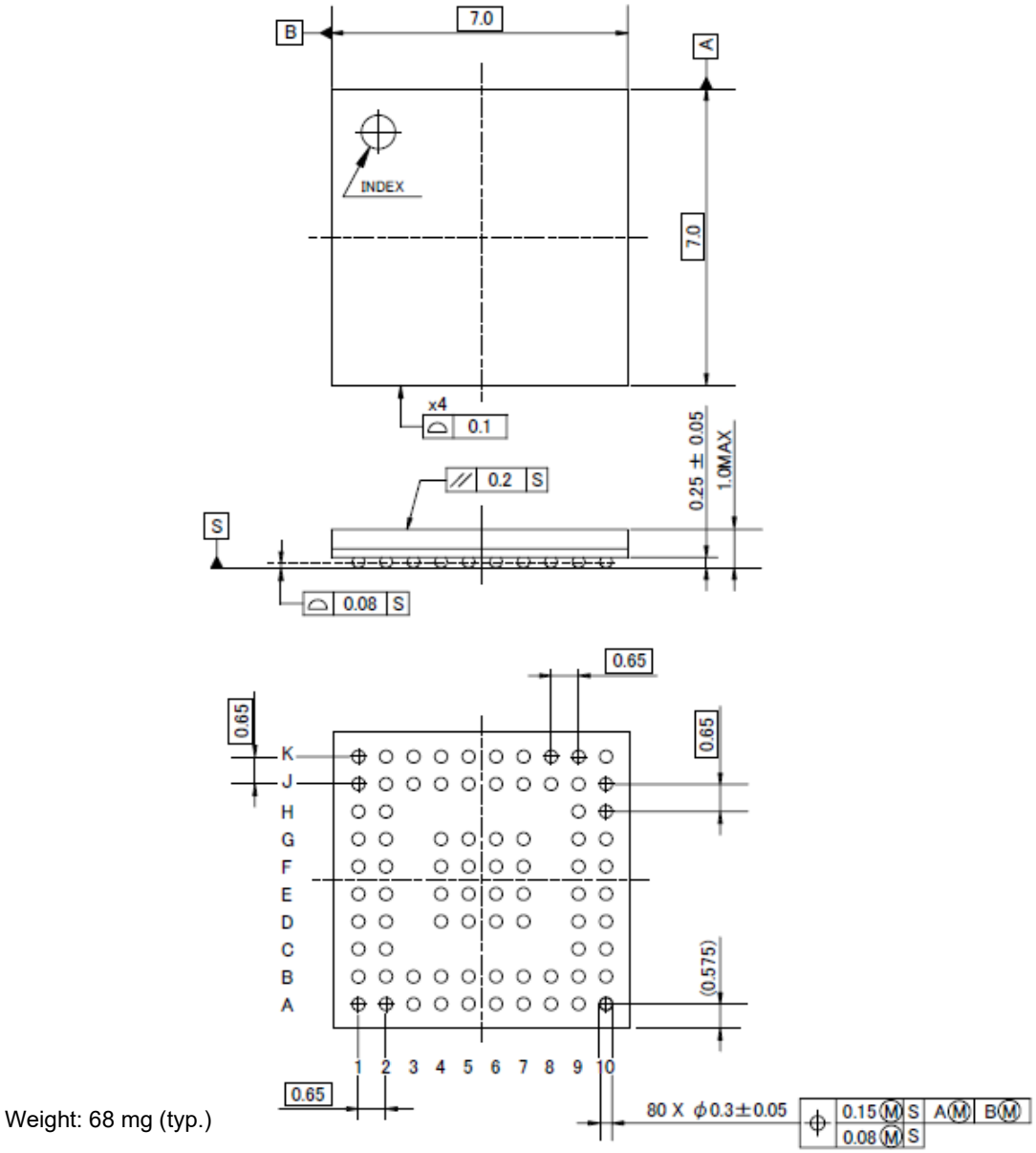
Dimension	Min	Typ.	Max
Solder ball pitch	—	0.4 mm	—
Solder ball height	0.15 mm	0.2 mm	0.25 mm
Package dimension	—	4.5 × 4.5 mm^2	—
Package height	—	—	1.0 mm

4.2. TC358778XBG/TC9594XBG Package

The package for TC358778XBG/TC9594XBG is described in the figure below.

P-VFBGA80-0707-0.65-001

Unit: mm



Weight: 68 mg (typ.)

Figure 4.2 TC358778XBG/TC9594XBG P-VFBGA80-0707-0.65-001 package

Table 4.2 TC358778XBG/TC9594XBG P-VFBGA80-0707-0.65-001 Mechanical Dimension

Dimension	Min	Typ.	Max
Solder ball pitch	—	0.65 mm	—
Solder ball height	0.20 mm	0.25 mm	0.30 mm
Package dimension	—	7.0 × 7.0 mm^2	—
Package height	—	—	1.0 mm

5. Electrical Characteristics

5.1. Absolute Maximum Ratings

VSS = 0 V reference

Parameter	Symbol	Rating	Unit
Supply voltage (1.8 V - Digital IO)	VDDIO	-0.3 to +3.9	V
Supply voltage (1.2 V – Digital Core)	VDDC	-0.3 to +1.8	V
Supply voltage (1.2 V – MIPI PHY)	VDD_MIPI	-0.3 to +1.8	V
Input voltage (DSI IO)	V_{IN_DSI}	-0.3 to VDD_MIPI + 0.3	V
Output voltage (DSI IO)	V_{OUT_DSI}	-0.3 to VDD_MIPI + 0.3	V
Input voltage (Digital IO)	V_{IN_IO}	-0.3 to VDDIO + 0.3	V
Output voltage (Digital IO)	V_{OUT_IO}	-0.3 to VDDIO + 0.3	V
Storage temperature	T_{stg}	-40 to +125	°C

5.2. Operating Condition

VSS = 0 V reference

Parameter	Symbol	Min	Typ.	Max	Unit
Supply voltage (1.8 V – Digital IO)	VDDIO	1.65	1.8	1.95	V
Supply voltage (3.3 V – Digital IO)	VDDIO	3.0	3.3	3.6	V
Supply voltage (1.2 V – Digital Core)	VDDC	1.1	1.2	1.3	V
Supply voltage (1.2 V – MIPI PHY)	VDD_MIPI	1.1	1.2	1.3	V
Operating temperature (ambient temperature with voltage applied) for TC358768AXBG/TC358778XBG	T_a	-30	+25	+85	°C
Operating temperature (ambient temperature with voltage applied) for TC9594XBG	T_a	-40	+25	+105	°C
Supply Noise Voltage (Peak to Peak)	V_{SN}	—	—	100	mV

5.3. DC Electrical Specification

Parameter	Symbol	Min	Typ.	Max	Unit
Input voltage, High level input (Note 1)	V_{IH}	0.7 VDDIO	—	VDDIO	V
Input voltage, Low level input (Note 1)	V_{IL}	0	—	0.3 VDDIO	V
Input voltage High level CMOS Schmitt Trigger (Note 1), (Note 2)	V_{IHS}	0.7 VDDIO	—	VDDIO	V
Input voltage Low level CMOS Schmitt Trigger (Note 1), (Note 2)	V_{ILS}	0	—	0.3 VDDIO	V
Output voltage High level (Note 1), (Note 2) (Condition: I_{OH} = -0.4 mA)	V_{OH}	0.8 VDDIO	—	VDDIO	V
Output voltage Low level (Note 1), (Note 2) (Condition: I_{OL} = 2 mA)	V_{OL}	0	—	0.2 VDDIO	V
Input leak current, High level Normal IO or Pull-up IO) (Condition: V_{IN} = +VDDIO, VDDIO = 3.6 V)	I_{ILH1} (Note 3)	-10	—	10	μA
Input leak current, High level (Pull-down IO) (Condition: V_{IN} = +VDDIO, VDDIO = 3.6 V)	I_{ILH2} (Note 3)	—	—	100	μA
Input leak current, Low level (Normal IO or Pull-down IO) (Condition: V_{IN} = 0 V, VDDIO = 3.6 V)	I_{ILL1} (Note 4)	-10	—	10	μA
Input leak current, Low level (Pull-up IO) (Condition: V_{IN} = 0 V, VDDIO = 3.6 V)	I_{ILL2} (Note 4)	—	—	200	μA

Note 1: Each power source is operating within operating condition.

Note 2: Current output value is specified to each IO buffer individually. Output voltage changes with output current value.

Note 3: Normal pin or Pull-up IO pin applied VDDIO supply voltage to V_{IN} (input voltage)

Note 4: Normal pin or Pull-down IO pin applied VSSIO (0 V) to V_{IN} (input voltage)

6. Revision History

Table 6.1 Revision History

Revision	Date	Description
1.11	2014-05-28	Newly released
1.12	2016-04-01	• Package's weight is rounding up digits after the decimal point to form an integer. • Modified TC358768AXBG's package code.
2.00	2026-05-25	Changed header, footer and the last page. Changed corporate name.
1.65	2019-02-08	Modified descriptions of trademark and service mark. Corrected typos. Corrected weight of TC358778XBG in cover page and chapter 4. Revised the last page "RESTRICTIONS ON PRODUCT USE" and added URL.
2.00	2026-05-25	Marged with TC9594XBG. Updated the terms "Master/Slave" to "Controller/Target". Corrected typos. Revised the last page "RESTRICTIONS ON PRODUCT USE".

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