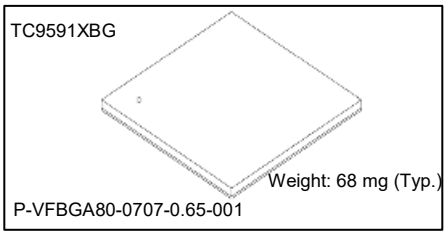
CMOS Digital Integrated Circuit Silicon Monolithic

TC9591XBG

Automotive Peripheral Devices



Overview

The MIPI® CSI-2SM to Parallel port and Parallel port to CSI-2 (TC9591XBG) is a bridge device that has both functions to convert MIPI data transfers from devices such as a camera to an application processor over a Parallel port interface and to convert parallel data transfers to an application over a MIPI CSI-2 interface. All internal registers can be accessed through I2C or SPI (in CSI out case only).

Features

- CSI-2 TX/RX interface
  - ✧ MIPI CSI-2 compliant (Version 1.01 Revision 0.04 – 2 April 2009)
  - ✧ Configurable to TX or RX controller
  - ✧ Supports up to 1Gbps per data lane
  - ✧ Supports up to 4 data lanes
  - ✧ Supports video data formats
    - RX: RAW8/10/12/14, YUV422 (CCIR/ITU 8/10-bit), RGB888/666/565 and User-Defined 8-bit
    - TX: YUV422 (CCIR/ITU 8/10-bit), YUV444, RGB888/666/565 and RAW8/10/12/14
- Parallel Port Interface
  - ✧ Supports data formats
    - 24-bit bus – un-packed format (Both Input and Output mode)
      - ➢ RGB888/666/565, RAW8/10/12/14 and YUV422 8-bit (on 8/16-bit data bus) and 10-bit data formats.
      - ➢ YUV444 (Parallel Input mode only)
    - YUV422 8-bit – ITU BT.656 and ITU BT.601 (Parallel input mode only)
      - ➢ Up to 100 MHz PCLK frequency for Output mode, and 166 MHz for Input mode.
- I2C Slave Interface (CS = L)
  - ✧ Support for normal (100 kHz), fast mode (400 kHz) and special mode (1 MHz)
  - ✧ Configure all TC9591XBG internal registers
- SPI Slave Interface (Only applicable in CSIOut configuration, MSEL = H, and CS = H)
  - ✧ SPI interface support for up to 25 MHz operation.
  - ✧ Configure all TC9591XBG internal registers
- GPIO signals
  - ✧ 3 GPIO signals
    - Three GPIO signals can be configured as control signals (MCLK, CXRST, XShutdown) for CSI-2 RX device.
    - Or one GPIO signal can be configured as INT signal for Parallel interface.
- 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
- Operation temperature
  Ta = -40 °C to 105 °C
- AEC-Q100 qualified with the following definition
  - ✧ Grade 2 : -40 °C to 105 °C ambient operating temperature range

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REFERENCES

1. MIPI D-PHY, “MIPI_D-PHY_specification_v01-00-00, May 14, 2009"
2. MIPI CSI-2, "MIPI Alliance Standard for Camera Serial Interface 2 (CSI-2) Version 1.01 Revision Nov 2010"
3. I^2C bus specification, version 2.1, January 2000, Philips Semiconductor

1. Overview

The MIPI CSI-2 to Parallel port and Parallel port to CSI-2 (TC9591XBG) is a bridge device that has both functions to convert MIPI data transfers from devices such as a camera to an application processor over a Parallel port interface and to convert parallel data transfers to an application over a MIPI CSI-2 interface. All internal registers can be accessed through I^2C or SPI (in CSI out case only).

There are several system configurations where TC9591XBG is typically used.

- CSI-2 RX with Parallel output mode for scanner application. In this mode, TC9591XBG (CSI-2 to Parallel converter) is a bridge device that converts serial data transfers from devices such as a camera to an application processor over a parallel interface.
- CSI-2 TX with Parallel Input mode for Analog TV, TelePresence Type, and Specialty/Older Cameras application. In this mode, TC9591XBG (Parallel to CSI-2 converter) is a bridge device that converts parallel data transfers to an application over a MIPI CSI-2 interface.

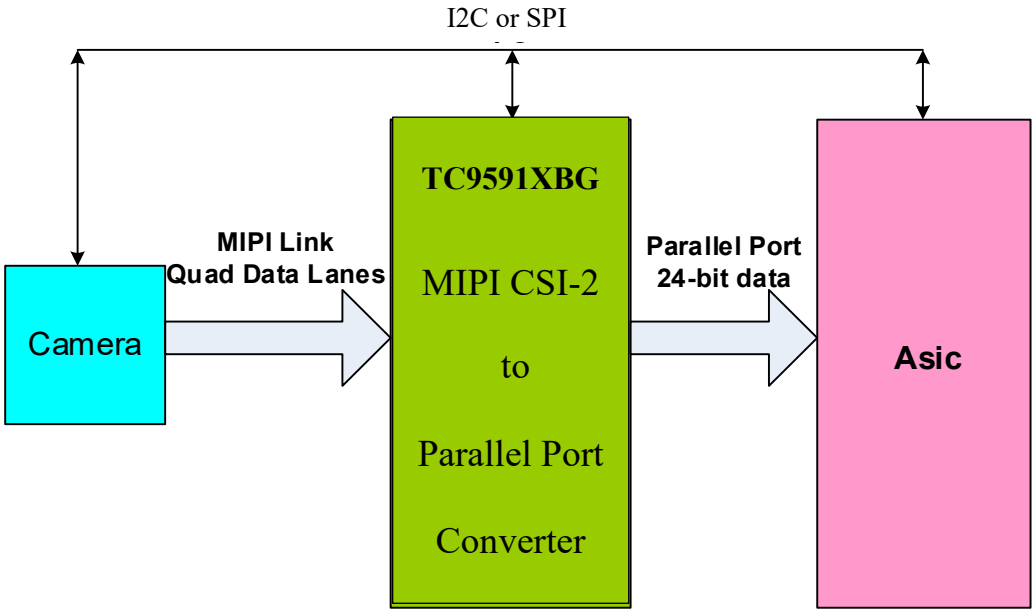

Figure 1.1 System Overview with TC9591XBG in CSI-2 RX to Parallel Port Configuration

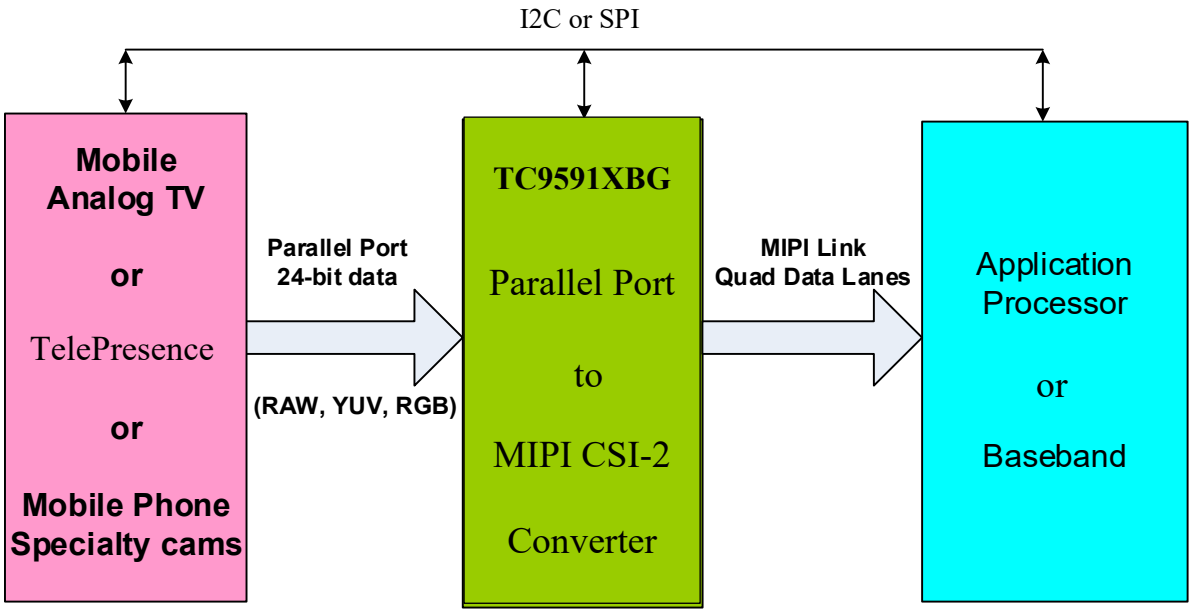

Figure 1.2 System Overview with TC9591XBG in Parallel Port to CSI-2 TX Configuration

2. Features

Below are the main features supported by TC9591XBG.

- CSI-2 TX/RX Interface
  - ✧ MIPI CSI-2 compliant (Version 1.01 Revision 0.04 – 2 April 2009)
  - ✧ Configurable to TX or RX controller
  - ✧ Supports up to 1Gbps per data lane
  - ✧ Supports up to 4 data lanes
  - ✧ Supports video data formats
    - RX: RAW8/10/12/14, YUV422 (CCIR/ITU 8/10-bit), RGB888/666/565 and User-Defined 8-bit
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  - ✧ Up to 100 MHz PCLK frequency for Output mode, and 166 MHz for Input mode.
- I^2C Slave Interface (CS = L)
  - ✧ Support for normal (100 kHz), fast mode (400 kHz) and special mode (1 MHz)
  - ✧ Configure all TC9591XBG internal registers
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    - Three GPIO signals can be configured as control signals (MCLK, CXRST, XShutdown) for CSI-2 RX device.
    - Or one GPIO signal can be configured as INT signal for Parallel interface.
- 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
- AEC-Q100 Qualified with the following definition
  - ✧ Grade 2 : -40 °C to 105 °C ambient operating temperature range

2.1. Typical Power Consumption

Parallel_In → CSI_Out, 500 MHz CSICLk, 1080P @60fps				
	VDDIO (3.3 V)	VDDC (1.2 V)	VDD_MIPI (1.2 V)	Total Power
Current (mA)	0.44	40.4	24.5	
Power (mW)	1.45	48.48	29.40	79.33

CSI_In → Parallel_Out, 500 MHz CSICLk, 100 MHz PCIk ColorBar @60fps				
	VDDIO (3.3 V)	VDDC (1.2 V)	VDD_MIPI (1.2 V)	Total Power
Current (mA)	18.9	13.9	12.3	
Power (mW)	62.37	16.68	14.76	93.81

3. External Pins

3.1. TC9591XBG pinout description

TC9591XBG resides in BGA pin packages. The following table gives the signals of TC9591XBG and their function.

Table 3.1 TC9591XBG Functional Signal List

Group	Pin Name	I/O		Type	Initial (O)	Function	Note
		MSEL=0	MSEL=1				
System: Reset & Clock (4)	RESX	I	I	Sch	-	System reset input, active low	-
	REFCLK	I	I	N	-	Reference clock input (6MHz – 40MHz)	-
	MSEL	I	I	N	-	Mode Select 1'b0: CSI-2 RX in –> Parallel out 1'b1: Parallel in -> CSI-2 TX	-
	CS	I	I	N	-	Chip Select, active low MSEL= 0 (CSI-2 RX in –> Parallel out) - When CS = 0, chip selected Normal operation - When CS = 1, chip not selected Cannot access to internal registers and optionally Parallel output ports can be tri-state when 0x0004[15] is set MSEL= 1 (Parallel in -> CSI-2 TX) - CS = 0, I²C I/F is selected - CS = 1, SPI I/F is chosen	-
MIPI-CSI (10)	MIPI_CP	I	O	PHY	LP11	MIPI-CSI clock positive	-
	MIPI_CN	I	O	PHY	LP11	MIPI-CSI clock negative	-
	MIPI_D0P	I	O	PHY	LP11	MIPI-CSI Data 0 positive	-
	MIPI_D0N	I	O	PHY	LP11	MIPI-CSI Data 0 negative	-
	MIPI_D1P	I	O	PHY	LP11	MIPI-CSI Data 1 positive	-
	MIPI_D1N	I	O	PHY	LP11	MIPI-CSI Data 1 negative	-
	MIPI_D2P	I	O	PHY	LP11	MIPI-CSI Data 2 positive	-
	MIPI_D2N	I	O	PHY	LP11	MIPI-CSI Data 2 negative	-
	MIPI_D3P	I	O	PHY	LP11	MIPI-CSI Data 3 positive	-
	MIPI_D3N	I	O	PHY	LP11	MIPI-CSI Data 3 negative	-
I2C I/F (2)	I2C_SCL	I	I	Sch	-	I²C serial clock or SPI_SCLK	4 mA
	I2C_SDA	I	I	Sch	-	I²C serial data or SPI_MOSI	4 mA
Parallel Port I/F (27)	PD[23:0]	O	I	N	L	Parallel Port Data - PD[23:12] can configs to be GPIO[15:4]	4 mA
	VVALID	O	I	N	L	Parallel port VVALID signal	4 mA
	HVALID	O	I	N	L	Parallel port HVALID signal	4 mA
	PCLK	O	I	N	L	Parallel Port Clock signal	4 mA
GPIO (3)	GPIO[2:0]	I	I	N	-	**GPIO[2:0] signals** CSI-2 RX in –> Parallel out - (GPIO[0] option to become MCLK signal) - (GPIO[1] option to become CXRST or INT) - (GPIO[2] option to become XShutdown) Parallel in -> CSI-2 TX - (GPIO[0] option to become MCLK signal) - (GPIO[1] option to become SPI_SS or INT) - (GPIO[2] option to become SPI_MISO)	4 mA
POWER (9)	VDDC (1.2 V)	NA	-	-	-	VDD for Internal Core (2)	-
	VDDIO (1.8 V or 3.3 V)	NA	-	-	-	VDDIO is for IO power supply (3)	-
	VDD_MIPI (1.2 V)	NA	-	-	-	VDD for the MIPI CSI2 (2)	-
Ground (25)	VSS	NA	-	-	-	Ground	-

3.2. TC9591XBG BGA80 Pin Count Summary

Table 3.2 TC9591XBG BGA 80 Pin Count Summary

Group Name	Pin Count	Notes
SYSTEM	4	-
MIPI-CSI	10	-
I2C I/F	2	-
GPIO	3	-
Parallel Port I/F	27	-
POWER	9	IO, MIPI and Core Power
GROUND	25	-
TOTAL	**80**	

3.3. TC9591XBG 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	HVALID	CS	MIPI_D0P	MIPI_D0N
K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
PD5	PD3	PD1	VDDC	VDDIO	REFCLK	VVALID	GPIO0	VDDIO	VSS

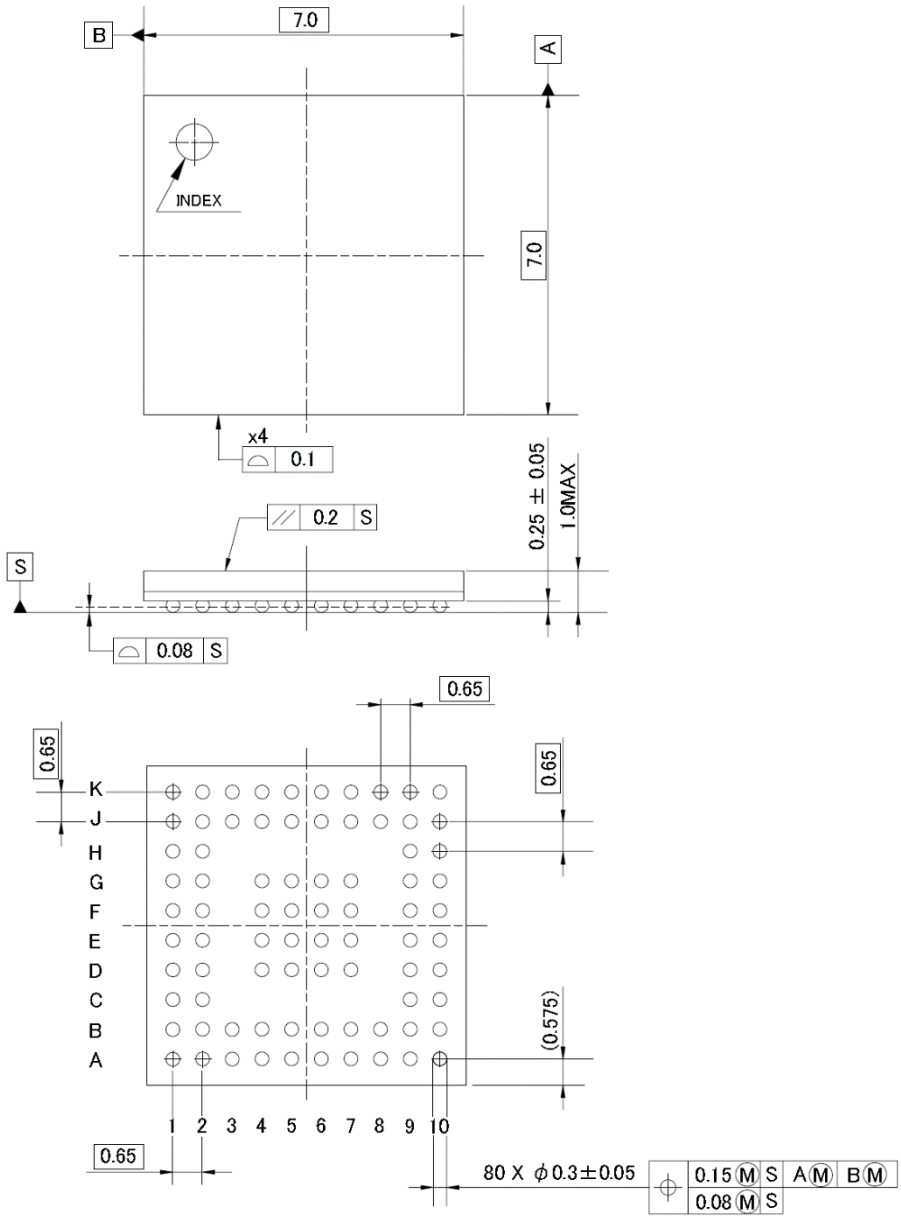
Figure 3.1 TC9591XBG 80-Pin Layout (Top View)

4. Package

4.1. TC9591XBG Package

The packages for TC9591XBG are described in the figures below.

Unit: mm



Weight: 68 mg (Typ.)

Figure 4.1 TC9591XBG P-VFBGA80-0707-0.65-001 package

Table 4.1 TC9591XBG 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= 0V reference

Parameter	Symbol	Rating	Unit
Supply voltage (1.8V - Digital IO)	VDDIO	-0.3 to +3.9	V
Supply voltage (1.2V – Digital Core)	VDDC	-0.3 to +1.8	V
Supply voltage (1.2V – MIPI CSI PHY)	VDD_MIPI	-0.3 to +1.8	V
Input voltage (CSI IO)	V_{IN_CSI}	-0.3 to VDD_MIPI+0.3	V
Output voltage (CSI IO)	V_{OUT_CSI}	-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
Junction temperature	Tj	125	°C
Storage temperature	Tstg	-40 to +125	°C

5.2. Operating Condition

VSS= 0V reference

Parameter	Symbol	Min	Typ.	Max	Unit
Supply voltage (1.8V – Digital IO)	VDDIO	1.65	1.8	1.95	V
Supply voltage (3.3V – Digital IO)	VDDIO	3.0	3.3	3.6	V
Supply voltage (1.2V – Digital Core)	VDDC	1.1	1.2	1.3	V
Supply voltage (1.2V – MIPI CSI PHY)	VDD_MIPI	1.1	1.2	1.3	V
Operating temperature (ambient temperature with voltage applied)	Ta	-40	+25	+105	°C
Supply Noise Voltage	V_{SN}	-	-	100	mV_{pp}

5.3. DC Electrical Specification

Parameter	Symbol	Min	Typ.	Max	Unit
Input voltage, High level input Note1	V_{IH}	0.7 VDDIO	-	VDDIO	V
Input voltage, Low level input Note1	V_{IL}	0	-	0.3 VDDIO	V
Input voltage High level CMOS Schmitt Trigger Note1, Note2	V_{IHS}	0.7 VDDIO	-	VDDIO	V
Input voltage Low level CMOS Schmitt Trigger Note1, Note2	V_{ILS}	0	-	0.3 VDDIO	V
Output voltage High level Note1, Note2 **(Condition: IOH = -0.4mA)**	V_{OH}	0.8 VDDIO	-	VDDIO	V
Output voltage Low level Note1, Note2 **(Condition: IOL = 2mA)**	V_{OL}	0	-	0.2 VDDIO	V
Input leak current, High level (Normal IO or Pull-up IO) (Condition: VIN = +VDDIO, VDDIO = 3.6V)	I_{ILH1} (Note4)	-10	-	10	μA
Input leak current, High level (Pull-down IO) (Condition: VIN = +VDDIO, VDDIO = 3.6V)	I_{ILH2} (Note4)	-	-	100	μA
Input leak current, Low level (Normal IO or Pull-down IO) (Condition: VIN = 0V, VDDIO = 3.6V)	I_{ILL1} (Note5)	-10	-	10	μA
Input leak current, Low level (Pull-up IO) (Condition: VIN = 0V, VDDIO = 3.6V)	I_{ILL2} (Note5)	-	-	200	μA

Note1: Each power source is operating within operation condition.

Note2: Current output value is specified to each IO buffer individually. Output voltage changes with output current value.

Note4: Normal pin or Pull-up IO pin applied VDDIO supply voltage to Vin (input voltage)

Note5: Normal pin or Pull-down IO pin applied VSSIO (0V) to Vin (input voltage)

6. Revision History

Table 6.1 Revision History

Revision	Date	Description
1.0	2020-06-05	Newly released

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