TOSHIBA

8 Bit Microcontroller
TLCS-870/C Series

TMP86C987XB

TOSHIBA CORPORATION

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For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance/Handling Precautions. 030619_S

Revision History

Date	Revision	
2006-7-21	1.0	First release

CMOS 8-Bit Microcontroller

TMP86C987XB

The TMP86C987XB is an emulation chip supporting the TMP86CH87/CM87 and TMP86CH09/C809. The TMP86C987XB can be used, in combination with development tools for the TLCS-870/C Series, to check and debug the functional operations of application programs for the supported microcontrollers.

The emulation chip is normally mounted on a socket on an emulation module and connected to a target system via a target connecting board.

For the details about the functions of a microcontroller, refer to the technical documentation of each supported microcontroller. For the emulation functions and usage directions, refer to the instruction manual of the RTE870/C emulation module.

Part Number	ROM	RAM	Package	Emulation Module	Target Connecting Board
TMP86C987XB	Not available	Not available	P-FBGA272-1515-0.80A7	BMP86A2000 20A	BMP86D044DE0A (For CH87/CM87) BMP86D032NB0A (For CH09/C809)

Note: This product is intended to be used as part of development tools (having a part number starting with “BM”). Do not use this product for any other purposes and systems.

2.1 Pin Configuration (Bottom View)

	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	T	U
1	N.C		GND	CBUS7	CBUS2	X1	GND	TVDD	(tg04) TEST	(tg08) $\overline{\text{RESET}}$	(tg12) P02	(tg17) P07	(tg21) P14	(tg25) P10	(tg31) P35	(tg35) AVDD	
2	N.C	TMAD1	TMAD0	XT2	CBUS5	GND	VDD	(tg01) VSS	(tg05) VDD	(tg09) P20	(tg14) P04	(tg19) P16	(tg24) P11	(tg29) P33	(tg33) P37	(tg37) P40	GND
3	N.C	TMAD3	TMAD2	$\overline{\text{CBALE}}$	$\overline{\text{INIT}}$	CBUS1	EVA	$\overline{\text{CBWR}}$	(tg02) XIN	(tg10) P00	(tg15) P05	(tg20) P15	(tg27) P31	(tg32) P36	(tg36) AVSS	(tg38) P41	(tg41) P44
4	TMAD11	TMAD7	TMAD5	$\overline{\text{CBRD}}$	XT1	CBUS4	X2	$\overline{\text{RUNR}}$	(tg03) XOUT	(tg11) P01	(tg16) P06	(tg23) P12	(tg30) P34	(tg39) P42	(tg40) P43	(tg42) P45	(tg45)
5	TMAD15	TMAD12	TMAD9	TMAD6	TMAD4	CBUS6	CBUS0	GND	(tg06) P21	(tg13) P03	(tg18) P17	(tg26) P30	(tg34) VAREF	(tg43) P46	(tg44) P47	(tg47)	(tg50)
6	$\overline{\text{TMAS}}$	$\overline{\text{TMWS}}$	VDD	TMAD13	TMAD10	TMAD8	CBUS3	SYSCKM	GND	(tg07) P22	(tg22) P13	(tg28) P32	(tg46)	(tg48)	(tg51)	(tg53)	(tg55)
7	PMD4	PMD2	PMD1	PMD0	$\overline{\text{TMDS}}$	TMAD14	N.C	N.C		N.C	N.C	(tg49)	(tg52)	(tg54)	(tg56)	(tg58)	(tg59)
8	GND	PMD7	PMD6	PMD5	PMD3	$\overline{\text{EMC}}$		N.C			N.C	(tg57)	(tg60)	(tg61)	(tg62)	(tg64)	(tg63)
9	BMD1	BMD2	$\overline{\text{BMCS}}$	BMD0	BMD3	$\overline{\text{PBRQ}}$						(tg70)	(tg69)	(tg66)	(tg65)	(tg68)	(tg67)
10	$\overline{\text{PMWR}}$	$\overline{\text{PMRD}}$	$\overline{\text{ESMCS}}$	$\overline{\text{PMCS}}$	PMA0	PMA3	N.C	N.C		N.C	N.C	GND	(tg76)	(tg74)	(tg73)	(tg72)	(tg71)
11	PMA1	PMA2	PMA4	PMA6	PMA8	PMA11		N.C			N.C	(tg85)	(tg81)	(tg79)	(tg78)	(tg77)	(tg75)
12	PMA5	PMA7	PMA9	PMA12	PMA14	(tg153)	(tg147)	(tg133)	(tg132)	(tg119)	(tg111)	(tg91)	(tg89)	(tg86)	(tg83)	(tg82)	(tg80)
13	PMA10	PMA13	PMA16	$\overline{\text{RUNM}}$	(tg159)	(tg151)	(tg143)	(tg139)	(tg131)	(tg122)	(tg114)	(tg108)	(tg97)	(tg93)	(tg90)	(tg87)	(tg84)
14	PMA15	SYSTEM	VDD	GND	(tg155)	(tg148)	(tg141)	(tg137)	(tg128)	(tg123)	(tg116)	(tg110)	(tg105)	(tg102)	(tg95)	(tg92)	(tg88)
15	$\overline{\text{VDDM}}$	GND	GND	(tg157)	(tg152)	(tg145)	GND	(tg136)	(tg127)	(tg124)	(tg118)	(tg113)	(tg106)	(tg103)	(tg98)	(tg96)	(tg94)
16	VDD		(tg158)	(tg154)	(tg149)	(tg144)	(tg140)	(tg135)	(tg130)	(tg126)	(tg120)	(tg115)	(tg109)	(tg104)	(tg101)	(tg99)	
17	TVDD	(tg160)	(tg156)	(tg150)	(tg146)	(tg142)	(tg138)	(tg134)	(tg129)	(tg125)	(tg121)	(tg117)	(tg112)	(tg107)	GND	(tg100)	N.C

Note 1: The tg01 to tg44 pins of the emulation chip correspond to pins 1 to 44 of a microcontroller. These pins are connected to a 44-pin target connecting board and function as external output pins for a pin protector/QFP adatper.
The target connecting board to be used varies with package type. Be sure to use the correct board.

Note 2: Shaded areas do not have pins (solder balls).

2.2 Pin Function

Pin Name	Input/Output	Functions	Pin Name (MCU)
tg17	I/O (Input)	MCU Function Input/Output Ports	P07 (TC1, INT4)
tg16	I/O (I/O)		P06 (INT3, $\overline{PPG}$)
tg15	I/O (Input)		P05 ($\overline{SS}$)
tg14	I/O (I/O)		P04 (MISO, Rx)
tg13	I/O (I/O)		P03 (MOSI, Tx)
tg12	I/O (I/O)		P02 (SCLK)
tg11	I/O (Input)		P01 (RxD, Rx)
tg10	I/O (Output)		P00 (TxD, Tx)
1g18	I/O		P17
tg19	I/O		P16
tg20	I/O (Input)		P15 (INT2)
tg21	I/O		P14
tg22	I/O		P13
tg23	I/O (Output)		P12 ($\overline{DVO}$)
tg24	I/O (Input)		P11 (INT1)
tg25	I/O (Input)		P10 ($\overline{INT0}$)
tg07	I/O (Output)		P22 (XTOUT)
tg06	I/O (Input)		P21 (XTIN)
tg09	I/O (Input)		P20 ($\overline{INT5}$,$\overline{STOP}$)
tg33	I/O (Input)		P37 (AIN5, STOP5)
tg32	I/O (Input)		P36 (AIN4, STOP4)
tg31	I/O (Input)		P35 (AIN3, STOP3)
tg30	I/O (Input)		P34 (AIN2, STOP2)
tg29	I/O (Input)		P33 (AIN1)
tg28	I/O (Input)		P32 (AIN0)
tg27	I/O (I/O)		P31 (TC4, $\overline{PDO4}$, $\overline{PWM4}$, $\overline{PPG4}$)
tg26	I/O (I/O)		P30 (TC3, $\overline{PDO3}$, $\overline{PWM3}$)
tg44	I/O (Input)		P47 (AIN17)
tg43	I/O (Input)		P46 (AIN16)
tg42	I/O (Input)		P45 (AIN15)
tg41	I/O (Input)		P44 (AIN14)
tg40	I/O (Input)		P43 (AIN13)
tg39	I/O (Input)		P42 (AIN12)
tg38	I/O (Input)		P41 (AIN11)
tg37	I/O (Input)		P40 (AIN10)
tg02, tg03	Input, Output	MCU Function Control Pins	XIN, XOUT
tg08	Input		$\overline{RESET}$
tg04	Input		TEST
tg05, tg01	Power supply	MCU Function Power supply	VDD,VSS
tg34		MCU Function Analog reference pin for the AD converter	VAREF
tg35		MCU Function Power supply for the AD converter	AVDD
tg36		MCU Function Analog GND pin for the AD converter	AVSS

Pin Name	Input/Output	Functions	Pin Name (MCU)
CBUS0 to CBUS7	I/O	Emulation System Control Pins	
$\overline{\text{CBALE}}$	Input		
$\overline{\text{CBRD}}$	Input		
$\overline{\text{CBWR}}$	Input		
$\overline{\text{INIT}}$	Input		
PMA0 to PMA15	Output		
PMD0 to PMD7	I/O		
BMD0 to BMD3	I/O		
$\overline{\text{PMRD}}$	I/O		
$\overline{\text{PMWR}}$	I/O		
PMA16	Output		
$\overline{\text{PMCS}}$	Output	Emulation System Control Pins	
$\overline{\text{ESMCS}}$	Output		
$\overline{\text{BMCS}}$	Output		
$\overline{\text{EMC}}$	Input		
$\overline{\text{PBRG}}$	Input		
SYSTEM	Input		
$\overline{\text{RUNR}}$	Input		
$\overline{\text{RUNM}}$	Output		
TMAD0 to TMAD15	I/O		
$\overline{\text{TMAS}}$	Output		
$\overline{\text{TMDS}}$	Output		
$\overline{\text{TMWS}}$	Output		
SYSCKM	Output		
X1, X2	Input		
XT1, XT2	Input		
EVA	Input		
$\overline{\text{VDDM}}$	Output		
N.C	–		
EVDD	Power supply	Power supply for Emulation Function	
TVDD		Power supply for MCU Function	
GND		GND	

Note: Emulation System Control pins, EVDD, TVDD and GND are specified pins for Emulation chip. For the details about these pins, refer to the instruction manual of 870/C emulation module.

2.3 Operational Description

The TMP86C987XB can emulate the following microcontrollers:

TMP86CH87/CM87

TMP86CH09/C809

2.3.1 Emulation Functions

The main emulation functions include mapping, break and trace functions. The mapping is initially set for the TMP86CM87 (ROM: 32 KB, RAM: 1 KB). Therefore, please set the corresponding mapping of ROM or RAM when it emulates the product other than 32 KB of ROM or 1 KB of RAM.

The TMP86C987XB controls programs from an emulation system (host system) and does not contain program memory (mask ROM, OTP, flash memory) and data memory (RAM). The emulation memory on the emulation module is used for storing programs and data.

For detailed information about the emulation functions, refer to the “TLCS-870/C Series Debugger Operation Manual”.

2.3.2 MCU Functions

The TMP86C987XB is equivalent to or upwardly compatible with the microcontrollers it can emulate except that it contains no program memory and data memory. For detailed information about the MCU functions, refer to the technical documentation of each microcontroller to be emulated.

2.4 Pin Input/Output Circuits

2.4.1 MCU Function Control Pins

The control pins for the MCU functions (XIN, XOUT and $\overline{\text{RESET}}$ pins) are configured in the same way as those of the microcontrollers the TMP86C987XB can emulate.

Note: TMP86C987XB has a pull-down resistor in TEST pin.

2.4.2 MCU Function Input/Output Ports

The input/output ports of the TMP86C987XB are basically configured in the same way as those of the microcontrollers it can emulate.

2.4.3 Emulation System Control Pins

The control pins for the emulation system are basically configured as CMOS hysteresis inputs (or TTL inputs in some cases)/CMOS tri-state outputs. The CBUS and TMAD pins have pull-up resistors, and all the emulation system control pins have protective diodes on the VDD/VSS side.

2.5 Electrical Characteristics

2.5.1 Absolute Maximum Ratings

The absolute maximum ratings are rated values which must not be exceeded during operation, even for an instant. Any one of the ratings must not be exceeded. If any absolute maximum rating is exceeded, a device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user. Thus, when designing products which include this device, ensure that no absolute maximum rating value will ever be exceeded.

(GND = V_{SS} = 0 V)

Parameter	Symbol	Pins	Ratings	Unit
Supply voltage	EV_{DD}	EVDD	−0.3 to 6.5	V
	V_{DD}	VDD, TVDD	−0.3 to EVDD	
Input voltage	V_{IN}		−0.3 to V_{DD} + 0.3	
Output voltage	V_{OUT}		−0.3 to V_{DD} + 0.3	
Output current (Per 1 pin)	I_{OUT1}	P0, P1, P3, P4 ports	−1.8	mA
	I_{OUT2}	P1, P2, P3, P4 ports	3.2	
	I_{OUT3}	P0 port	30	
Output current (Total)	ΣI_{OUT1}	P0, P1, P3, P4 ports	−30	
	ΣI_{OUT2}	P1, P2, P3, P4 ports	60	
	ΣI_{OUT3}	P0 port	80	
Power dissipation [Topr = 60°C]	P_D	Emulation + MCU	650	mW
Storage temperature	Tstg		−55 to 125	°C
Operating temperature	Topr		0 to 60	

Note: The above shows the value in under the condition in which there is no connection to an emulation module.

2.5.2 Recommended Operating Condition

The recommended operating conditions for a device are operating conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating conditions other than the recommended operating conditions (supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating conditions for the device are always adhered to.

($GND = V_{SS} = 0$ V, $V_{DD} = T_{VDD} \leq E_{VDD}$, Topr = 0 to 60°C)

Parameter	Symbol	Pins	Condition		Min	Max	Unit
Supply voltage	E_{VDD}	EVDD			4.75	5.25	V
	V_{DD}	VDD, TVDD	fc = 16 MHz	NORMAL1, 2 mode	4.5	5.25	
				IDLE0, 1, 2 mode			
			fc = 8 MHz	NORMAL1, 2 mode IDLE0, 1, 2 mode			
			fs = 32.768 kHz	SLOW1, 2 mode			
				SLEEP0, 1, 2 mode			
				STOP mode			
Input high level	V_{IH1}	Except hysteresis input			$V_{DD} \times 0.70$	V_{DD}	
	V_{IH2}	Hysteresis input			$V_{DD} \times 0.75$		
Input low level	V_{IL1}	Except hysteresis input			0	$V_{DD} \times 0.30$	
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
Clock frequency	fc	XIN, XOUT	V_{DD} = 4.5 V to 5.25 V		1.0	16.0	MHz
	fs	XTIN, XTOUT	V_{DD} = 4.5 V to 5.25 V		30.0	34.0	kHz

2.5.3 DC Characteristics

($GND = V_{SS} = 0$ V, $V_{DD} = T_{VDD} \leq E_{VDD}$, Topr = 0 to 60°C)

Parameter	Symbol	Pins	Condition	Min	Typ.	Max	Unit
Hysteresis voltage	V_{HS}	Hysteresis input		–	0.9	–	V
Input current	I_{IN1}	TEST	V_{DD} = 5.25 V, V_{IN} = 5.25 V/0 V	–	–	±2	μA
	I_{IN2}	Sink open drain, Tri-state					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input resistance	R_{IN2}	$\overline{RESET}$ pull-up	V_{DD} = 5.25 V, V_{IN} = 0 V	100	220	450	kΩ
Output leakage current	I_{LO}	Sink open drain, Tri-state	V_{DD} = 5.25 V, V_{OUT} = 5.25 V/0 V	–	–	±2	μA
Output high voltage	V_{OH}	P0, P1, P3, P4 ports	V_{DD} = 4.5 V, I_{OH} = –0.7 mA	4.1	–	–	V
Output low voltage	V_{OL}	P1, P2, P3, P4 ports	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	–	–	0.4	
Output low current	I_{OL}	P0 port	V_{DD} = 4.5 V, V_{OL} = 1.0 V	–	20	–	mA
Supply current in NORMAL 1, 2 mode	I_{DD}		V_{DD} = 5.25 V V_{IN} = 5.05/0.2 V fc = 16 MHz fs = 32.768 kHz CAN controller is enabled.	–	10	15	
Supply current in IDLE 0, 1, 2 mode				–	8	12	
Supply current in NORMAL 1, 2 mode			V_{DD} = 5.25 V V_{IN} = 5.05/0.2 V fc = 16 MHz fs = 32.768 kHz CAN controller is disabled.	–	7.5	9	
Supply current in IDLE 0, 1, 2 mode				–	5.5	6.5	
Supply current in SLOW 1 mode			V_{DD} = 5.25 V V_{IN} = 5.05/0.2 V fs = 32.768 kHz	–	15	35	μA
Supply current in SLEEP 1 mode				–	7	25	
Supply current in SLEEP 0 mode				–	6	25	
Supply current in STOP mode			V_{DD} = 5.25 V V_{IN} = 5.05 V/0.2 V	–	0.5	15	

Note 1: Typical values show those at Topr = 25°C, $V_{DD} = T_{VDD} = E_{VDD} = 5$ V

Note 2: Input current (I_{IN1}, I_{IN2}); The current through pull-up or pull-down resistor is not included.

Note 3: I_{DD} does not include I_{REF} current.

Note 4: The supply currents of SLOW 2 and SLEEP 2 modes are equivalent to IDLE 0, 1, 2.

2.5.4 AD Conversion Characteristics

($GND = V_{SS} = 0.0$ V, 4.5 V ≤ V_{DD} ≤ 5.25 V, Topr = 0 to 60°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Analog reference voltage	V_{AREF}		A_{VDD} – 1.0	–	A_{VDD}	V
Power supply voltage of analog control circuit (Note6)	A_{VDD}	$V_{DD} = T_{VDD} \leq E_{VDD}$	V_{DD}			
Analog input voltage	V_{AIN}		A_{VSS}	–	V_{AREF}	
Power supply current of analog reference voltage	I_{REF}	$V_{DD} = A_{VDD} = V_{AREF}$ = 5.25 V $V_{SS} = A_{VSS}$ = 0.0 V	–	0.6	1.0	mA
Non linearity error		$V_{DD} = A_{VDD} = V_{AREF}$ = 5.0 V $V_{SS} = A_{VSS}$ = 0.0 V	–	–	±2	LSB
Zero point error			–	–	±2	
Full scale error			–	–	±2	
Total error			–	–	±2	

Note 1: The total error includes all errors except a quantization error, and is defined as a maximum deviation from the ideal conversion line.

Note 2: Conversion time is different in recommended value by power supply voltage.
About conversion time, please refer to “Register Configuration”.

Note 3: Please use input voltage to AIN input Pin in limit of V_{AREF} to V_{SS}. When voltage of range outside is input, conversion value becomes unsettled and gives affect to other channel conversion value.

Note 4: Analog reference voltage range: $V_{AREF} = V_{AREF} - V_{SS}$

Note 5: The A_{VDD} pin should be fixed on the V_{DD} level even though AD converter is not used.

2.5.5 SEI Operating Conditions (Slave mode)

(V_{SS} = 0 V, $V_{DD} = T_{VDD} \leq E_{VDD}$, V_{DD} = 4.5 to 5.25 V, Topr = 0 to 60°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Transfer rate			15.625 k	–	fc/4	bps

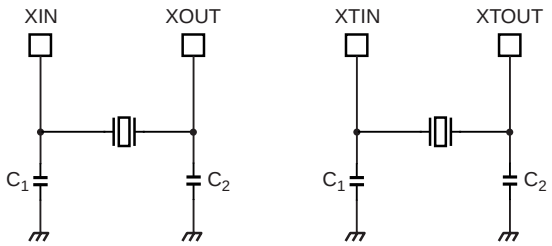
2.5.6 AC Characteristics

(V_{SS} = 0 V, $V_{DD} = T_{VDD} \leq E_{VDD}$, V_{DD} = 4.5 to 5.25 V, Topr = 0 to 60°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.25	–	4	μs
		IDLE1, 2 mode				
		SLOW1, 2 mode	117.6	–	133.3	
		SLEEP1, 2 mode				
High level clock pulse width	t_{WCH}	For external clock operation (XIN input) fc = 16 MHz	–	31.25	–	ns
Low level clock pulse width	t_{WCL}					
High level clock pulse width	t_{WCH}	For external clock operation (XTIN input) fs = 32.768 kHz	–	15.26	–	μs
Low level clock pulse width	t_{WCL}					

2.5.7 Recommended Oscillating Conditions

(V_{SS} = 0 V, $V_{DD} = T_{VDD} \leq E_{VDD}$, V_{DD} = 4.5 V to 5.25 V, Topr = 0 to 60°C)



(1) High-frequency Oscillation (2) Low-frequency Oscillation

Note 1: To ensure stable oscillation, the resonator position, load capacitance, etc. must be appropriate. Because these factors are greatly affected by board patterns, please be sure to evaluate operation on the board on which the device will actually be mounted.

Note 2: For the resonators to be used with Toshiba microcontrollers, we recommend ceramic resonators manufactured by Murata Manufacturing Co., Ltd.
For details, please visit the website of Murata at the following URL:

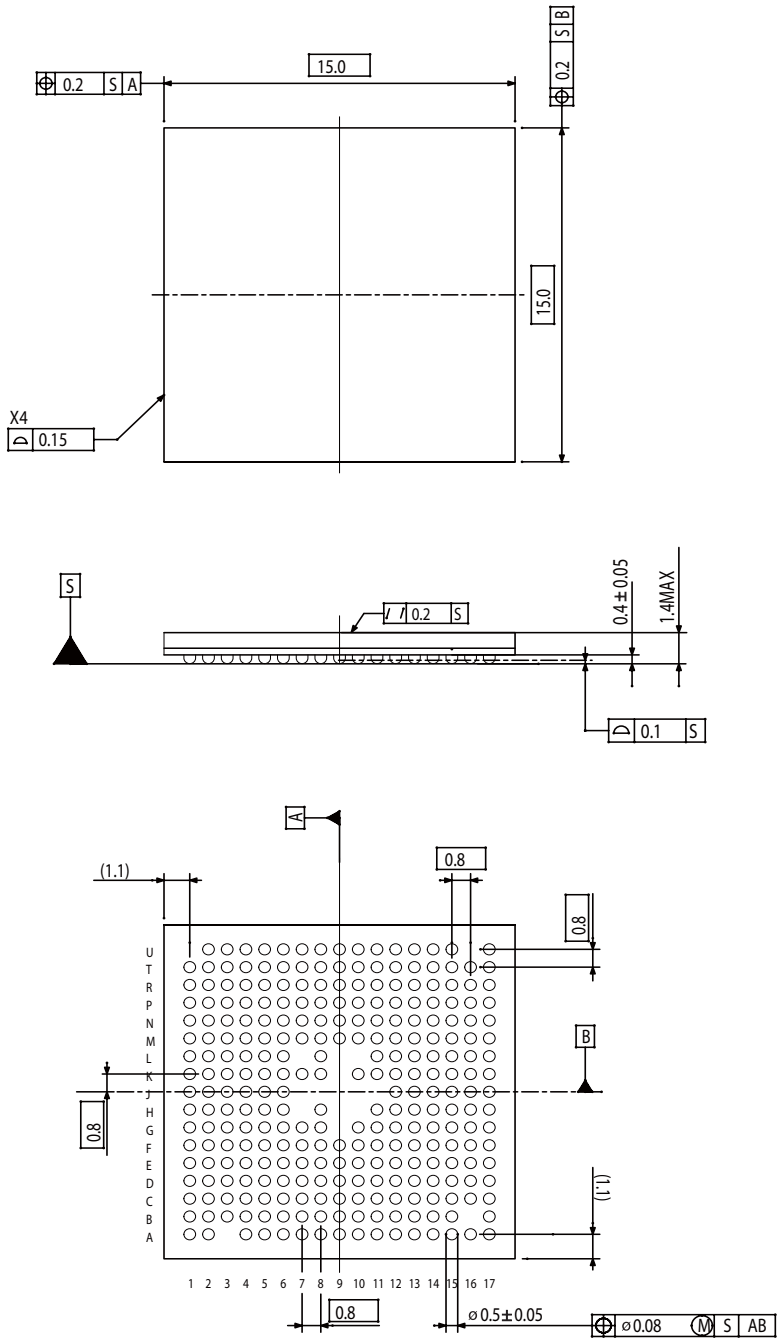
http://www.murata.com

2.6 Package Dimensions

272-in FBGA for TMP86C987XB

Package name: P-FBGA272-1515-0.80A7

Unit: mm



This is a technical document that describes the operating functions and electrical specifications of the 8-bit microcontroller series TLCS-870/C (LSI).

Toshiba provides a variety of development tools and basic software to enable efficient software development.

These development tools have specifications that support advances in microcomputer hardware (LSI) and can be used extensively. Both the hardware and software are supported continuously with version updates.

The recent advances in CMOS LSI production technology have been phenomenal and microcomputer systems for LSI design are constantly being improved. The products described in this document may also be revised in the future. Be sure to check the latest specifications before using.

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