



# LC89515K

## CD-ROM/CD-I Error Correction/ Host Interface LSI

### Overview

The LC89515K is a version of the LC8951 in which certain aspects of the internal registers have been improved to make them even easier to use in CD-ROM and CD-I products. The basic blocks are identical to those in the LC8951 and these products are software and pin compatible. Thus this product can replace the LC8951 without change. (However, this product is provided in a slightly different package: a short lead type QIP-80E as opposed to the QIP-80A.)

The LC89515K is an error correction and host interface LSI for use in CD-ROM and CD-I products. This product integrate in a single chip all CD-ROM specific functions, including the error correction that was previously implemented in software on a microprocessor and the CD player and host computer interfaces that were previously implemented in discrete components or gate arrays. The use of the LSI can provide significant improvements in CD-ROM and CD-I players, including increased transfer rates, miniaturization, increased reliability, an improved cost performance ratio, and a more efficient development period.

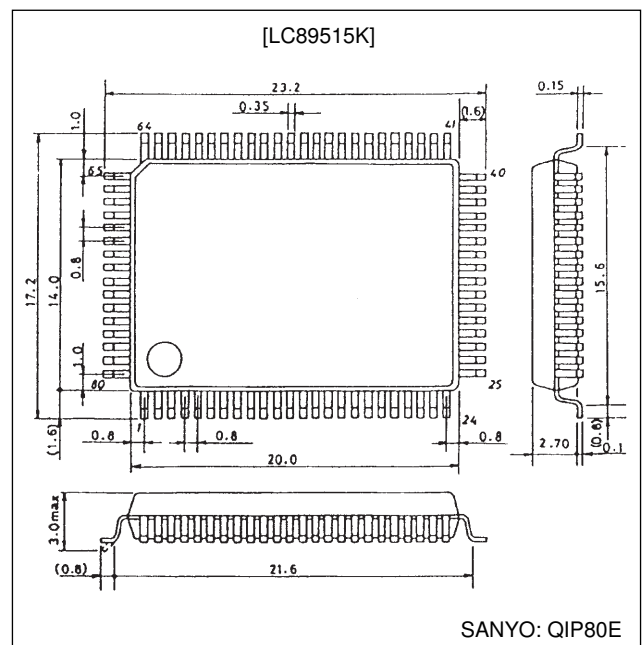
### Features

- Software and pin compatibility with the LC8951 (Changes were made to internal registers, the SRAM interface, and other aspects.)
- Support for CD-ROM (mode 1) and CD-I (mode 2, forms 1 and 2)
- All CD-ROM/CD-I special functions implemented on a single chip
- Hardware error detection and correction for high speed, without relying on software
- Real-time error correction: Error correction and detection are possible without interrupting the host interface bus.
- Fast transfers: up to 2.3 MB/s (18.4 Mb/s)
- Support for low-speed hosts (multiple block buffering)
- Built-in host interface command FIFO (for easy SCSI support)
- Built-in 12-byte status FIFO
- CMOS circuits, single 5 V power supply

### Package Dimensions

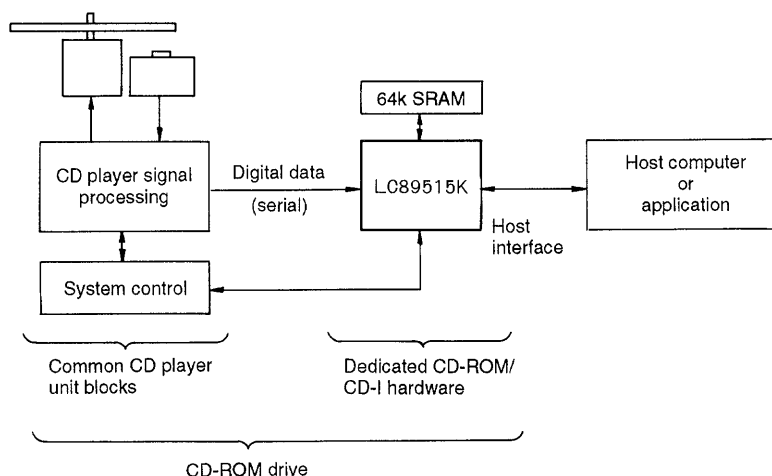
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#### 3174-QFP80E

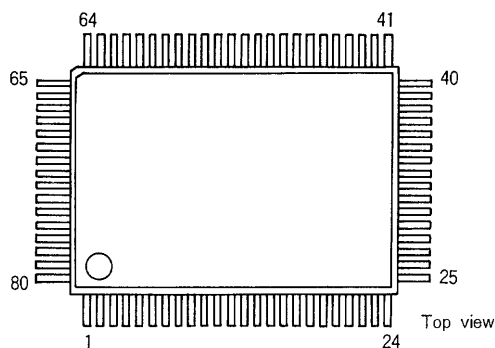


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## System Block Diagram



## Pin Assignment



Type: I: Input pin, O: Output pin, B: Bidirectional pin, P: Power supply pin, NC: No connection

Pin No.	Pin	Type	Pin No.	Pin	Type	Pin No.	Pin	Type
1	V <sub>SS</sub>	P	28	TEST2	I	55	HWR	I
2	RA6	O	29	CSEL	I	56	HRD	I
3	RA7	O	30	LMSEL	I	57	CMD	I
4	RA8	O	31	V <sub>DD</sub>	P	58	WAIT	O
5	RA9	O	32	LRCK	I	59	DTEN	O
6	RA10	O	33	SDATA	I	60	STEN	O
7	RA11	O	34	BCK	I	61	EOP	O
8	RA12	O	35	C4LR	I	62	RCS	O
9	RA13	O	36	C2PO	I	63	HDE	O
10	RA14	O	37	MCK	O	64	V <sub>SS</sub>	P
11	RA15	O	38	D0	B	65	HD7	B
12	RWE	O	39	D1	B	66	HD6	B
13	V <sub>SS</sub>	P	40	D2	B	67	HD5	B
14	ROE	O	41	V <sub>SS</sub>	P	68	HD4	B
15	ERA	B	42	D3	B	69	HD3	B
16	IO8	B	43	D4	B	70	HD2	B
17	IO7	B	44	D5	B	71	HD1	B
18	IO6	B	45	D6	B	72	HD0	B
19	IO5	B	46	D7	B	73	V <sub>DD</sub>	P
20	IO4	B	47	RS	I	74	SELDRO	I
21	IO3	B	48	RD	I	75	RA0	O
22	IO2	B	49	WR	I	76	RA1	O
23	IO1	B	40	CS	I	77	RA2	O
24	V <sub>SS</sub>	P	51	INT	O	78	RA3	O
25	XTALCK	I	52	V <sub>SS</sub>	P	79	RA4	O
26	XTAL	O	53	RESET	I	80	RA5	O
27	TEST1	I	54	ENABLE	I			

Note: Do not leave any of the V<sub>DD</sub> or V<sub>SS</sub> pins open. All of the V<sub>DD</sub> and V<sub>SS</sub> pins must be connected to ground or the power supply, respectively.

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## Block Functions

The LC89515K consist of three major blocks. This section describes those blocks.

### 1. CD Player Interface and Data Input Block

This LSI can handle three serial input formats selectable by setting external pin voltages. That is, differences in CD player serial data formats can be compensated for by setting the CSEL and LMSEL inputs.

Internal operations are synchronized with the input data in block (sector) units using a synchronization detector circuit. The synchronization circuit not only uses pattern detection on the externally input data, but also performs synchronization protection with a synchronization signal interpolation circuit. These two synchronization systems can be turned on or off under program control.

The input data is written to a buffer RAM in 8-bit units after passing through a descrambling circuit. The C2 pointer (error flag) from the CD player is also written to RAM at this time. Although applications that use the C2 pointer must provide a 9-bit RAM, the C2 pointer may be omitted and such applications need only provide an 8-bit RAM. However, note that erasure correction cannot be performed if the C2 pointer is not used.

All input data, including sync, header, subheader and parity (2352 bytes) is stored in RAM in the order received from the CD player in its entirety.

Furthermore, the LC89515K provides an output pin (MCK) for use with the CD LSI's oscillator input pin. Therefore, the number of oscillator elements in the end product can be reduced by selecting the LC89515K master clock frequency to be twice the CD LSI clock frequency.

### 2. Error Detection and Correction Block

Error correction code decoding is performed after a full block (sector: 2352 bytes) of data has been stored in RAM. The LC89515K error correction function operates in real time completely internally. The system software merely waits for that processing to complete. Furthermore, buffering of data from the CD and transfer to the host computer are performed simultaneously. That is, the LC89515K can transfer to the host computer data that has been error corrected without any reduction in the data transfer rate from the CD.

The error correction technique not only consists of error detection and correction, but also supports combination with erasure correction referencing the C2 pointer. This means that data with high reliability is acquired. The error detection and correction process can correct single symbol errors, and can correct two symbol errors when combined with erasure correction.

Furthermore, the error correction algorithm is programmable, and the LC89515K can be instructed to perform a wide variety of procedures, such as iterative correction or QP/PQ correction, to improve data reliability.

After decoding the error correction codes (ECC), a 32-bit CRC error check is performed using the error detection codes (EDC). During the CRC check the header and subheader are loaded into LC89515K internal registers.

After completing the CRC check the LC89515K issues a decoding complete interrupt to the control microprocessor. The microprocessor then reads the header and subheader of the decoded block, the start address of the block in buffer RAM, and a decoding result status indicator from the LC89515K.

### 3. Host Interface Block

The data transfer rate to the host computer has been improved significantly, to 2.3 MB/s, and since the amount of buffering RAM has been increased to 64 kB, up to 27 sectors (blocks) of the CD ROM drive can be stored. This memory can also be used as a disk cache memory.

The host interface provides an 8-byte FIFO for receiving commands from the host. The host can write up to 8 bytes of commands at one time by asserting the  $\overline{\text{HWR}}$  signal. When the host writes to the FIFO, the LC89515K issues a command interrupt to the control microprocessor. Here, the commands written to the 8-byte FIFO are never interpreted by the LC89515K.

When transferring data to the host, the control microprocessor writes the number of bytes to transfer and the start address in buffer RAM of the block to be transferred. Then, it performs a write operation to the transfer start trigger register. This causes the  $\overline{\text{DTEN}}$  pin to go low and informs the host of the data transfer start. While the  $\overline{\text{DTEN}}$  pin is low the host reads data items one after another by generating  $\overline{\text{HRD}}$  read pulses. If the host reads extremely rapidly, i.e., over about 2.3 MB/s, then the LC89515K will output a  $\overline{\text{WAIT}}$  signal. The host must not set  $\overline{\text{HRD}}$  high while  $\overline{\text{WAIT}}$  is low. During this single block transfer operation, the microprocessor does nothing other than waiting for the transfer complete interrupt that occurs when the transfer is done.

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Furthermore, the LC89515K  $\overline{\text{SELDRQ}}$  pin can be used to perform DRQ (data request) transfers. This is a technique in which transfers are performed by the host outputting  $\overline{\text{HRD}}$  pulses according to a data request signal output from the LC89515K and is similar to DMA controller operation.

When the last byte of the count specified by the control microprocessor is read,  $\overline{\text{EOP}}$  goes active while the read pulse is output. Also  $\overline{\text{DTEN}}$  is set inactive after this time. Next, a transfer complete interrupt is issued to inform the control microprocessor that the transfer to the host has completed.

The LC89515K control microprocessor can pass the decoding result for the data requested by the host and the CD-ROM drive status information to the host by writing to the LC89515K internal status registers. The status registers are a 12-byte FIFO, and the host reads out data while the  $\overline{\text{STEN}}$  signal is low. The  $\overline{\text{STEN}}$  signal goes high when the last byte is read. The LC89515K has nothing to do with the content of the status registers.

Since the command and status registers are neither interpreted nor executed by the LC89515K, the LC89515K user can define the command and status data as unrestricted protocols between the host and the microprocessor. This allows CD-ROM application systems to be designed without restriction, and also allows an existing system to be replaced by a system using the LC89515K.

#### 4. Points Common to All Blocks

The LC89515K performs data input and decoding at the same time in a pipelined manner. Also, writes of input data to the buffer RAM, writes of data to be decoded, and reads to the buffer RAM for transfers to the host all proceed at the same time with synchronization always being maintained by the LC89515K. Therefore there is no need for the control microprocessor to be concerned with which master (system block) is accessing the buffer RAM.

#### 5. Register Table

##### Read

RS	AR	No.	Symbol	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
0	—	—	AR	0	0	0	0	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
1	0000	R0	COMIN	msb	—	—	—	—	—	—	lsb
	0001	R1	IFSTAT	$\overline{\text{CMDI}}$	$\overline{\text{DTEI}}$	$\overline{\text{DECI}}$	1	$\overline{\text{DTBSY}}$	$\overline{\text{STBSY}}$	$\overline{\text{DTEN}}$	$\overline{\text{STEN}}$
	0010	R2	DBCL	B <sub>7</sub>	B <sub>6</sub>	B <sub>5</sub>	B <sub>4</sub>	B <sub>3</sub>	B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>
	0011	R3	DBCH	DTEI	DTEI	DTEI	DTEI	B <sub>11</sub>	B <sub>10</sub>	B <sub>9</sub>	B <sub>8</sub>
	0100	R4	HEAD0	msb	—	—	—	—	—	—	lsb
	0101	R5	HEAD1	msb	—	—	—	—	—	—	lsb
	0110	R6	HEAD2	msb	—	—	—	—	—	—	lsb
	0111	R7	HEAD3	msb	—	—	—	—	—	—	lsb
	1000	R8	PTL	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
	1001	R9	PTH	A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>
	1010	R10	WAL	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
	1011	R11	WAH	A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>
	1100	R12	STAT0	CRCOK	ILSYNC	NOSYNC	LBLK	WSHORT	SBLK	ERABLK	UCEBLK
	1101	R13	STAT1	MINERA	SECERA	BLKERA	MODERA	SH0ERA	SH1ERA	SH2ERA	SH3ERA
	1110	R14	STAT2	RMOD3	RMOD2	RMOD1	RMOD0	MODE	NOCOR	RFORM1	RFORM0
1111	R15	STAT3	$\overline{\text{VALST}}$	WLONG	CBLK						

Note: The values of the shaded bits are ignored.

## LC89515K

### Write

RS	AR	No.	Symbol	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
0	—	—	AR					A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
1	0000	R0	SBOUR	msb	—	—	—	—	—	—	lsb
	0001	R1	IFCTRL	CMDIEN	DTEIEN	DECIEN	CMDBK	DTWAI	STWAI	DOUTEN	SOUTEN
	0010	R2	DBCL	B <sub>7</sub>	B <sub>6</sub>	B <sub>5</sub>	B <sub>4</sub>	B <sub>3</sub>	B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>
	0011	R3	DBCH					B <sub>11</sub>	B <sub>10</sub>	B <sub>9</sub>	B <sub>8</sub>
	0100	R4	DACL	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
	0101	R5	DACH	A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>
	0110	R6	DTTRG								
	0111	R7	DTACK								
	1000	R8	WAL	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
	1001	R9	WAH	A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>
	1010	R10	CTRL0	DECEN		E01RQ	AUTORQ	ERAMRQ	WRRQ	QRQ	PRQ
	1011	R11	CTRL1	SYIEN	SYDEN	DSCREN	COWREN	MODRQ	FORMRQ	MBCKRQ	SHDREN
	1100	R12	PTL	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
	1101	R13	PTH	A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>
	1110	R14	CTRL2	0	0	0	BCKSL	DLAEN	0	STENCTL	STENTRG
1111	R15	RESET									

Note: The values of the shaded bits are ignored.

### 6. Additional Registers

#### Write

[R14] CTRL2: Control 2

#### STENCTL (STEN control)

0.....The external STEN pin goes to 0 when the microprocessor writes one byte of status information. (This is identical to LC8951 operation.)

1.....The external STEN pin goes to 0 due to 0 being written to the STENTRG register when the microprocessor writes \* bytes of status information.

This bit is set to 0 on reset.

#### STENTRG (STEN trigger)

This bit is only valid when STENCTL is 1.

The external STEN pin goes to 0 when a 0 is written to this bit.

This bit is reset when the host reads the last byte, i.e., when the external STEN pin has become 1.

#### DLAEN (drive last address enable)

When WRRQ is set to 0 during buffering, buffering continues until the next SYNC signal arrives and then stops.

This results in the sectors that are buffered when WRRQ was set to 0 becoming valid. (This bit is set to 0 on reset.)

#### BCKSL (bit clock select)

Setting this bit to 1 allows the bit clock from the CD-DSP to be inverted. (SDATA is acquired on the rising edge of BCK.) (This bit is set to 0 on reset.)

## Specifications

### Absolute Maximum Ratings at $V_{SS} = 0$ V

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{DD}$ max	$T_a = 25^\circ\text{C}$	-0.3 to +7.0	V
I/O voltages	$V_I, V_O$	$T_a = 25^\circ\text{C}$	-0.3 to $V_{DD} + 0.3$	V
Allowable power dissipation	$P_d$ max	$T_a \leq 70^\circ\text{C}$	350	mW
Operating temperature	$T_{opr}$		-30 to +70	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +125	$^\circ\text{C}$
Soldering temperature		10 seconds	260	$^\circ\text{C}$

### Allowable Operating Ranges at $T_a = -30$ to $+70^\circ\text{C}$ , $V_{SS} = 0$ V

Parameter	Symbol	Conditions	min	typ	max	Unit
Supply voltage	$V_{DD}$		4.5	5.0	5.5	V
Input voltage range	$V_{IN}$		0		$V_{DD}$	V

## Electrical Characteristics

### DC Characteristics at $T_a = -30$ to $+70^\circ\text{C}$ , $V_{SS} = 0$ V, $V_{DD} = 4.5$ to $5.5$ V

Parameter	Symbol	Conditions	min	typ	max	Unit
Input high level voltage	$V_{IH1}$	All input pins except those in (1) below and XTALCK	2.2			V
Input low level voltage	$V_{IL1}$				0.8	V
Input high level voltage	$V_{IH2}$	(1) $\overline{\text{RESET}}$ (Schmitt trigger), $\overline{\text{RD}}$ , $\overline{\text{WR}}$ , $\overline{\text{HRD}}$ , $\overline{\text{HWR}}$ , CMD, CS, ENABLE and all bus pins	2.5			V
Input low level voltage	$V_{IL2}$				0.6	V
Output high level voltage	$V_{OH}$	$I_{OH} = -2$ mA	2.4		0.4	V
Output low level voltage	$V_{OL1}$	$I_{OL} = 2$ mA				
Output low level voltage	$V_{OL2}$	$I_{OL} = 2$ mA			0.4	V
Input leakage current	$I_L$	$V_I = V_{SS}, V_{DD}$ : All input pins	-25		+25	$\mu\text{A}$
Pull-up resistance	$R_{UP}$	All bus pins, $\overline{\text{INT}}$	10	20	40	$\text{k}\Omega$

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