

**LC8904Q****Digital Audio Interface Receiver****Preliminary****Overview**

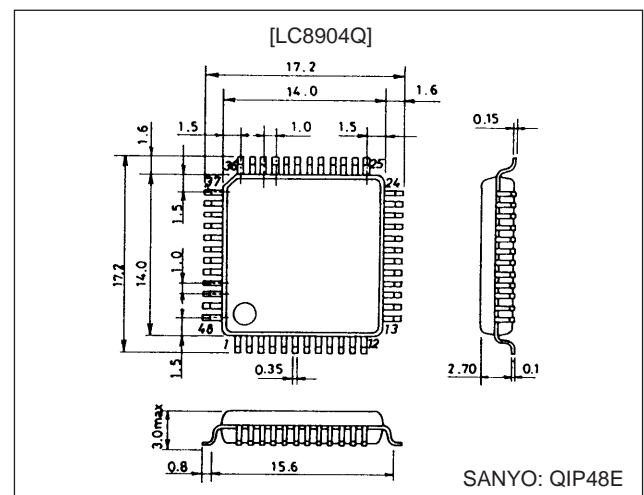
The LC8904Q demodulates data transmitted between digital audio equipment in the EIAJ format (CP-1201) to a normal format signal synchronized with the receiving side input signal.

**Features**

- Synchronizes with the transmitted EIAJ format signal using a built-in PLL circuit.
- Modes are set up and codes are output according to commands sent over a microprocessor interface.
  - Input pin and output data format setup
  - Selection of digital source mode or analog source mode
  - 32-bit channel status output (consumer product mode 0)
  - 80-bit subcode Q data output (CRC check included)
- Either a 384fs or a 512fs clock can be selected as the system clock.
- Provides 256fs, 128fs, BCLK, and LRCK clock outputs.
- Implements a CD subcode interface (CP-2401) using user bits.
- Fabricated in a CMOS single-voltage power supply process
- Package: QFP-48E

**Package Dimensions**

unit: mm

**3156-QFP48E**

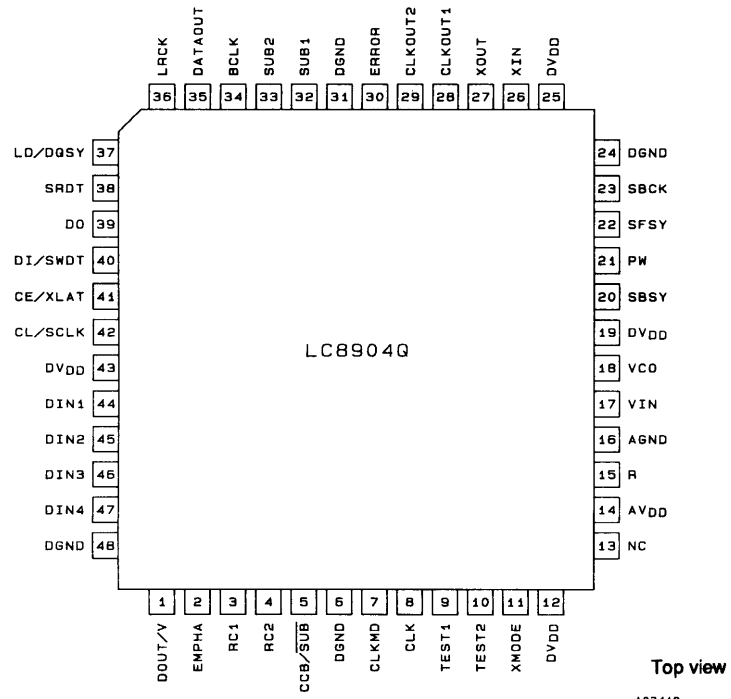
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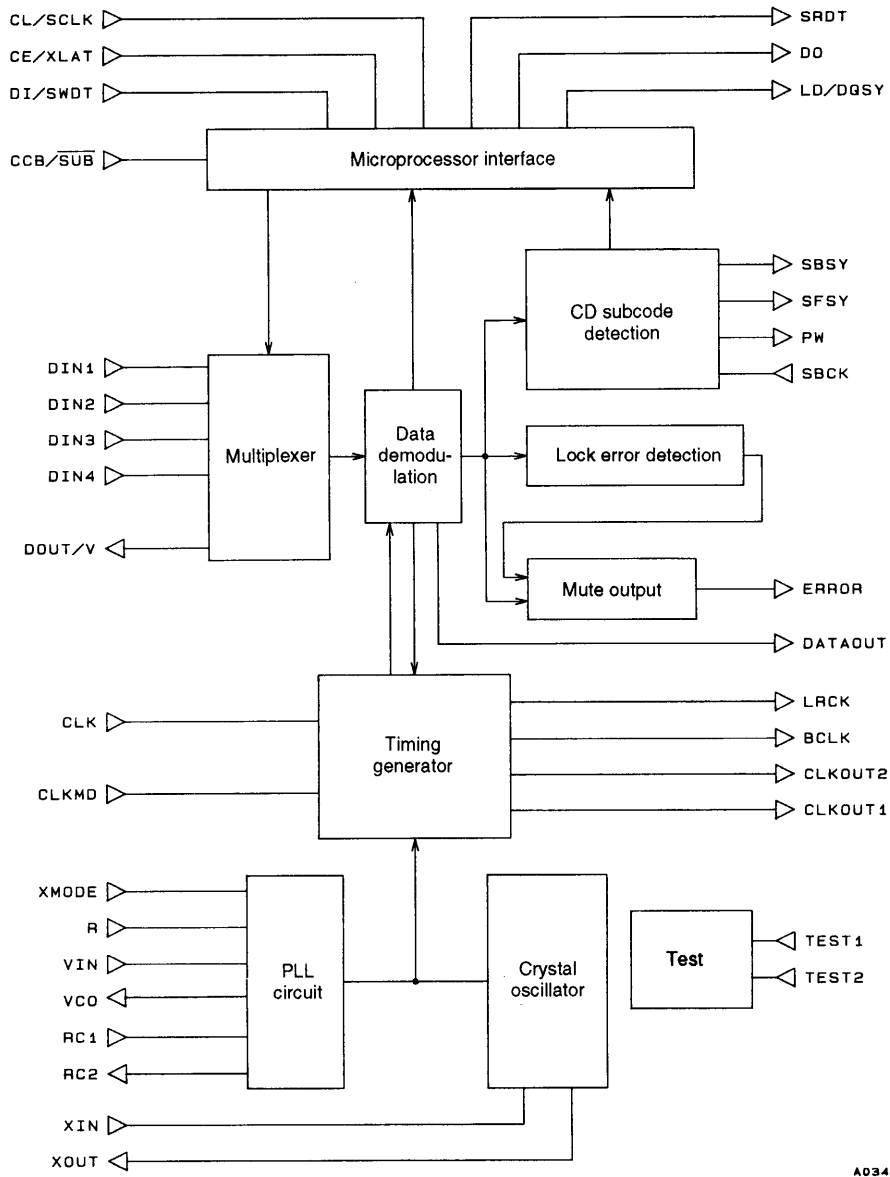
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## Pin Assignment



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## Block Diagram



## LC8904Q

### Pin Functions

No.	Symbol	I/O	Function
1	DOUV	O	EIAJ data and validity flag output
2	EMPHA	O	Emphasis monitor output (High: emphasis applied)
3	RC1	I	CR oscillator input
4	RC2	O	CR oscillator output
5	CCB/SUB	I	Microprocessor interface selection input (High: CCB, low: SUB)
6	DGND		Digital system ground
7	CLKMD	I	Clock output switching (High: 256fs, low: 128fs)
8	CLK	I	Clock switching input (High: 512fs, low: 384fs)
9	TEST1	I	Test pin (Must be tied low during normal operation.)
10	TEST2	I	Test pin (Must be tied low during normal operation.)
11	XMODE	I	Reset input
12	DV <sub>DD</sub>		Digital system power supply
13	NC		No connection
14	AV <sub>DD</sub>		Analog system power supply
15	R	I	VCO oscillator band adjustment input
16	AGND		Analog system ground
17	VIN	I	VCO free-running frequency setting input
18	VCO	O	PLL low-pass filter connection
19	DV <sub>DD</sub>		Digital system power supply
20	SBSY	O	CD subcode interface: block sync output
21	PW	O	CD subcode interface: data output
22	SFSY	O	CD subcode interface: frame sync output
23	SBCK	I	CD subcode interface: data read shift clock input
24	DGND		Digital system ground
25	DV <sub>DD</sub>		Digital system power supply
26	XIN	I	Crystal oscillator input
27	XOUT	O	Crystal oscillator output
28	CLKOUT1	O	VCO and crystal oscillator clock output
29	CLKOUT2	O	256fs or 128fs clock output (selected by CLKMD)
30	ERROR	O	Error mute output
31	DGND		Digital system ground
32	SUB1	O	Sampling frequency monitor output
33	SUB2	O	Sampling frequency monitor output
34	BCLK	O	Bit clock output
35	DATAOUT	O	Audio data output
36	LRCK	O	L/R clock output (High: left channel, low: right channel)
37	LD/DQSY	O	Microprocessor interface: subcode Q data sync output
38	SRDT	O	Microprocessor interface: data output when CCB/SUB is low (3-state output)
39	DO	O	Microprocessor interface: data output when CCB/SUB is high (High-level open drain output)
40	DI/SWDT	I	Microprocessor interface: data input
41	CE/XLAT	I	Microprocessor interface: chip enable/latch input
42	CL/SCLK	I	Microprocessor interface: clock input
43	DV <sub>DD</sub>		Digital system power supply
44	DIN1	I	Data input with built-in amplifier
45	DIN2	I	Data input with built-in amplifier
46	DIN3	I	Data input with built-in amplifier
47	DIN4	I	Data input with built-in amplifier
48	DGND		Digital system ground

## Specifications

### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{DD\text{ max}}$		-0.3 to +7.0	V
Input and output voltage	$V_I \cdot V_O$		-0.3 to $V_{DD} + 0.3$	V
Operating temperature	$T_{opr}$		-30 to +75	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +125	$^\circ\text{C}$

### Allowable Operating Ranges

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

## Electrical Characteristics

### DC Characteristics at $T_a = -30$ to $+75^\circ\text{C}$ , $V_{DD} = 4.5$ to $5.5$ V

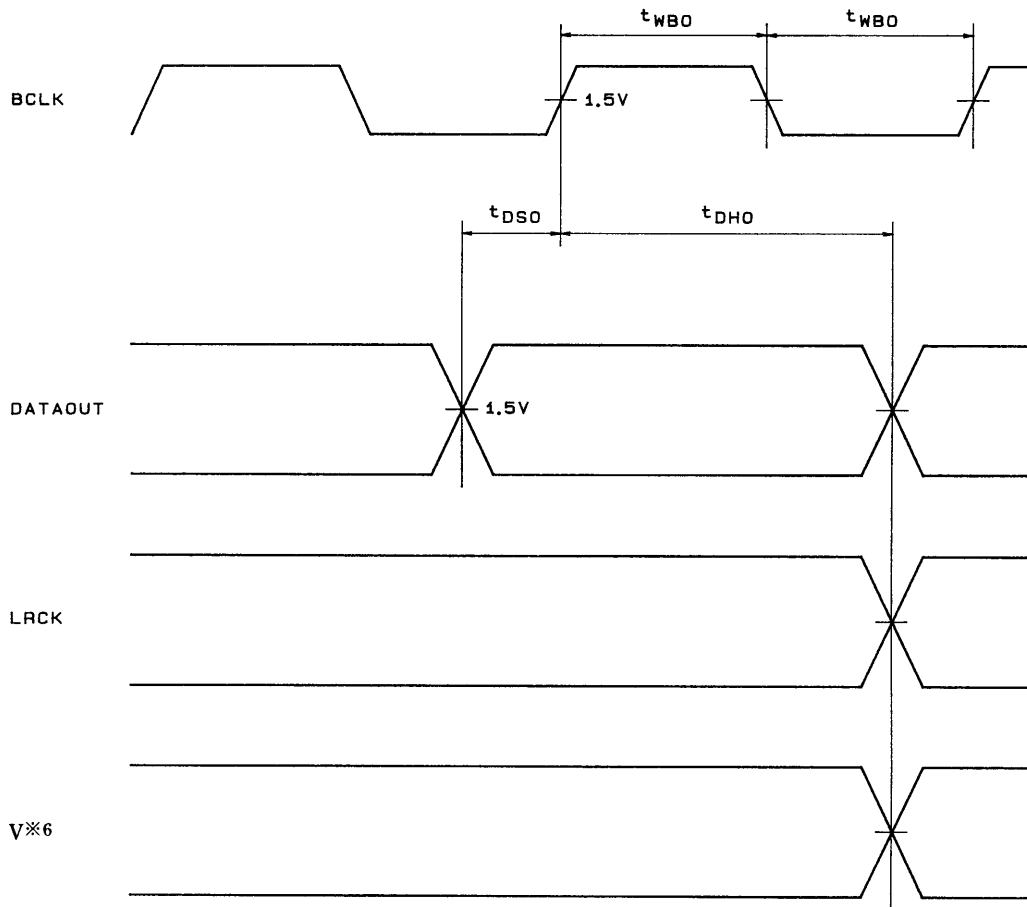
Parameter	Symbol	Conditions	min	typ	max	Unit
Input high-level voltage	$V_{IH1}$	*1	2.2		$V_{DD} + 0.3$	V
Input low-level voltage	$V_{IL1}$	*1	-0.3		+0.8	V
Input high-level voltage	$V_{IH2}$	*2	$0.7 V_{DD}$		$V_{DD} + 0.3$	V
Input low-level voltage	$V_{IL2}$	*2	-0.3		$0.3 V_{DD}$	V
Input high-level voltage	$V_{IH3}$	*3	$0.8 V_{DD}$		$V_{DD} + 0.3$	V
Input low-level voltage	$V_{IL3}$	*3	-0.3		$0.2 V_{DD}$	V
Output high-level voltage	$V_{OH}$	$I_{OH} = -1 \mu\text{A}$	$V_{DD} - 0.05$			V
Output low-level voltage	$V_{OL}$	$I_{OL} = 1 \mu\text{A}$			$V_{SS} + 0.05$	V
Current drain	$I_{DD}$	*4		30	45	mA
Input amplitude	$V_{PP}$	*5	0.4		$V_{DD} + 0.3$	V

- Note: 1. Input pins other than DIN1, DIN2, DIN3, DIN4, RC1, and XMODE. TTL compatible.  
 2. The XIN pin. CMOS compatible.  
 3. The XMODE and RC1 pins. CMOS Schmitt compatible.  
 4.  $V_{DD} = 5.0$  V,  $T_a = 25^\circ\text{C}$ , and input data with an  $f_s$  of 48 kHz.  
 5. Conditions prior to the capacitances of the DIN1, DIN2, DIN3, and DIN4 pins.

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### AC Characteristics at $T_a = -30$ to $+75^\circ\text{C}$ , $V_{DD} = 4.5$ to $5.5$ V

Parameter	Symbol	Conditions	min	typ	max	Unit
Output pulse width	$t_{WBO}$	$f_s = 48$ kHz, load = 30 pF	160			ns
Output data setup time	$t_{DSO}$	$f_s = 48$ kHz, load = 30 pF	80			ns
Output data hold time	$t_{DHO}$	$f_s = 48$ kHz, load = 30 pF	80			ns



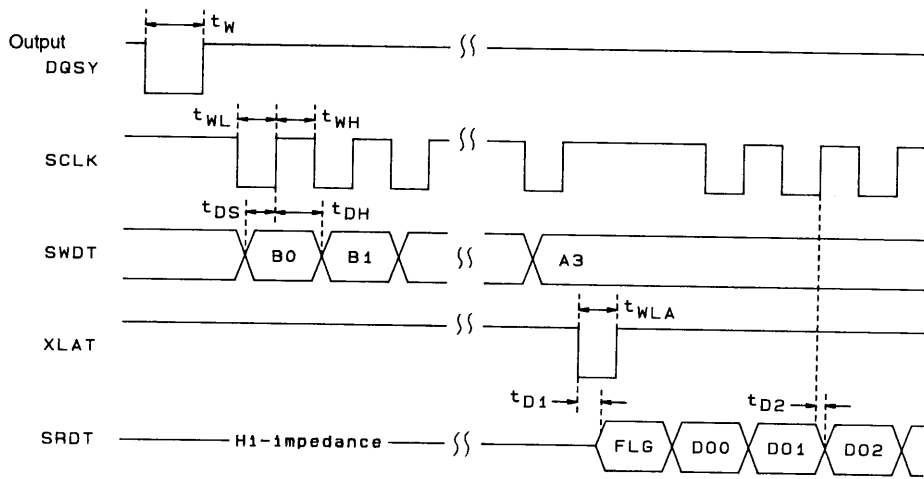
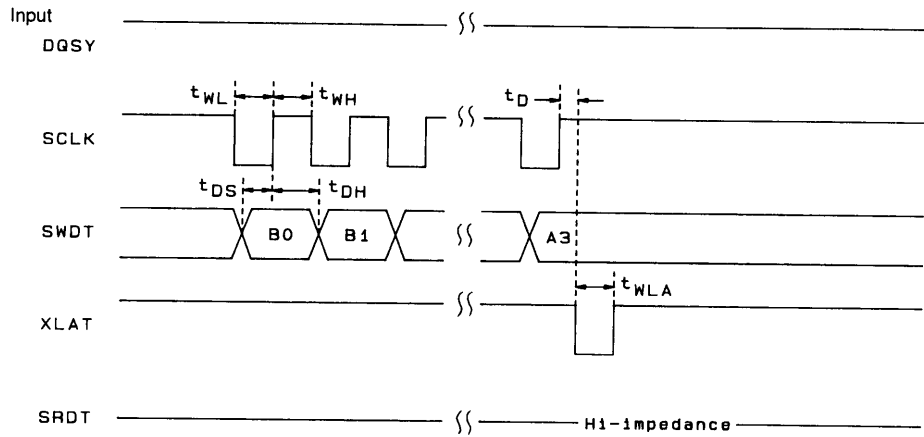
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Note: When the validity flag is output from the DOUT/V pin.

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## Microprocessor Interface AC Characteristics (when CCB/SUB is low) at Ta = -30 to +75°C, VDD = 4.5 to 5.5 V

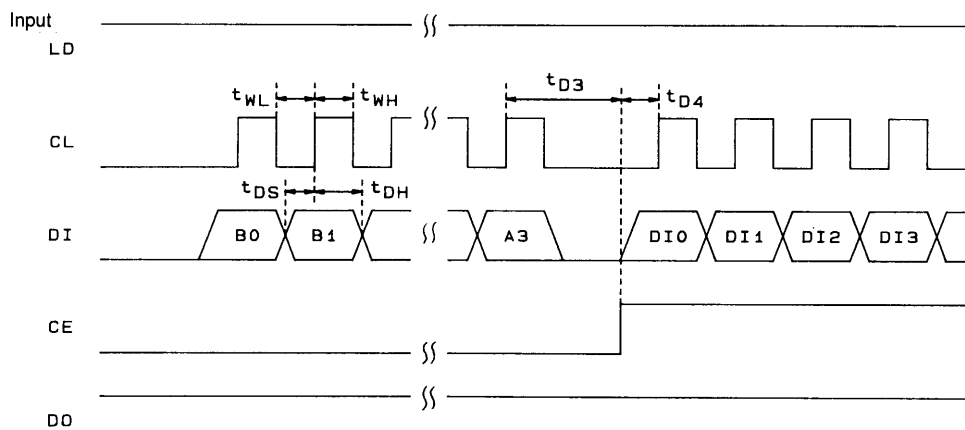
Parameter	Symbol	Conditions	min	typ	max	Unit
SCLK low-level pulse width	$t_{WL}$		100			ns
SCLK high-level pulse width	$t_{WH}$		100			ns
Setup time	$t_{DS}$		50			ns
Hold time	$t_{DH}$		50			ns
Delay time	$t_D$		100			ns
Latch pulse time	$t_{WLA}$		100			ns
DQSY pulse time	$t_W$	$f_s = 44.1 \text{ kHz}$		136		$\mu\text{s}$
Data delay time	$t_{D1}$	$C_L = 30 \text{ pF}$			75	ns
Data delay time	$t_{D2}$	$C_L = 30 \text{ pF}$			75	ns



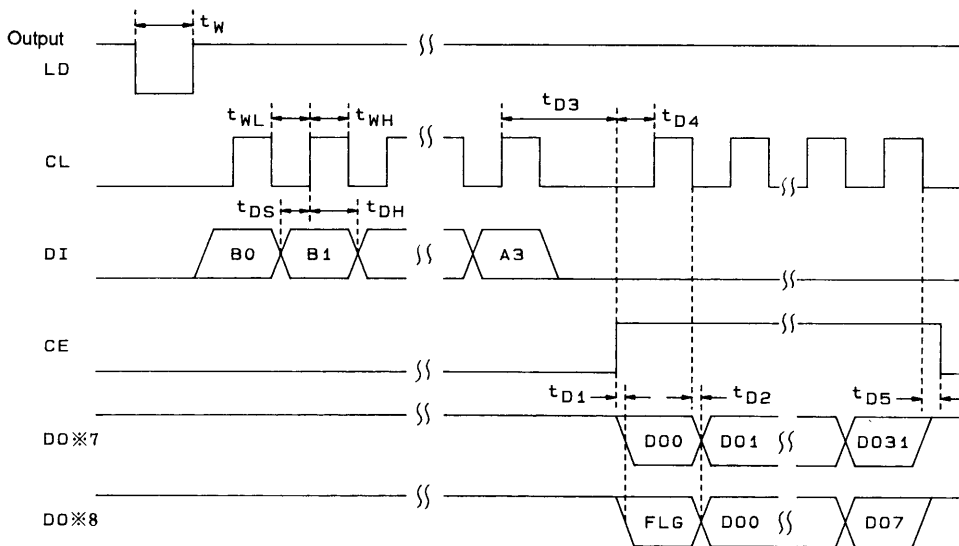
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## Microprocessor Interface AC Characteristics (when $\overline{\text{CCB}}/\overline{\text{SUB}}$ is high) at $T_a = -30$ to $+75^\circ\text{C}$ , $V_{DD} = 4.5$ to $5.5$ V

Parameter	Symbol	Conditions	min	typ	max	Unit
CL low-level pulse width	$t_{WL}$		100			ns
CL high-level pulse width	$t_{WH}$		100			ns
Data setup time	$t_{DS}$		50			ns
Data hold time	$t_{DH}$		50			ns
CE delay time	$t_{D3}$		1.0			$\mu\text{s}$
CL delay time	$t_{D4}$		50			ns
CE delay time	$t_{D5}$				100	ns
LD pulse time	$t_W$	$f_s = 44.1$ kHz		136		$\mu\text{s}$
Data delay time	$t_{D1}$	$C_L = 30$ pF			75	ns
Data delay time	$t_{D2}$	$C_L = 30$ pF			75	ns



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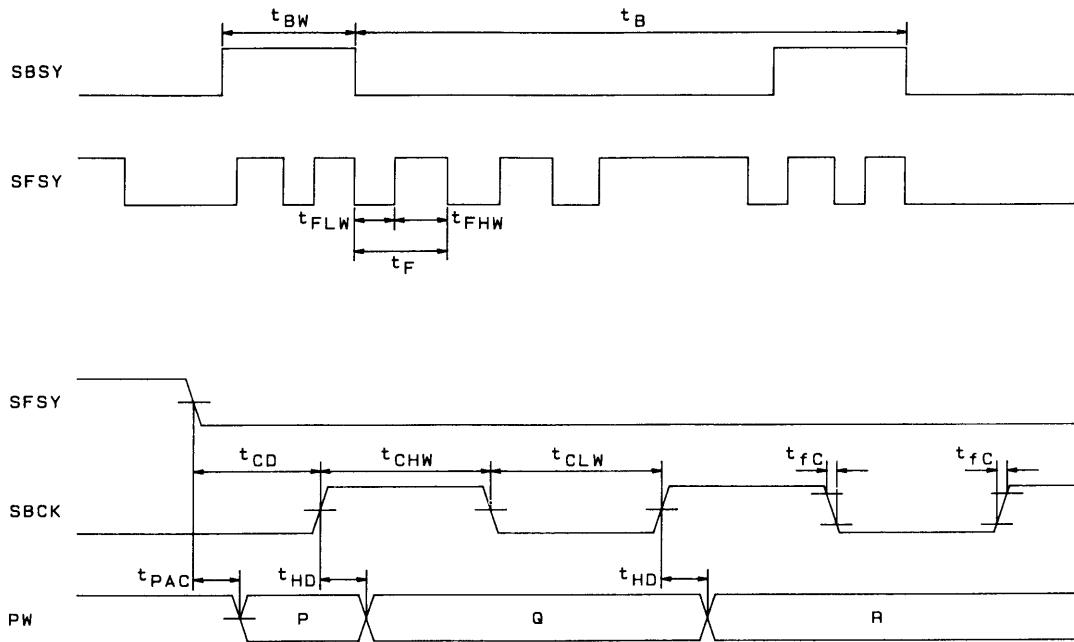
- Note 1. C bit output  
2. Subcode Q output



## LC8904Q

### CD Subcode Interface AC Characteristics at $T_a = -30$ to $+75^\circ\text{C}$ , $V_{DD} = 4.5$ to $5.5$ V

Parameter	Symbol	Conditions	min	typ	max	Unit
SBSY block period	$t_B$		12.0	13.3	14.7	ms
SBSY pulse width	$t_{BW}$	*1	110			$\mu\text{s}$
SFSY frame period	$t_F$	*2	90	136	165	$\mu\text{s}$
SFSY high-level pulse width	$t_{FHW}$		4			$\mu\text{s}$
SFSY low-level pulse width	$t_{FLW}$		1.5			$\mu\text{s}$
SBCK high-level pulse width	$t_{CHW}$	*3	2.0	4.0	5.0	$\mu\text{s}$
SBCK low-level pulse width	$t_{CLW}$	*3	2.0	4.0	5.0	$\mu\text{s}$
SBCK rise time	$t_{rC}$				30	ns
SBCK fall time	$t_{fC}$				30	ns
SBCK delay time	$t_{CD}$	*3	10	20	30	$\mu\text{s}$
P data access time	$t_{PAC}$			3	10	$\mu\text{s}$
Data hold time	$t_{HD}$		0			$\mu\text{s}$



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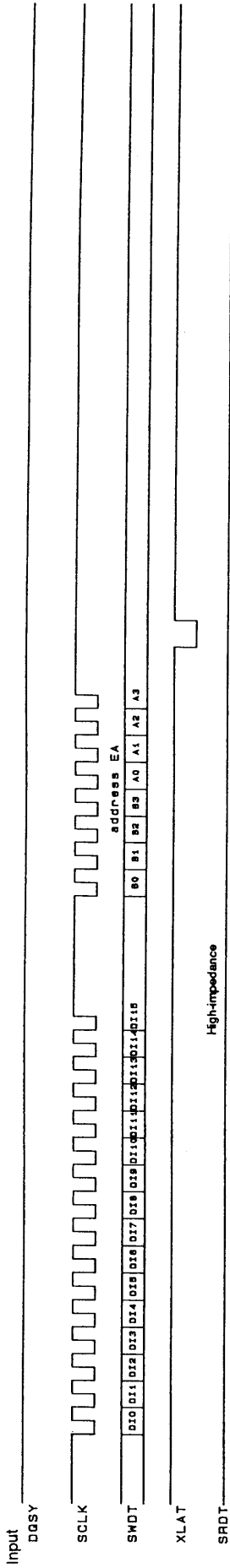
The LC8904Q subcode interface uses the user bit subcode sync word and start bit for system timing extraction. Therefore, since SBSY and SFSY will change with that timing, user bit transmission must follow the table shown below when using the values of  $t_{BW}$ ,  $t_F$ ,  $t_{CHW}$ ,  $t_{CLW}$ , and  $t_{CD}$  with the specifications listed in the preceding tables.

	1	2	3	4	5	6	7	8	9	10	11	12	
S0	0	0	0	0	0	0	0	0	0	0	0	0	Subcode sync word*1, 2
S1	0	0	0	0	0	0	0	0	0	0	0	0	
S2	1	Q2	R2	S2	T2	U2	V2	W2	0	0	0	0	
S3	1	Q3	R3	S3	T3	U3	V3	W3	0	0	0	0	
:	:	:	:	:	:	:	:	:	:	:	:	:	
:	:	:	:	:	:	:	:	:	:	:	:	:	
S97	1	Q97	R97	S97	T97	U97	V97	W97	0	0	0	0	Subcode sync word*1, 2
S0	0	0	0	0	0	0	0	0	0	0	0	0	
S1	0	0	0	0	0	0	0	0	0	0	0	0	Word length*2, 3
S2	1	Q2	R2	S2	T2	U2	V2	W2	0	0	0	0	
:	:	:	:	:	:	:	:	:	:	:	:	:	
:	:	:	:	:	:	:	:	:	:	:	:	:	

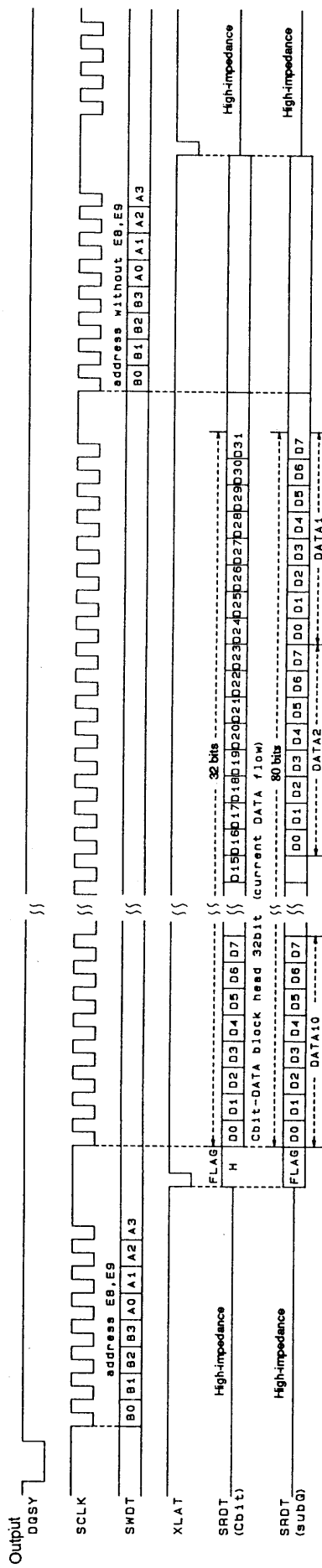
- Note: 1. The subcode sync word is defined as the block sync section (block start) when 0-valued data has been received consecutively for at least 22 bits.  
 2. The period of the frame sync signal S0 is 90.7  $\mu$ s. The S1 period also has a minimum length of 90.7  $\mu$ s (when 0-valued data is received consecutively for 22 bits), depending on the subcode sync word period. Not that the shortest word is 10 bits.  
 3. The SBCK signal input delay ( $t_{HD}$ ) and pulse widths ( $t_{CHW}$  and  $t_{CLW}$ ) must be set to values less than or equal to the typical values when the shortest user data word length is used.

Microprocessor Interface

1. When CCB/SUB is low



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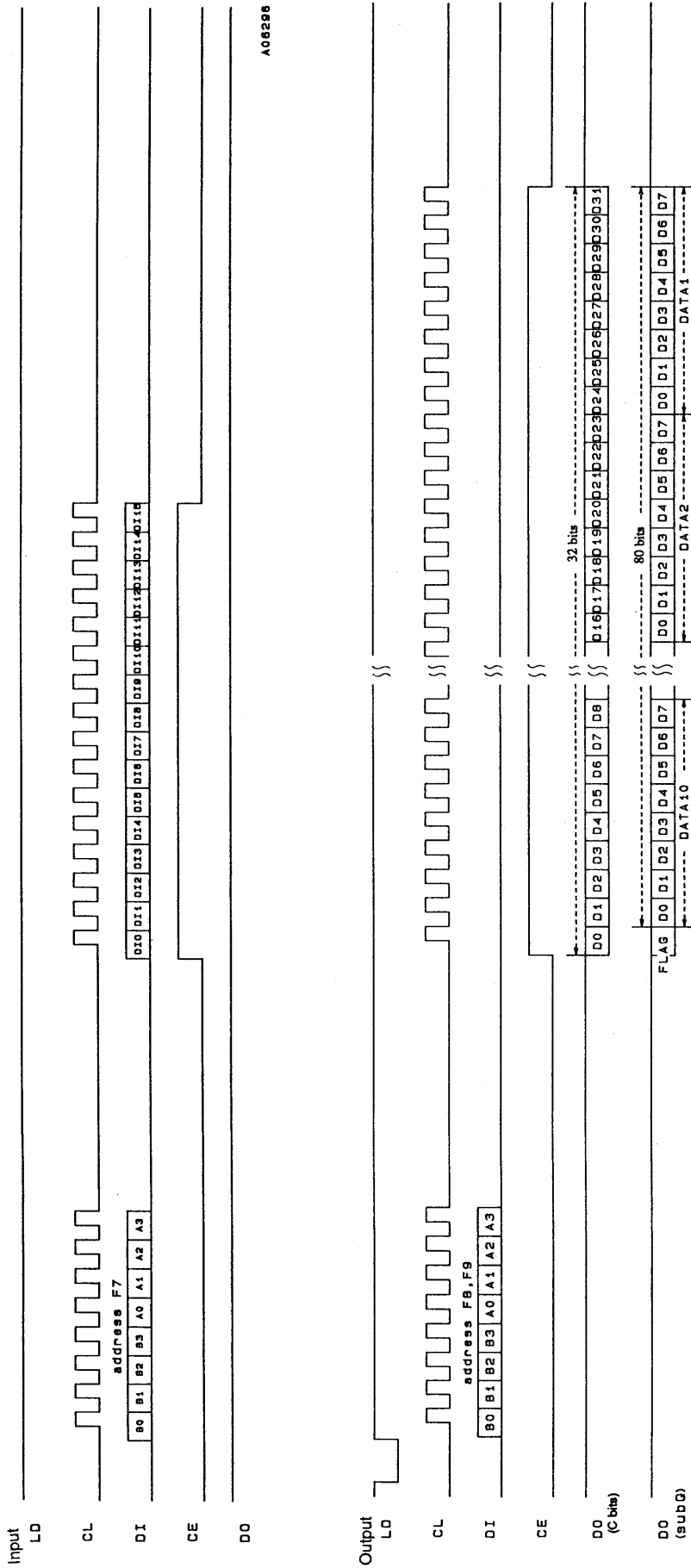


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CPU,IF address	DATA bit	FLAG	DATA flow
E9	32 bits	H const	bit0 to bit31
E8	80 bits	CRC ERROR L	DATA10, DATA9, DATA8, DATA7, DATA6, DATA5, DATA4, DATA3, DATA2, DATA1
		ADRS:CTL	MIN (POINT)
		TNO	INDEX (POINT)
		SEC	ZERO
		FRAME	AMIN (PMIN)
		ASEC	AFRAME (PFRAME)
		DATA1	DATA1

sub Q IF to CPU: LSB first 8 bits form output

2. When CCB/SUB is high



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CPU IF address	DATA bit	FLAG	DATA flow									
F8	32 bits	---	bit0 to bit31									
F9	80 bits	CRC ERROR L	DATA10 ADRS/CTL	DATA9 TNO	DATA8 INDEX (POINT)	DATA7 MIN	DATA6 SEC	DATA5 FRAME ZERO	DATA4 AMIN (PMIN)	DATA3 ASEC (PSEC)	DATA2 AFRAME (PFRAME)	DATA1

sub Q /F to CPU: LSB first 8 bits form output

**The microprocessor interface controls the following settings and outputs.**

1. System stop
2. Data input pin settings
3. Validity flag (V flag) output selection
4. Analog source mode setting
5. Output data format setting
6. Channel status (32 bits) output
7. Output of the 80-bit subcode Q data with CRC flags.

- CCB/SUB pin

The CCB/SUB pin selects one of two formats. The clocks and codes must be set up appropriately for each of these formats. SRDT is the output pin when CCB/SUB is low. SRDT goes to the high-impedance state when the CCB/SUB pin is high, during writes, and when an address for a different output is latched. In contrast with the SRT pin, the DO pin is a high-level open drain output that functions as the output pin when CCB/SUB is high.

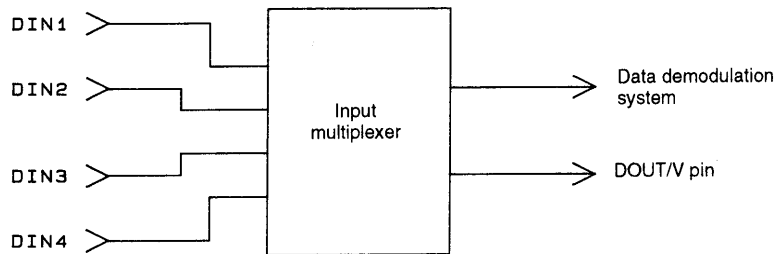
- Data I/O address

Address are allocated according to the differing formats as listed below.

I/O \ Format	CCB/SUB = low									CCB/SUB = high								
		B0	B1	B2	B3	A0	A1	A2	A3		B0	B1	B2	B3	A0	A1	A2	A3
Data input	EA	0	1	0	1	0	1	1	1	F7	1	1	1	0	1	1	1	1
Data output (C bits)	E9	1	0	0	1	0	1	1	1	F8	0	0	0	1	1	1	1	1
Data output (subcode Q)	E8	0	0	0	1	0	1	1	1	F9	1	0	0	1	1	1	1	1

- Input

The DIN1 to DIN4 data input pins have built-in amplifiers, and can accept signals with amplitudes of about 400 Vp-p. Note that the DOUT pin can be set up to output the EIAJ format data by microprocessor interface commands. (It can also be used to output the V flag.)



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- Input code settings

System stop by stopping both the VCO and crystal oscillators (DI4)

DI4	L	H
System	Run	Stop

Selection of data to demodulate (DI5, DI6)

DI5	L	H	L	H
DI6	L	L	H	H
Demodulation data input	DIN1	DIN2	DIN3	DIN4

Input data (EIAJ format) output selection

DI7	L	H	L	H
DI8	L	L	H	H
DOUT/V pin	DIN1	DIN2	DIN3	DIN4

V flag output selection (DI9)

DI9	L	H
DOUT/V pin	Data selected by DI7 and DI8	V flag

Source selection (DI10)

DI10	L	H
Mode	Digital source	Analog source

Audio data output format setting (DI11, DI12, DI13)

DI11	L	L	H	H	H	H
DI12	L	L	L	H	L	H
DI13	L	H	L	L	H	H
DATAOUT	16 bits MSB first Rear packed	16 bits MSB first Front packed	20 bits MSB first Rear packed	20 bits LSB first Rear packed	20 bits MSB first Front packed	20 bits LSB first Front packed

DI4 to DI13 are set to an initial value of low, immediately after the XMODE pin goes from low to high. Since DI0 to DI3 and DI14 to DI15 are unused they can be set to either low or high.

• Output

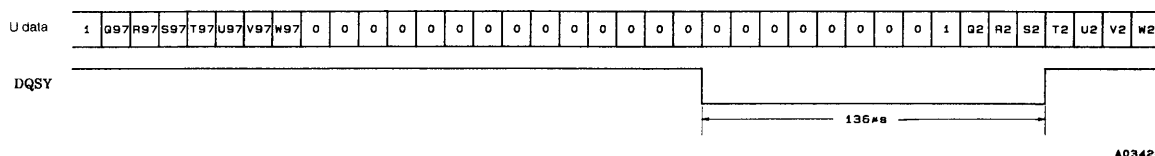
C bits

- This product only supports 32 bits, since it is designed for mode 0 consumer applications.
- In readout when  $\overline{\text{CCB}}/\overline{\text{SUB}}$  is low, after the output address is loaded into SWDT, the flag (fixed at the high level) is output on the fall of XLAT, and then 32 bits of data is output according to SCLK.
- In readout when  $\overline{\text{CCB}}/\overline{\text{SUB}}$  is high, after the output address is loaded into DI, the 32 bits of data are output from DO according to CL while CE is high.
- Since the C bits are not checked for errors, processing is performed after the PLL lock state is detected. Therefore, data must be read out only after the ERROR pin goes low.
- If a lock error occurs during readout (ERROR = high), the shift register will be reset and all data will become 0 (low). However, while the ERROR pin will also go high on a parity error, this error processing will not be performed.
- An interval of at least 6 ms or longer must be provided between readout operations.

Subcode Q

- The LC8904Q provides the following two functions for subcode readout:
  1. CD subcode interface (CP-2401) is possible
  2. Output of subcode Q data with CRC flags included, which corresponds to the CD and MD formats
 The microprocessor interface uses the readout function of item 2.
- The subcode Q data, which is reproduced at 1 bit per frame, is input to an 80-bit register and a CRC checking circuit. After the 96 bits of data have been input, it is loaded into a shift register on the falling edge of LD/DQSY. The data must be read out after this load operation.
- In readout when  $\overline{\text{CCB}}/\overline{\text{SUB}}$  is low, after the output address has been loaded into SWDT, the CRC flags are output on the falling edge of XLAT. If the CRC flags indicate that the check was OK, a high level is output. Next, 80 bits of data is output from SRDT according to SCLK. Note that the subcode Q data is updated on every falling edge of the DQSY signal.
- Readout when  $\overline{\text{CCB}}/\overline{\text{SUB}}$  is high is identical to that described in item 3. (See the timing charts for details.)
- The data output from SRDT (DO) has the same order on a per-byte basis, but the bit order within each byte is LSB first.
- If a lock error occurs between the fall of DQSY and the fall of XLAT, the CRC flags will go low. However, if a lock error after the fall of XLAT, the CRC flags will not go low, since correct data will be output.

- When the 96 bits of the subcode Q data have been read in with the PLL circuit in the locked state, a sync signal that has a low period with a pulse width of 136  $\mu$ s is output by outputting at least 22 bits of continuous 0-valued data after the 96 bits of W data (W97) from DQSY. Note that this sync signal low-level pulse will not be output unless 96 bits of subcode Q data including the CRC flags are input.



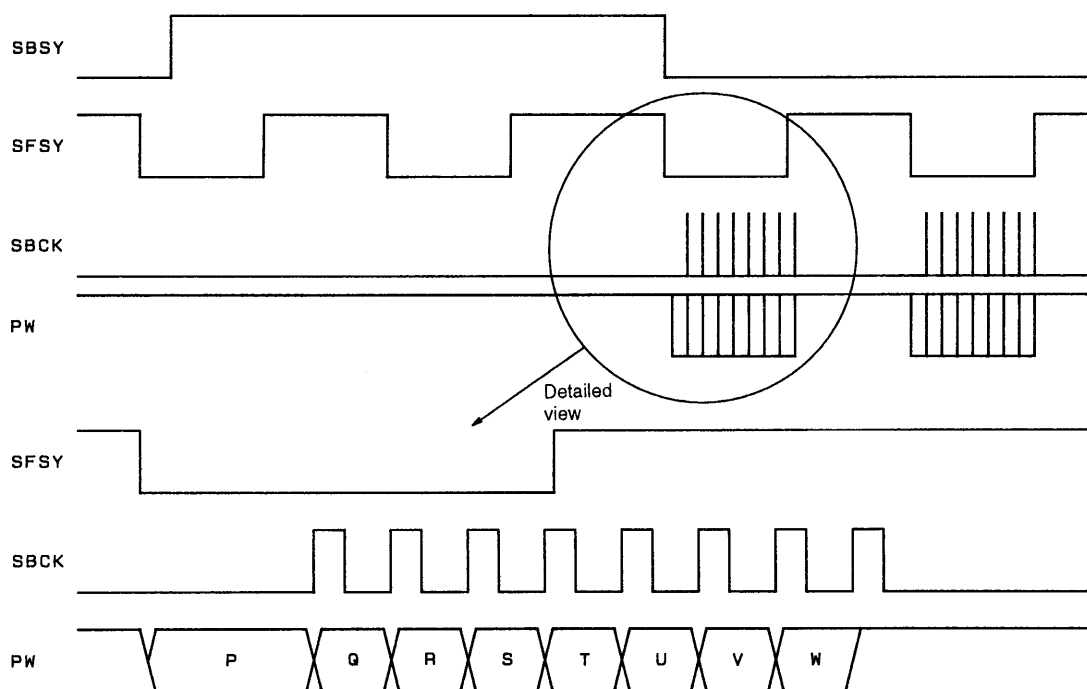
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### When not Using the Microprocessor Interface

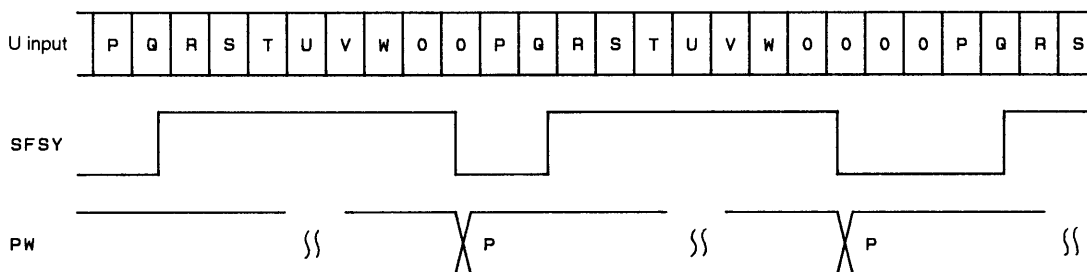
If the LC8904Q is used without using the microprocessor interface, the microprocessor interface pins must be tied to fixed levels and data only input to pin DIN1. This configuration can be useful as a simplified circuit evaluation method.

### CD Subcode Interface

The LC8904Q outputs CD subcode data from the SFSY, SBCK, PW, and SBSY pins. These pins output user bits that were transmitted according to the CP-1201 standard and that were converted to the CP-2401 standard.



The timing of the rise and fall of the SFSY signal is converted into that shown in the figure below according to the timing of the start bit in the user bits in the input data.



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### The CLK, CLKMD, CLKOUT1, and CLKOUT2 Pins

The output clocks for the CLKOUT1 and CLKOUT2 clock output pins is selected by the CLK and CLKMD pins.

CLK	CLKOUT*1	CLKMD	CLKOUT2
L	Outputs a 384fs clock	L	Outputs a 256fs clock*2
H	Outputs a 512fs clock	H	Outputs a 128fs clock

Note: 1. The crystal oscillator clock is output in analog source mode.  
 2. The 256fs clock has a H:L duty ratio of 2:1 when the CLK pin is low.

### The SUB1 and SUB2 Pins

These pins indicate the sampling frequency of the input data.

Pin	32 kHz	44.1 kHz	48 kHz	#1
SUB1	H	L	L	H
SUB2	H	L	H	L

The state “#1” is indicated on a PLL lock error and in analog source mode.  
 Also note that the DATAOUT and EMPHA pins will output low levels in this state.

### The EMPHA Pin

Pin	Emphasis applied	Emphasis not applied	Analog source mode
EMPHA	H	L	L

### The ERROR pin and Error Processing

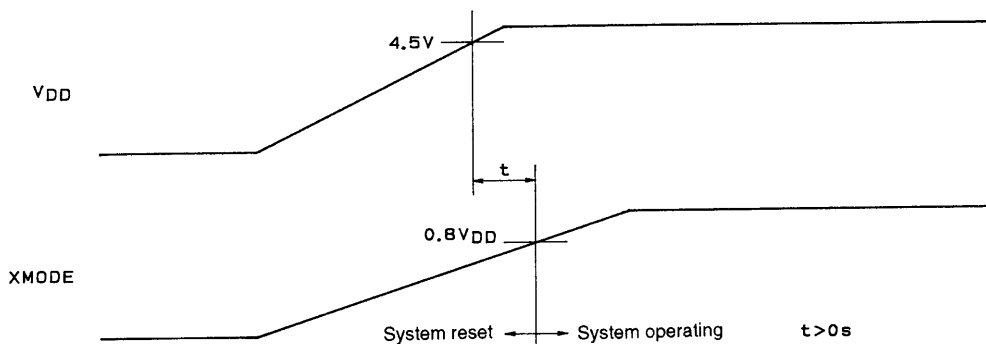
ERROR pin: When an error exists in the input data or when the PLL circuit is in the unlocked state, this pin goes high and holds that high level for about 200 to 300 ms after data demodulation returns to normal. The table below lists the data processing applied when an error occurs.

Type of error	DATAOUT	SUB1, SUB2	C bit	Sub Q*
Up to eight consecutive parity errors	Previous data	Output	Output	Output
Eight or more consecutive parity errors	L	Output	Output	Output
PLL lock error	L	#1	L	L

Note: \* The CRC flags go low when a PLL lock error occurs.  
 Note: PLL lock error determination is performed starting from preamble detection.

### The XMODE Pin

This pin is used for system reset. The system will start to operate normally if this pin is set high after the power supply has risen to at least 4.5 V. If XMODE is set low, the VCO free-running clock will be output from the CLKOUT1 pin.



After application of power, the system will be reset if the XMODE pin is set low again.



## Analog Source Mode

The LC8904Q enters analog source mode in the following two cases:

1. Analog source mode is selected from the microprocessor interface.
2. If the input pin specified for data demodulation goes to the no signal state.

In this mode, the clock that operates the whole system is taken from the crystal oscillator clock, and the PLL and data demodulation circuits are stopped. The BCLK, LRCK, CLKOUT1, and CLKOUT2 clocks are output.

The output pins have the following functions in analog source mode:

1. DOUT/V  
Data output as specified by the microprocessor interface
2. ERROR  
Outputs the error state, i.e. a high level.
3. SUB1 and SUB2  
These pins output the “#1” lock error state.
4. DATAOUT  
Outputs the lock error state, i.e., a low level.
5. EMPHA  
Outputs the lock error state, i.e., a low level.
6. Microprocessor interface codes  
Input codes: The codes loaded from the microprocessor interface are retained.  
Output codes: The same codes as output for a PLL lock error.

## Crystal Oscillator

1. A built-in detector circuit determines whether or not a data input signal is present. This circuit operates from either the VCO or the crystal oscillator clock. When the power supply is coming up, this clock is supplied from the VCO, and if a no-data state is detected, the system switches to the crystal oscillator clock. Here, if the clock is not supplied from the crystal oscillator after a no-data state is detected, the whole system goes to the stopped state, and, since the detector circuit does not operate even if data is supplied, the system will remain in the stopped state.
2. The XIN and XOUT pins include a built-in oscillator amplifier circuit, and operate as follows when a crystal oscillator element is attached.

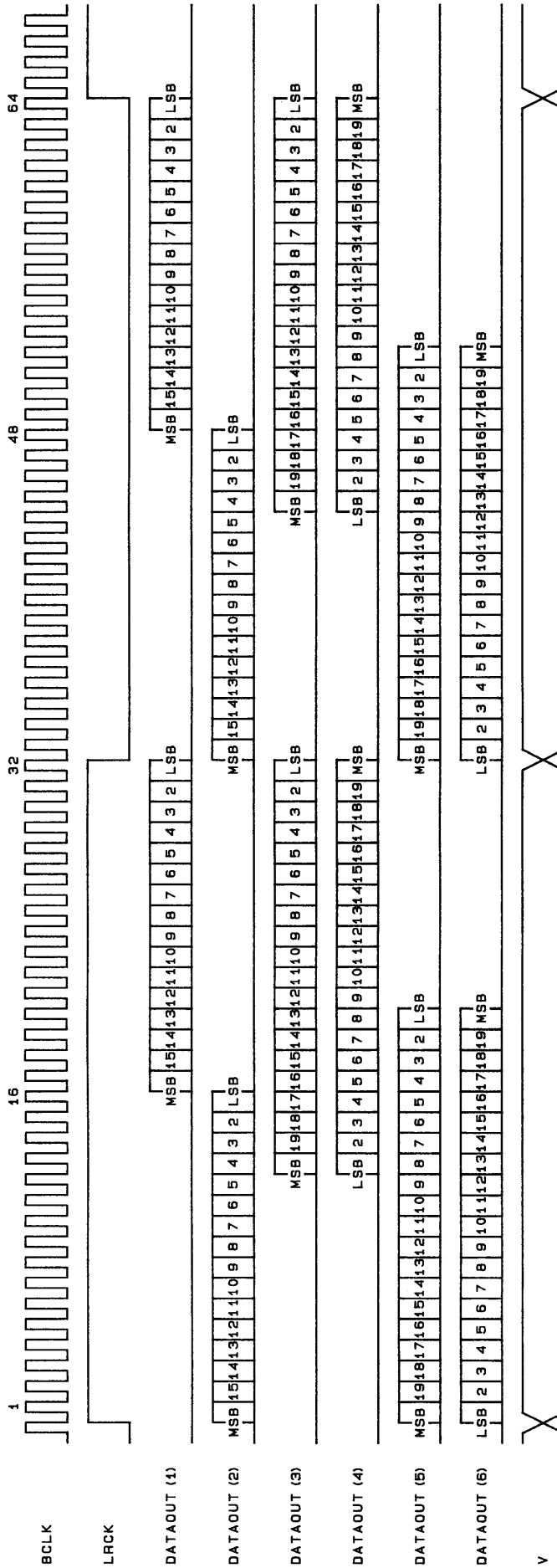
Pin	Data present*	No data
XIN	H	Crystal oscillator input accepted
XOUT	L	Outputs the inverse of the XIN pin state.

Note: \* When data is present, the XIN pin is pulled up internally.

## Data Output Timing

1. Data is output in synchronization with the falling edge of the BCLK signal.
2. Data, BCLK, and LRCK are output in synchronization with the rising edge of the 256fs clock.
3. The figure on the following page shows the data output timing.

Data Output Timing



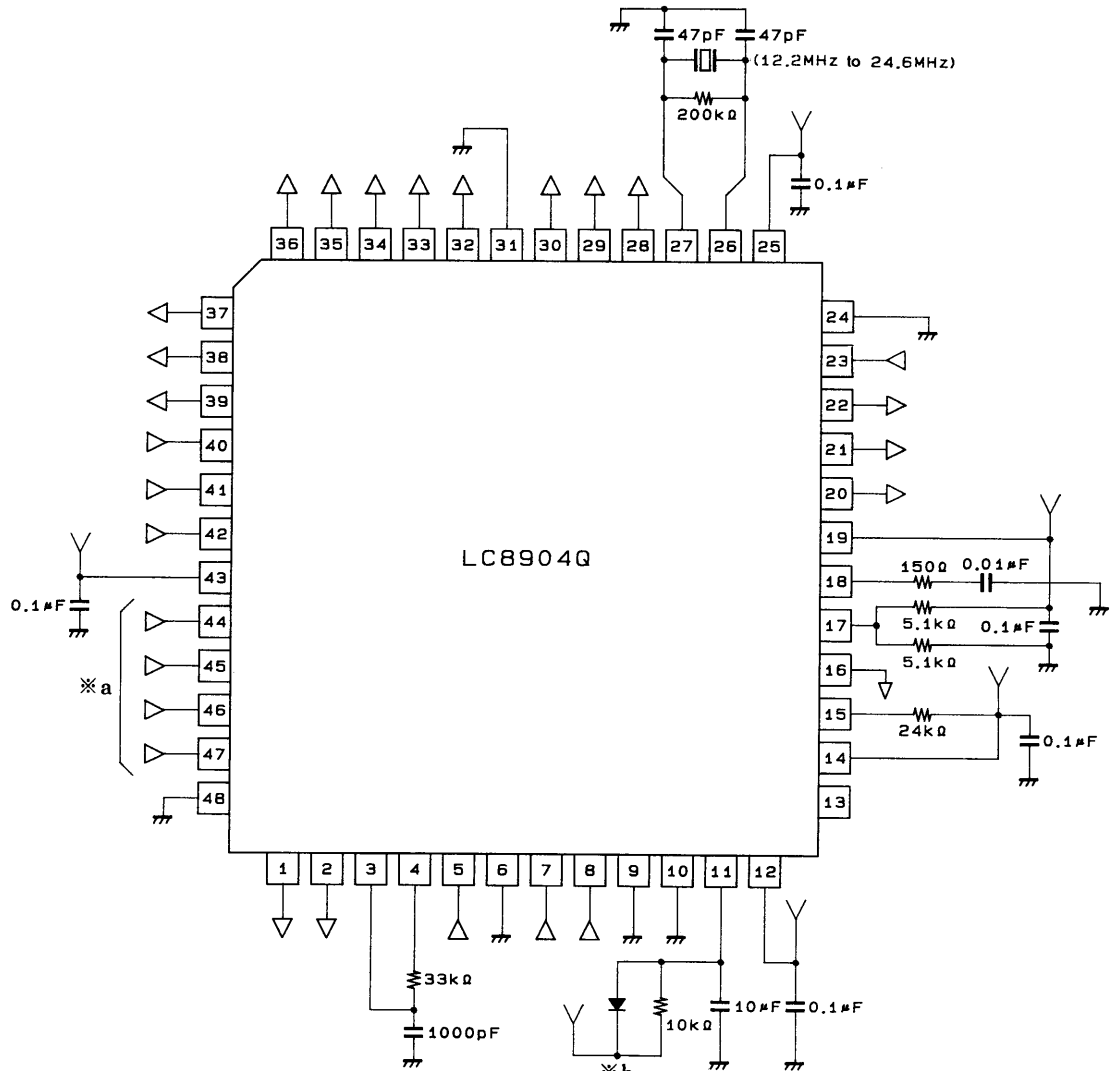
A03431

- (1) 16-bit MSB-first rear-justified data output
- (2) 16-bit MSB-first front-justified data output
- (3) 20-bit MSB-first rear-justified data output
- (4) 20-bit LSB-first rear-justified data output
- (5) 20-bit MSB-first front-justified data output
- (6) 20-bit LSB-first front-justified data output

- (1) 16-bit MSB-first rear-justified data output
- (2) 16-bit MSB-first front-justified data output
- (3) 20-bit MSB-first rear-justified data output

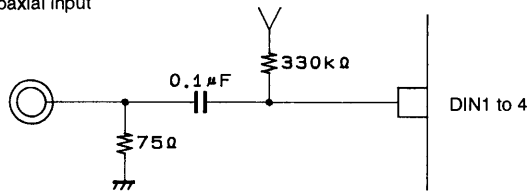
# LC8904Q

## Application Circuit Example

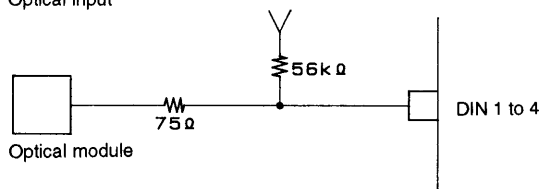


A04750

※ a Coaxial input



Optical input



※ b

Shows the case for power on reset.

A03433

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