



LC83025E

Digital Signal Processor for Karaoke Products

Overview

The LC83025E is a special-purpose karaoke DSP that implements the signal processing required by karaoke systems, including pitch shift, microphone echo, voice muting and simple surround, with only a single 256Kb external DRAM. Since the LC83025E includes built-in A/D and D/A converters, it can also handle analog inputs and outputs in addition to digital inputs and outputs. The LC83025E uses serial transfer of coefficient data from a microcontroller to handle changes in functions and characteristics required for each application.

Features

- Applications

- Pitch shift

The LC83025E can shift the music pitch or the microphone pitch by ± 15 steps in $1/4$ interval steps, or ± 1 octave in scale tone steps according to command data sent from the microcontroller. Furthermore, the pitch can be changed up to ± 1 octave in arbitrary steps by setting internal coefficients.

- Microphone echo

The LC83025E implements echo processing for the signal input from the microphone A/D converter. The amount of echo, the delay time and other parameters can be changed by setting coefficients.

- Voice mute

The LC83025E implements processing that removes monaural signal components included in the music signal. This allows CDs with vocals to be used as karaoke CDs. Command data is used to turn the voice mute function on or off.

- Simple surround

The LC83025E implements a simple surround function by adding delayed components to the music signal. The LC83025E includes six sets of simple surround coefficients as built-in preset data. These values can be switched by sending command data. Applications can implement their own original surround effects by setting the coefficients. However, the algorithm itself is fixed.

- Flexible input mixing

The LC83025E supports hybrid mixing of digital and analog left and right channel song inputs, and thus can handle a wide range of disk processing configurations.

- Audio inputs and outputs

- Inputs: Digital - One system (stereo)

A/D converter - Three channels

- Outputs: Digital - One system (stereo)

D/A converter - Two channels

- A/D converter

Second order $\Delta\Sigma$ modulation - Three channels

- D/A converter

4 \times oversampling digital filters

plus second order noise shaper

plus 5-bit PWM system - Two channels

- Master clock: 768 fs

- External memory: Up to two 256K (64K \times 4-bit) DRAMs can be used

- Microcontroller input: Synchronous 8-bit serial data

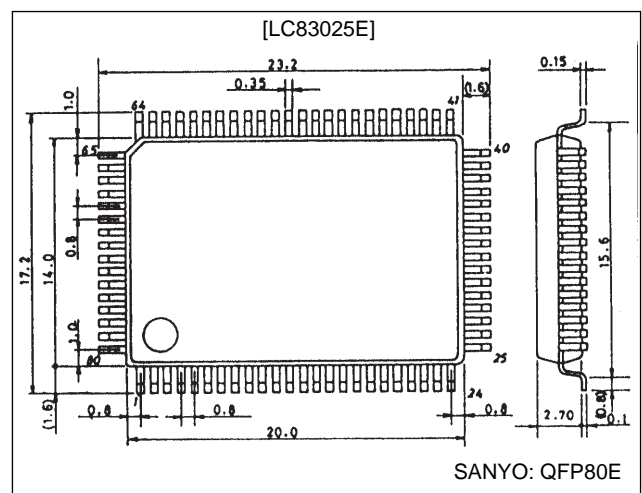
- Supply voltage: 5 V single-voltage

- Package: QFP80E

Package Dimensions

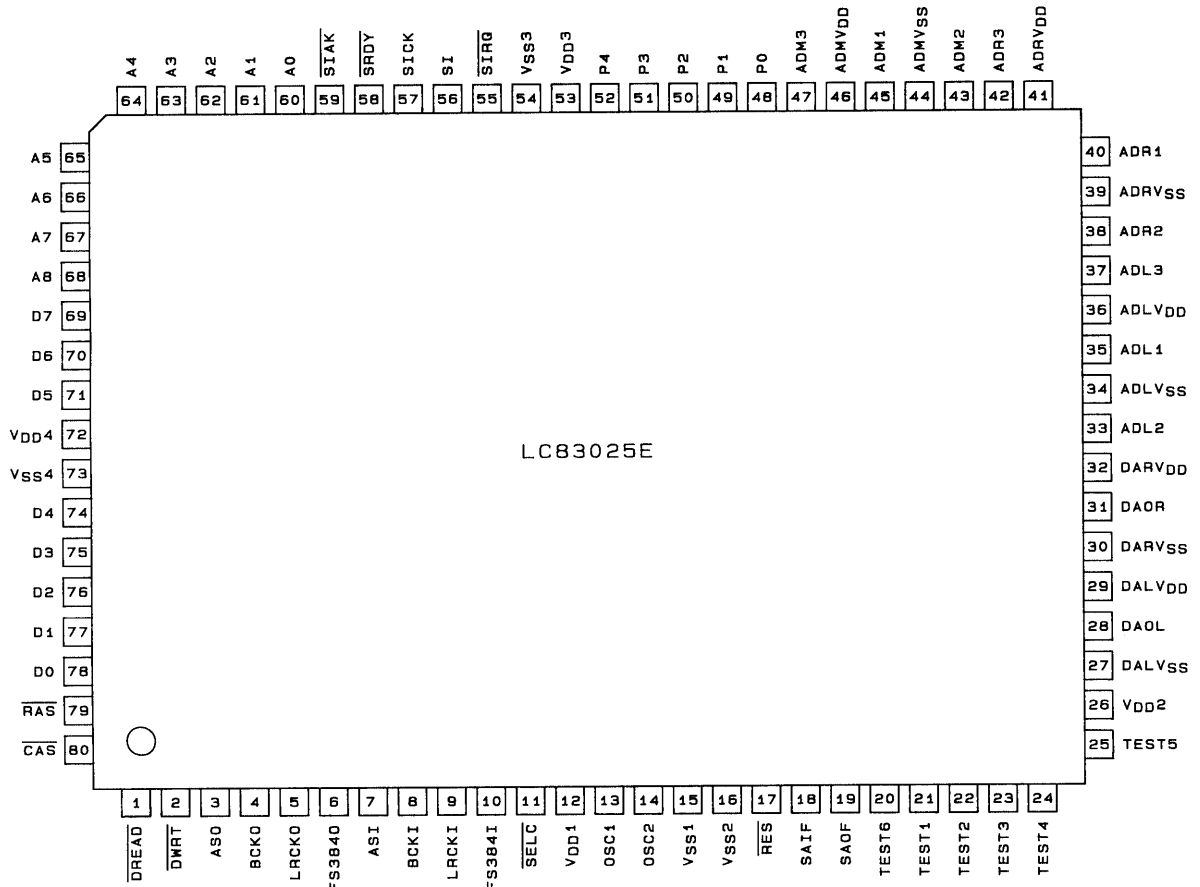
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3174-QFP80E



LC83025E

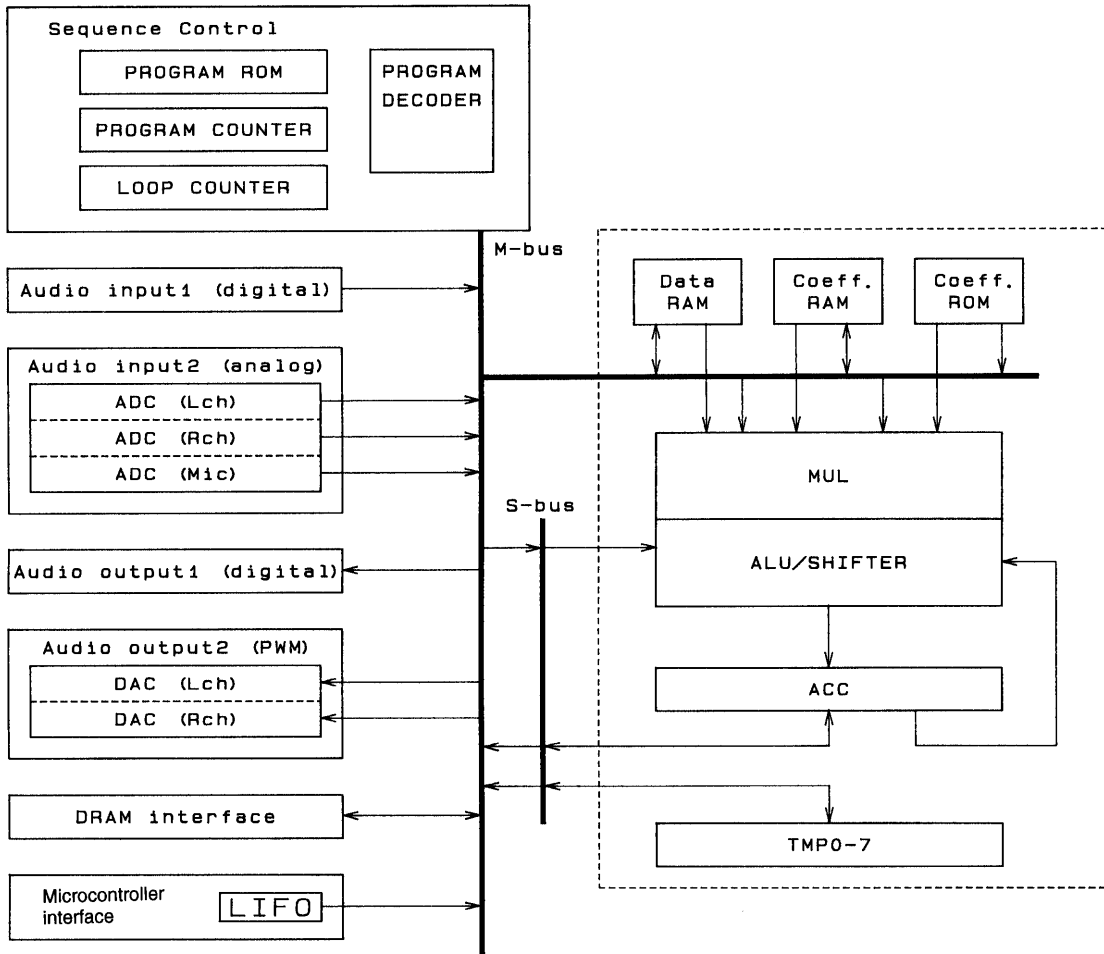
Pin Assignment



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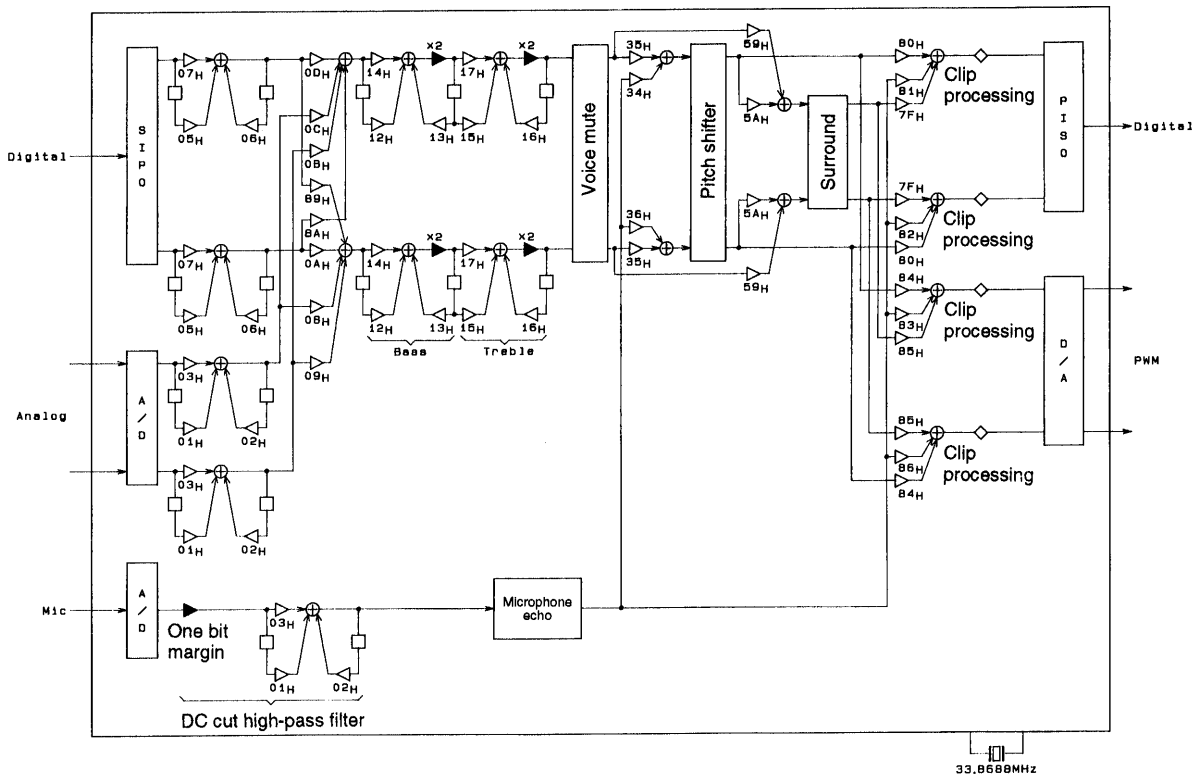
Top view

Block Diagram



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Signal Flow Overview



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Pin Functions

| Pin No. | Symbol | I/O | Function |
|-----------------------------|---------------------------------|-----|---|
| [Control pins] | | | |
| 13 | OSC1 | I | Crystal oscillator connection (768 fs) |
| 14 | OSC2 | O | Crystal oscillator connection (768 fs) |
| 10 | FS384I | I | 384 fs input (Apply a clock that is equal to the OSC1/OSC2 768 fs clock divided by 2.) |
| 11 | $\overline{\text{SEL}}\text{C}$ | I | Audio clock source switching (High: Fixes FS384I as the clock) |
| 18 | SAIF | I | Digital audio input mode switching (Low: backward packed, High: forward packed) |
| 19 | SAOF | I | Digital audio output mode switching (Low: 48 fs, High: 64 fs) |
| 17 | $\overline{\text{RES}}$ | I | Reset |
| 25 to 21 | TEST5 to TEST1 | I | Test (Must be tied to ground in normal operation.) |
| 20 | TEST6 | O | Test (Must be left open in normal operation.) |
| 48 | P0 | I | Coefficient transfer mode switching |
| 50, 49 | P2, P1 | I | Initial operating mode setting (This pin should be held high in normal operation.) |
| 51 | P3 | O | Microphone signal present (low output) or absent (high output) indication output |
| 52 | P4 | O | Music signal present (low output) or absent (high output) indication output |
| [External memory interface] | | | |
| 79 | $\overline{\text{RAS}}$ | O | $\overline{\text{RAS}}$ signal output |
| 80 | $\overline{\text{CAS}}$ | O | $\overline{\text{CAS}}$ signal output |
| 1 | $\overline{\text{DREAD}}$ | O | External memory read signal output |
| 2 | $\overline{\text{DWRT}}$ | O | External memory write signal output |
| 68 to 60 | A8 to A0 | O | Address outputs |
| 69 to 71, 74 to 78 | D7 to D0 | I/O | Data I/O (Normally, only D3 to D0 are used.) |
| [Audio interface] | | | |
| 9 | LRCKI | I | ASI L/R clock input (1 fs) |
| 5 | LRCKO | O | ASO L/R clock output (1 fs) |
| 8 | BCKI | I | ASI bit clock input (32 fs or higher) |
| 4 | BCKO | O | ASO bit clock output (48 fs or 64 fs) |
| 6 | FS384O | O | ASO 384 fs output |
| 7 | ASI | I | Digital audio data input (MSB first, 16 bits) |
| 3 | ASO | O | Digital audio data output (MSB first, backward packed, 16 bits) |
| 35 | ADL1 | I | A/D converter input (left channel) |
| 33 | ADL2 | O | A/D converter output (left channel) |
| 37 | ADL3 | O | A/D converter output (left channel) |
| 40 | ADR1 | I | A/D converter input (right channel) |
| 38 | ADR2 | O | A/D converter output (right channel) |
| 42 | ADR3 | O | A/D converter output (right channel) |
| 45 | ADM1 | I | A/D converter input (microphone) |
| 43 | ADM2 | O | A/D converter output (microphone) |
| 47 | ADM3 | O | A/D converter output (microphone) |
| 28 | DAOL | O | D/A converter output (left channel) |
| 31 | DAOR | O | D/A converter output (right channel) |
| [Microcontroller interface] | | | |
| 55 | $\overline{\text{SIRQ}}$ | I | Serial input request signal input |
| 59 | $\overline{\text{SIAK}}$ | O | Output indicating serial input execution in progress |
| 56 | SI | I | Serial data input from the control microcontroller (8-bit serial data) |
| 57 | SICK | I | SI transfer clock input |
| 58 | $\overline{\text{SRDY}}$ | I | Ready signal input from the control microcontroller that indicates that serial data input has completed |

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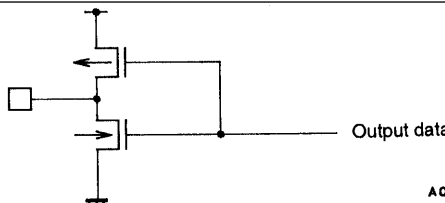

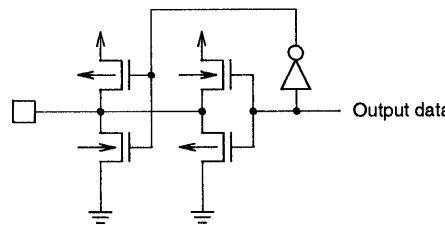
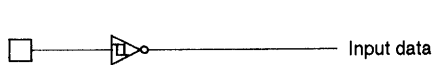
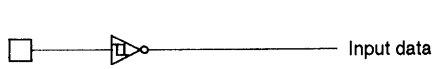
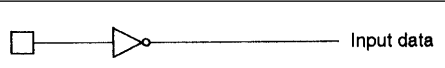
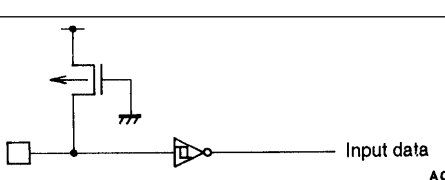
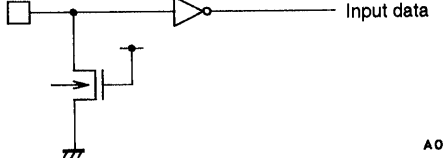
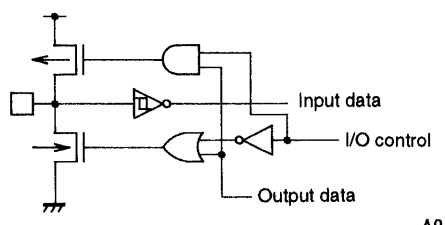
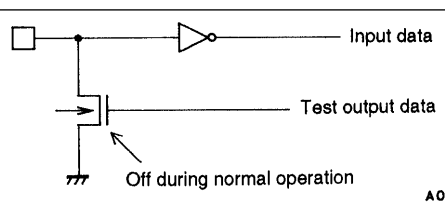

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| Pin No. | Symbol | I/O | Function |
|---------------------|-------------|-----|--|
| [Power supply pins] | | | |
| 12, 26, 53, 72 | V_{DD} | — | V_{DD} for the digital block (Connect to +5 V.) (Keep connections as short as possible so that potential differences between the V_{DD} pins do not occur.) |
| 15, 16, 54, 73 | V_{SS} | — | V_{SS} for the digital block (Connect to ground.) (Keep connections as short as possible so that potential differences between the V_{SS} pins do not occur.) |
| 36 | $ADLV_{DD}$ | — | A/D converter V_{DD} (left channel) (Connect to +5 V.) |
| 41 | $ADRV_{DD}$ | — | A/D converter V_{DD} (right channel) (Connect to +5 V.) |
| 46 | $ADMV_{DD}$ | — | A/D converter V_{DD} (microphone) (Connect to +5 V.) |
| 29 | $DALV_{DD}$ | — | D/A converter V_{DD} (left channel) (Connect to +5 V.) |
| 32 | $DARV_{DD}$ | — | D/A converter V_{DD} (right channel) (Connect to +5 V.) |
| 34 | $ADLV_{SS}$ | — | A/D converter V_{SS} (left channel) (Connect to ground.) |
| 39 | $ADRV_{SS}$ | — | A/D converter V_{SS} (right channel) (Connect to ground.) |
| 44 | $ADMV_{SS}$ | — | A/D converter V_{SS} (microphone) (Connect to ground.) |
| 27 | $DALV_{SS}$ | — | D/A converter V_{SS} (left channel) (Connect to ground.) |
| 30 | $DARV_{SS}$ | — | D/A converter V_{SS} (right channel) (Connect to ground.) |

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Pin Circuits

| Specification | Circuit | Pins |
|--|---|---|
| TTL output |  | ASO, LRCKO, BCKO, $\overline{\text{RAS}}$, $\overline{\text{CAS}}$, $\overline{\text{DREAD}}$, $\overline{\text{DWRT}}$, FS384O, A0 to A8 |
| CMOS intermediate current output |  | P3, P4, $\overline{\text{SIK}}$, TEST6 |
| Analog output |  | DAOL, DAOR, ADL2, ADL3, ADM2, ADM3, ADR2, ADR3 |
| Schmitt input |  | SI, SICK, $\overline{\text{SIRQ}}$, $\overline{\text{SRDY}}$, (OSC1) |
| Low Schmitt input |  | FS384I, BCKI, ASI, LRCKI |
| Normal input |  | TEST1 to TEST5 |
| Input with built-in pull-up resistor |  | $\overline{\text{RES}}$ |
| Input with built-in pull-down resistor |  | $\overline{\text{SEL}}$ C, SAIF, SAOF |
| CMOS intermediate current output Low Schmitt input |  | D0 to D7 |
| N-channel open drain intermediate current output Normal input |  | P0 to P2 |
| Analog input |  | ADL1, ADR1, ADM1 |

Specifications

Absolute Maximum Ratings at Ta = 25°C, VSS = 0 V

| Parameter | Symbol | Conditions | Ratings | Unit | Note |
|-----------------------------|---------------------|--|---------------------------------------|------|------|
| Maximum supply voltage | V _{DD} max | | -0.3 to +7.0 | V | |
| Output voltage | V _{O1} | OSC2 output | Allowed up to the oscillator voltage. | V | |
| | V _{O2} | Pins other than OSC2 | -0.3 to V _{DD} + 0.3 | V | |
| Input voltage | V _{IN} | | -0.3 to V _{DD} + 0.3 | V | |
| Peak output current | I _{OP1} | Audio interface, external RAM interface | -2 to +4 | mA | 1 |
| | I _{OP2} | Microcontroller interface, P3, P4 | -2 to +10 | mA | 2 |
| Average output current | I _{OA1} | Audio interface, external RAM interface: per pin | -2 to +4 | mA | 1 |
| | I _{OA2} | Microcontroller interface, P3, P4: per pin | -2 to +10 | mA | 2 |
| | ΣI _{OA1} | Total for FS384O, LRCKO, BCKO, and ASO | -10 to +10 | mA | |
| | ΣI _{OA2} | Total for DWRT, DREAD, RAS, CAS, A3 to A8 and D0 to D7 | -30 to +30 | mA | |
| | ΣI _{OA3} | Total for A0 to A2, SIAK, P3 and P4 | -10 to +10 | mA | |
| Allowable power dissipation | Pd max | Ta = -30 to +70°C | 700 | mW | |
| Operating temperature | Topr | | -30 to +70 | °C | |
| Storage temperature | Tstg | | -40 to +125 | °C | |

Allowable Operating Ranges

at Ta = -30 to +70°C, all V_{DD} = 4.75 to 5.25 V, all V_{SS} = 0 V unless otherwise specified

| Parameter | Symbol | Conditions | min | typ | max | Unit | Note |
|--|-------------------|---|----------------------|-----|----------------------|------|------|
| Operating supply voltage | V _{DD} | | 4.75 | | 5.25 | V | |
| Input high level voltage | V _{IH1} | Audio interface, external RAM interface | 2.4 | | | V | 4 |
| | V _{IH2} | P0 to P2, SELC, SAIF, SAOF, TEST1 to TEST5 | 0.7 V _{DD} | | | V | 5 |
| | V _{IH3} | RES, OSC1, microcontroller interface | 0.75 V _{DD} | | | V | 6 |
| Input low level voltage | V _{IL1} | Audio interface, external RAM interface | | | 0.8 | V | 4 |
| | V _{IL2} | P0 to P2, SELC, SAIF, SAOF, TEST1 to TEST5 | | | 0.3 V _{DD} | V | 5 |
| | V _{IL3} | RES, OSC1, microcontroller interface | | | 0.25 V _{DD} | V | 6 |
| Instruction cycle time | t _{CYC} | | 58 | | 59.11 | ns | |
| [External Clock Input Conditions] | | | | | | | |
| Frequency | f _{EXT} | | 16.85 | | 17.01 | MHz | |
| Pulse width | t _{EXTH} | Related to the FS384I pin. Shown in Figure 1. max: 44.1 kHz × 384 × 1.005 min: 44.1 kHz × 384 × 0.995 | 23 | | | ns | |
| | t _{EXTL} | | 23 | | | ns | |
| Rise time | t _{EXTR} | | | | 9 | ns | |
| Fall time | t _{EXTF} | | | | 9 | ns | |
| [Self-Excitation Oscillation Conditions] | | | | | | | |
| Oscillator frequency | f _{OSC} | OSC1 and OSC2: shown in Figure 2. 44.1 kHz × 768 × ± 0.1% | 33.84 | | 33.90 | MHz | |
| Oscillator stabilization period | f _{OSCS} | Shown in Figure 3. | | | 100 | ms | |
| [Audio Data Input Conditions] | | | | | | | |
| Transfer bit clock period | t _{BCYC} | Related to the BCKI and ASI pins. Shown in Figure 4. | 354 | | | ns | |
| Transfer bit clock pulse width | t _{BCW} | | 100 | | | ns | |
| Data setup time | t _S | | 70 | | | ns | |
| Data hold time | t _H | | 70 | | | ns | |
| [Serial Input Clock Conditions] | | | | | | | |
| Serial clock period | t _{SCYC} | Related to the microcontroller interface. Shown in Figure 5. (Related to the SICK, SI and SRDY pins.) | 480 | | | ns | |
| Serial clock pulse width | t _{SCW} | | 200 | | | ns | |
| Data setup time | t _{SS} | | 70 | | | ns | |
| Data hold time | t _{SH} | | 70 | | | ns | |
| SRDY hold time | t _{SYH} | | 200 | | | ns | |
| SRDY pulse width | t _{SYW} | | 200 | | | ns | |
| [DRAM Input Conditions] | | | | | | | |
| Input data setup time | t _{DSI} | Related to external DRAM data input. Shown in Figure 6. (Related to the CAS and D0 to D7 pins.) | 20 | | | ns | |
| Input data hold time | t _{DHI} | | 0 | | | ns | |

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Electrical Characteristics 1

at Ta = -30 to +70°C, all V_{DD} = 4.75 to 5.25 V, all V_{SS} = 0 V unless otherwise specified

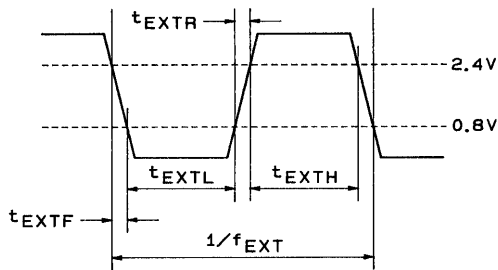
| Parameter | Symbol | Conditions | min | typ | max | Unit | Note |
|-------------------------------|------------------|--|-----------------------|-------|-----|------|---------|
| Input low level current | I _{IL1} | RES, V _{IN} = V _{SS} (Input pins with built-in pull-up resistor) | -250 | -100 | | μA | 8 |
| | I _{IL2} | P0 to P2, V _{IN} = V _{SS} | -10 | | | μA | |
| | I _{IL3} | Other input-only pins | -10 | | | μA | |
| Input high level current | I _{IH1} | SELC, SAIF, SAOF, V _{IN} = V _{DD} (Input pins with built-in pull-down resistor) | | 100 | 250 | μA | 8 |
| | I _{IH2} | P0 to P2, V _{IN} = V _{DD} (n-channel transistor: off) | | | 10 | μA | |
| | I _{IH3} | Other input-only pins | | | 10 | μA | |
| Output high level voltage | V _{OH1} | I _{OH} = -0.4 mA | 4.0 | 4.98 | | V | 1, 8 |
| | V _{OH2} | I _{OH} = -50 μA | V _{DD} - 1.2 | 4.997 | | V | 2, 3, 8 |
| Output low level voltage | V _{OL1} | I _{OL} = 2 mA | | 0.065 | 0.4 | V | 1, 8 |
| | V _{OL2} | I _{OL} = 10 mA | | 0.32 | 1.5 | V | 2, 3, 8 |
| Output off leakage current | I _{OFF} | V _O = V _{SS} , V _{DD} | -40 | | +40 | μA | |
| I/O capacitance | C _{IO} | | | | 10 | pF | |
| [Audio Data Output Timing] | | | | | | | |
| Output data hold time | t _{OH} | BCKO and ASO: shown in Figure 7. | -30 | | | ns | 7 |
| Output data delay time | t _{OD} | | | | 50 | ns | 7 |
| [External DRAM Access Timing] | | | | | | | |
| RAS high pulse width | t _{RP} | Timing for output to the external DRAM. Shown in Figure 8. | 80 | | | ns | 7 |
| RAS low pulse width | t _{RAS} | | 700 | | | ns | 7 |
| CAS high pulse width | t _{CP} | | 50 | | | ns | 7 |
| CAS low pulse width | t _{CAS} | | 95 | | | ns | 7 |
| CAS cycle time | t _{PC} | | 175 | | | ns | 7 |
| RAS to CAS delay time | t _{RCD} | | 60 | | | ns | 7 |
| CAS hold time | t _{CSH} | | 170 | | | ns | 7 |
| RAS hold time | t _{RSH} | | 95 | | | ns | 7 |
| RAS address setup time | t _{ASR} | | 60 | | | ns | 7 |
| RAS address hold time | t _{RAH} | | 20 | | | ns | 7 |
| CAS address setup time | t _{ASC} | | 30 | | | ns | 7 |
| CAS address hold time | t _{CAH} | | 90 | | | ns | 7 |
| DWRT pulse width | t _{WP} | | 95 | | | ns | 7 |
| Write command setup time | t _{WCS} | | 12 | | | ns | 7 |
| Write command hold time | t _{WCH} | | 65 | | | ns | 7 |
| Output data setup time | t _{DSO} | | 30 | | | ns | 7 |
| Output data hold time | t _{DHO} | | 100 | | | ns | 7 |
| Crystal oscillator | C1 | OSC1 and OSC2: shown in Figure 2. | | 13 | | pF | 8 |
| | C2 | | | 29 | | pF | 8 |
| Current drain | L | V _{DD1} , V _{DD2} , V _{DD3} ; oscillator frequency: 33.8688 MHz | | 1.5 | | μH | 8 |
| | I _{DD} | | | 60 | 95 | mA | 9 |

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Electrical Characteristics 2 at Ta = 25°C, all V_{DD} = 5.0 V, all V_{SS} = 0 V unless otherwise specified

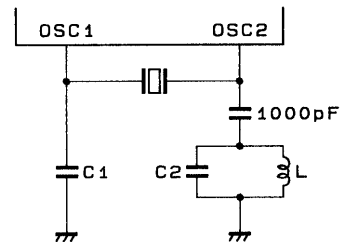
| Parameter | Symbol | Conditions | min | typ | max | Unit | Note |
|---------------------------|---------|------------------|-----|-------|-----|------|--------|
| [A/D Converter Block] | | | | | | | |
| Total harmonic distortion | A-THD | 1 kHz, 0 dB: Lch | | 0.065 | | % | 10, 11 |
| | | 1 kHz, 0 dB: Rch | | 0.065 | | % | 10, 11 |
| | | 1 kHz, 0 dB: Mic | | 0.070 | | % | 10, 11 |
| Signal-to-noise ratio | A-S/N | 1 kHz, 0 dB | 70 | 75 | | dB | 10, 11 |
| Crosstalk | A-C · T | 1 kHz, 0 dB | | -72 | | dB | 10 |
| [D/A Converter Block] | | | | | | | |
| Total harmonic distortion | D-THD | 1 kHz, -1 dB | | 0.045 | | % | 10 |
| Signal-to-noise ratio | D-S/N | 1 kHz, -1 dB | | 78 | | dB | 10 |
| Crosstalk | D-C · T | 1 kHz, -1 dB | | -75 | | dB | 10 |

- Note:
1. TTL output level pins: ASO, FS384O, BCKO, LRCKO, D0 to D7, A0 to A8, RAS, CAS, DREAD, DWRT
 2. CMOS intermediate current output pins: P3, P4, SIAK, TEST6
 3. N-channel open-drain intermediate current output pins: P0 to P2
 4. Low Schmitt input pins: BCKI, ASI, LRCKI, D0 to D7, FS384I
 5. Normal input pins: P0 to P2, TEST1 to TEST5, SELC, SAIF, SAOF
 6. Schmitt input pins: RES, SI, SICK, SIRQ, SRDY, OSC1
 7. When the load capacitance is 50 pF
 8. The values for the oscillator capacitors C1 and C2 include the wiring capacitances.
 9. The value for the current drain is a typical value for V_{DD} = 5 V, room temperature, and a typical sample.
 10. With weight A filter present, with Fs = 44.1 kHz, and tested in the Sanyo evaluation board.
 11. Varies with the values of the external components. The listed value is for the circuit structure and values shown in Figure 9 in the Sanyo evaluation board.



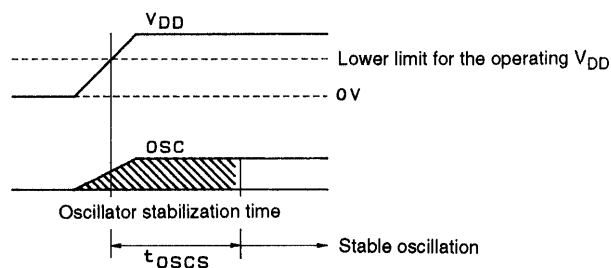
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Figure 1 External Clock Input Waveform (FS384I)



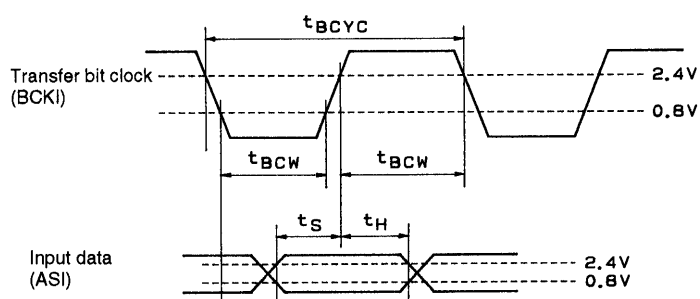
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Figure 2 Crystal Oscillator Circuit



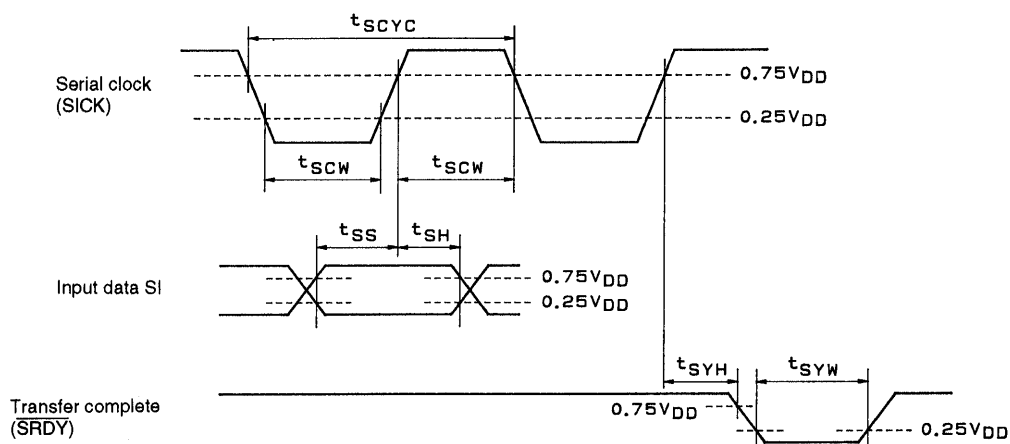
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Figure 3 Oscillator Stabilization Time



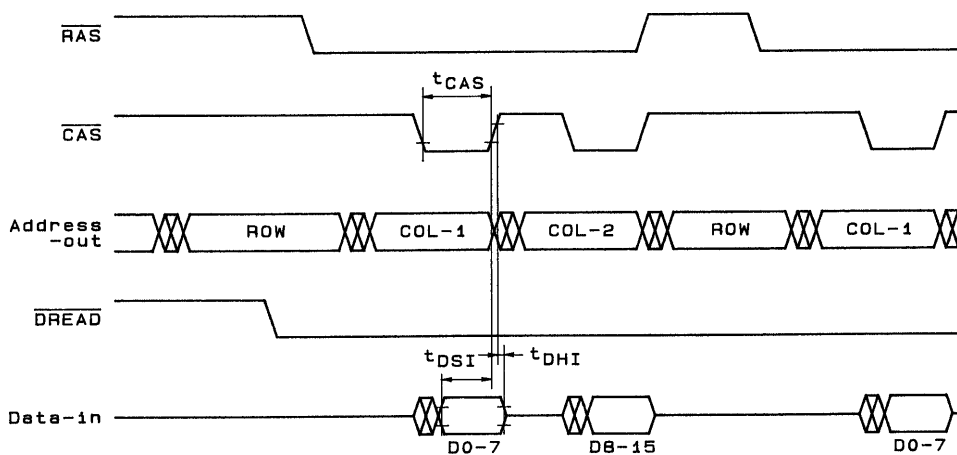
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Figure 4 Audio Data Input Conditions



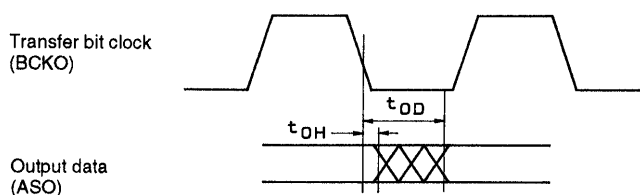
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Figure 5 Microcontroller Interface



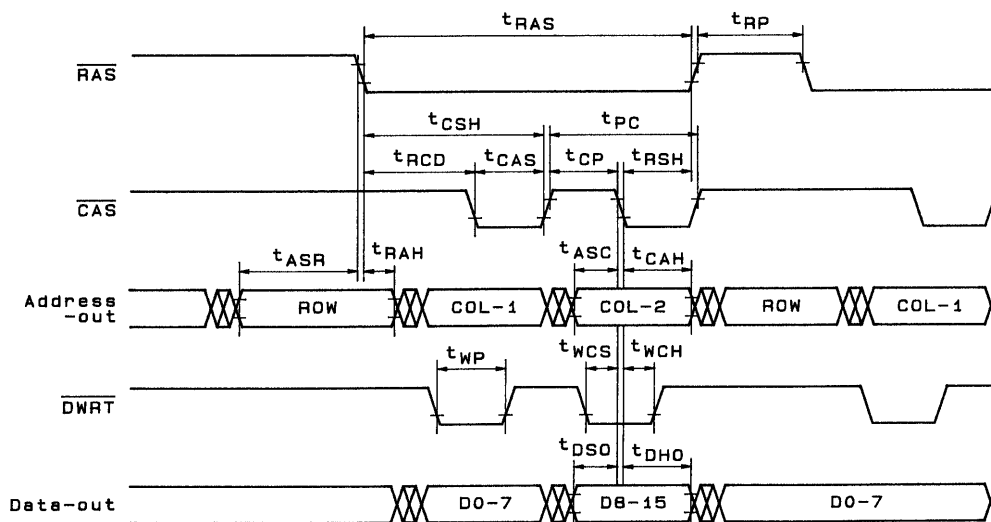
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Figure 6 Timing for Data Input from External DRAM



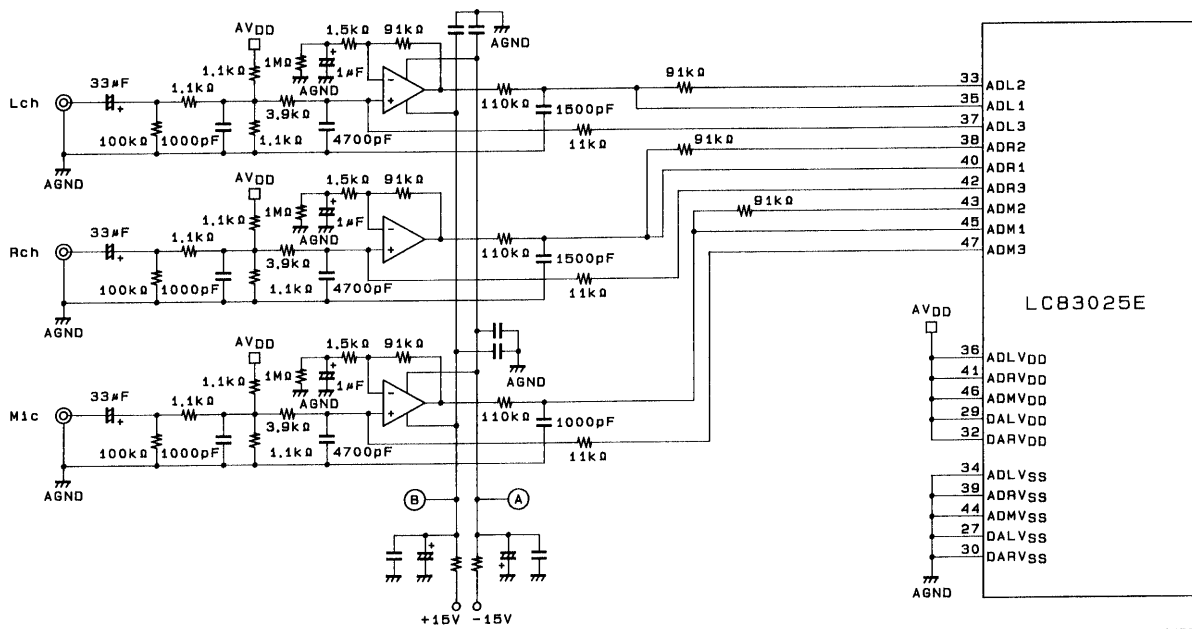
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Figure 7 Audio Data Output Timing



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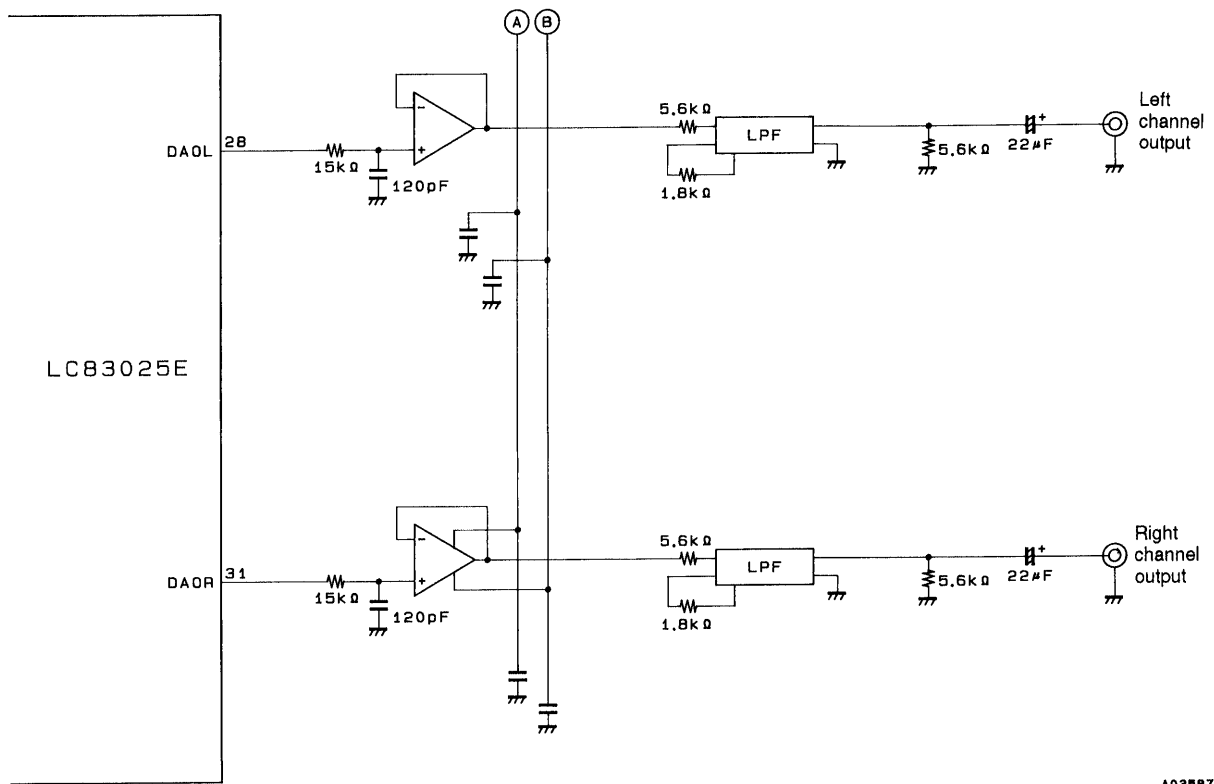
Figure 8 Timing for Data Output to External DRAM



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Figure 9 Sample A/D Converter External Circuit

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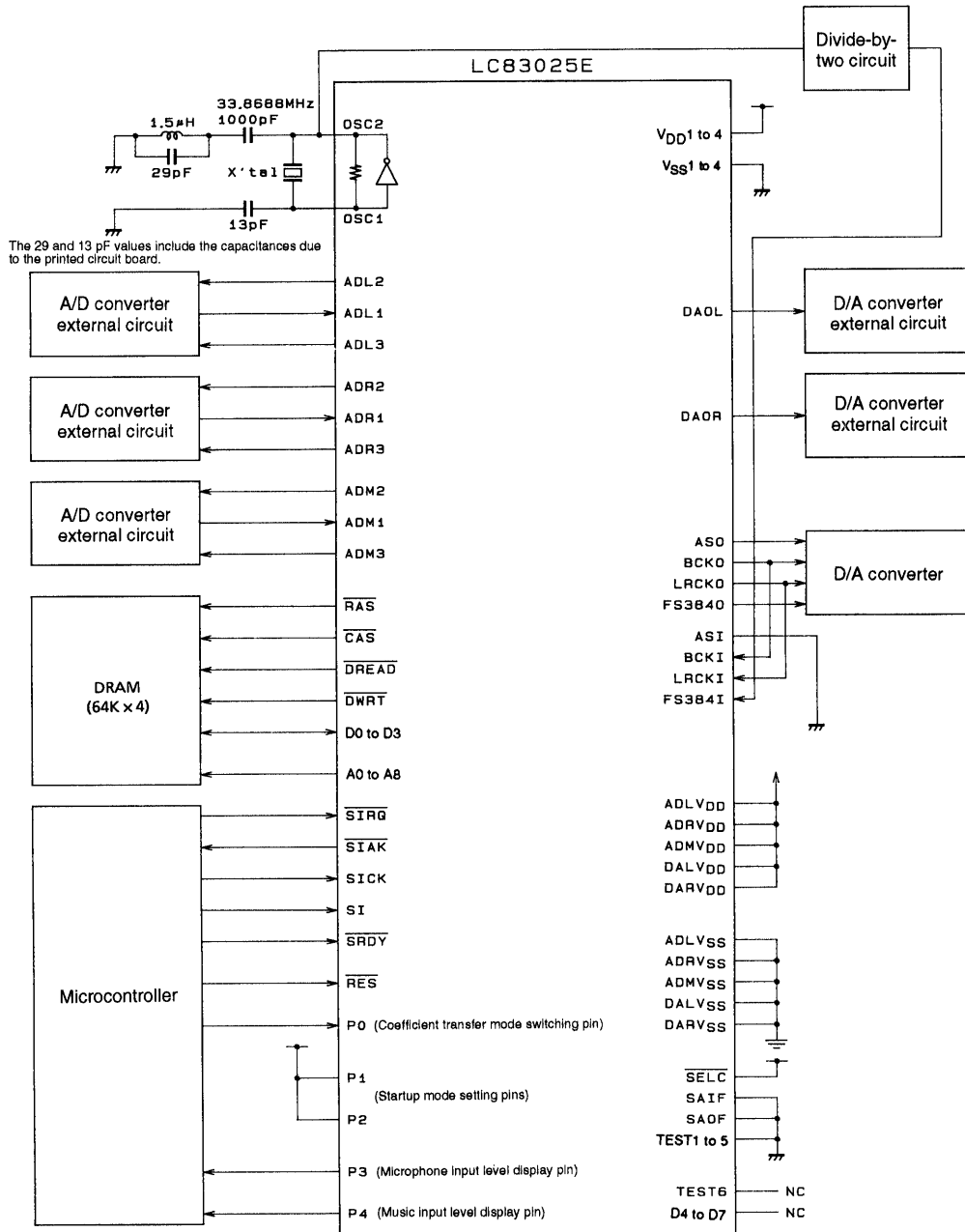


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Figure 10 Sample D/A Converter External Circuit

LC83025E

Sample Peripheral Circuit Connection (For applications that do not use digital input)

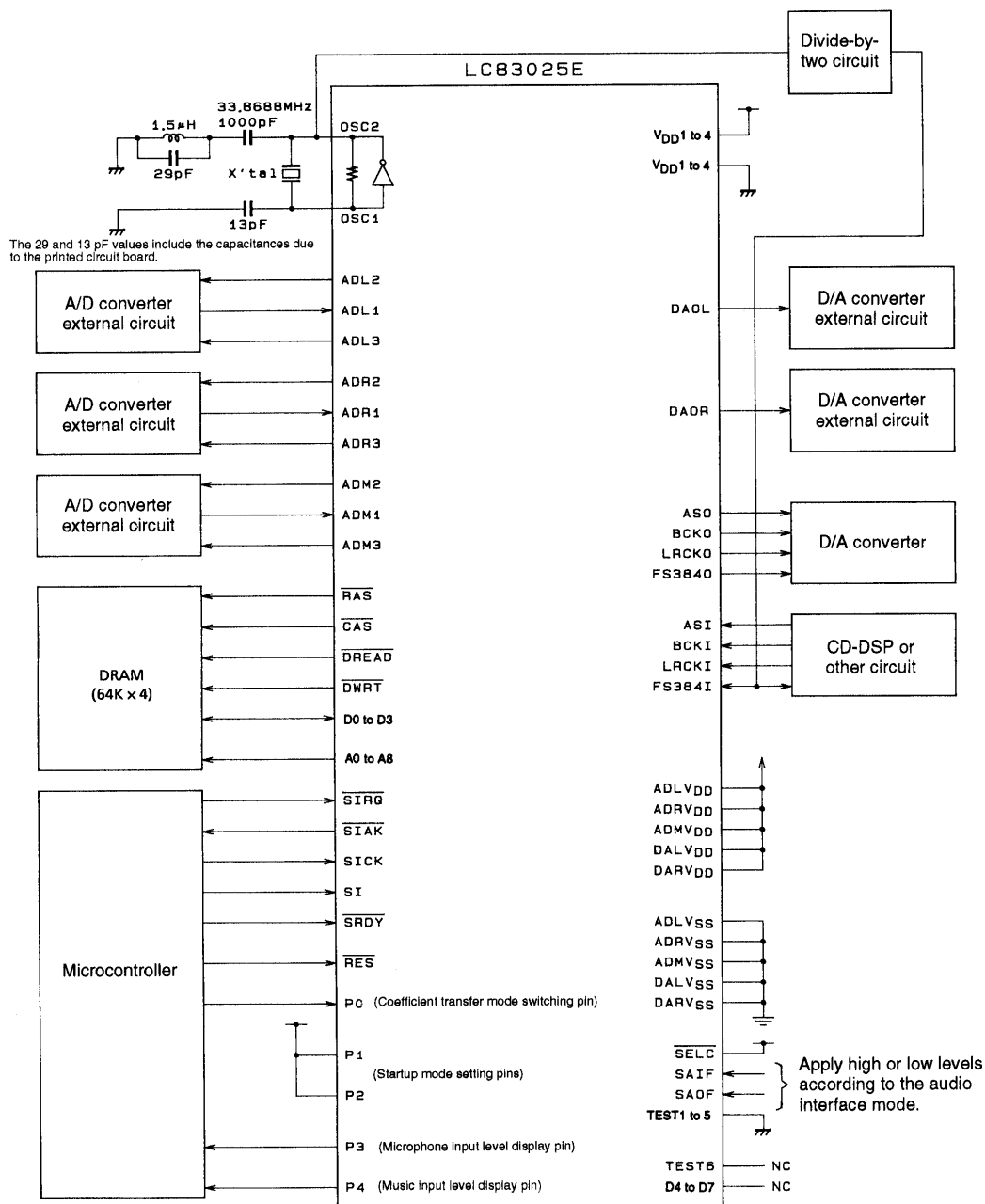


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Whether or not the digital outputs and the analog L/R outputs will be used will be determined by the end product specifications. These pins should be left open if unused.

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Sample Peripheral Circuit Connection (For applications that use digital input.)



Whether or not the analog L/R inputs and the analog L/R outputs will be used will be determined by the end product specifications. A high or low level should be applied to unused input pins, and unused output pins should be left open.

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