

**SANYO**

No. ※4676

**LC78832M****16 Bits D/A Converter LSI  
with On-Chip Digital Filters****Preliminary****Overview**

The LC78832M is a CMOS two-channel 16 bits D/A converter LSI that includes 2 × oversampling digital filters on chip.

**Features****[Digital Filter Block]**

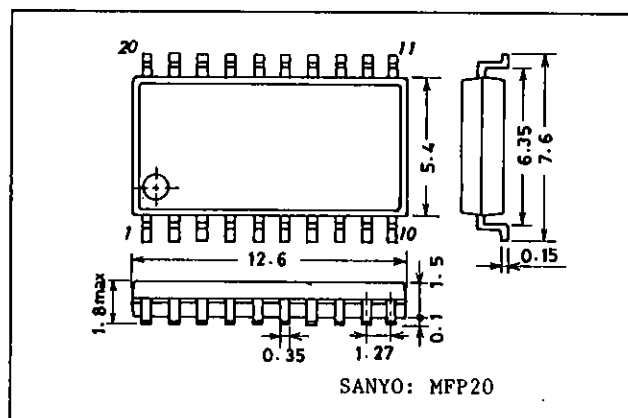
- 2 × oversampling digital filters: FIR 43rd order
- De-emphasis filter:  $F_s = 44.1$  kHz

**[D/A Converter Block]**

- Dynamic level shift conversion 16 bits D/A converters
- D/A converters for two channels on chip (common mode outputs)
- On-chip output op-amps
- System clock: 384 fs
- Single voltage power supply: 3.2 to 5.5 V
- Si gate CMOS process (low power dissipation)

**Package Dimensions**

unit: mm

**3036B-MFP20****Specifications****Absolute Maximum Ratings at  $T_a = 25^\circ\text{C}$** 

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{DD\ max}$		-0.3 to +7.0	V
Maximum input voltage	$V_{IN\ max}$		-0.3 to $V_{DD} + 0.3$	V
Maximum output voltage	$V_{OUT\ max}$		-0.3 to $V_{DD} + 0.3$	V
Operating temperature range	$T_{opr}$		-30 to +75	$^\circ\text{C}$
Storage temperature range	$T_{stg}$		-40 to +125	$^\circ\text{C}$

**Allowable Operating Ranges**

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage	$V_{DD}$		3.2	5.0	5.5	V
Reference voltage high level	$V_{ref\ H}$		$V_{DD} - 0.3$		$V_{DD}$	V
Reference voltage low level	$V_{ref\ L}$		0		0.3	V

**DC Characteristics at  $T_a = -30$  to  $+75^\circ\text{C}$ ,  $V_{DD} = 3.2$  to  $5.5$  V,  $V_{SS} = 0$  V**

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Input high level voltage 1	$V_{IH1}$	Input pins other than SYSCLOCK	2.2			V
Input low level voltage 1	$V_{IL1}$	Input pins other than SYSCLOCK			0.8	V
Input high level voltage 2	$V_{IH2}$	The SYSCLOCK pin	$0.7 V_{DD}$			V
Input low level voltage 2	$V_{IL2}$	The SYSCLOCK pin			$0.3 V_{DD}$	V

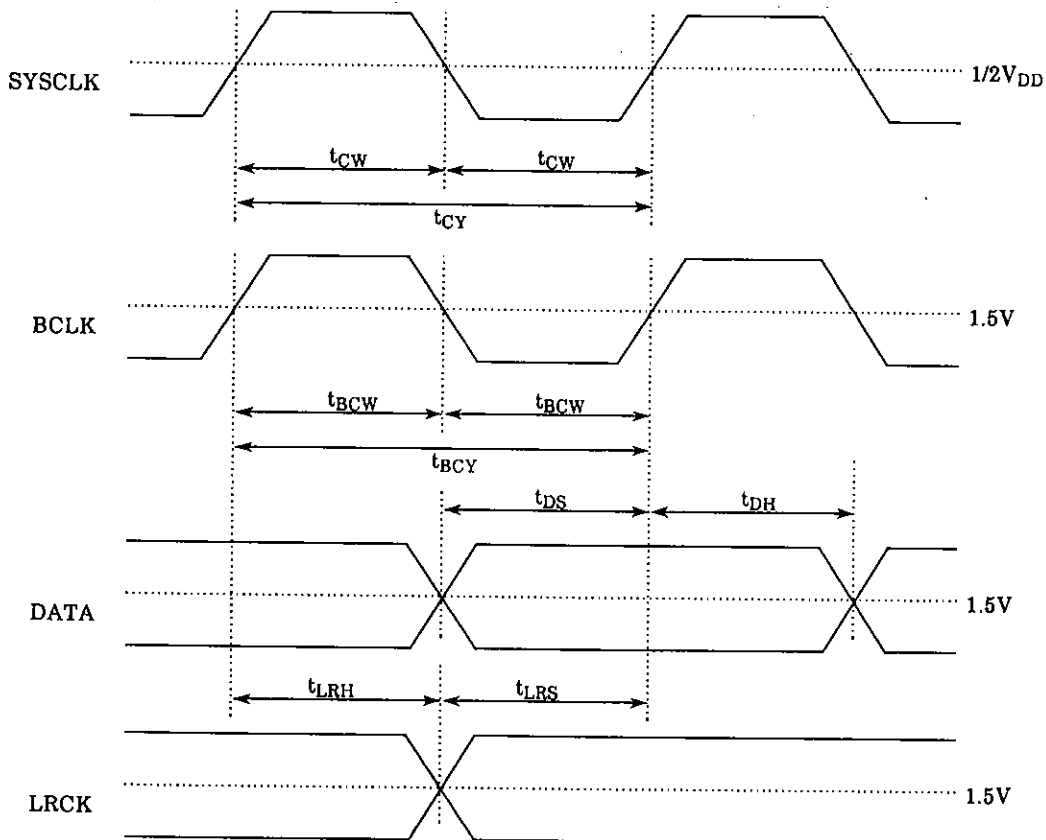
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## LC78832M

### AC Characteristics at $T_a = -30$ to $+75^\circ\text{C}$ , $V_{DD} = 3.2$ to $5.5\text{ V}$ , $V_{SS} = 0\text{ V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Clock pulse width	$t_{CW}$		25			ns
Clock pulse period	$t_{CY}$		50		1000	ns
BCLK pulse width	$t_{BCW}$		60			ns
BCLK pulse period	$t_{BCY}$		120			ns
Data setup time	$t_{DS}$		40			ns
Data hold time	$t_{DH}$		40			ns
LRCK setup time	$t_{LRS}$		40			ns
LRCK hold time	$t_{LRH}$		40			ns

### Input Waveforms



### Electrical Characteristics (1)

at  $T_a = 25^\circ\text{C}$ ,  $DV_{DD} = AV_{DD} = V_{ref H} = 5.0\text{ V}$ ,  $DGND = AGND = V_{ref L} = 0\text{ V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
D/A converter resolution	RES			16		Bits
Total harmonic distortion	THD	At 1 kHz, 0 dB			0.08	%
Dynamic range	DR	At 1 kHz, -60 dB	90			dB
Cross talk	CT	At 1 kHz, 0 dB			-85	dB
Signal to noise ratio	S/N	JIS-A	96			dB
Full-scale output voltage	VFS			2.8		V <sub>p-p</sub>
Power dissipation	P <sub>d</sub>			100	150	mW
Output load resistance	R <sub>L</sub>	Pins 1 and 20	5			k $\Omega$

Note: Test circuit results apply to application circuits.

## LC78832M

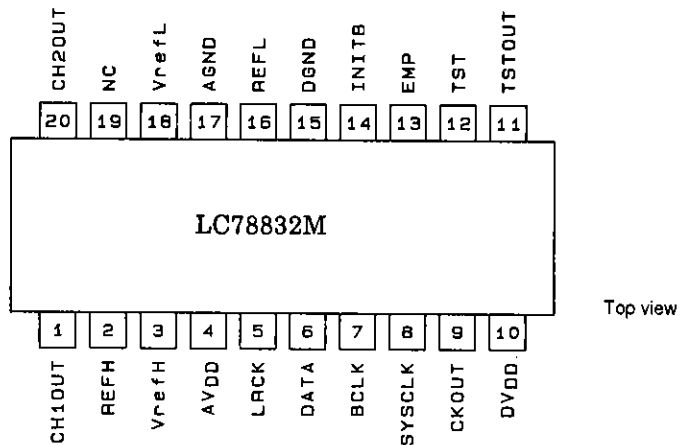
### Electrical Characteristics (2)

at  $T_a = 25^\circ\text{C}$ ,  $DV_{DD} = AV_{DD} = V_{refH} = 3.2\text{ V}$ ,  $DGND = AGND = V_{refL} = 0\text{ V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
D/A converter resolution	RES			16		Bits
Total harmonic distortion	THD	At 1 kHz, 0 dB			0.1	%
Dynamic range	DR	At 1 kHz, -60 dB	90			dB
Cross talk	CT	At 1 kHz, 0 dB			-85	dB
Signal to noise ratio	S/N	JIS-A	96			dB
Full-scale output voltage	VFS			1.8		V <sub>p-p</sub>
Power dissipation	P <sub>d</sub>			30	45	mW
Output load resistance	R <sub>L</sub>	Pins 1 and 20	30			kΩ

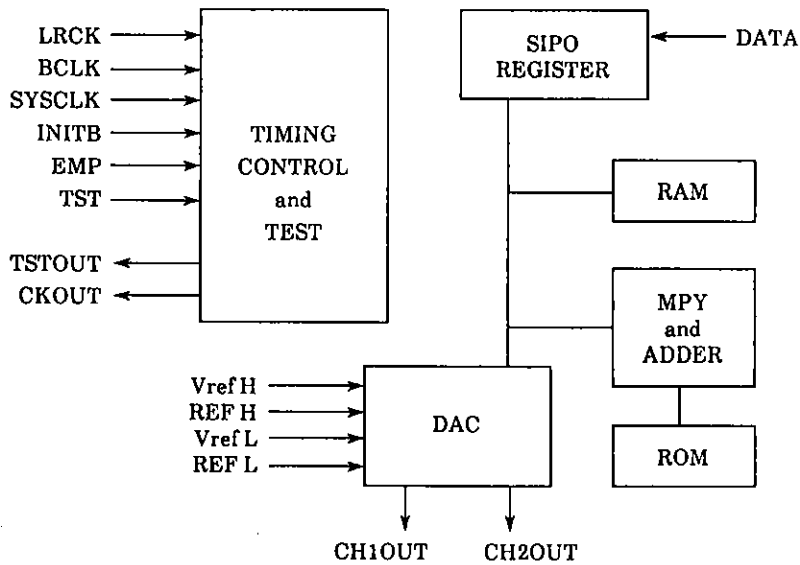
Note: Test circuit results apply to application circuits.

### Pin Assignments



### Block Diagram

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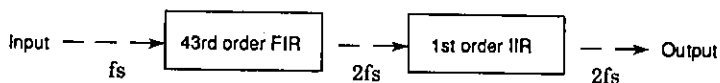
## Pin Functions

Pin No.	Pin	Function
1	CH1OUT	Channel 1 analog output
2	REFH	Reference voltage high level Normally connected to AGND through a capacitor.
3	Vref H	Reference voltage high level input
4	AV <sub>DD</sub>	Analog system power supply
5	LRCK	LR clock input The channel 1 signal is input when high, channel 2 when low.
6	DATA	Digital audio data input Data is input in a two's complement MSB first format.
7	BCLK	Bit clock input
8	SYSCLK	System clock input
9	CKOUT	System clock output
10	DV <sub>DD</sub>	Digital system power supply
11	TSTOUT	Test output pin
12	TST	Test input pin
13	EMP	De-emphasis filter on/off switch The filter is on when high, off when low. The filter is designed for an $F_s$ of 44.1 kHz.
14	INITB	Initialization signal input: The LSI is initialized when this pin is low.
15	DGND	Digital system ground
16	REFL	Reference voltage low Normally connected to AGND through a capacitor.
17	AGND	Analog system ground
18	Vref L	Reference voltage low input
19	NC	No connection
20	CH2OUT	Channel 2 analog output

## Operating Description

### 1. Digital filters

The LC78832M performs the processing shown in the figure below.



- Oversampling

Oversampling is performed by the  $2\times$  interpolation filter formed by the 43rd order FIR.  
The filter characteristics are shown in the logical values figures.

- De-emphasis

The first-order IIR filter performs de-emphasis.

The filter coefficients correspond to an  $f_s$  of 44.1 kHz.

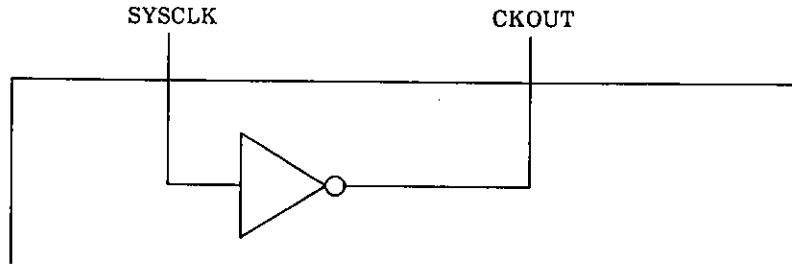
The filter characteristics are shown in the logical values figures.

The EMP pin is used to turn the de-emphasis filter on and off.

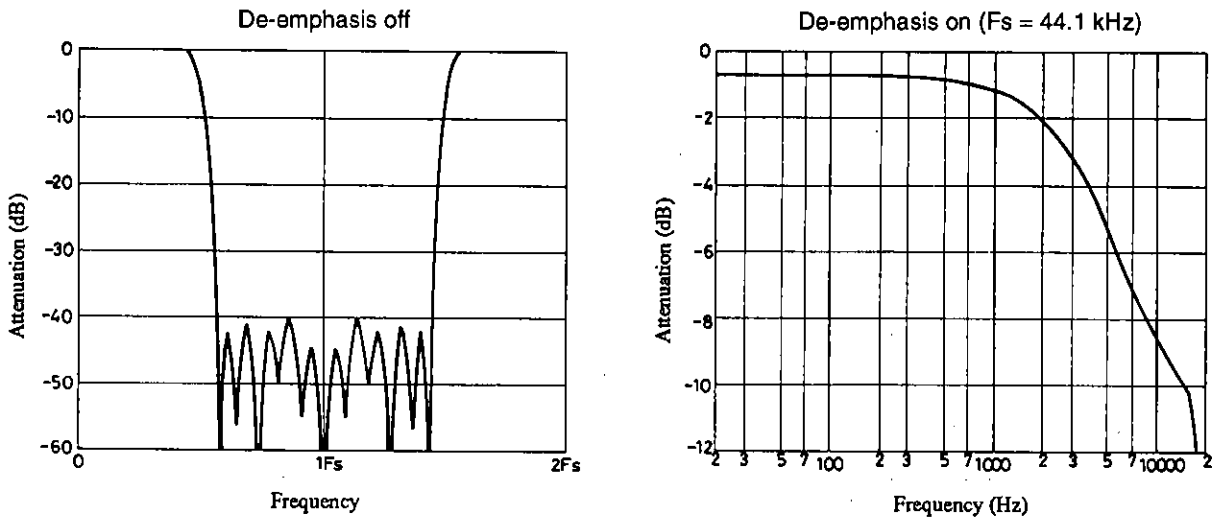
When the EMP is high, the de-emphasis filter will be on; when the EMP is low, the de-emphasis filter will be off.

2. System Clock

The LC78832M uses a 384 fs system clock. A 384 fs clock must be input to the SYSCLK pin. Note that SYSCLK and CKOUT have the relationship shown in the figure.



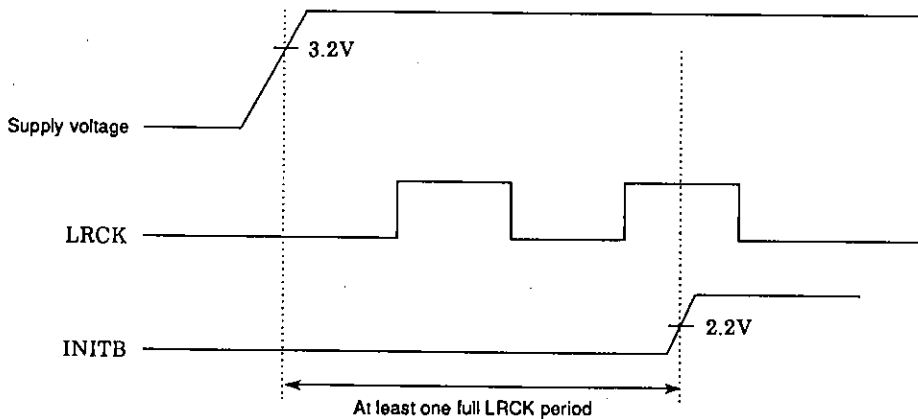
Filter Characteristics (Logical Values)



3. Initialization

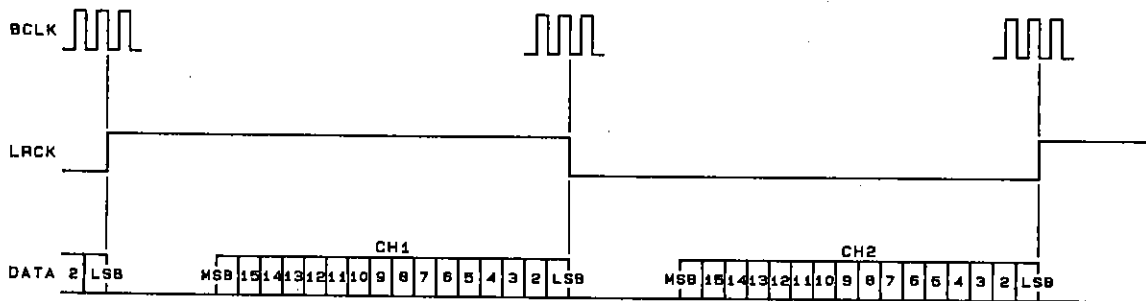
The LC78832M must be initialized after power is applied. Initialization is performed by holding the INITB pin low. This low period must be at least one full LRCK period long, and must start after the power supply voltage has stabilized and after SYSCLK, BCLK, and LRCK have been applied, as shown in the figure.

While INITB is low, the output of the digital filters will be zero in all 16 bits, and the D/A converter outputs (CH1OUT and CH2OUT) will be analog zero (a potential essentially equal to  $(REFH + REFL)/2$ ).



4. Digital Audio Data Input

The digital audio data is a 16-bit serial signal and is in an MSB first two's complement format. The 16-bit serial data is input from the DATA pin to an internal register on the rising edge of BCLK, and is read in on the rising and falling edges of LRCK.



Digital audio data input timing

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5. D/A Converter

The LC78832M provides independent 16-bit D/A converters with built-in output op-amps for channel 1 and channel 2. These D/A converters use a dynamic level shifting conversion scheme that combines a resistor string D/A converter (R-string D/A converter), a pulse-width modulation D/A converter (PWM D/A converter), and a level shift D/A converter.

- R-string D/A converter

The R-string D/A converter is a 9-bit D/A converter circuit that consists of 512 (i.e.,  $2^9$ ) individual resistors connected in series. These resistors divide the voltage applied at the ends of the string into 512 equal divisions. A switching circuit outputs two adjacent potentials from these divided potentials according to the upper 9 bits of the data. These two potentials are output to the PWM D/A converter. Here the relationship

$$V_2 - V_1 = (V_H - V_L)/512$$

will hold.

- PWM D/A converter

The PWM D/A converter is a three-bit D/A converter circuit that uses a PWM (pulse width modulation) circuit to divide the span of the two potentials  $V_1$  and  $V_2$  output from the R-string D/A converter by eight. This D/A converter outputs either  $V_1$  or  $V_2$  depending on the middle 3 bits of the data.

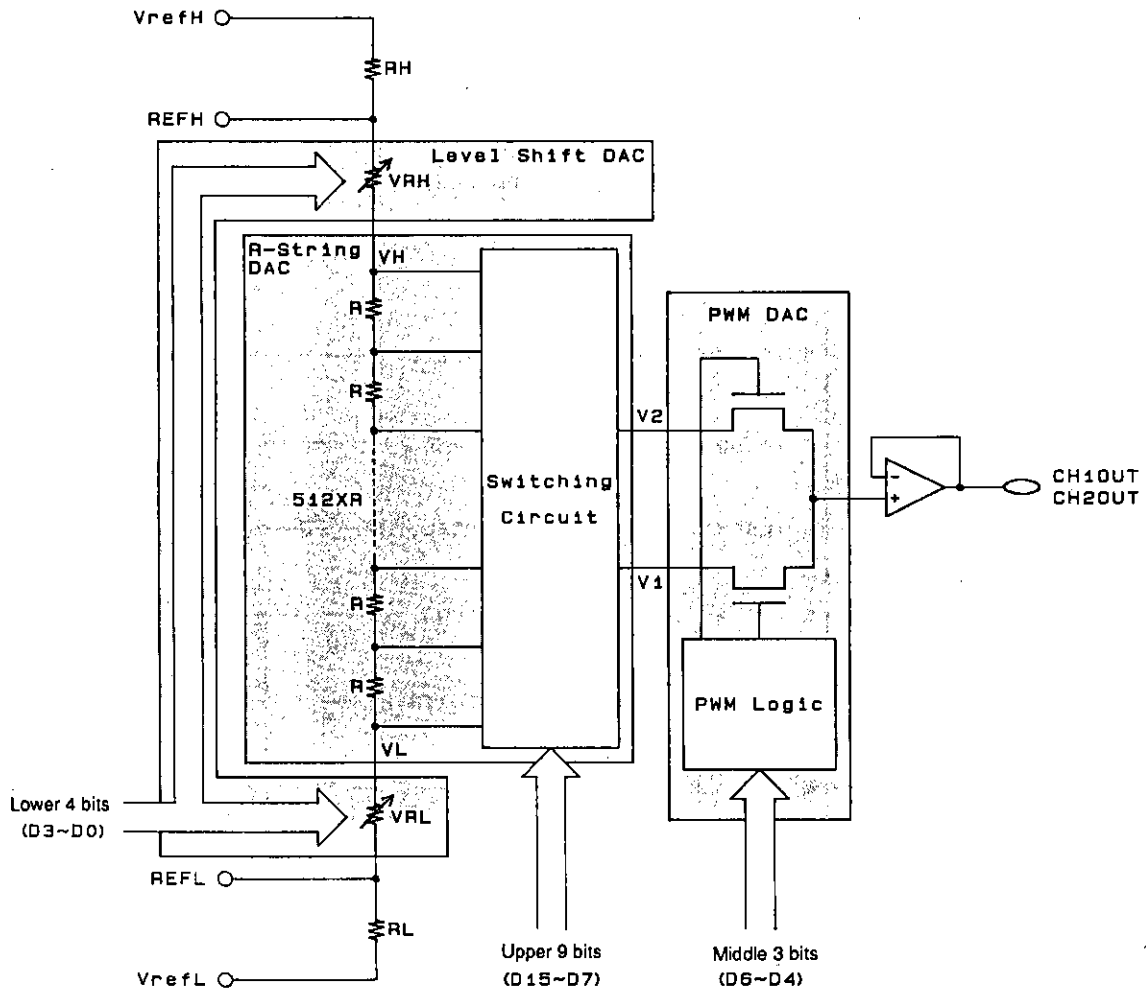
- Level shift D/A converter

The level shift D/A converter is a four-bit D/A converter formed by connecting the variable resistors  $VR_H$  and  $VRL$  in series at the ends of the R-string DAC. The lower four bits of data are used to adjust these variable resistors as follows:

- The value  $(VR_H + VRL)$  is constant for all values of the data.
- The values of  $VR_H$  and  $VRL$  are varied over the range 0 to  $15R/128$  (where  $R$  is the value of the unit resistors in the R-string D/A converter) in steps of  $R/128 \Omega$ .

This results in the  $V_1$  and  $V_2$  outputs of the R-string D/A converter varying in steps of  $\Delta V/128$  over the range 0 to  $15 \times \Delta V/128$  (where  $\Delta V = (V_H - V_L)/512$ ) according to the value of the low-order four bits of the data.

LC78832M D/A Conversion Scheme

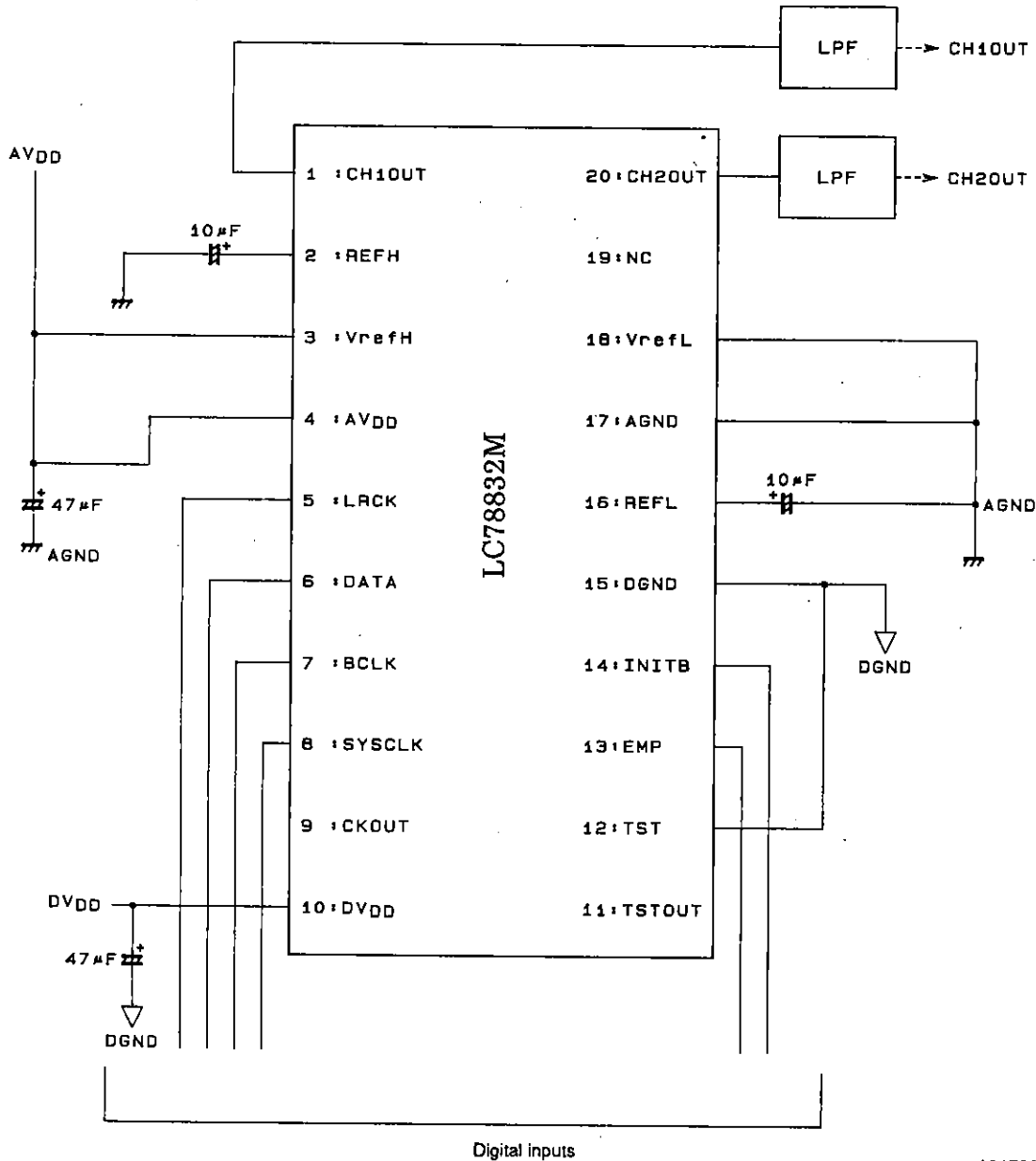


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**Vref H, Vref L, REFH, and REFL**

Normally the Vref H and Vref L pins, which supply the reference voltage to the resistor string, are connected to AV<sub>DD</sub> and AGND respectively. Also, 10 μF capacitors are connected between REFH and AGND, and between REFL and AGND.

Application Circuit Example



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- Note:
1. Use a low-impedance high-stability power supply (a commercial three terminal regulator or equivalent) for  $V_{DD}$  and  $V_{ref H}$ .
  2. Since the circuit may latch up if there is a discrepancy in the rise time of the power signals applied to pin 4 ( $AV_{DD}$ ) and pin 10 ( $DV_{DD}$ ), design application circuits so that pins 4 and 10 come up at the same time.
  3. Connect bypass capacitors between  $AV_{DD}$  and  $AGND$  and between  $DV_{DD}$  and  $DGND$ . To reduce noise, these capacitors should be placed as close as possible to the LSI.

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