

8-bit 125 MSPS Flash A/D Converter

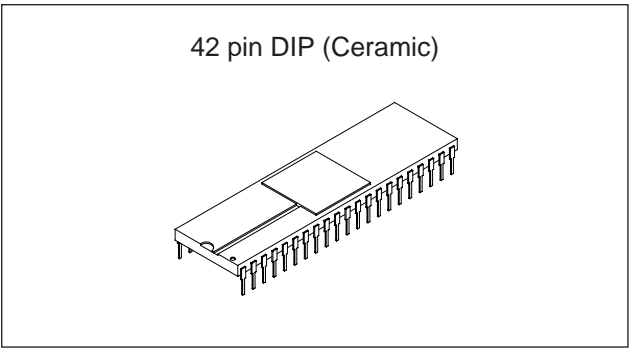
Description

The CXA1396D are 8-bit ultrahigh-speed flash A/D converter ICs capable of digitizing analog signals at the maximum rate of 125 MSPS. The digital I/O levels of these A/D converters are compatible with the ECL 100K/10KH/10K.

The CXA1396D is pin-compatible with the earlier model CX20116. They can replace the earlier models respectively, without any design changes, in most cases. Compared with the earlier models, these new models have been greatly improved in performance, by incorporating advanced process, new circuit design and carefully considered layout.

Features

- Ultrahigh-speed operation with maximum conversion rate of 125 MSPS (Min.)
- Wide analog input bandwidth: 200MHz (Min. for full-scale input)
- Low power consumption: 870mW (Typ.)
- Single power supply: -5.2V
- Low input capacitance
- Built-in integral linearity compensation circuit
- Low error rate
- Operable at 50% clock duty cycle
- Good temperature characteristics
- Capable of driving 50Ω loads



Structure

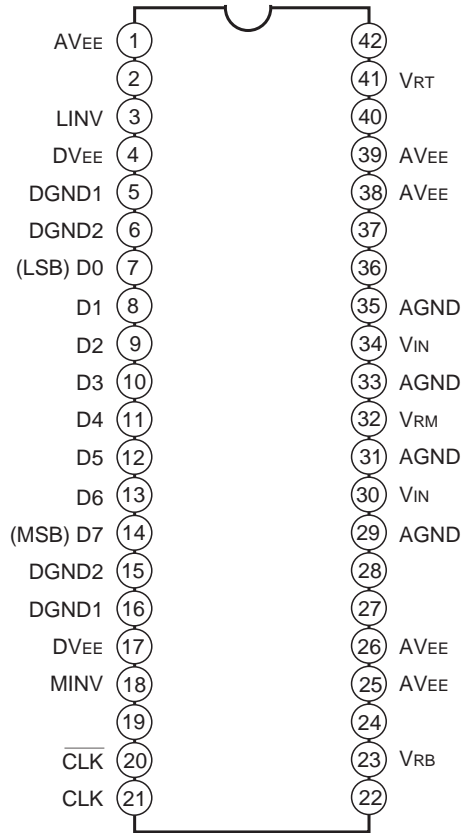
Bipolar silicon monolithic IC

Applications

- Digital oscilloscopes
- HDTV (high-definition TVs)
- Other apparatus requiring ultrahigh-speed A/D conversion

Pin Configuration

Pins without name are NC pins (not connected).



(Top View)

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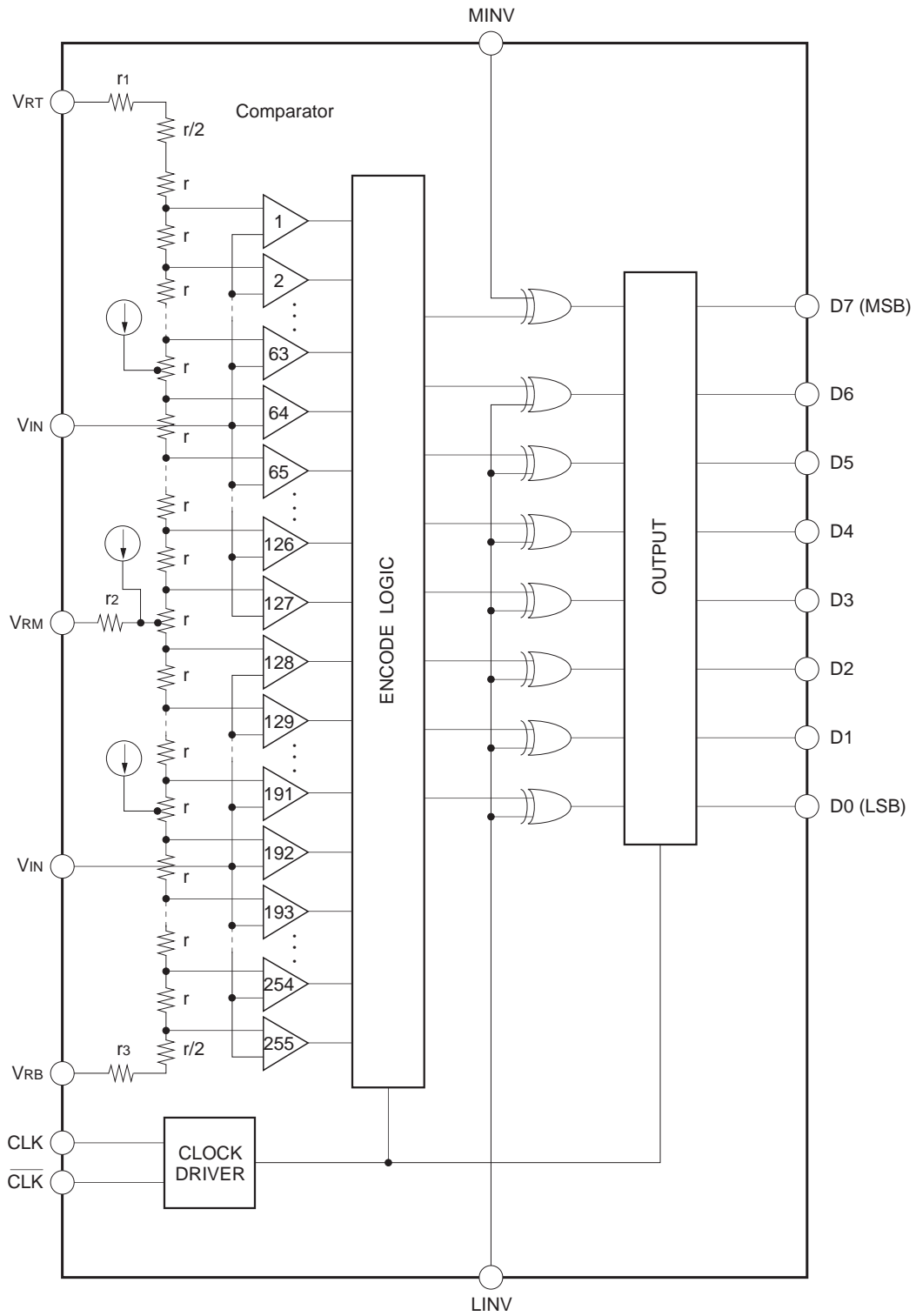
Absolute Maximum Ratings ($T_a = 25^\circ\text{C}$)

| | | | |
|------------------------------|-----------------------------------|--------------|------------------|
| • Supply voltage | A_{VEE}, D_{VEE} | -7 to +0.5 | V |
| • Analog input voltage | V_{IN} | -2.7 to +0.5 | V |
| • Reference input voltage | V_{RT}, V_{RB}, V_{RM} | -2.7 to +0.5 | V |
| | $ V_{RT} - V_{RB} $ | 2.5 | V |
| • Digital input voltage | $CLK, \overline{CLK}, MINV, LINV$ | -4 to +0.5 | V |
| | $ CLK - \overline{CLK} $ | 2.7 | V |
| • V_{RM} pin input current | I_{VRM} | -3 to +3 | mA |
| • Digital output current | ID_0 to ID_7 | -30 to 0 | mA |
| • Storage temperature | T_{stg} | -65 to +150 | $^\circ\text{C}$ |

Recommended Operating Conditions

| | | Min. | Typ. | Max. | unit |
|---------------------------|---------------------|----------|------|----------|------------------|
| • Supply voltage | A_{VEE}, D_{VEE} | -5.5 | -5.2 | -4.95 | V |
| | $A_{VEE} - D_{VEE}$ | -0.05 | 0 | +0.05 | V |
| | $AGND - DGND$ | -0.05 | 0 | +0.05 | V |
| • Reference input voltage | V_{RT} | -0.1 | 0 | +0.1 | V |
| | V_{RB} | -2.2 | -2.0 | -1.8 | V |
| • Analog input voltage | V_{IN} | V_{RB} | | V_{RT} | |
| • Pulse width of clock | TPW_1 | 4.0 | | | ns |
| | TPW_0 | 4.0 | | | ns |
| • Operating temperature | T_a | -20 | | +75 | $^\circ\text{C}$ |

Block Diagram



Pin Description and I/O Pin Equivalent Circuit

| Pin No. | Symbol | I/O | Standard voltage level | Equivalent circuit | Description |
|-------------------|-------------------------|-----|------------------------|--------------------|---|
| 29, 31, 33, 35 | AGND | — | 0V | | Analog GND. Used as GND for input buffers and latches of comparators. Isolated from DGND1, DGND2. |
| 1, 25, 26, 38, 39 | AV _{EE} | — | -5.2V | | Analog V _{EE} . -5.2V (Typ.). Internally connected with DV _{EE} (resistance: 4 to 6Ω). A ceramic chip capacitor of at least 0.1μF should be used to connect to AGND and be placed near the pins. |
| 21 | CLK | I | ECL | | CLK input |
| 20 | $\overline{\text{CLK}}$ | | | | Complementary input to CLK. With open connection, kept at threshold voltage (-1.3V). Device is operable without $\overline{\text{CLK}}$ input, but use of complementary inputs of CLK and $\overline{\text{CLK}}$ is recommended to obtain the stable high-speed operation. |
| 5, 16 | DGND1 | — | 0V | | Digital GND for internal circuits. |
| 6, 15 | DGND2 | — | 0V | | Digital GND for output transistors. |
| 4, 17 | DV _{EE} | — | -5.2V | | Digital V _{EE} . Internally connected with AV _{EE} (resistance: 4 to 6Ω). A ceramic chip capacitor of at least 0.1μF should be used to connect to DGND near the pins. |

| Pin No. | Symbol | I/O | Standard voltage level | Equivalent circuit | Description |
|---------|-----------------|---|------------------------------------|--------------------|--|
| 7 | D0 | O | ECL | | LSB of data outputs. External pull-down resistor is required. |
| 8 | D1 | | | | Data outputs. External pull-down resistors are required. |
| 9 | D2 | | | | |
| 10 | D3 | | | | |
| 11 | D4 | | | | |
| 12 | D5 | | | | |
| 13 | D6 | | | | |
| 14 | D7 | MSB of data outputs. External pull-down resistor is required. | | | |
| 3 | LINV | I | ECL | | Input pin for D0 (LSB) to D6 output polarity inversion (see output code table). With open connection, kept at "L" level. |
| 18 | MINV | I | ECL | | Input pin for D7(MSB) output polarity inversion (see output code table). With open connection, kept at "L" level. |
| 30, 34 | V _{IN} | I | V _{RT} to V _{RB} | | Analog input pins. These two pins must be connected externally, since they are not internally connected. See Application Note for precautions. |

| Pin No. | Symbol | I/O | Standard voltage level | Equivalent circuit | Description |
|---------------------------------------|-----------------|-----|------------------------|--------------------|--|
| 23 | V _{RB} | I | -2V | | Reference voltage (bottom). Typically -2V. A ceramic capacitor of at least 0.1μF and a tantalum capacitor of at least 10μF should be used to connect to AGND near the pins. |
| 32 | V _{RM} | I | V _{RB} /2 | | Reference voltage mid point. Can be used as a pin for integral linearity compensation. |
| 41 | V _{RT} | I | 0V | | Reference voltage (top). Typically 0V. When a voltage except for AGND is applied to this pin, a ceramic capacitor of at least 0.1μF and a tantalum capacitor of at least 10μF should be used to connect to AGND near the pins. |
| 2, 19, 22, 24, 27, 28, 36, 37, 40, 42 | NC | — | — | | Unused pins. No internal connections have been made to these pins. Connecting them to AGND or DGND on PC board is recommended. |

Electrical Characteristics

(Ta = 25°C, AV_{EE} = DV_{EE} = -5.2V, V_{RT} = 0V, V_{RB} = -2V)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|--------------------------------|------------------|--|-------|------|------------------|-------|
| Resolution | n | | | 8 | | bits |
| DC characteristics | | | | | | |
| Integral linearity error | E _{IL} | F _c = 125MSPS | | ±0.3 | ±0.5 | LSB |
| Differential linearity error | E _{DL} | F _c = 125MSPS | | ±0.3 | ±0.5 | LSB |
| Analog input | | | | | | |
| Analog input capacitance | C _{IN} | V _{IN} = -1V + 0.07V _{rms} | | 17 | | pF |
| Analog input resistance | R _{IN} | | | 190 | | kΩ |
| Input bias current | I _{IN} | V _{IN} = -1V | | 130 | 320 | μA |
| Reference inputs | | | | | | |
| Reference resistance | R _{REF} | | 75 | 110 | 155 | Ω |
| Offset voltage V _{RT} | E _{OT} | | 8 | 19 | 32 | mV |
| Offset voltage V _{RB} | E _{OB} | | 0 | 15 | 24 | mV |
| Digital inputs | | | | | | |
| Logic H level | V _{IH} | | -1.13 | | | V |
| Logic L level | V _{IL} | | | | -1.50 | V |
| Logic H current | I _{IH} | Input connected to -0.8V | 0 | | 50 | μA |
| Logic L current | I _{IL} | Input connected to -1.6V | -50 | | 50 | μA |
| Input capacitance | | | | 7 | | pF |
| Switching characteristics | | | | | | |
| Maximum conversion rate | F _c | Error rate 10 ⁻⁹ TPS*1 | 125 | | | MSPS |
| Aperture jitter | T _{aj} | | | 10 | | ps |
| Sampling delay | T _{ds} | | | 1.5 | | ns |
| Output delay | T _{do} | | 3.0 | 3.6 | 4.2 | ns |
| H pulse width of clock | TPW ₁ | | 4.0 | | | ns |
| L pulse width of clock | TPW ₀ | | 4.0 | | | ns |
| Digital outputs | | | | | | |
| Logic H level | V _{OH} | R _L = 50Ω to -2V | -1.10 | | | V |
| Logic L level | V _{OL} | R _L = 50Ω to -2V | | | -1.62 | V |
| Output rising time | T _r | R _L = 50Ω to -2V, 20% to 80% | | 0.8 | | ns |
| Output falling time | T _f | R _L = 50Ω to -2V, 80% to 20% | | 1.0 | | ns |
| Dynamic characteristics | | | | | | |
| Input bandwidth | | V _{IN} = 2V _{p-p} , 3dB down | 200 | | | MHz |
| S/N ratio | | { Input = 1MHz, FS Clock = 125MHz | | 46 | | dB |
| | | { Input = 31.5MHz, FS Clock = 125MHz | | 40 | | dB |
| Error rate | | { Input = 31.249MHz, FS Error > 16LSB Clock = 125MHz | | | 10 ⁻⁹ | TPS*1 |
| Differential gain error | DG | } NTSC 40IRE mod.ramp, | | 1.0 | | % |
| Differential phase error | DP | } F _c = 125MSPS | | 0.5 | | deg |
| Power supply | | | | | | |
| Supply current | I _{EE} | | -230 | -160 | | mA |
| Power consumption*2 | P _d | | | 870 | | mW |

*1 TPS: times Per Sample

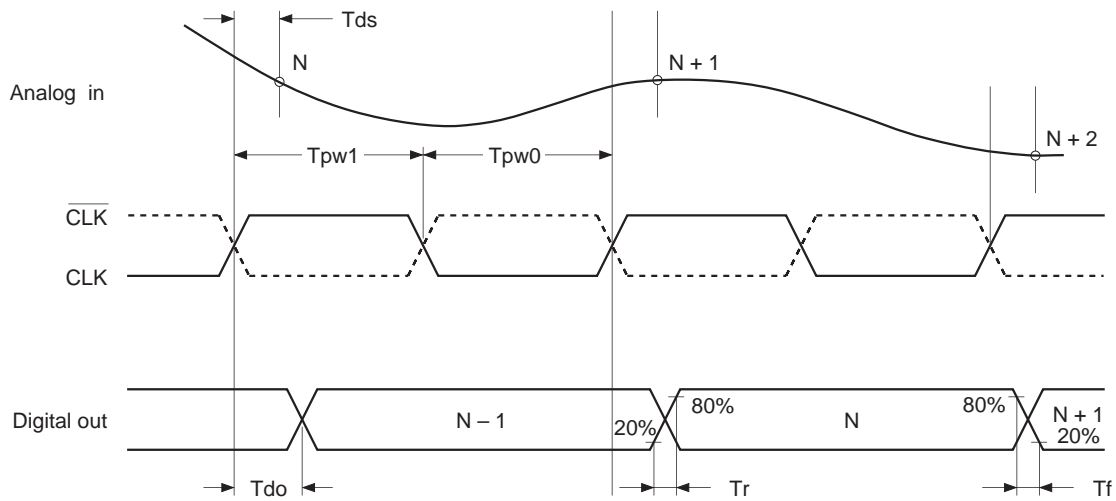
$$*2 P_d = I_{EE} \cdot V_{EE} + \frac{(V_{RT} - V_{RB})^2}{R_{REF}}$$

Output Code Table

| VIN* | Step | MINV 1 | 0 | 1 | 0 | | | | |
|------|------|--------|-----|-------|-----|-------|-----|-------|-----|
| | | LINV 1 | 1 | 0 | 0 | | | | |
| | | D7 | D0 | D7 | D0 | D7 | D0 | D7 | D0 |
| 0V | 0 | 0 0 0 | 0 0 | 1 0 0 | 0 0 | 0 1 1 | 1 1 | 1 1 1 | 1 1 |
| | 1 | 0 0 0 | 0 0 | 1 0 0 | 0 0 | 0 1 1 | 1 1 | 1 1 1 | 1 1 |
| | | ⋮ | | ⋮ | | ⋮ | | ⋮ | |
| -1V | 127 | 0 1 1 | 1 1 | 1 1 1 | 1 1 | 0 0 0 | 0 0 | 1 0 0 | 0 0 |
| | 128 | 1 0 0 | 0 0 | 0 0 0 | 0 0 | 1 1 1 | 1 1 | 0 1 1 | 1 1 |
| | | ⋮ | | ⋮ | | ⋮ | | ⋮ | |
| -2V | 254 | 1 1 1 | 1 0 | 0 1 1 | 1 0 | 1 0 0 | 0 1 | 0 0 0 | 0 1 |
| | 255 | 1 1 1 | 1 1 | 0 1 1 | 1 1 | 1 0 0 | 0 0 | 0 0 0 | 0 0 |
| | | 1 1 1 | 1 1 | 0 1 1 | 1 1 | 1 0 0 | 0 0 | 0 0 0 | 0 0 |

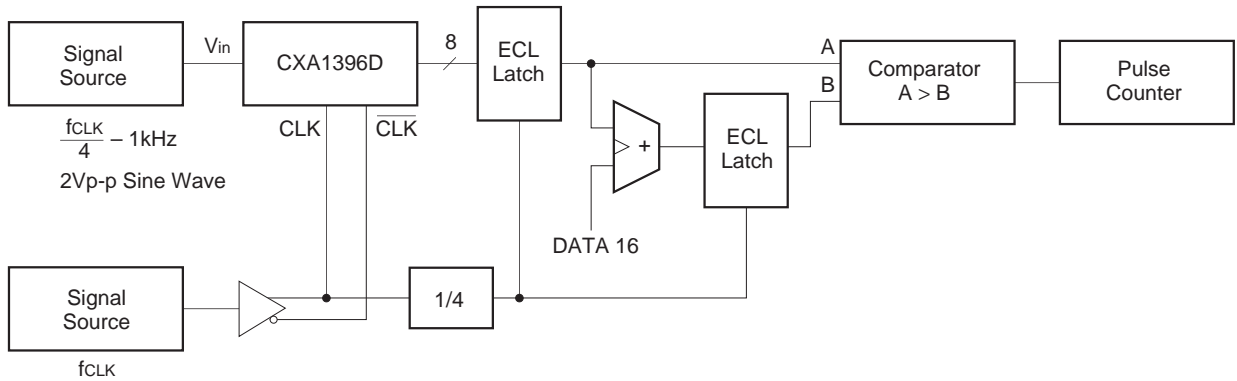
* V_{RT} = 0V, V_{RB} = -2V

Timing diagram



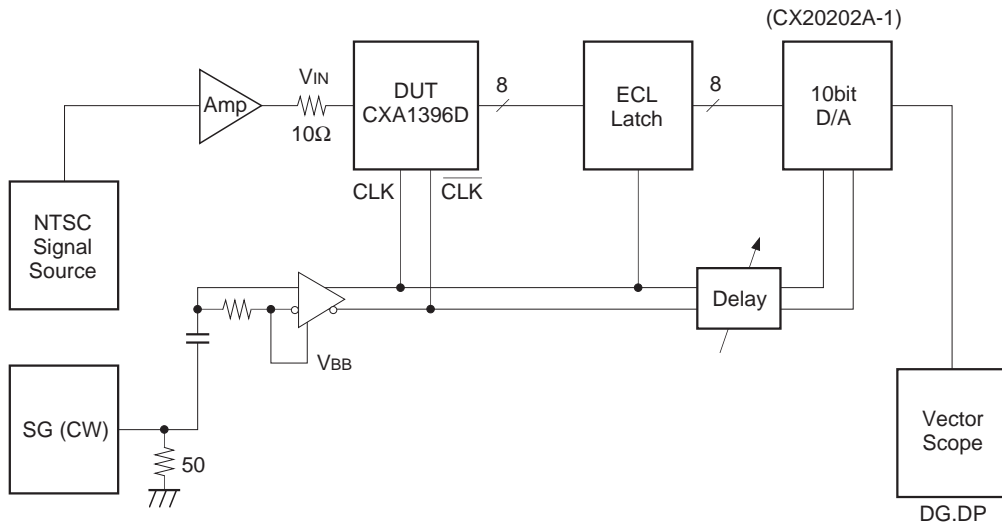
Electrical Characteristics Test Circuit

Maximum conversion rate test circuit



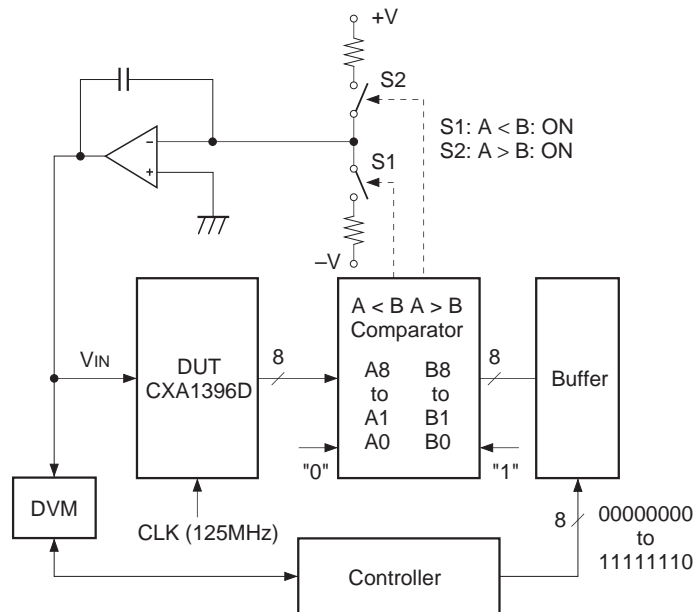
Differential gain error test circuit

Differential phase error test circuit



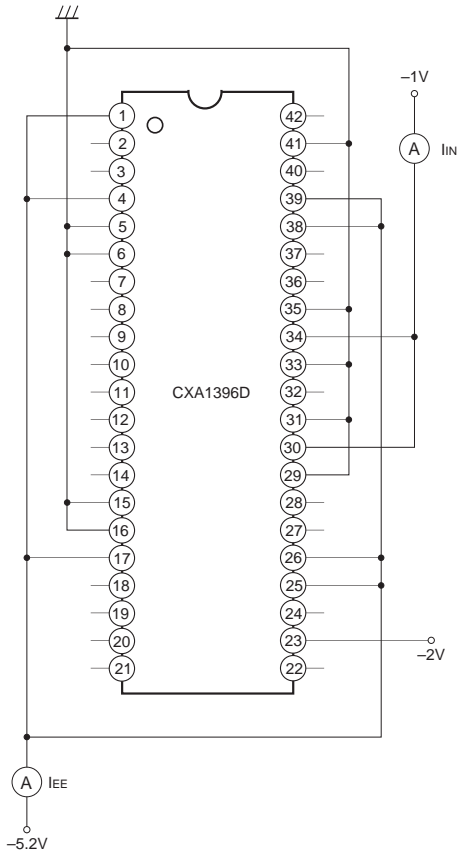
Integral linearity error test circuit

Differential linearity error test circuit



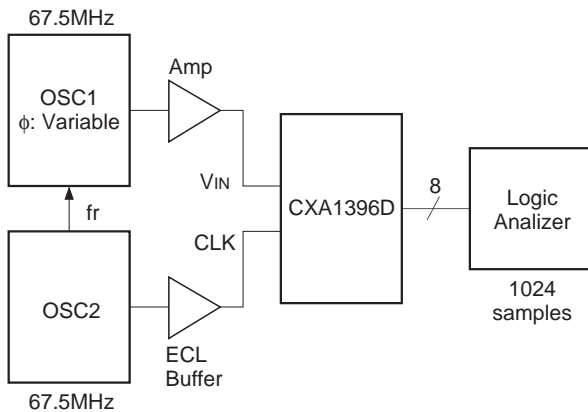
Power Supply Current Test Circuit

Analog input bias current test circuit

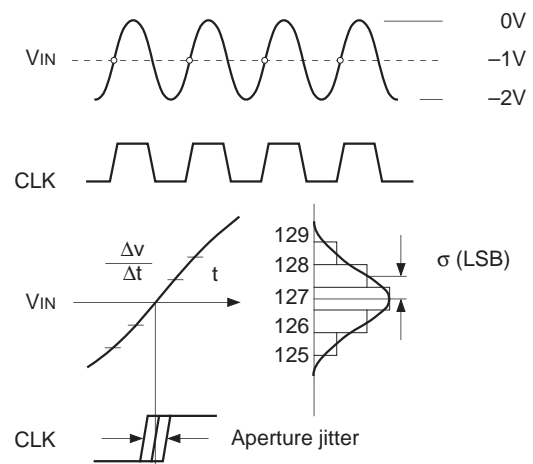


Sampling delay test circuit

Aperture jitter test circuit



Aperture jitter test method



Aperture jitter is defined as follows:

$$T_{aj} = \sigma / \frac{\Delta v}{\Delta t} = \sigma / \left(\frac{256}{2} \times 2\pi f \right),$$

Where σ (unit : LSB) is the deviation of the output codes when the input frequency is exactly the same as the clock and is sampled at the largest slew rate point.

8-bit, 125MSPS ADC Evaluation board

Description

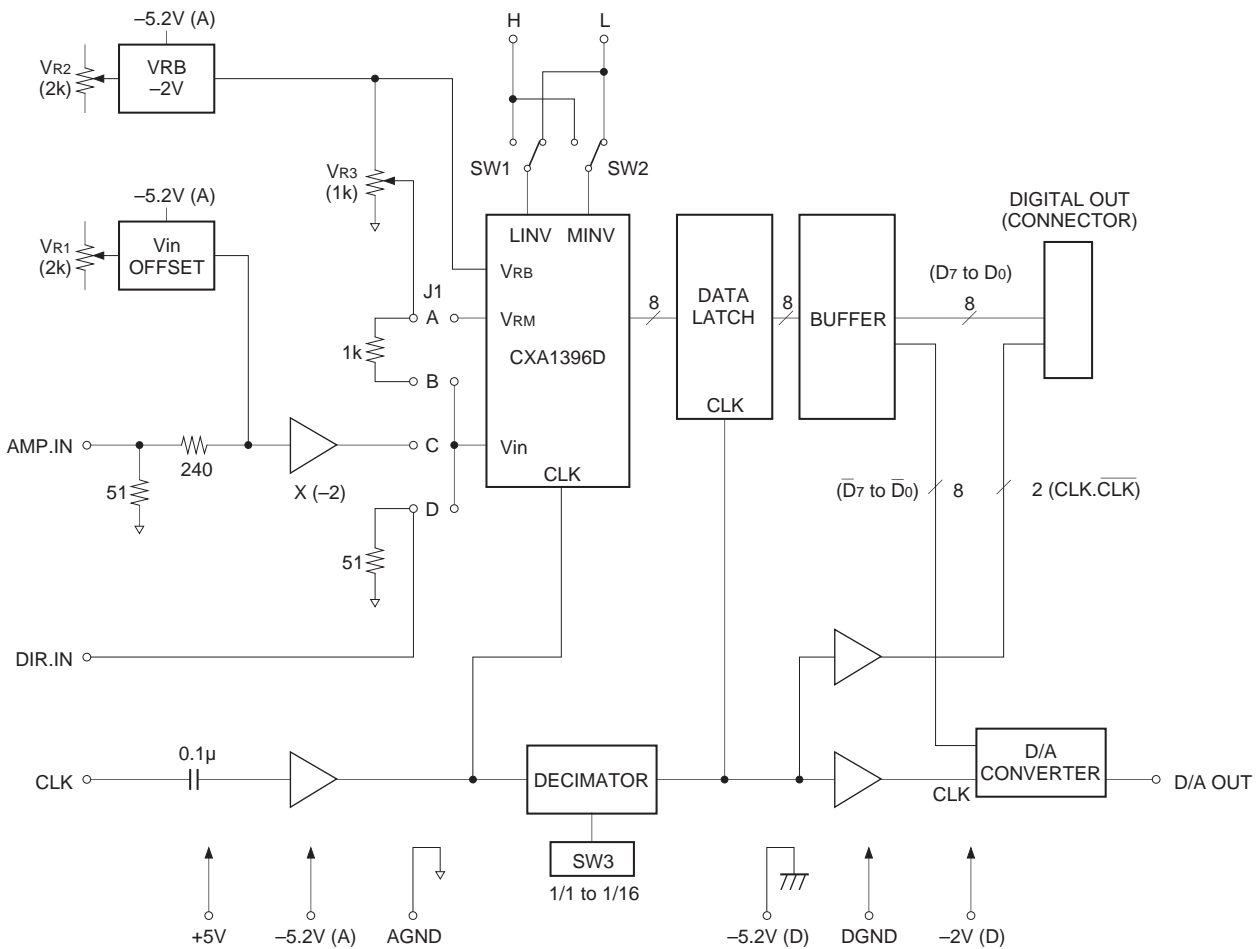
The CXA1396D EVALUATION BOARD WITH DAC is a tool for customers to evaluate the performance of the CXA1396D (8-bit, 125MSPS, high-speed A/D converter). In addition to indispensable features such as the reference voltage generator, this tool equips two sets of analog inputs (the direct input and the buffer amplifier input), the input voltage offset generator, the clock decimator, the output data latches, the 10-bit high-speed DAC, and the 20-pin cable connector for digital outputs.

This evaluation board provides full performance of the CXA1396D and it is designed to facilitate evaluation.

Features

- Resolution: 8bits
- Maximum conversion rate: 125MSPS
- Supply voltage: +5.0V, -5.2V, -2.0V
- Two analog inputs (Direct input, buffer amplifier input)
- Clock level converter: Sine wave to ECL level signal
- Reference voltage adjustment circuit for the A/D converter
- Built-in clock frequency decimation circuit: (1/1 to 1/16)

Fig. 1. Block Diagram



Supply Current

| Item | Min. | Typ. | Max. | Unit |
|-------|------|------|------|------|
| -5.2V | | 0.85 | 1.0 | A |
| +5.0V | | 15 | 30 | mA |
| -2.0V | | 0.45 | 0.6 | A |

(Note: Supply current -2.0V is the value when Rn10, Rn11 and Rn12 are not mounted.)

Analog Input (DIR. IN, AMP. IN)

| Item | Min. | Typ. | Max. | Unit |
|-------------------------|------|------|------|------|
| Input voltage (DIR. IN) | -2.0 | | 0 | V |
| (AMP. IN) *1 | -0.5 | | +0.5 | V |
| Input impedance | | 50 | | Ω |

(*1: Adjustable by VR1)

Clock Input (CLK)

| Item | Min. | Typ. | Max. | Unit |
|---------------------------------|------|------|------|------|
| Input voltage (Peak to Peak) | | 1.0 | | Vp-p |
| Input impedance | | 50 | | Ω |

Digital Output (D0 to D7)

ECL 10KH level

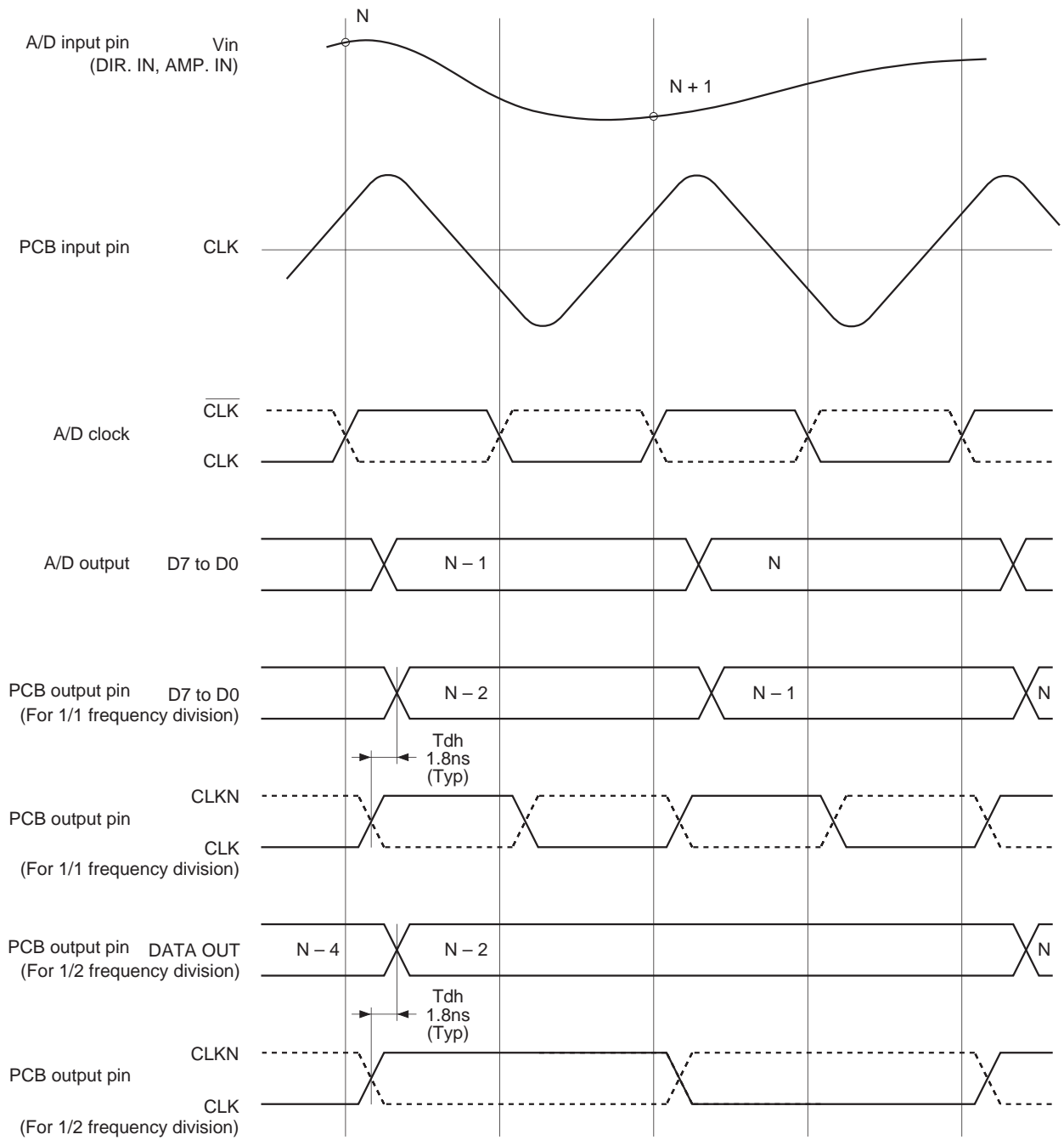
Clock Output

ECL 10KH level, complementary output

Output Code Table

| | MINV LINV | 0 0 | 0 1 | 1 0 | 1 1 |
|-----------------|--------------|-----------------|-----------------|-----------------|-----------------|
| V _{IN} | 0V | 1 1 1 1 1 | 1 0 0 0 0 | 0 1 1 1 1 | 0 0 0 0 0 |
| | : | 1 1 1 1 0 | 1 0 0 0 1 | 0 1 1 1 0 | 0 0 0 0 1 |
| | : | : | : | : | : |
| | : | : | : | : | : |
| | : | 1 0 0 0 0 | 1 1 1 1 1 | 0 0 0 0 0 | 0 1 1 1 1 |
| | : | 0 1 1 1 1 | 0 0 0 0 0 | 1 1 1 1 1 | 1 0 0 0 0 |
| | : | : | : | : | : |
| | : | : | : | : | : |
| | : | 0 0 0 0 1 | 0 1 1 1 0 | 1 0 0 0 1 | 1 1 1 1 0 |
| | -2V | 0 0 0 0 0 | 0 1 1 1 1 | 1 0 0 0 0 | 1 1 1 1 1 |

Fig. 2. Timing Chart



Adjustment Methods and Notes on Operation

- 1) Vin Offset (VR1)
The volume to adjust the signal range (0V center assumed) with the A/D converter input range when a waveform is input through AMP. IN.
- 2) A/D Full Scale (VR2)
The volume to adjust A/D converter VRB voltage.
- 3) Linearity (VR3)
The volume to adjust VRM (linearity) voltage. When DIR. IN input selected and it is supplied through the capacitor, VR3 can be used to adjust the input offset voltage.
- 4) D/A Full Scale (VR4)
The volume to adjust D/A output full scale (-1V).
- 5) J1 (Input selection)
A: Shorts to adjust VRM voltage.
B: Shorts to supply DC voltage to Vin.
C: Shorts to select AMP.IN input.
D: Shorts to select DIR.IN input.

[Jumper Position at Shipment]

| J1 | J1 | J1 |
|-----------------------|-------------------------|--|
| A○○ Input through the | A⊖⊖ Input through the | A○○ Input through the capacitor |
| B○○ buffer amplifier | B○○ buffer amplifier | B⊖⊖ (When the offset is adjusted using the |
| C⊖⊖ | C⊖⊖ (When the linearity | C○○ DIR IN. at the evaluation board) |
| D○○ | D○○ is adjusted) | D○○ 0.1μF |

- 6) SW1
The switch for LINV High/Low.
- 7) SW2
The switch for MINV High/Low.
- 8) SW3 (Decimation)
The switch to select clock frequency decimation.
Switch position: decimation ratio
0: 1/1
1: 1/2
2: 1/4
3: 1/8
4: 1/16
- 9) SW4 (D/A INV)
The switch for D/A converter output inversion.

- 10) Rn10, Rn11 and Rn12 are not mounted at shipment. They are not required during evaluation.
- 11) Waveform probe pins P5 and P8 through P28 are devised to facilitate GND connection in order to reduce the distortion. As shown in the diagram below, the distance between the probe point and the GND is 300 mil, and there is $\phi 1.2\text{mm}$ through hole at each. The signal and GND locations are suit for a Tektronix GND tip (part number 013-1185-00).

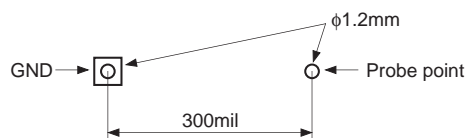
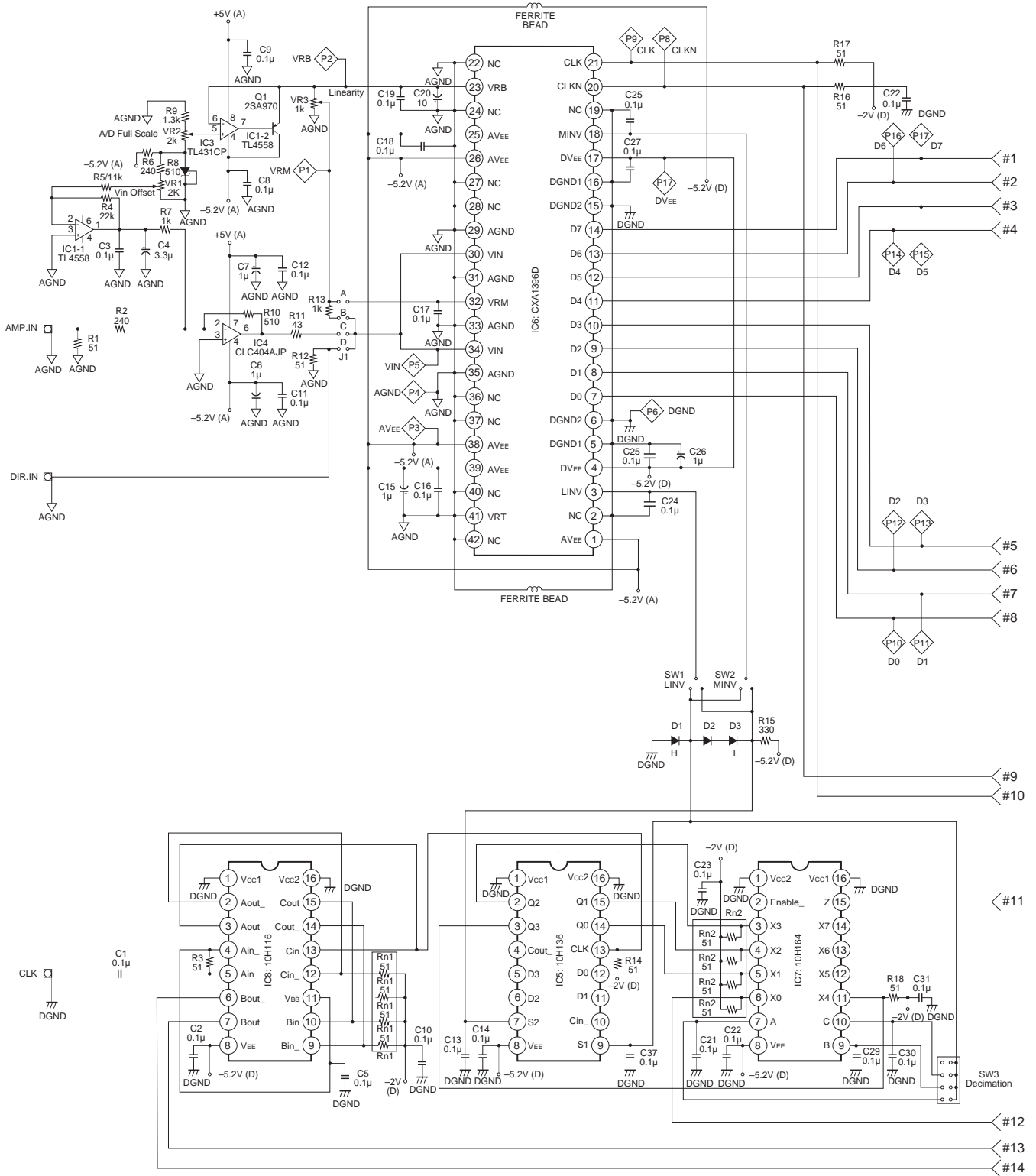
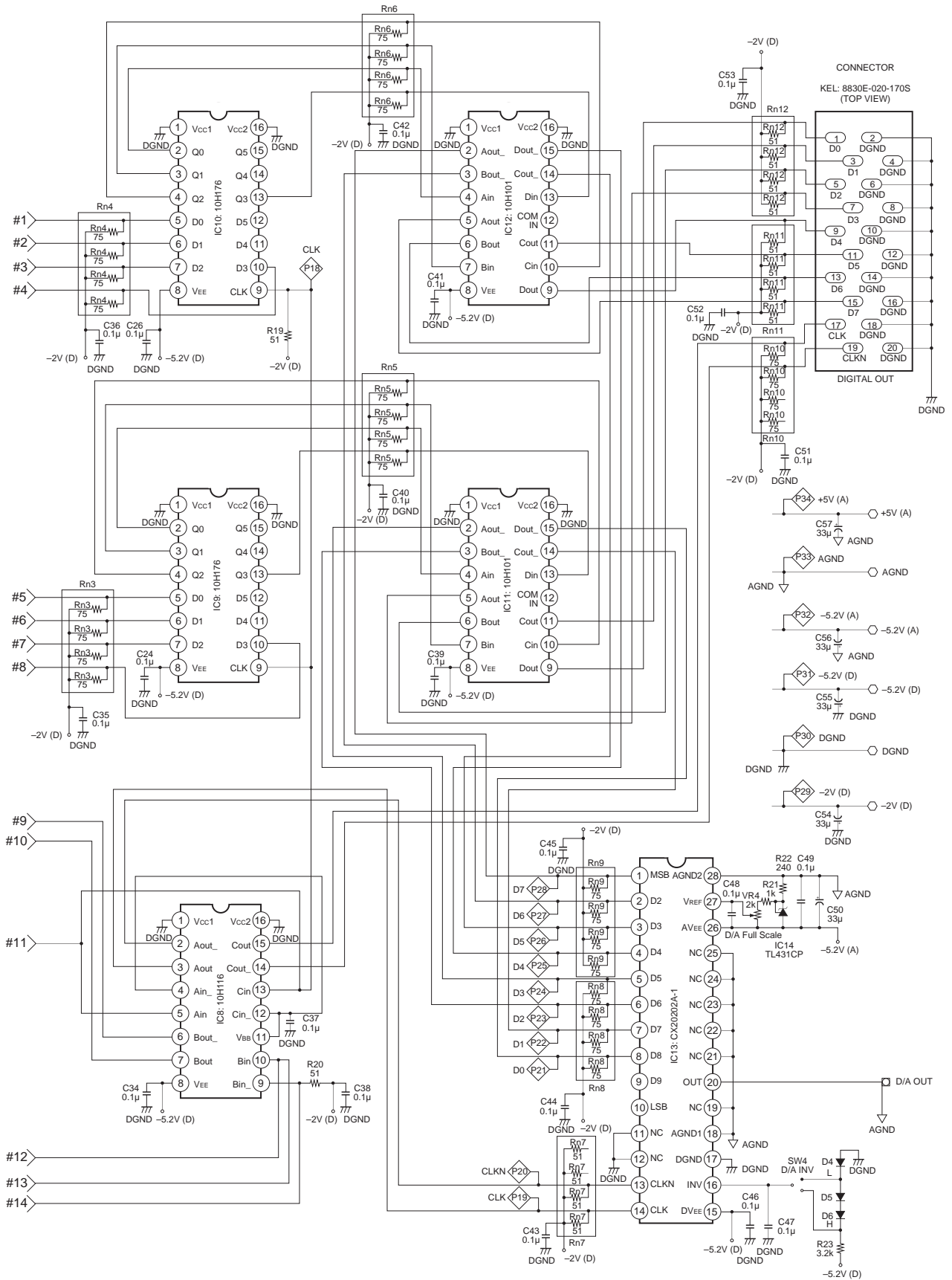


Fig. 3

- 12) D/A converter (IC13) input data (waveform probe pins P21 through P28) are the complementary signals of the decimated A/D converter outputs. Those are inverted again in the D/A converter so that the direction of reproduced waveform can agree with the A/D input signal converter.
- 13) The part number of the digital output connector is KEL 8830E-020-170S. A corresponding connector and cable assembly is JUNKOSMA KBO020MCG50BI.

PCB Circuit Schematic





Characteristic Graph

Fig. 5. Gain vs. Input frequency

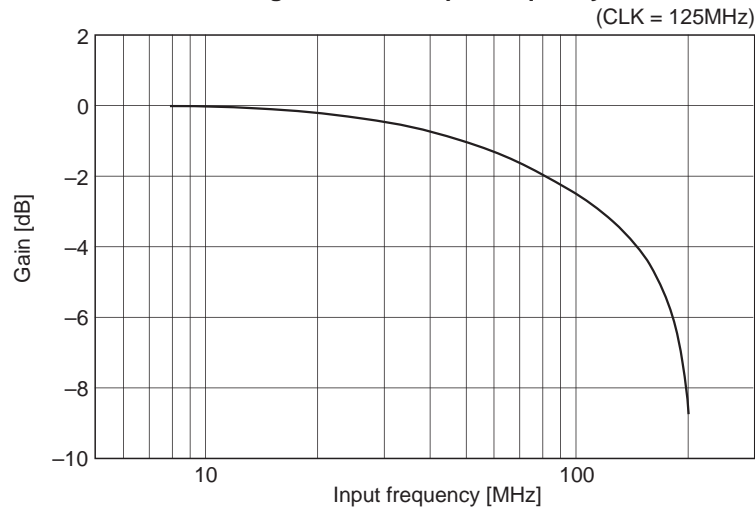


Fig. 6. SNR vs. Input frequency

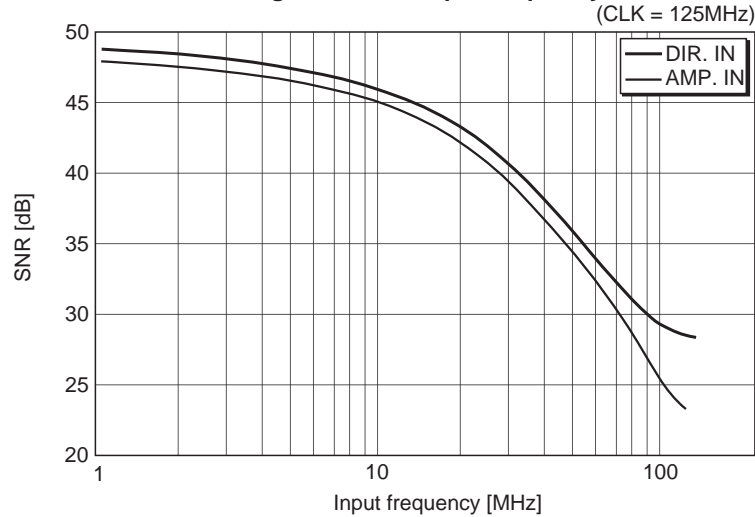
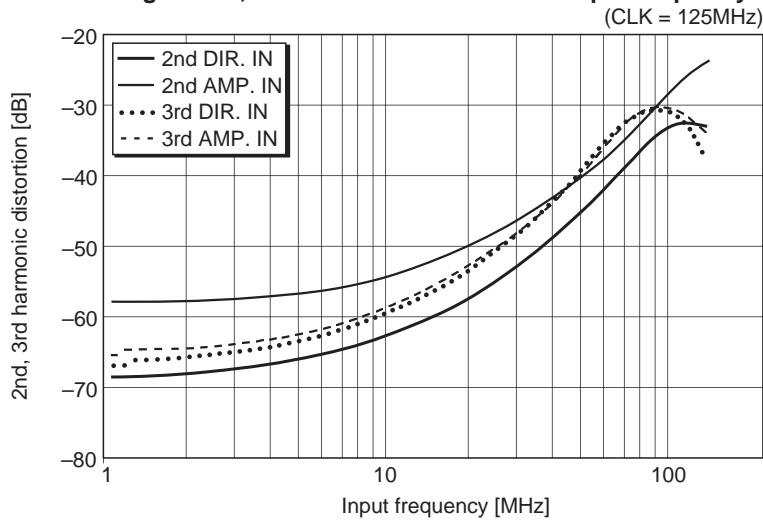


Fig. 7. 2nd, 3rd harmonic distortion vs. Input frequency

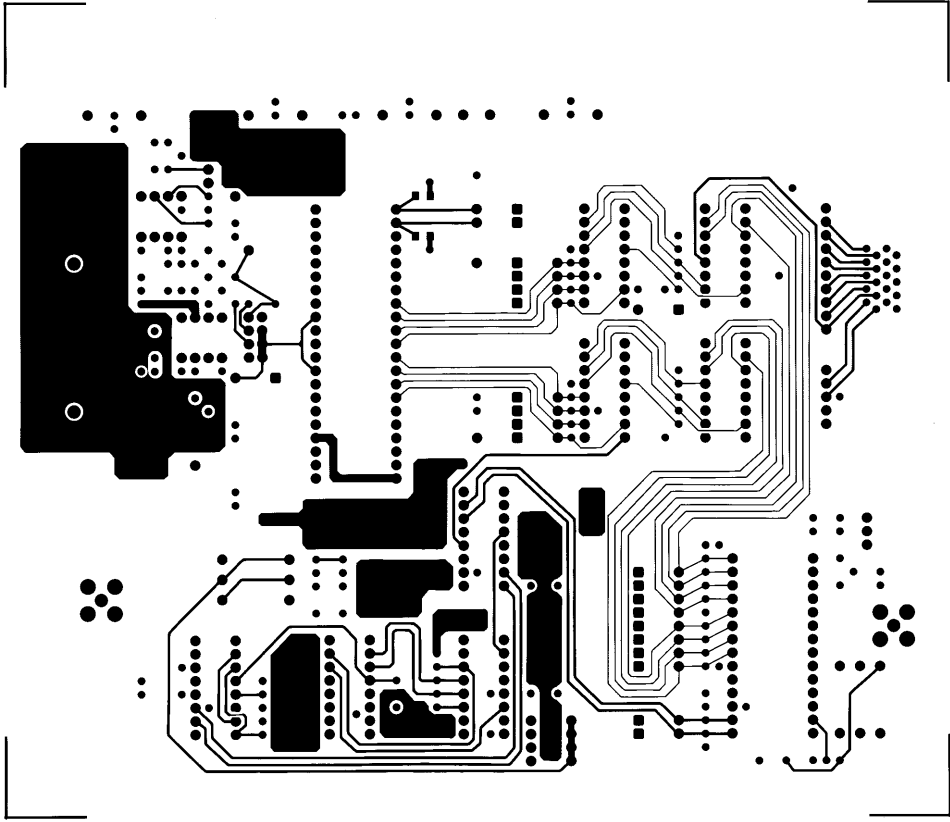


Measurement data

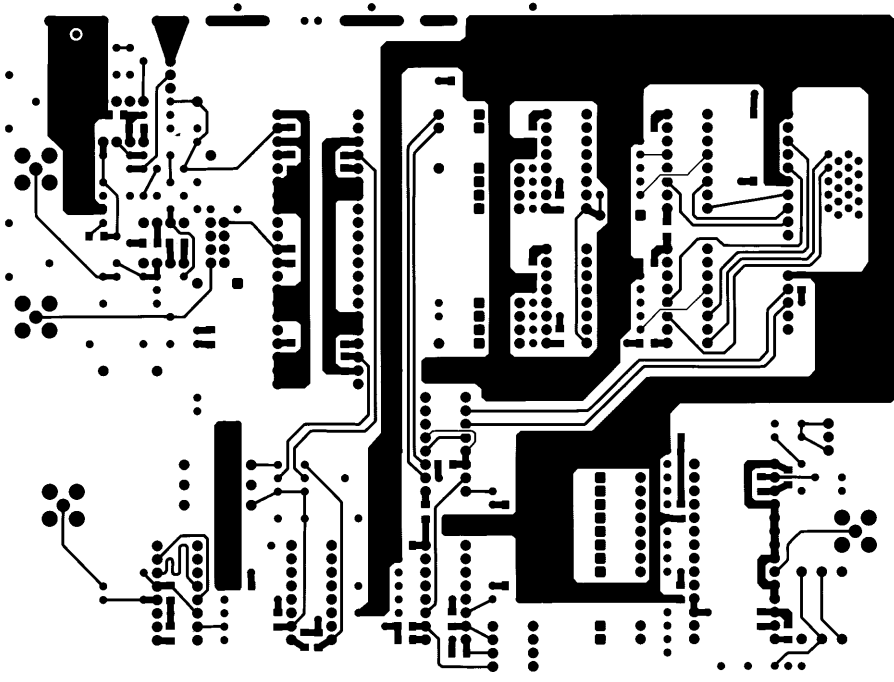
Figs. 5, 6 and 7 show the characteristic graphs.

DIR. IN is the characteristic where the signal is directly input to the ADC and AMP. IN is the characteristic where the signal is input to ADC through the amplifier.

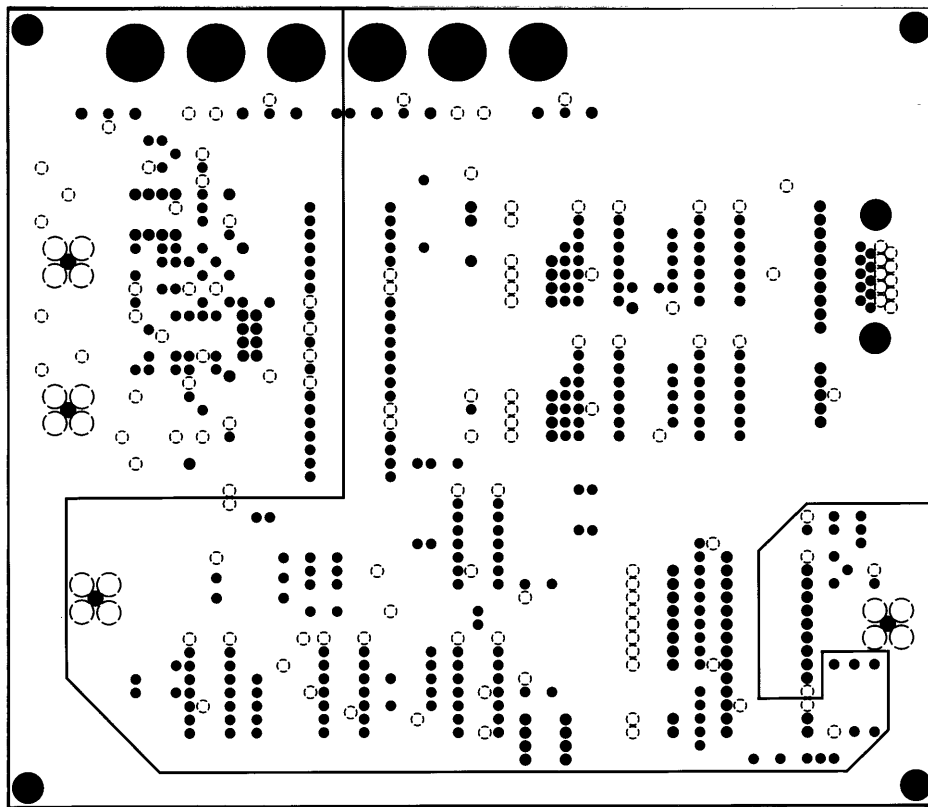
Printed Pattern



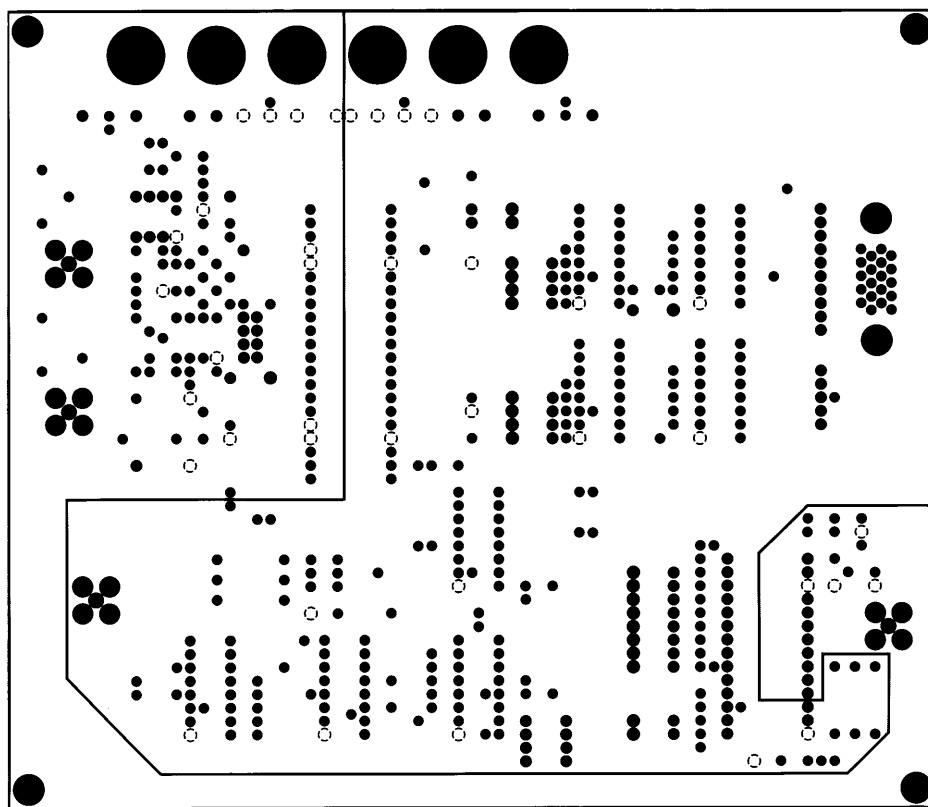
1st layer Component plane (Top View)



4th layer Solder plane (Top View)



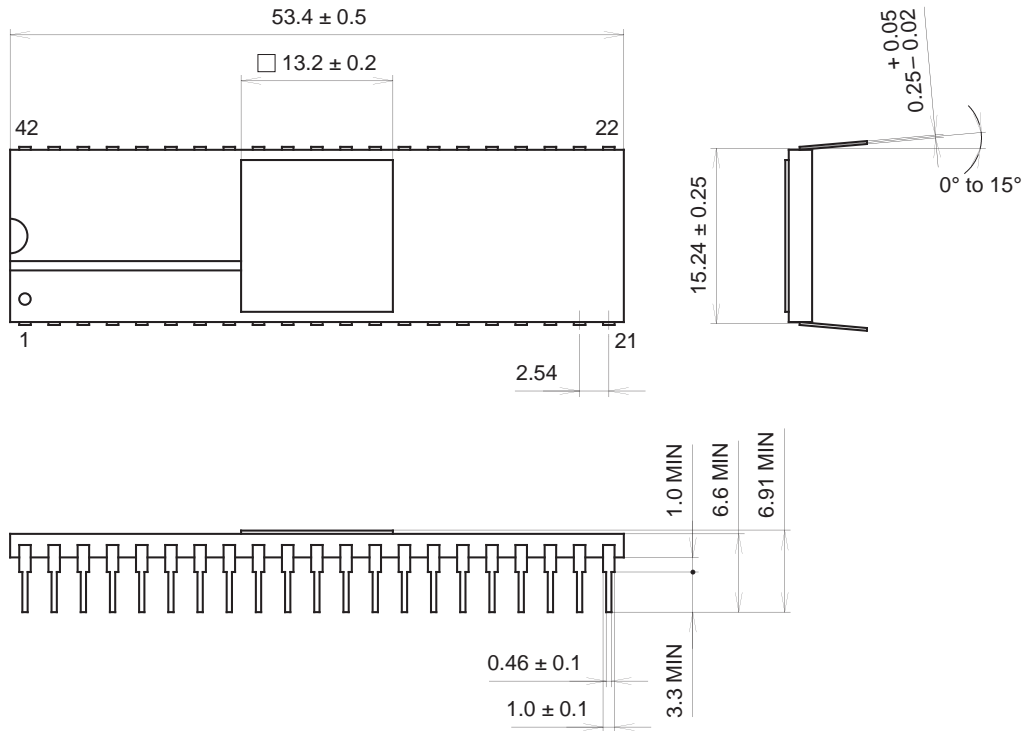
2nd layer GND plane (Top View)



3rd layer Power supply plane (Top View)

Package Outline Unit: mm

42PIN DIP (CERAMIC) 600mil



PACKAGE STRUCTURE

| | |
|------------|------------------|
| SONY CODE | DIP-42C-01 |
| EIAJ CODE | *DIP042-C-0600-A |
| JEDEC CODE | _____ |

| | |
|------------------|--------------|
| PACKAGE MATERIAL | CERAMIC |
| LEAD TREATMENT | GOLD PLATING |
| LEAD MATERIAL | 42 ALLOY |
| PACKAGE WEIGHT | 6.7g |