# FAIRCHILD
## SEMICONDUCTOR®

# KM4110/KM4120
## 0.5mA, Low Cost, +2.7V & +5V, 75MHz Rail-to-Rail Amplifiers

## Features
- 505µA supply current
- 75MHz bandwidth
- Power down to $I_S$ = 33µA (KM4120)
- Fully specified at +2.7V and +5V supplies
- Output voltage range: 0.07V to 4.86V; $V_S$ = +5
- Input voltage range: -0.3V to +3.8V; $V_S$ = +5
- 50V/µs slew rate
- ±15mA linear output current
- ±30mA output short circuit current
- 12nV/√Hz input voltage noise
- Directly replaces AD8031 in single supply applications
- Small package options (SOT23-5 and SOT23-6)

## Applications
- Portable/battery-powered applications
- A/D buffer
- Active filters
- Signal conditioning
- Portable test instruments

## General Description
The KM4110 (single) and KM4120 (single with disable) are low cost, voltage feedback amplifiers. These amplifiers are designed to operate on +2.7V, +5V, or ±2.5V supplies. The input voltage range extends 300mV below the negative rail and 1.2V below the positive rail.
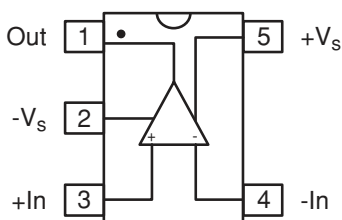
The KM4110 offers superior dynamic performance with a 75MHz small signal bandwidth and 50V/µs slew rate. The combination of low power, high output current drive, and rail-to-rail performance make the KM4110 well suited for battery-powered communication/ computing systems.

The combination of low cost and high performance make the KM4110 suitable for high volume applications in both consumer and industrial applications such as wireless phones, scanners, and color copiers.
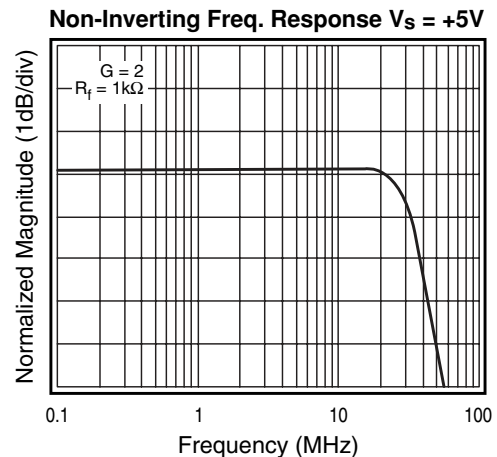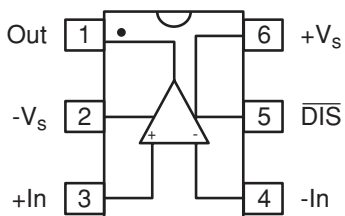
The KM4210 dual op amp is also available.

## KM4110/KM4120 Packages

### SOT23-5 (KM4110)

| | | | |
|---|---|---|---|
| Out | 1 | 5 | +$V_S$ |
| -$V_S$ | 2 | | |
| +In | 3 | 4 | -In |

### SOT23-6 (KM4120)

| | | | |
|---|---|---|---|
| Out | 1 | 6 | +$V_S$ |
| -$V_S$ | 2 | 5 | $\overline{DIS}$ |
| +In | 3 | 4 | -In |

**Non-Inverting Freq. Response $V_S$ = +5V**



G = 2
$R_f$ = 1kΩ

Normalized Magnitude (1dB/div)

Frequency (MHz)

## KM4110/KM4120 Electrical Characteristics ($V_s$ = +2.7V, G = 2, $R_L$ = 1kΩ to $V_s$/2, $R_f$ = 1kΩ; unless noted)

| Parameters | Conditions | TYP | Min & Max | UNITS | NOTES |
|---|---|---|---|---|---|
| Case Temperature | | +25°C | +25°C | | |
| **Frequency Domain Response** | | | | | |
| -3dB bandwidth | G = +1, $V_O$ = 0.05$V_{pp}$ | 65 | | MHz | 1 |
| | G = +2, $V_O$ < 0.2$V_{pp}$ | 30 | | MHz | |
| full power bandwidth | G = +2, $V_O$ = 2$V_{pp}$ | 12 | | MHz | |
| gain bandwidth product | | 28 | | MHz | |
| **Time Domain Response** | | | | | |
| rise and fall time | 0.2V step | 7.5 | | ns | |
| settling time to 0.1% | 1V step | 60 | | ns | |
| overshoot | 1V step, | 10 | | % | |
| slew rate | 2V step, G = -1 | 40 | | V/μs | |
| **Distortion and Noise Response** | | | | | |
| 2nd harmonic distortion | 1$V_{pp}$, 1MHz | 67 | | dBc | |
| 3rd harmonic distortion | 1$V_{pp}$, 1MHz | 72 | | dBc | |
| THD | 1$V_{pp}$, 1MHz | 65 | | dB | |
| input voltage noise | >10kHz | 12 | | nV/√Hz | |
| **DC Performance** | | | | | |
| input offset voltage | | 0 | ±5 | mV | 2 |
|   average drift | | 10 | | μV/°C | |
| input bias current | | 1.2 | ±3.5 | μA | 2 |
|   average drift | | 3.5 | | nA/°C | |
| input offset current | | 30 | 350 | nA | 2 |
| power supply rejection ratio | DC | 66 | 60 | dB | 2 |
| open loop gain | | 98 | 65 | dB | 2 |
| quiescent current | | 470 | 600 | μA | 2 |
| **Disable Characteristics** | | | | | |
| turn on time | | 0.54 | | μs | |
| turn off time | | 4.3 | | μs | |
| off isolation | 5MHz, $R_L$ = 100Ω | 58 | | dB | |
| quiescent current | | 15 | | μA | |
| **Input Characteristics** | | | | | |
| input resistance | | 9 | | MΩ | |
| input capacitance | | 1.5 | | pF | |
| input common mode voltage range | | -0.3 to 1.5 | | V | |
| common mode rejection ratio | DC, $V_{cm}$ = 0V to $V_s$ - 1.5 | 98 | 78 | dB | 2 |
| **Output Characteristics** | | | | | |
| output voltage swing | $R_L$ = 10kΩ to $V_s$/2 | 0.05 to 2.6 | | V | |
| | $R_L$ = 1kΩ to $V_s$/2 | 0.09 to 2.53 | 0.2 to 2.35 | V | 2 |
| linear output current | | ±15 | | mA | |
| short circuit output current | | ±25 | | mA | |
| power supply operating range | | 2.7 | 2.5 to 5.5 | V | |

Min/max ratings are based on product characterization and simulation.  Individual parameters are tested as noted.  Outgoing quality levels are determined from tested parameters.

**NOTES:**

1) For G = +1,  $R_f$ = 0.

2) 100% tested at +25°C.

## Absolute Maximum Ratings

| | |
|---|---|
| supply voltage | 0 to +6V |
| maximum junction temperature | +175°C |
| storage temperature range | -65°C to +150°C |
| lead temperature (10 sec) | +260°C |
| operating temperature range (recommended) | -40°C to +85°C |
| input voltage range | +$V_s$ +0.5V; -$V_s$ -0.5V |
| internal power dissipation | see power derating curves |

## Package Thermal Resistance

| Package | $\theta_{JA}$ |
|---|---|
| 5 lead SOT23 | 256°C/W |
| 6 lead SOT23 | 230°C/W |

## KM4110/KM4120 Electrical Characteristics ($V_s$ = +5V, G = 2, $R_L$ = 1k$\Omega$ to $V_s$/2, $R_f$ = 1k$\Omega$; unless noted)
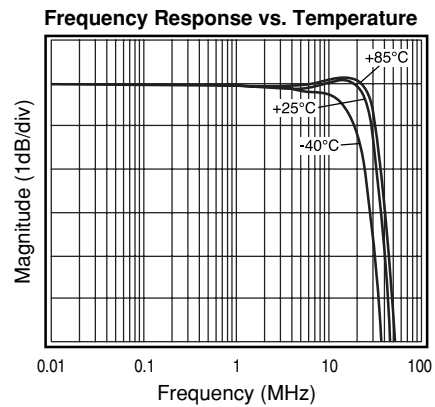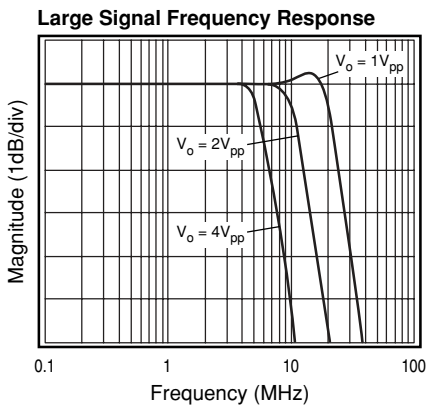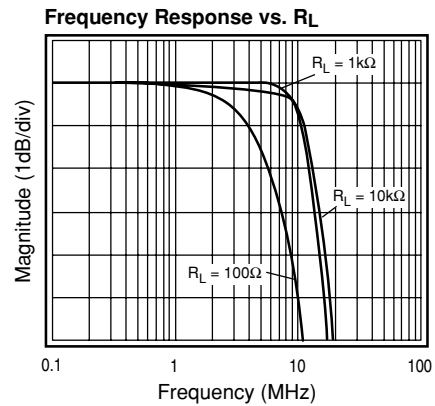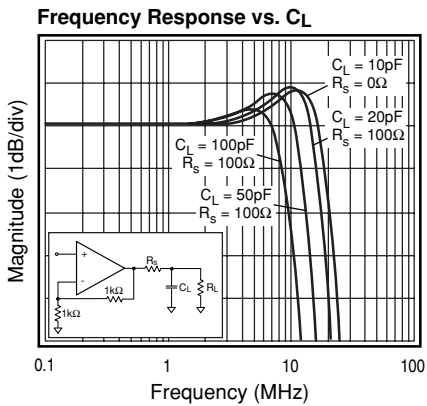
| PARAMETERS | CONDITIONS | TYP | MIN & MAX | UNITS | NOTES |
|---|---|---|---|---|---|
| Case Temperature | | +25°C | +25°C | | |
| **Frequency Domain Response** | | | | | |
| -3dB bandwidth | G = +1, $V_O$ = 0.05$V_{pp}$ | 75 | | MHz | 1 |
| | G = +2, $V_O$ < 0.2$V_{pp}$ | 35 | | MHz | |
| full power bandwidth | G = +2, $V_O$ = 2$V_{pp}$ | 15 | | MHz | |
| gain bandwidth product | | 33 | | MHz | |
| **Time Domain Response** | | | | | |
| rise and fall time | 0.2V step | 6 | | ns | |
| settling time to 0.1% | 2V step | 60 | | ns | |
| overshoot | 2V step, | 12 | | % | |
| slew rate | 2V step, G = -1 | 50 | | V/$\mu$s | |
| **Distortion and Noise Response** | | | | | |
| 2nd harmonic distortion | 2$V_{pp}$, 1MHz | 64 | | dBc | |
| 3rd harmonic distortion | 2$V_{pp}$, 1MHz | 62 | | dBc | |
| THD | 2$V_{pp}$, 1MHz | 60 | | dB | |
| input voltage noise | >10kHz | 12 | | nV/$\sqrt{Hz}$ | |
| **DC Performance** | | | | | |
| input offset voltage | | -1 | ±5 | mV | 2 |
|   average drift | | 10 | | $\mu$V/°C | |
| input bias current | | 1.2 | ±3.5 | $\mu$A | 2 |
|   average drift | | 3.5 | | nA/°C | |
| input offset current | | 30 | 350 | nA | 2 |
| power supply rejection ratio | DC | 65 | 60 | dB | 2 |
| open loop gain | | 80 | 65 | dB | 2 |
| quiescent current | | 505 | 620 | $\mu$A | 2 |
| **Disable Characteristics** | | | | | |
| turn on time | | 0.33 | | $\mu$s | |
| turn off time | | 5.5 | | $\mu$s | |
| off isolation | 5MHz, $R_L$ = 100$\Omega$ | 58 | | dB | |
| quiescent current | | 33 | | $\mu$A | |
| **Input Characteristics** | | | | | |
| input resistance | | 9 | | M$\Omega$ | |
| input capacitance | | 1.5 | | pF | |
| input common mode voltage range | | -0.3 to 3.8 | | V | |
| common mode rejection ratio | DC, $V_{cm}$ = 0V to $V_s$ - 1.5 | 92 | 78 | dB | 2 |
| **Output Characteristics** | | | | | |
| output voltage swing | $R_L$ = 10k$\Omega$ to $V_s$/2 | 0.08 to 4.84 | | V | |
| | $R_L$ = 1k$\Omega$ to $V_s$/2 | 0.13 to 4.73 | 0.2 to 4.65 | V | 2 |
| linear output current | | ±15 | | mA | |
| short circuit output current | | ±30 | | mA | |
| power supply operating range | | 5 | 2.5 to 5.5 | V | |

Min/max ratings are based on product characterization and simulation.  Individual parameters are tested as noted.  Outgoing quality levels are determined from tested parameters.
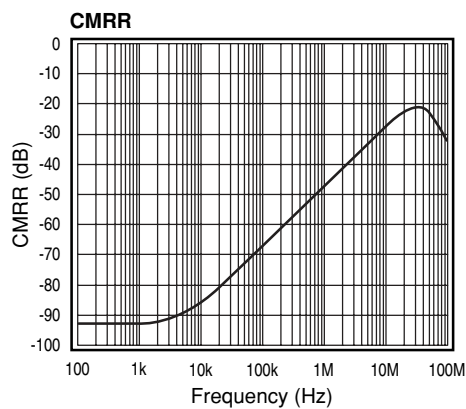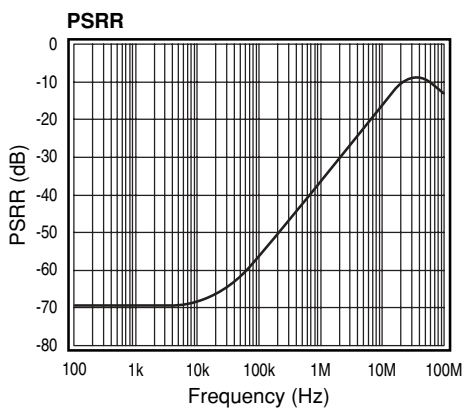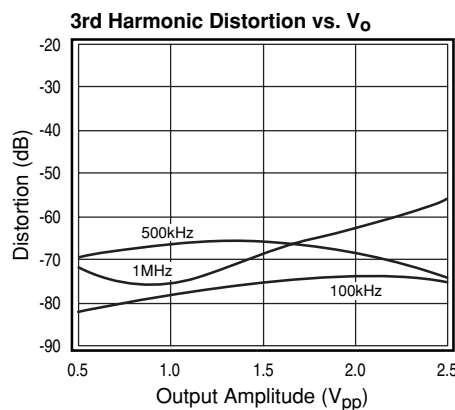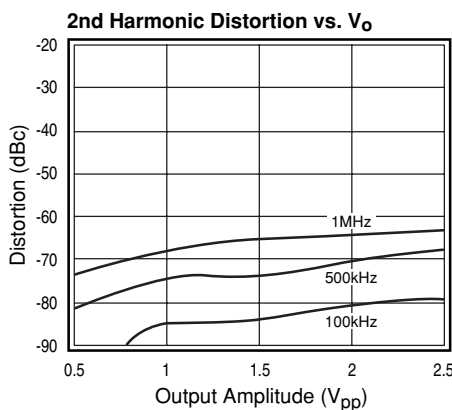
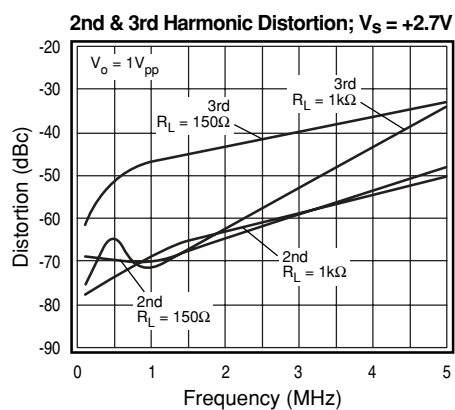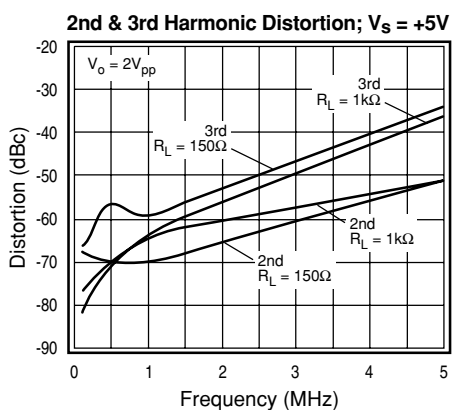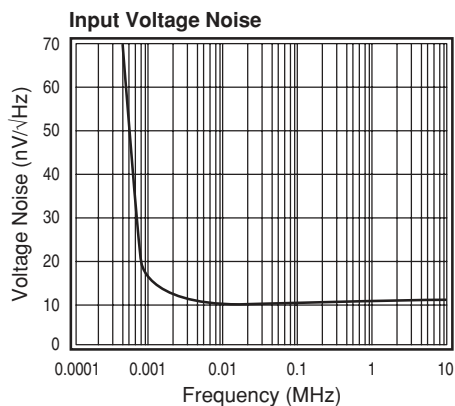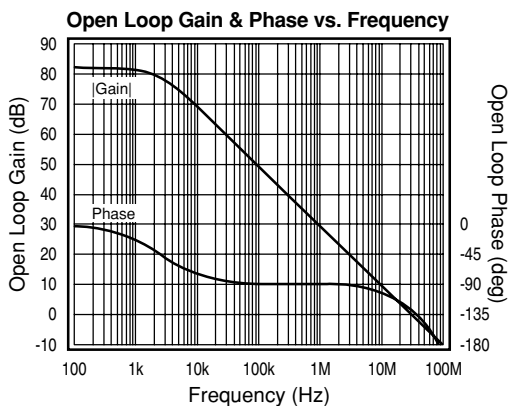**NOTES:**

1) For G = +1,  $R_f$ = 0.

2) 100% tested at +25°C.

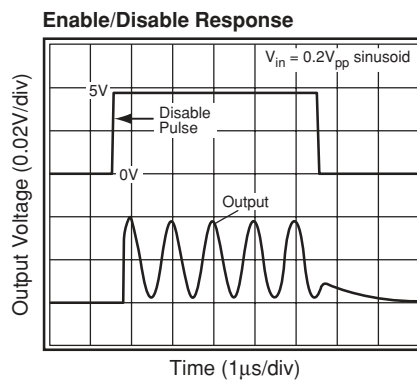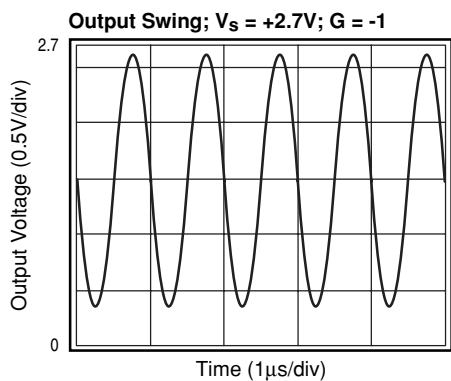## KM4110/KM4120 Performance Characteristics (V$_S$ = +5V, G = 2, R$_L$ = 1kΩ to V$_S$/2, R$_f$ = 1kΩ; unless noted)

**Non-Inverting Freq. Response V$_S$ = +5V**

G = 1
R$_f$ = 0

G = 2
R$_f$ = 1kΩ

G = 10
R$_f$ = 1kΩ

G = 5
R$_f$ = 1kΩ

Normalized Magnitude (1dB/div)

Frequency (MHz)

**Inverting Freq. Response V$_S$ = +5V**

G = -2
R$_f$ = 1kΩ

G = -10
R$_f$ = 1kΩ

G = -5
R$_f$ = 1kΩ

G = -1
R$_f$ = 1kΩ

Normalized Magnitude (1dB/div)

Frequency (MHz)

**Non-Inverting Freq. Response V$_S$ = +2.7V**

G = 1
R$_f$ = 0

G = 2
R$_f$ = 1kΩ

G = 10
R$_f$ = 2kΩ

G = 5
R$_f$ = 1kΩ

Normalized Magnitude (2dB/div)

Frequency (MHz)

**Inverting Freq. Response V$_S$ = +2.7V**

G = -1
R$_f$ = 1kΩ

G = -2
R$_f$ = 1kΩ

G = -10
R$_f$ = 1kΩ

G = -5
R$_f$ = 1kΩ

Normalized Magnitude (1dB/div)

Frequency (MHz)

**Frequency Response vs. C$_L$**

C$_L$ = 10pF
R$_S$ = 0Ω

C$_L$ = 20pF
R$_S$ = 100Ω

C$_L$ = 100pF
R$_S$ = 100Ω

C$_L$ = 50pF
R$_S$ = 100Ω

Magnitude (1dB/div)

Frequency (MHz)

**Frequency Response vs. R$_L$**

R$_L$ = 1kΩ

R$_L$ = 10kΩ

R$_L$ = 100Ω

Magnitude (1dB/div)

Frequency (MHz)

**Large Signal Frequency Response**

V$_o$ = 1V$_{pp}$

V$_o$ = 2V$_{pp}$

V$_o$ = 4V$_{pp}$

Magnitude (1dB/div)

Frequency (MHz)

**Frequency Response vs. Temperature**
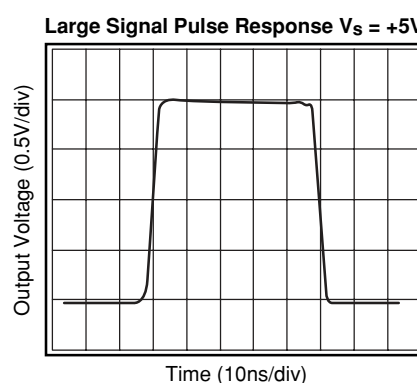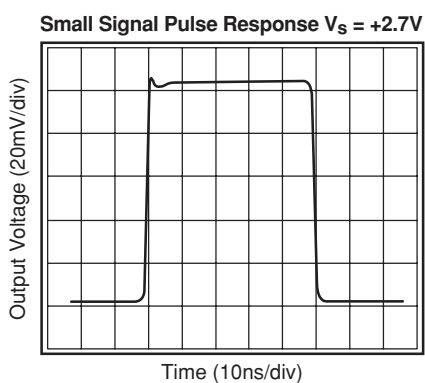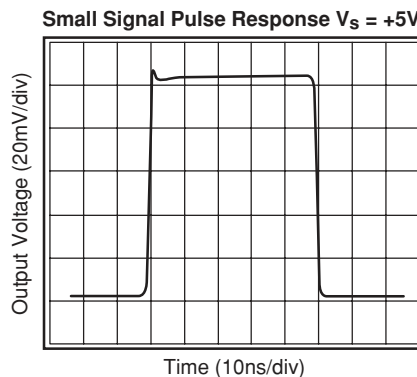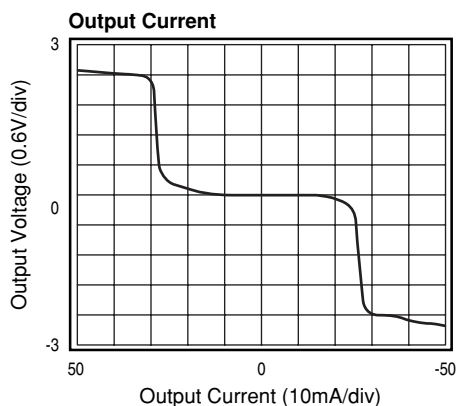
+85°C

+25°C

-40°C

Magnitude (1dB/div)

Frequency (MHz)

# KM4110/KM4120 Performance Characteristics ($V_S$ = +5V, G = 2, $R_L$ = 1k$\Omega$ to $V_S$/2, $R_f$ = 1k$\Omega$; unless noted)

**Open Loop Gain & Phase vs. Frequency**



**Input Voltage Noise**



**2nd & 3rd Harmonic Distortion; $V_S$ = +5V**



**2nd & 3rd Harmonic Distortion; $V_S$ = +2.7V**



**2nd Harmonic Distortion vs. $V_O$**



**3rd Harmonic Distortion vs. $V_O$**



**PSRR**



**CMRR**

# KM4110/KM4120 Performance Characteristics ($V_s$ = +5V, G = 2, $R_L$ = 1kΩ to $V_s$/2, $R_f$ = 1kΩ; unless noted)

**Output Current**

Output Voltage (0.6V/div)

Output Current (10mA/div)

**Small Signal Pulse Response $V_S$ = +5V**

Output Voltage (20mV/div)

Time (10ns/div)

**Small Signal Pulse Response $V_S$ = +2.7V**

Output Voltage (20mV/div)

Time (10ns/div)

**Large Signal Pulse Response $V_S$ = +5V**

Output Voltage (0.5V/div)

Time (10ns/div)

**Output Swing; $V_S$ = +2.7V; G = -1**

Output Voltage (0.5V/div)

Time (1µs/div)

**Enable/Disable Response**

Output Voltage (0.02V/div)

$V_{in}$ = 0.2$V_{pp}$ sinusoid

5V

Disable
Pulse

0V

Output

Time (1µs/div)

## General Description

The KM4110 is a single supply, general purpose, voltage-feedback amplifier fabricated on a complementary bipolar process. The KM4110 offers 75MHz unity gain bandwidth, 50V/$\mu$s slew rate, and only 505$\mu$A supply current. It features a rail-to-rail output stage and is unity gain stable.

The design utilizes a patent pending topology that provides increased slew rate performance. The common mode input range extends to 300mV below ground and to 1.2V below $V_S$. Exceeding these values will not cause phase reversal. However, if the input voltage exceeds the rails by more than 0.5V, the input ESD devices will begin to conduct. The output will stay at the rail during this overdrive condition.

The design uses a Darlington output stage. The output stage is short circuit protected and offers "soft" saturation protection that improves recovery time.

The typical circuit schematic is shown in Figure 1.
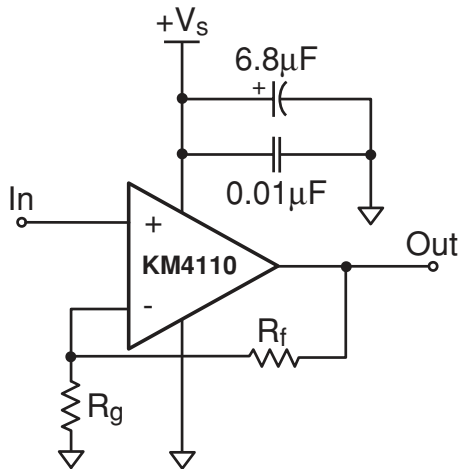


**Figure 1: Typical Configuration**

For optimum response at a gain of +2, a feedback resistor of 1k$\Omega$ is recommended. Figure 2 illustrates the KM4110 frequency response with both 1k$\Omega$ and 2k$\Omega$ feedback resistors.

## Enable/Disable Function (KM4120)

The KM4120 offers an active-low disable pin that can be used to lower its supply current. Leave the pin floating to enable the part. Pull the disable pin to the negative supply (which is ground in a single supply application) to disable the output. During the disable condition, the nominal supply current will drop to below 30$\mu$A and the output will be at high impedance with about 2pF capacitance.
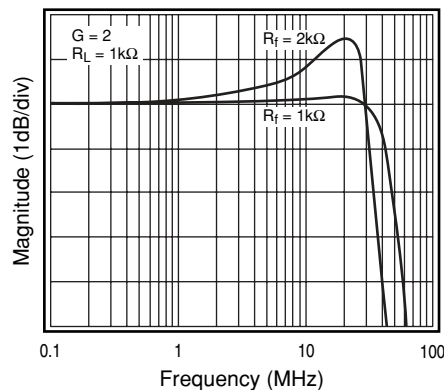


**Figure 2: Frequency Response vs. $R_f$**

## Power Dissipation

The maximum internal power dissipation allowed is directly related to the maximum junction temperature. If the maximum junction temperature exceeds 150°C, some reliability degradation will occur. If the maximum junction temperature exceeds 175°C for an extended time, device failure may occur.

The KM4110 is short circuit protected. However, this may not guarantee that the maximum junction temperature (+150°C) is not exceeded under all conditions. Follow the maximum power derating curves shown in Figure 3 to ensure proper operation.
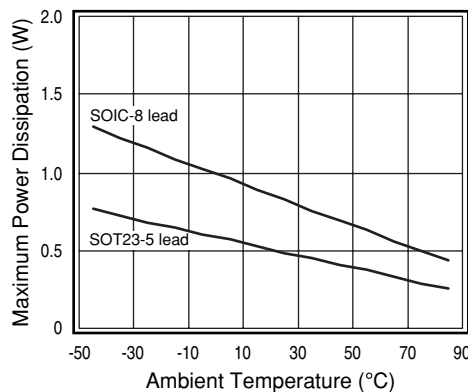


**Figure 3: Power Derating Curves**

## Overdrive Recovery

For an amplifier, an overdrive condition occurs when the output and/or input ranges are exceeded. The recovery time varies based on whether the input or output is overdriven and by how much the ranges are exceeded. The KM4110 will typically recover in less than 20ns from an overdrive condition. Figure 4 shows the KM4110 in an overdriven condition.
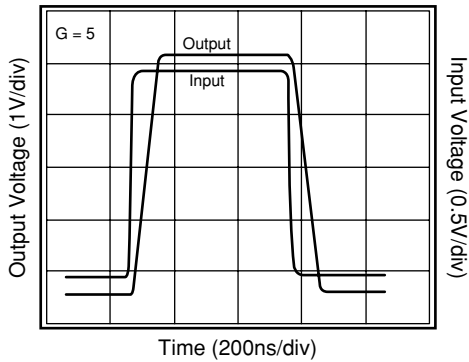
**Figure 4: Overdrive Recovery**

## Driving Capacitive Loads

The Frequency Response vs. $C_L$ plot on page 4, illustrates the response of the KM4110 and KM4120. A small series resistance ($R_s$) at the output of the amplifier, illustrated in Figure 5, will improve stability and settling performance. $R_s$ values in the Frequency Response vs. $C_L$ plot were chosen to achieve maximum bandwidth with less than 1dB of peaking. For maximum flatness, use a larger $R_s$.
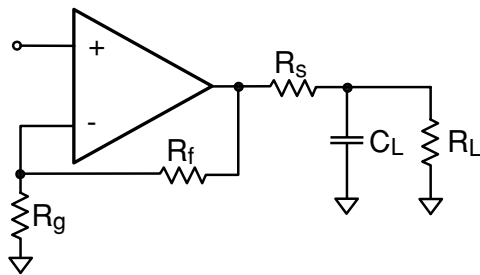


**Figure 5: Typical Topology for driving a capacitive load**

## Layout Considerations

General layout and supply bypassing play major roles in high frequency performance. Fairchild has evaluation boards to use as a guide for high frequency layout and to aid in device testing and characterization. Follow the steps below as a basis for high frequency layout:

■ Include 6.8μF and 0.01μF ceramic capacitors
■ Place the 6.8μF capacitor within 0.75 inches of the power pin
■ Place the 0.01μF capacitor within 0.1 inches of the power pin
■ Remove the ground plane under and around the part, especially near the input and output pins to reduce parasitic capacitance
■ Minimize all trace lengths to reduce series inductances

Refer to the evaluation board layouts shown in Figure 7 for more information.

## Evaluation Board Information

The following evaluation boards are available to aid in the testing and layout of this device:

| Eval Board | Description | Products |
|---|---|---|
| KEB002 | Single Channel, Dual Supply 5 & 6 lead SOT23 | KM4110IT5, KM4120IT6 |

Evaluation board schematics and layouts are shown in Figure 6 and Figure 7.

The KEB002 evaluation board is built for dual supply operation. Follow these steps to use the board in a single supply application:

1. Short -$V_s$ to ground
2. Use C3 and C4, if the -$V_s$ pin of the KM4110 or KM4120 is not directly connected to the ground plane.
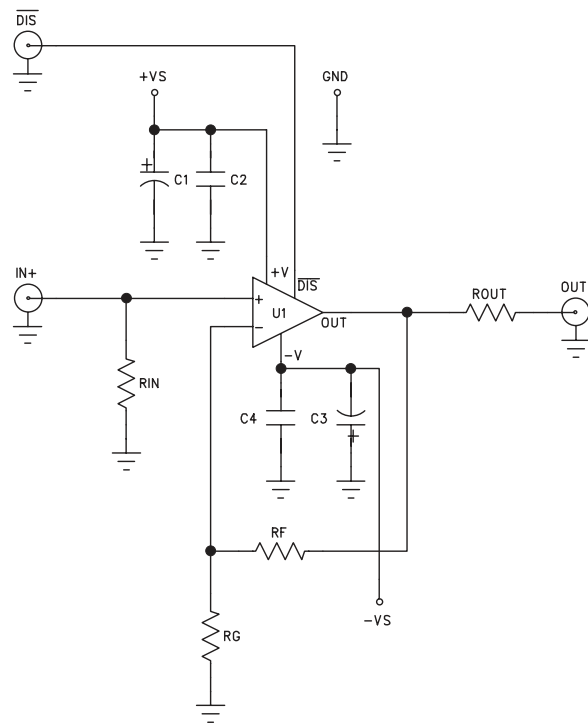


**Figure 6: Evaluation Board Schematic**
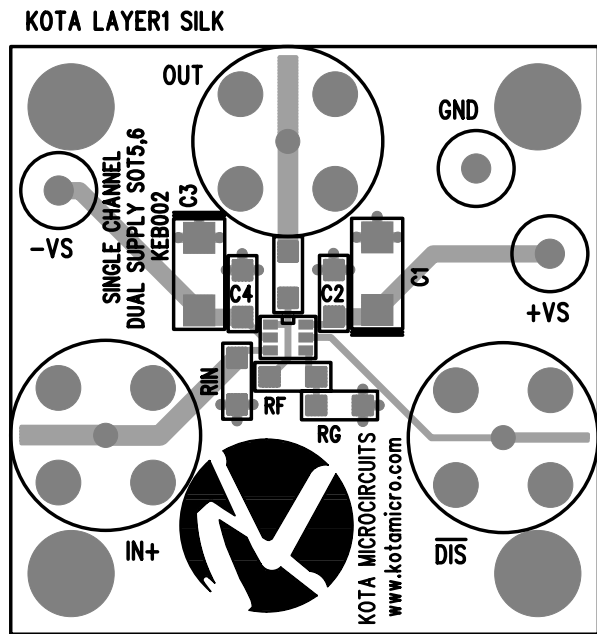
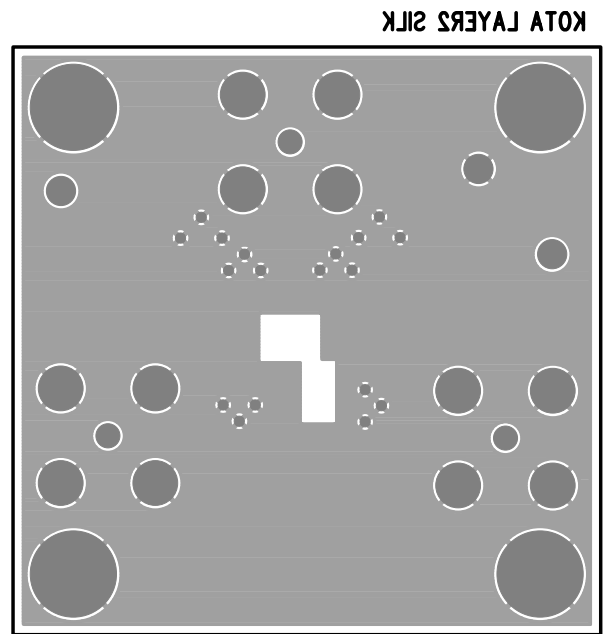## KM4110/KM4120 Evaluation Board Layout



**Figure 7a:  KEB002 (top side)**



**Figure 7b:  KEB002 (bottom side)**
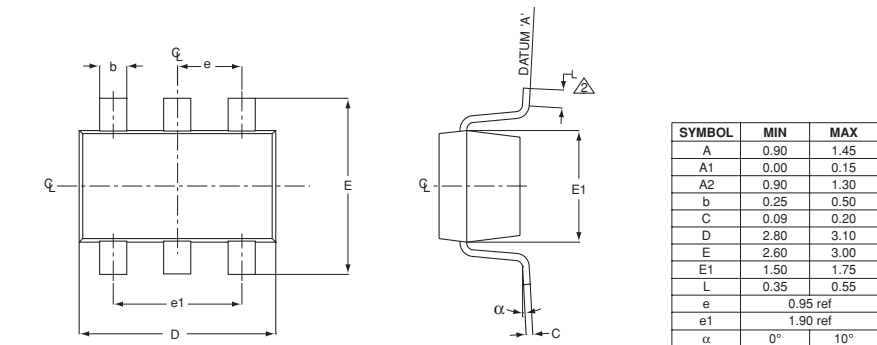
## KM4110/KM4120 Package Dimensions

**SOT23-5**
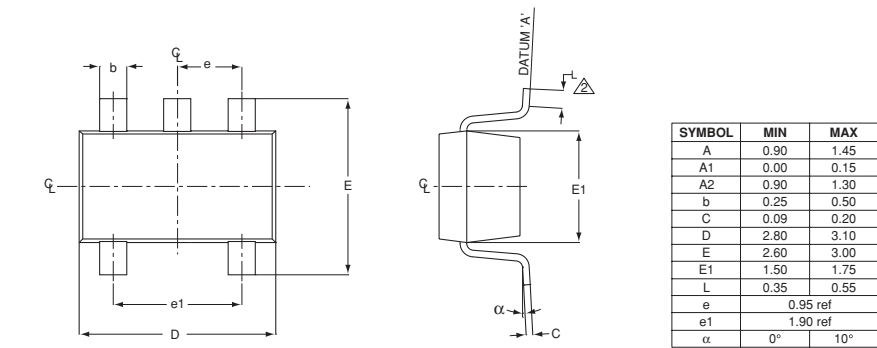


| SYMBOL | MIN | MAX |
|--------|-----|-----|
| A | 0.90 | 1.45 |
| A1 | 0.00 | 0.15 |
| A2 | 0.90 | 1.30 |
| b | 0.25 | 0.50 |
| C | 0.09 | 0.20 |
| D | 2.80 | 3.10 |
| E | 2.60 | 3.00 |
| E1 | 1.50 | 1.75 |
| L | 0.35 | 0.55 |
| e | 0.95 ref | |
| e1 | 1.90 ref | |
| α | 0° | 10° |

**NOTE:**
1. All dimensions are in millimeters.
2. Foot length measured reference to flat foot surface parallel to DATUM 'A' and lead surface.
3. Package outline exclusive of mold flash & metal burr.
4. Package outline inclusive of solder plating.
5. Comply to EIAJ SC74A.
6. Package ST 0003 REV A supercedes SOT-D-2005 REV C.

**SOT23-6**



| SYMBOL | MIN | MAX |
|--------|-----|-----|
| A | 0.90 | 1.45 |
| A1 | 0.00 | 0.15 |
| A2 | 0.90 | 1.30 |
| b | 0.25 | 0.50 |
| C | 0.09 | 0.20 |
| D | 2.80 | 3.10 |
| E | 2.60 | 3.00 |
| E1 | 1.50 | 1.75 |
| L | 0.35 | 0.55 |
| e | 0.95 ref | |
| e1 | 1.90 ref | |
| α | 0° | 10° |

**NOTE:**
1. All dimensions are in millimeters.
2. Foot length measured reference to flat foot surface parallel to DATUM 'A' and lead surface.
3. Package outline exclusive of mold flash & metal burr.
4. Package outline inclusive of solder plating.
5. Comply to EIAJ SC74A.
6. Package ST 0004 REV A supercedes SOT-D-2006 REV C.

## Ordering Information

| Model | Part Number | Package | Container | Pack Qty |
|-------|-------------|---------|-----------|----------|
| KM4110 | KM4110IT5 | SOT23-5 | Partial Rail | <3000 |
| KM4110 | KM4110IT5TR3 | SOT23-5 | Reel | 3000 |
| KM4120 | KM4120IT6 | SOT23-6 | Partial Rail | <3000 |
| KM4120 | KM4120IT6TR3 | SOT23-6 | Reel | 3000 |

Temperature range for all parts: -40°C to +85°C