LKP42xxST series
High-precision, low-power, low-dropout series reference source product manual

LKP42xx ST series high-precision, low-power, low-dropout series voltage reference

1 Features

- Low Dropout: 5mV
- High Output Current: ±10mA
- High Accuracy: 0.2% (Maximum)
- Low I_Q: 115μA (Maximum)
- Excellent Specified drift performance:
  30 ppm/°C (Maximum) from –40°C to +125°C
- Operating temperature: -40°C ~ +125°C
- Package: SOT23-3 (2.64 mm × 3.04 mm × 1.12 mm)

2 application

- Portable, Battery-Powered Equipment
- Data Acquisition System
- Medical Equipment
- Hand-Held Test Equipment

3 Description

The LK P42xxST series is a high-precision, low-power, low-dropout series voltage reference in a 3-pin SOT-23 package. Its compact size and low power consumption (100 μA typical) make it ideal for portable and battery-powered applications. This series requires no load capacitor, remains stable under any capacitive load, and can sink or output up to 10mA of output current.

When unloaded, the LKP42xxST series can operate at a supply voltage only 5mV higher than the output voltage. All models are suitable for a wide temperature range of -40 °C to +125 °C .

Device Information

PART NUMBER	PACKAGE	OUTPUT VOLTAGE (V)
LKP4212ST	SOT23-3	1.25
LKP4220ST	SOT23-3	2.048
LKP4225ST	SOT23-3	2.5
LKP4230ST	SOT23-3	3.0
LKP4233ST	SOT23-3	3.3
LKP4240ST	SOT23-3	4.096

Figure 1 Typical application

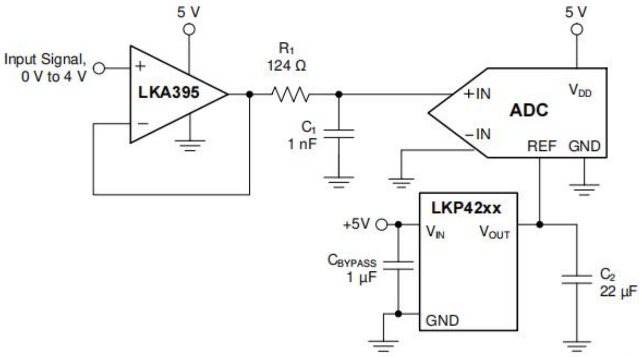
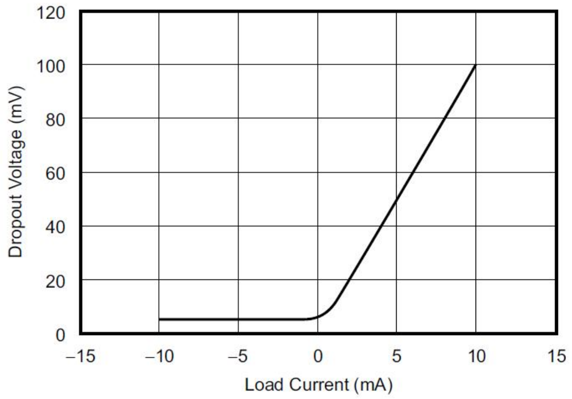


Figure 2 Dropout Voltage vs Load Current



Head record

4 Pin **Configuration and Functions**

4.1 Pin arrangement

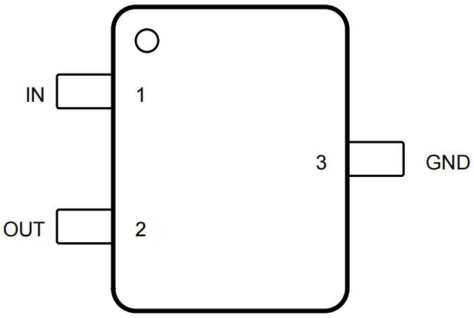


Figure 3 Pin arrangement diagram (top view)

Table 1 **Pin Functions**

Pin number	Pin Name	I/O	DESCRIPTION
1	IN	I	Input supply voltage
2	OUT	O	Reference output voltage
3	GND	-	Ground

5 Electrical properties

5.1 Absolute Maximum Rating

parameter		Minimum value	Maximum value	unit
V+ to V-	Supply voltage			V
-	Output short circuit current (2)	continuous		
T_A	Operating temperature			℃
T_J	Junction temperature			℃
T_{STG}	Storage temperature T_{stg}			℃

Note:

Exceeding the absolute maximum ratings listed in the table may result in permanent damage to the device. Prolonged operation at absolute maximum ratings may affect reliability. It is never recommended to operate the device beyond the conditions specified in the recommended standards.

5.2 ESD Ratings

parameter		Test Standards	value	unit
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001		V
		Charged Device Model (CDM),per JEDEC specification JESD22-C101		

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

parameter		Minimum value	Typical value	Maximum value	unit
V_{IN}	Input voltage		-		V
I_{LOAD}	Load current		-		mA
T_A	Operating temperature		-		℃
(1) The minimum supply voltage for the LKP4212ST is 1.8V.					

5.4 Thermal performance information

THERMAL METRIC	LK P42xx	unit
	3 pins	
$R_{\theta JA}$ junction to ambient thermal resistance		°C/W
$R_{\theta JC(top)}$ junction to the outer casing (top) thermal resistance		°C/W
$R_{\theta JB}$ junction to circuit board thermal resistance		°C/W
ψ_{JT} junction to top characteristic parameters		°C/W
ψ_{JB} junction to circuit board characteristic parameters		°C/W

5.5 Electrical Characteristics

At TA = 25°C, ILOAD = 0 mA, and VIN = 5 V (unless otherwise noted)

PARAMETER TEST CONDITIONS

PARAMETER		Minimum	Typical	Maximum	UNIT	TEST CONDITIONS
LKP4212ST (1.25V) (1)						
V_{OUT}	Output voltage				V	-
-	initial accuracy				-	-
-	Output voltage noise				μV_{PP}	f = 0.1 Hz ~ 10 Hz
					μV_{RMS}	f = 10Hz ~ 10kHz
LKP4220ST (2.048V)						
V_{OUT}	Output voltage				V	-
-	initial accuracy				-	-
-	Output voltage noise				μV_{PP}	f = 0.1 Hz ~ 10 Hz
					μV_{RMS}	f = 10Hz ~ 10kHz
LKP4225ST (2.5V)						
V_{OUT}	Output voltage				V	-
-	initial accuracy				-	-
-	Output voltage noise				μV_{PP}	f = 0.1 Hz ~ 10 Hz
					μV_{RMS}	f = 10Hz ~ 10kHz
LKP4230ST (3.0V)						
V_{OUT}	Output voltage				V	-

PARAMETER			Minimum	Typical	Maximum	UNIT	TEST CONDITIONS
-	initial accuracy					-	-
-	Output voltage noise					μV_{PP}	f = 0.1 Hz ~ 10 Hz
						μV_{RMS}	f = 10Hz ~ 10kHz
LKP4233ST (3.3V)							
V_{OUT}	Output voltage					V	-
-	initial accuracy					-	-
-	Output voltage noise					μV_{PP}	f = 0.1 Hz ~ 10 Hz
						μV_{RMS}	f = 10Hz ~ 10kHz
LKP4240ST (4.096V)							
V_{OUT}	Output voltage					V	-
-	initial accuracy					-	-
-	Output voltage noise					μV_{PP}	f = 0.1 Hz ~ 10 Hz
						μV_{RMS}	f = 10Hz ~ 10kHz
LKP42xxST							
dV_{OUT}/dT	Output voltage temperature drift (2)					ppm/°C	0°C ≤ T_A ≤ 70°C
							-40°C ≤ T_A ≤ + 12.5 °C
-	Long-term stability					ppm	0000h ~ 1000h
-	Linear adjustment rate					p pm /V	V_{REF} + 0.05 (1) ≤ V_{IN} ≤ 5.5V
dV_{OUT}/dI_{LOAD}	Load regulation rate (3)	Sourcing				μV/mA	0mA<I_{LOAD} < 10 mA,V_{IN} =V_{REF} + 25 0mV (1)
		Sinking					–10mA < I_{LOAD} < 0mA, V_{IN} = V_{REF} + 100mV (1)
dT	Thermal hysteresis (4)	First loop				ppm	-
		Subsequent loop					-
$V_{IN} - V_{OUT}$	Differential voltage (1)					mV	T_A = –40°C ~ +125°C
I_{LOAD}	Output current					mA	-
I_{SC}	short circuit current	Sourcing				mA	-
		Sinking					-
-	Conductor establishment time					μs	With $_{CL}$ = 0 μF and $_{VIN}$ = +5V, an accuracy of 0.1% is achieved.
Power supply							
V_S	power supply voltage					V	I_{LOAD} = 0, T_A = –40°C ~ +125°C
I_Q	Static current					μA	I_{LOAD} = 0, TA = 25°C
							I_{LOAD} = 0, T_A =-40°C ~ +125°C

（1）The minimum supply voltage of the LKP4212ST is 1.8V.

（2）Temperature drift was measured using the box method.

（3）Typical load regulation values are based on forced sensing contact measurements; see the Load Regulation section for details.

（4）For detailed thermal hysteresis test procedures, please refer to the thermal hysteresis chapter.

6 Detailed Description

6.1 Function Overview

The LKP4 2xx ST series is a CMOS precision bandgap voltage reference source. Its basic topology is described in the *functional block diagram* section. After biasing transistors Q1 and Q2, the current density of Q1 is higher than that of Q2 . The emitter voltage difference between the two (Vbe1-Vbe2) has a positive temperature coefficient and is applied across resistor R1 . This voltage is amplified and superimposed on the emitter voltage of Q2, which has a negative temperature coefficient , resulting in a final output voltage that is essentially unaffected by temperature. The bandgap voltage curvature shown in Figure 6 originates from the slight nonlinear temperature coefficient of the Q2 emitter voltage.

The LKP4 2xx ST series are cascaded precision bandgap voltage references based on CMOS technology. The basic bandgap topology is shown in the functional block diagram. The bias design of transistors Q1 and Q2 results in a higher current density for Q1 than for Q2 . The emitter -junction voltage difference between the two transistors (Vbe1 - Vbe2) has a positive temperature coefficient and is applied across resistor R1 . This voltage is amplified and superimposed on the emitter-junction voltage of Q2, which has a negative temperature coefficient , ultimately yielding an output voltage that is almost unaffected by temperature. The bandgap voltage curvature shown in Figure 6 originates from the slight nonlinear temperature coefficient of the Q2 emitter-junction voltage.

6.2 Functional block diagram

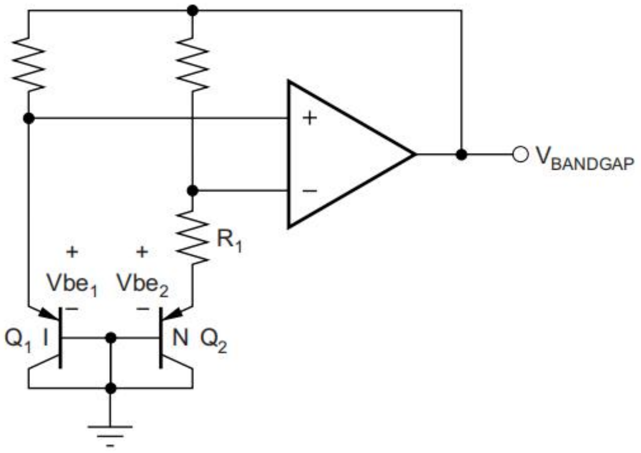


Figure 20Functional Block Diagram

6.3 Feature Description

6.3.1 Supply Voltage

The LKP4 2xx ST series of references features an extremely low dropout voltages. With the exception of the LKP4212ST (minimum supply voltage requirement 1.8V), other models can operate under no -load conditions with a supply voltage only 5mV higher than the output voltage .

The LKP4 2xx ST series features low quiescent current characteristics, which are highly stable under varying temperatures and supply voltages. The typical quiescent current at room temperature is 100 μA, and the maximum quiescent current over the entire temperature range is only 135 µA. As shown in Figure 2.4 , the variation in quiescent current is typically less than 2 µA across the entire supply voltage range.

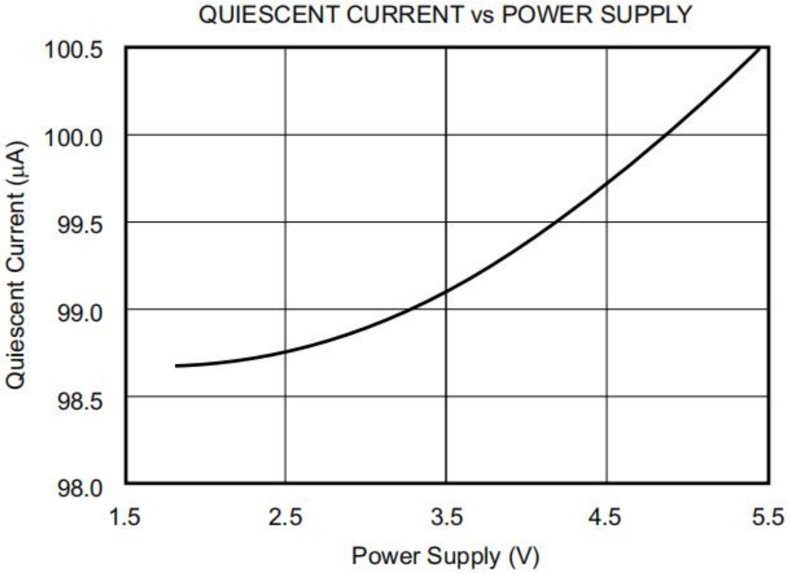


Figure 21. Supply Current vs Supply Voltage

Feature Description (continued)

Supply voltage below the specified levels can cause the LKP4 2xx ST to momentarily draw currents greater than the typical quiescent current. . This can be prevented by using a power supply with a fast rise time and low output impedance .

6.3.2 Thermal hysteresis

Thermal hysteresis of the LKP4 2 xx ST series is defined as the change in output voltage after operating the device at 25°C, cycles through a specified temperature range, and then returns to 25° C. It can be expressed as:

$$V_{HYST} = \left(\frac{\text{abs}|V_{REF} - V_{POST}|}{V_{NOM}}\right) * 10^6 (\text{ppm})$$

Where:

- V_{HYST} : Thermal hysteresis
- V_{PRE} : Output voltage measured at 25°C before temperature cycling.
- V_{POST} : The output voltage measured after the device has cycled through a specified temperature range of -40°C to +125° C and returned to 25° C (1).
-

6.3.3 Temperature Drift

The LKP4 2xx ST series is designed to exhibit minimal drift error, defined as the change in output voltage over varying temperature. The drift is calculated using the box method, which is described in Formula 2:

$$\text{Drift}=\left(\frac{V_{OUTMAX}\text{-}V_{OUTMIN}}{V_{OUT}.\text{Temperature Range}}\right).10^6(\text{ppm})(2)$$

The LKP4 2 xx ST series has a typical drift coefficient of 5 ppm/°C from 0°C to 70° C. the primary temperature temperature range of –40°C to +125° C, the typical temperature drift coefficient of the LKP4 2 xx series increases to 10 ppm/°C.

Feature Description (continued)

6.3.4 Load regulation

Load regulation is defined as the change in output voltage caused by a change in load current. The load regulation of the LKP4 2xx ST series is measured using a forced-sensing contact (see Figure 27). The forced line and sensing line connected to the contact area of the output pins reduce the influence of contact and trace resistance, thus accurately measuring the load regulation caused solely by the LKP4 2xx ST itself. For applications requiring improved load regulation, the forced-sensing line is recommended.

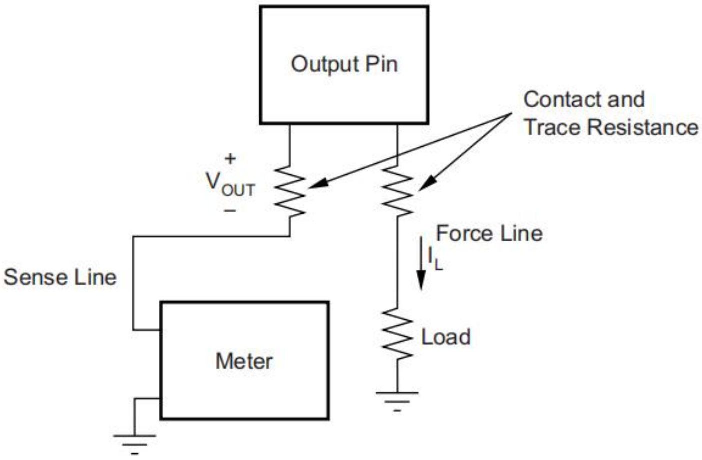


Figure 24LKP42xx

Device Functional modes

6.3.5 negative reference voltage

In applications requiring positive and negative reference voltages, the LKA395 operational amplifier can be used in conjunction with the LKP4 2xx ST to provide dual-supply references via a ±5V supply. Figure 30 shows the LKP4 2 25 ST used to provide a ±2.5V reference voltage. The low offset voltage and low drift characteristics of the LKA395 complement the low drift performance of the LKP4 2xx ST , providing a high-precision solution for power supply applications.

And negative reference voltages, the LKP4 2xx ST can be used in conjunction with the LKA395 to provide dual-supply references via a ±5V supply. Figure 28 illustrates a scheme using the LKP4 2 25 ST to provide a ±2.5V reference voltage. The low drift performance of the LKP4 2xx ST complements the low offset voltage and low drift characteristics of the LKA395 , providing a high-precision solution for power supply applications.

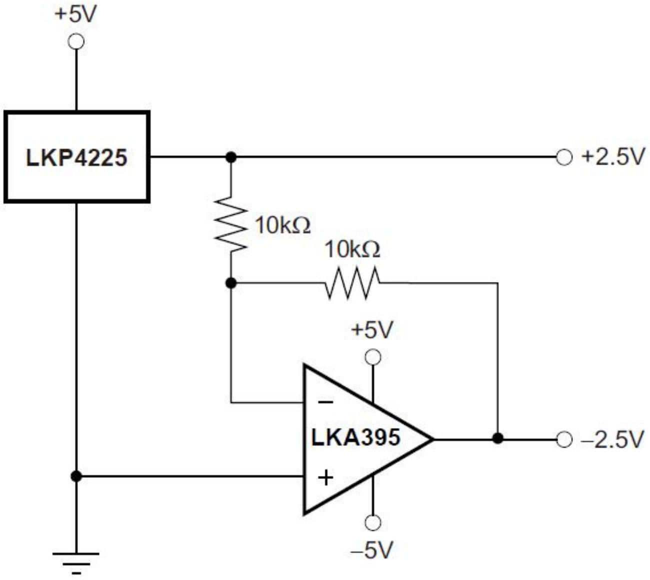


Figure 25 Schematic diagram of generating positive and negative reference voltages using LKP4 2 25 ST and LKA395 combination.

6.3.6 Data collection

Data acquisition systems ofen require stable voltage reference to maintain accuracy. The LKP4 2xx ST series features stability and a wide range of voltages suitable for most microcontrollers and data converters. Figures 29 , 30 , and 31 show basic data acquisition system schemes.

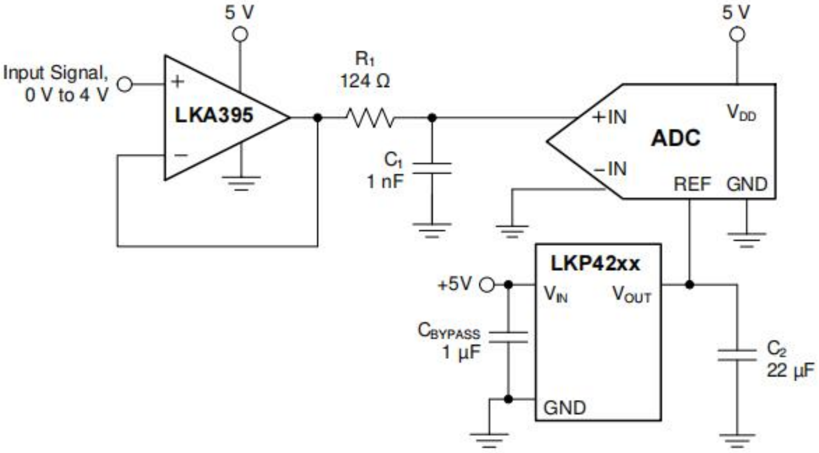


Figure 26Basic Data Acquisition System 1

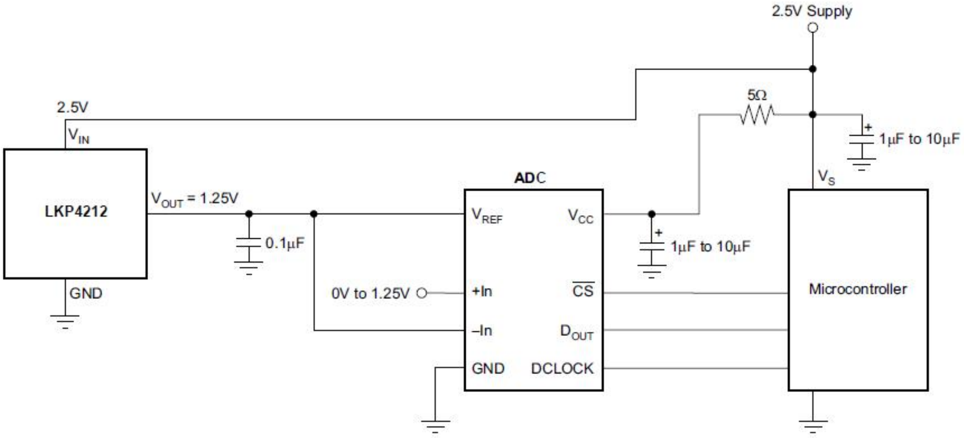


Figure 27. Basic Data Acquisition System 2

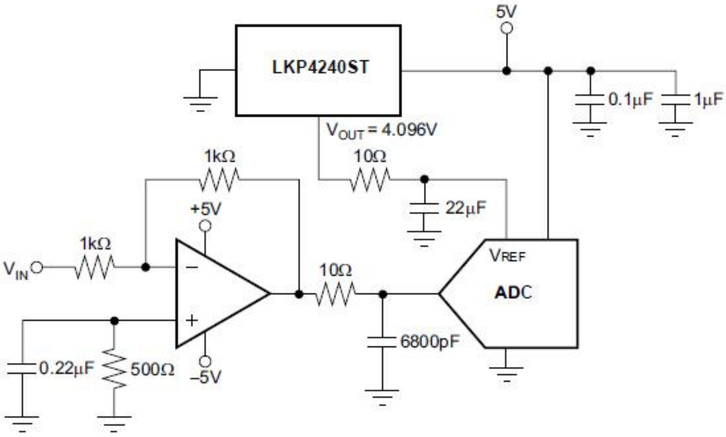


Figure 28 The LKP4240ST provides a precise reference circuit for ADCs .

7 Application and Implementation

The LKP42xx ST requires no load capacitor and is stable under any capacitive load. Figure 32 shows a typical operating connection for the LKP42xx ST . TI recommends using a power supply decoupling capacitor of 0.47μF or higher.

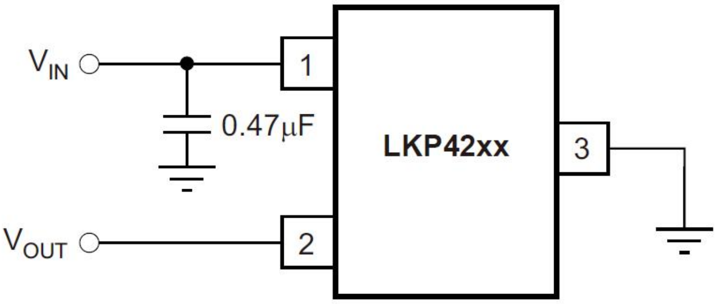


Figure 29 Typical connections for Operating LKP42xxST series

7.1 Typical Applications

Figure 33 shows a low-power reference and conditioning circuit. This circuit attenuates and levels a bipolar input voltage to suit the input range of a single-supply low-power 16-bit ΔΣ ADC (such as a microcontroller -integrated ADC or other similar single-supply ADCs). The precision reference circuit levels the input signal, provides the ADC reference voltage, and supplies a stable power supply voltage to the low-power analog circuitry. The low-power zero-drift operational amplifier circuit attenuates and levels the input signal.

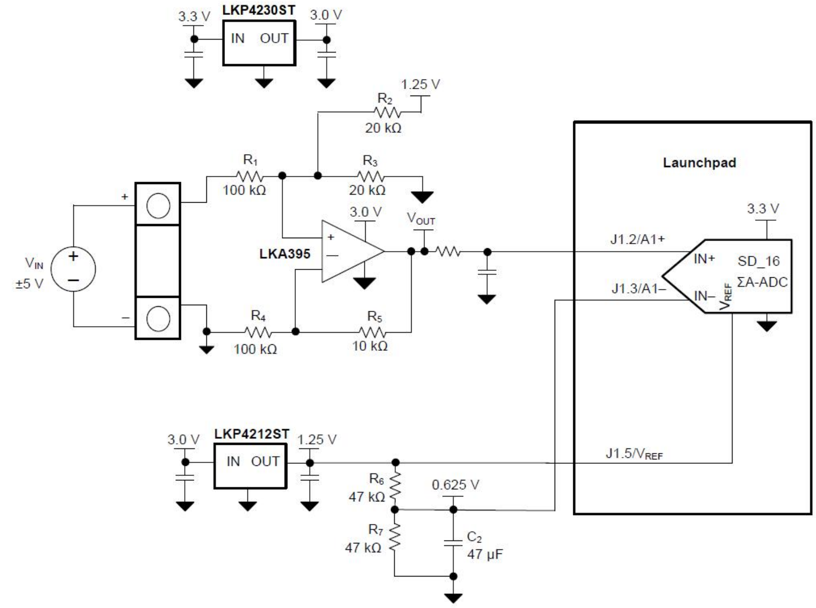


Figure 30 Low-power reference and bipolar voltage conditioning circuit for low-power analog-to-digital converter

7.1.1 Design Requirements

- Supply Voltage: 3.3V
- Maximum input voltage: ± 6V
- Specified Input Voltage: ± 5 V
- ADC Reference Voltage: 1.25V

The goal of this design is to precisely condition a ±5V bipolar input voltage to a voltage suitable for a low-voltage analog-to-digital converter (ADC) with a reference voltage VREF = 1.25V and an input voltage range of VREF / 2); the circuit can still operate over a wider input range (at least ±6V) (with a possible slight performance degradation) to facilitate overvoltage protection.

7.1.2 Detailed design process

Figure 33 is a simplified schematic of the design, including the analog-to-digital converter (ADC) input and full input conditioning circuitry. The ADC is configured for a bipolar measurement where final conversion result is the differential voltage between the voltage at the positive and negative ADC inputs. The bipolar, GND-referenced input signal must be level-shifted and attenuated by the op amp so that the output is biased to VREF/2 and has a differential voltage that is within the ±VREF/2 input range of the ADC.

7.2 Power supply Recommendation

The LKP4 2xx ST series references feature extremely low dropout voltage. Except for the LKP4212ST, which requires a minimum supply voltage of 1.8V, other models can operate under no-load conditions with a supply voltage only 5mV higher than the output voltage. Typical dropout voltage versus load under load conditions can be found in the "Dropout Voltage vs. Load Current" graph on the homepage. It is recommended to use a power supply decoupling capacitor of 0.47 µF or higher .

7.3 Layout Guidelines

Figure 37 shows an example of the printed circuit board (PCB) layout for the LKP4 2 xx ST series . Key considerations are as follows:

- Connect a low-ESR 0.1µF ceramic bypass capacitor to the VIN $_{\text{pin}}$ of the LKP4 2xx ST .
- Provide decoupling for other active devices in the system according to device specifications.
- Using a complete ground plane helps with heat dissipation and reduces electromagnetic interference (EMI) noise pickup.
- External components should be placed as close as possible to the device to avoid parasitic errors (such as the Seebeck effect).
- Shorten the trace length between the reference source and the instrumentation amplifier (INA) and ADC bias connection to reduce noise pickup.
- Sensitive analog traces must not run parallel to digital traces; avoid crossing digital traces with analog traces as much as possible, and if crossing is unavoidable, use a perpendicular crossing.

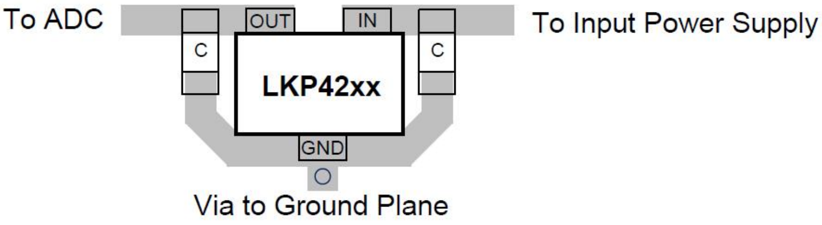
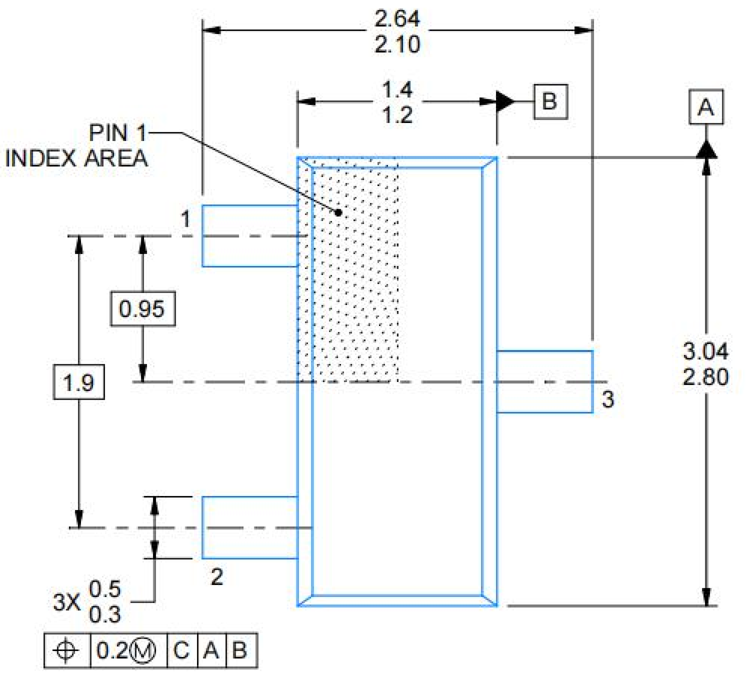
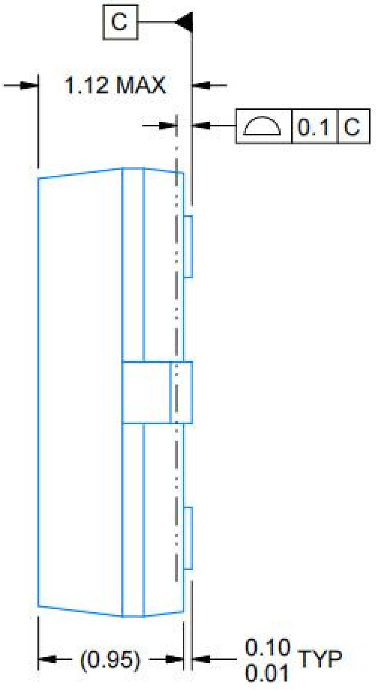
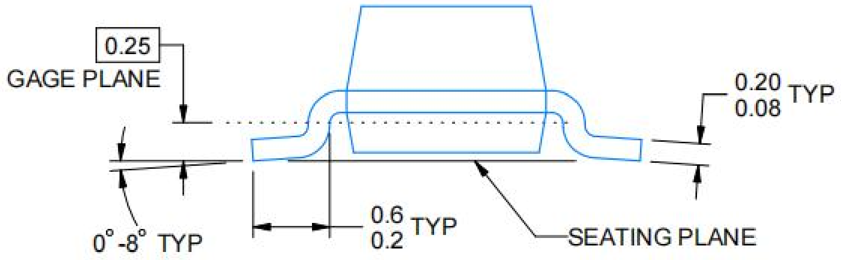


Figure 34. Layout Example

8 Packaging


2.64
2.10
1.4
1.2
B
A
PIN 1
INDEX AREA
1
0.95
1.9
3
3.04
2.80
2
3X 0.5
0.3
⌖ 0.2Ⓜ C A B


C
1.12 MAX
⌓ 0.1 C
(0.95)
0.10
0.01 TYP


0.25
GAGE PLANE
0.20
0.08 TYP
0°-8° TYP
0.6
0.2 TYP
SEATING PLANE

8.1 Ordering Information

LK	**P**	**42xx**	**ST**
①	②	③	④

① Product series code

② Category Identifier

③ Product Code

④ Encapsulation type

Table 2 Order Information Form

model	Packaging	Quality grade	Operating temperature
LKP 4212ST	SOT23-3 , plastic package	Industrial grade	-40 ℃ ～ + 125 ℃
LKP 4220ST	SOT23-3 , plastic package	Industrial grade	
LKP 4225ST	SOT23-3 , plastic package	Industrial grade	
LKP 4230ST	SOT23-3 , plastic package	Industrial grade	
LKP 4233ST	SOT23-3 , plastic package	Industrial grade	
LKP 4240ST	SOT23-3 , plastic package	Industrial grade	

9 Version information

Version number	date	Version Notes	Change Notes
REV 1.00	2025-12-02	Updated version	—