



# ACF2101

ABRIDGED DATA SHEET  
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## Low Noise, Dual SWITCHED INTEGRATOR

### FEATURES

- INCLUDES INTEGRATION CAPACITOR, RESET AND HOLD SWITCHES, AND OUTPUT MULTIPLEXER
- LOW NOISE:  $10\mu\text{Vrms}$
- LOW CHARGE TRANSFER:  $0.1\text{pC}$
- WIDE DYNAMIC RANGE: 120dB
- LOW BIAS CURRENT:  $100\text{fA}$

### APPLICATIONS

- CURRENT TO VOLTAGE CONVERSION
- PHOTODIODE INTEGRATOR
- CURRENT MEASUREMENT
- CHARGE MEASUREMENT
- CT SCANNER FRONT END
- MEDICAL, SCIENTIFIC, AND INDUSTRIAL INSTRUMENTATION

### DESCRIPTION

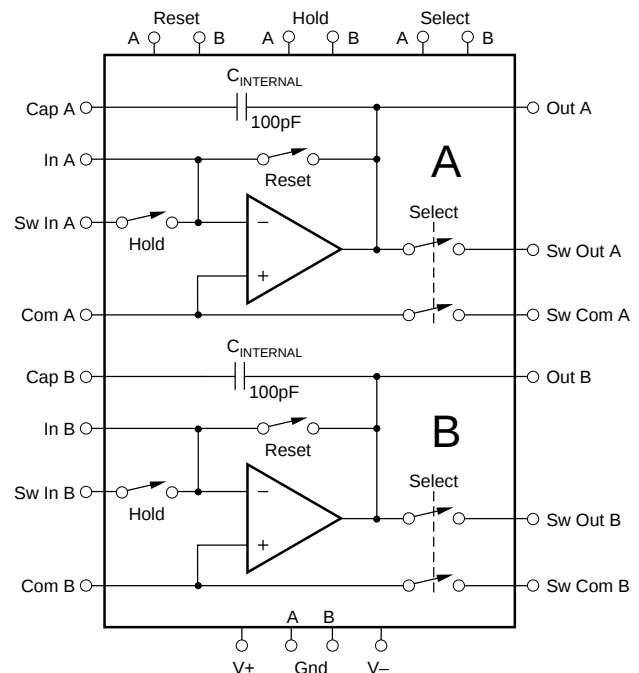
The ACF2101 is a dual switched integrator for precision applications. Each channel can convert an input current to an output voltage by integration, using either an internal or external capacitor. Included on the chip are precision  $100\text{pF}$  integration capacitors, hold and reset switches, and output multiplexers.

As a complete circuit on a single chip, the ACF2101 eliminates many of the problems commonly encountered in discrete designs, such as leakage current errors and noise pickup. The integrating approach can provide lower noise than conventional transimpedance amplifier designs and also eliminates the need for high performance, high value feedback resistors.

The extremely low bias current and low noise of the ACF2101's *Difet*® amplifiers, along with active laser trimming of both offset and drift, assure precision current to voltage conversion.

Although designed for +5V, -15V supplies, the ACF2101 can be operated on supplies up to  $\pm 18\text{VDC}$ . It is available in both 24-pin plastic DIP and SOIC packages.

*Difet*® Burr-Brown Corp.



International Airport Industrial Park • Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706  
Tel: (520) 746-1111 • Twx: 910-952-1111 • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

# SPECIFICATIONS

## ELECTRICAL

At  $T_A = +25^{\circ}\text{C}$ ,  $V+ = +5\text{V}$ ,  $V- = -15\text{V}$ , Internal  $C_{\text{INTEGRATION}} = C_{\text{INTERNAL}} = 100\text{pF}$ , unless otherwise noted.

| PARAMETER                                                                                                                                                                                                                                            | CONDITIONS                                                                                      | ACF2101BP, BU                                         |                                  |               | UNITS                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------|---------------|------------------------------------------|
|                                                                                                                                                                                                                                                      |                                                                                                 | MIN                                                   | TYP                              | MAX           |                                          |
| ANALOG INPUT                                                                                                                                                                                                                                         |                                                                                                 |                                                       |                                  |               |                                          |
| INPUT RANGE<br>Input Current Range<br>Switched Input (Sw In A, Sw In B)<br>Direct Input (In A, In B)                                                                                                                                                 |                                                                                                 |                                                       |                                  | ±100<br>±100  | μA<br>μA                                 |
| INPUT IMPEDANCE<br>Switched Input<br>Hold Switch OFF<br>Hold Switch ON<br>Direct Input                                                                                                                                                               |                                                                                                 |                                                       | 1000<br>1.5<br>Virtual Ground    |               | GΩ<br>kΩ                                 |
| HOLD SWITCH VOLTAGE<br>Hold Switch Withstand Voltage                                                                                                                                                                                                 | Hold Switch OFF                                                                                 | −10                                                   |                                  | +0.5          | V                                        |
| OFFSET VOLTAGE<br>Input Offset Voltage<br>Average Drift                                                                                                                                                                                              |                                                                                                 |                                                       | ±0.5<br>±1                       | ±2<br>±5      | mV<br>μV/°C                              |
| DIGITAL INPUTS                                                                                                                                                                                                                                       |                                                                                                 |                                                       |                                  |               |                                          |
| Logic Family<br>V <sub>IH</sub> (Logic 1 = Switch OFF)<br>V <sub>IL</sub> (Logic 0 = Switch ON)<br>I <sub>IH</sub><br>I <sub>IL</sub><br>Switching Speed (All Switches)<br>Switch ON<br>Switch OFF                                                   | TTL Compatible<br><br>V <sub>IH</sub> = +5V<br>V <sub>IL</sub> = 0V                             | 2<br>−0.5                                             | 2<br>0<br><br>200<br>200         | 5.5<br>0.8    | V<br>V<br>μA<br>μA<br>ns<br>ns           |
| TRANSFER CHARACTERISTICS                                                                                                                                                                                                                             |                                                                                                 |                                                       |                                  |               |                                          |
| TRANSFER FUNCTION                                                                                                                                                                                                                                    |                                                                                                 | $V_{OUT} = -\frac{1}{C_{INTEGRATION}} \int I_{IN} dt$ |                                  |               | V                                        |
| DYNAMIC CHARACTERISTICS<br>Integrate Mode<br>Slew Rate<br>Reset Mode<br>Slew Rate<br>Settling Time to 0.01%FSR <sup>(1)</sup><br>Overload Recovery<br>Output Multiplexer (Select Switches)<br>Settling Time to 0.01%FSR<br>Settling Time to 0.01%FSR | 10V Step<br>Positive or Negative<br><br>C <sub>LOAD</sub> < 1000pF<br>C <sub>LOAD</sub> < 100pF | 1                                                     | 3<br><br>3<br>5<br>5<br>6.5<br>2 | 10            | V/μs<br><br>V/μs<br>μs<br>μs<br>μs<br>μs |
| INTEGRATION CAPACITOR (C <sub>INTERNAL</sub> )<br>Internal Capacitor<br>Value<br>Accuracy<br>Temperature Coefficient<br>Memory                                                                                                                       |                                                                                                 | −50                                                   | 100<br>0.5<br>−25<br>30          | 2<br>0<br>100 | pF<br>%<br>ppm/°C<br>ppm of FSR          |
| RESET SWITCH<br>Impedance<br>Reset OFF<br>Reset ON                                                                                                                                                                                                   |                                                                                                 |                                                       | 1000<br>1.5                      |               | GΩ<br>kΩ                                 |
| MODES OF OPERATION<br>Switch<br>Integrate Mode<br>Hold Mode<br>Reset Mode<br>(Logic 1 = OFF, Logic 0 = ON)                                                                                                                                           | Hold<br>ON<br>OFF<br>ON/OFF<br>Reset<br>OFF<br>OFF<br>ON                                        |                                                       |                                  |               |                                          |

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# SPECIFICATIONS (CONT)

At  $T_A = +25^{\circ}\text{C}$ ,  $V_+ = +5\text{V}$ ,  $V_- = -15\text{V}$ , Internal  $C_{\text{INTEGRATION}} = C_{\text{INTERNAL}} = 100\text{pF}$ , unless otherwise noted.

| PARAMETER                                    | CONDITIONS             | ACF2101BP, BU                                |                                                    |        | UNITS    |      |
|----------------------------------------------|------------------------|----------------------------------------------|----------------------------------------------------|--------|----------|------|
|                                              |                        | MIN                                          | TYP                                                | MAX    |          |      |
| OUTPUT                                       |                        |                                              |                                                    |        |          |      |
| Voltage Output Range (All Outputs)           | Select Switch OFF      | −10                                          | −13.5, +1.0                                        | +0.5   | V        |      |
| Current Output, Direct Output (Out A, Out B) |                        | ±5                                           |                                                    |        | mA       |      |
| Short Circuit Current                        |                        |                                              |                                                    |        |          |      |
| Direct Output                                |                        |                                              | ±25                                                |        | mA       |      |
| Switched Output (Sw Out A, Sw Out B)         |                        | ±2                                           | ±8                                                 |        | mA       |      |
| Select Switch Withstand Voltage              |                        |                                              |                                                    |        |          |      |
| Switched Output                              |                        | −10                                          |                                                    | +0.5   | V        |      |
| Switched Common (Sw Com A, Sw Com B)         |                        | −0.5                                         |                                                    | +0.5   | V        |      |
| Output Impedance                             |                        |                                              |                                                    |        |          |      |
| Direct Output                                |                        |                                              | 0.1                                                |        | Ω        |      |
| Switched Output                              |                        |                                              |                                                    |        |          |      |
| Select Switch ON                             |                        |                                              | 250    5                                           |        | Ω    pF  |      |
| Select Switch OFF                            |                        |                                              | 1000    4                                          |        | GΩ    pF |      |
| Leakage Current                              |                        |                                              | 10                                                 | 100    | pA       |      |
| Load Capacitance Stability                   |                        |                                              |                                                    |        |          |      |
| Direct Output                                |                        |                                              |                                                    | 500    | pF       |      |
| Switched Output                              |                        |                                              |                                                    | Any    | pF       |      |
| OUTPUT ACCURACY                              |                        |                                              |                                                    |        |          |      |
| Nonlinearity                                 |                        | V <sub>S</sub> = +4.5V to +18V, −10V to −18V |                                                    | ±0.005 | ±0.01    | %FSR |
| Channel Separation                           |                        |                                              |                                                    | −80    |          | dB   |
| Op Amp Bias Current                          |                        |                                              |                                                    |        |          |      |
| Value                                        |                        |                                              | 100                                                | 1000   | fA       |      |
| Temperature Coefficient                      |                        |                                              | Doubles Each +10°C                                 |        |          |      |
| Hold Mode Droop                              |                        |                                              | 1                                                  | 10     | nV/μs    |      |
| Integrate Mode Droop                         |                        |                                              | 1                                                  | 10     | nV/μs    |      |
| Voltage Offset <sup>(2)</sup>                |                        |                                              |                                                    |        |          |      |
| Value                                        |                        |                                              | 3                                                  |        | mV       |      |
| Temperature Coefficient                      |                        |                                              | 5                                                  |        | μV/°C    |      |
| Power Supply Rejection                       |                        |                                              | 80                                                 | 100    | dB       |      |
| OUTPUT NOISE                                 |                        |                                              |                                                    |        |          |      |
| Total Output Noise <sup>(3)</sup>            | BW = 0.1Hz to 10Hz     |                                              | 2                                                  |        | μVrms    |      |
| Integrate Mode <sup>(4)</sup>                | BW = 0.1Hz to 250kHz   |                                              | 10(1 + C <sub>IN</sub> /C <sub>INTEGRATION</sub> ) |        | μVrms    |      |
| Hold Mode                                    | BW = 0.1Hz to 250kHz   |                                              | 10                                                 |        | μVrms    |      |
| Reset Mode                                   | BW = 0.1Hz to 250kHz   |                                              | 10                                                 |        | μVrms    |      |
| CHARGE TRANSFER ERRORS <sup>(5)</sup>        |                        |                                              |                                                    |        |          |      |
| Reset to Integrate Mode <sup>(6)</sup>       | C <sub>IN</sub> > 50pF |                                              |                                                    |        |          |      |
| Charge Transfer                              |                        |                                              | 0.1                                                | 0.5    | pC       |      |
| Charge Transfer TC                           |                        |                                              | 0.2                                                |        | fC/°C    |      |
| Charge Offset Error                          |                        |                                              | 1                                                  | 5      | mV       |      |
| Charge Offset TC                             |                        |                                              | 2                                                  |        | μV/°C    |      |
| Integrate to Hold Mode                       |                        |                                              |                                                    |        |          |      |
| Charge Transfer                              |                        |                                              | 0.2                                                | 1      | pC       |      |
| Charge Transfer TC                           |                        |                                              | 0.4                                                |        | fC/°C    |      |
| Charge Offset Error                          |                        |                                              | 2                                                  | 10     | mV       |      |
| Charge Offset TC                             |                        |                                              | 4                                                  |        | μV/°C    |      |
| Hold to Integrate Mode                       |                        |                                              |                                                    |        |          |      |
| Charge Transfer                              |                        | C <sub>IN</sub> > 50pF                       |                                                    | 0.2    | 1        | pC   |
| Charge Transfer TC                           |                        |                                              | 0.4                                                |        | fC/°C    |      |
| Charge Offset Error                          |                        |                                              | 2                                                  | 10     | mV       |      |
| Charge Offset TC                             |                        |                                              | 4                                                  |        | μV/°C    |      |
| POWER SUPPLY                                 |                        |                                              |                                                    |        |          |      |
| Specified Operating Voltage                  | For Dual<br>For Dual   |                                              | +5, −15                                            |        | V        |      |
| Operating Voltage Range                      |                        |                                              |                                                    |        |          |      |
| Positive Supply                              |                        | +4.5                                         |                                                    | +18    | V        |      |
| Negative Supply                              |                        | −10                                          |                                                    | −18    | V        |      |
| Current                                      |                        |                                              |                                                    |        |          |      |
| Positive Supply                              |                        |                                              | 12                                                 | 15     | mA       |      |
| Negative Supply                              |                        |                                              | 3.5                                                | 5.2    | mA       |      |
| TEMPERATURE RANGE                            |                        |                                              |                                                    |        |          |      |
| Specification                                |                        | Junction to Ambient                          | −40                                                |        | +85      | °C   |
| Operation                                    |                        |                                              | −40                                                |        | +125     | °C   |
| Storage                                      |                        |                                              | −40                                                |        | +125     | °C   |
| Thermal Resistance (both packages)           |                        |                                              |                                                    | 100    |          | °C/W |

NOTES: (1) FSR is Full Scale Range = 10V (0 to -10V). (2) Includes offset errors from all modes of operation. (3) Total noise is rms total of noise for the modes of operation used. (4)  $C_{\text{IN}}$  = capacitance of sensor connected to ACF2101 input;  $C_{\text{INTEGRATION}} = C_{\text{INTERNAL}} + C_{\text{EXTERNAL}}$ . (5) Errors created when the internal switches are driven from one mode to another. (6) The charge transfer is 0.1pC; for an integration capacitance of 100pF, the resultant charge offset voltage error is 1mV.

## ABSOLUTE MAXIMUM RATINGS

|                                         |                      |
|-----------------------------------------|----------------------|
| Supply .....                            | ±18V                 |
| Input Current .....                     | ±5mA                 |
| Output Short Circuit Duration .....     | Continuous to Ground |
| Power Dissipation .....                 | 500mW                |
| Operating Temperature .....             | –40°C to +125°C      |
| Storage Temperature .....               | –40°C to +125°C      |
| Junction Temperature .....              | +150°C               |
| Lead Temperature (soldering, 10s) ..... | +300°C               |

## ORDERING INFORMATION

| MODEL     | PACKAGE             | TEMPERATURE RANGE |
|-----------|---------------------|-------------------|
| ACF2101BP | 24-Pin Plastic DIP  | –40°C to +85°C    |
| ACF2101BU | 24-Pin Plastic SOIC | –40°C to +85°C    |

## PACKAGE INFORMATION

| MODEL     | PACKAGE             | PACKAGE DRAWING NUMBER <sup>(1)</sup> |
|-----------|---------------------|---------------------------------------|
| ACF2101BP | 24-Pin Plastic DIP  | 243                                   |
| ACF2101BU | 24-Pin Plastic SOIC | 239                                   |

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

NOTE: DIP and SOIC package have different pin outs.

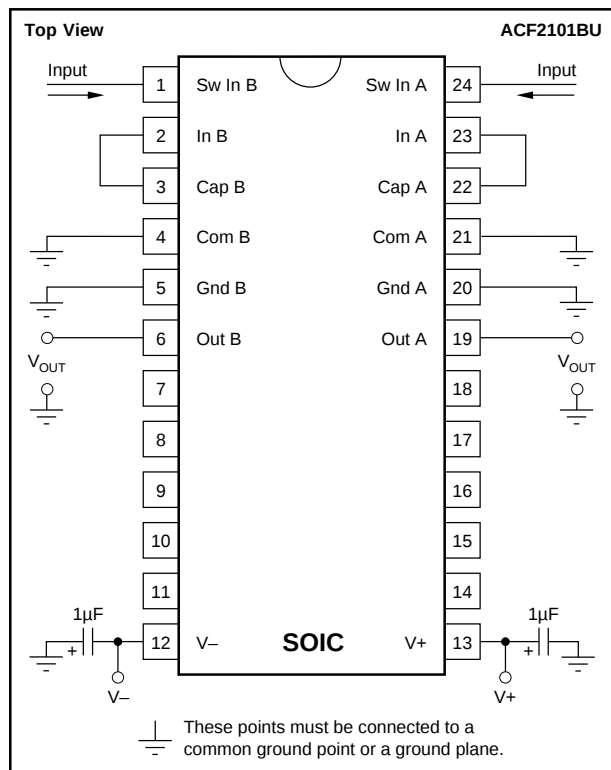


FIGURE 1a. Basic Circuit Connections, **SOIC** package.



## ELECTROSTATIC DISCHARGE SENSITIVITY

Electrostatic discharge can cause damage ranging from performance degradation to complete device failure. Burr-Brown Corporation recommends that all integrated circuits be handled and stored using appropriate ESD protection methods.

## BASIC CIRCUIT CONNECTION

### Basic Layout

As with any precision circuit, careful layout will ensure best performance. Make short, direct interconnections and avoid stray wiring capacitance—especially at the analog and digital input pins.

Figures 1a and 1b illustrate the basic connections needed for operation. Figures 1c and 1d illustrate the addition of external integration capacitors and input guards.

Leakage currents between printed circuit board traces can easily exceed the input bias current of the ACF2101. A circuit board “guard” pattern reduces leakage effects by surrounding critical high impedance input circuitry with a low impedance circuit connection at the same potential. Leakage will flow harmlessly to the low impedance node. Figure 2a and 2b show printed circuit patterns that can be used to guard critical pins. Note that traces leading to these pins should also be guarded.

Improper handling or cleaning may increase droop. Contamination from handling parts and circuit boards can be removed with cleaning solvents and de-ionized water.

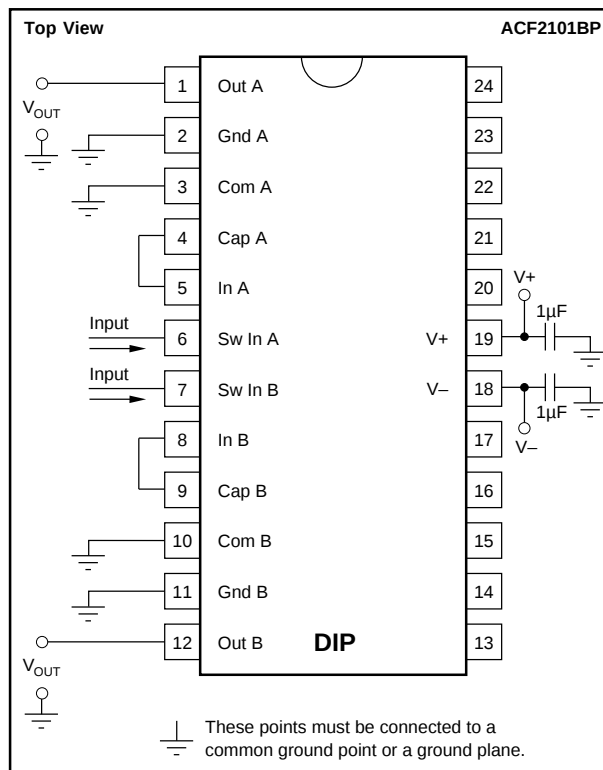


FIGURE 1b. Basic Circuit Connections, **DIP**.