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1992 AMPLIFIER APPLICATIONS GUIDE

First Printing Errata Sheet

ANALOG DEVICES

1992 Amplifier Applications Guide
First Printing Errata Sheet-August, 1992

Front Cover, Top diagram: Remove short between pin 6 and pin 2 of AD843 and replace with a capacitor.

Front Cover, Bottom diagram: Pin 13 of U2 should be labeled: +5V.

Back Cover, Top diagram: Remove short between pin 6 and pin 2. Replace with a capacitor. Reverse positions of 2.2μF and 0.1μF capacitors.

Back Cover, Bottom diagram: Reverse the polarity of the inputs to U3A.

Copyright Page: "Herin" should be spelled "Herein"

Outline section: Under SECTION II outline, under the third bullet point, add "Monolithic Thermocouple Amplifiers" after "Thermistors".

Outline section: Under SECTION XI outline, change "Effect" to "Affect".

Figure 1.1: Add OP-295 to list of Low Power, Single Supply Amplifiers

Figure 1.2: Change OP27 to OP275, Add OP27 between AD624 and AD829

Figure 1.4: Add label "VIDEO" to section below "PROFESSIONAL VIDEO"

Figure 1.6: Add AD844 between OP-160 and AD811 in middle of diagram.

Figure 1.7: Add OP-275 dot above AD811 dot between AD9630 and AD9620

Outline Page, Section II: add "Monolithic Thermocouple Amplifiers" after Thermistors in outline.

Figure 2.10: Pin 3 of second OP-177 should go to ground.

Figure 2.21: Make "-" sign on first op amp horizontal.

Figure 2.22: Remove "1%" label from 499Ω resistor and 27.4kΩ resistor.

Figure 2.23: Remove the erroneous "10" below Vout. Remove "1%" label from 475Ω resistor.

Figure 2.26: Second column total error should be 116, third column should be 112, and fourth column should be 280.

Figure 2.29: Re-label S1, S2, S3, S4 as SW1, SW2, SW3, SW4 to be consistent with the text.

Figure 2.31: Add comment ..."and low peak-to-peak voltage noise in 0.1 to 10Hz bandwidth" to first bullet point.

Figure 2.34: Change 1000 to 100 on horizontal scale of left-hand graph of voltage noise.

Figure 2.35: Remove "Ultra" from title and first bullet point. Change Hz in first and third bullet points to $\sqrt{Hz}$.

Figure 2.38: Change title to "Choosing Instrumentation Amplifiers".

Page 2.28: In second paragraph, change "Bifet" to "Super-Beta".

Figure 2.42: Title of first column should be "Gain Accuracy". Title of fourth column should be: CMRR dB @ 60Hz. In title of fifth column change hZ to Hz.

Figure 2.43: For Single Supply chart, change CMRR dB to CMRR dB @60Hz. In "Input-Overvoltage Protected" chart, add AD626 with +54V Max Input Voltage.

Figure 2.44: Change Gain Accuracy of AD626 to 0.5. Change title of last column to CMRR, dB @ 60Hz.

Figure 2.45: Remove AD526 from selection table! It is not an instrumentation amplifier!!!

Figure 2.47: Change fifth bullet point to show +5 to $\pm$15V specified supply range.

Figure 2.51: Add G=1000, and "Scope Synchronized to Chopper Frequency" to diagram.

Figure 2.52: Add "Scope Unsynchronized" to diagram.

Figure 2.53: Add "Scope Unsynchronized" to diagram.

Page 2.40: First column, line 12 should read: "When compared to other temperature sensors, thermocouples are quite linear. However, their low....."

Figure 2.60: AD592 should be shown as a current source.

Figure 2.61: AD592 should be shown as a current source. Label amplifiers from left to right: A1, A2, A3 since this is mentioned in text.

Page 2.59: In first paragraph, 0.5°C/mW should be 0.5°C/W.

Figure 2.67: "Guage" in title should be spelled "Gauge".

Figure 2.68: Drawn to show Kelvin connection better.

Page 2.68 2.69: Add section titled: "Monolithic Thermocouple Amplifiers with Cold Junction Compensation: The AD594/AD595/AD596/AD597. This is an extraction of the introductory remarks on the respective data sheets. **Complete text is attached to this Errata sheet.**

Figure 3.2: Ideal diode should be in parallel with photo current generator not in series.

Figure 3.9: Label the IC pin connect to the standoff as "Bent Lead".

Figure 3.16: Add pin numbers corresponding to AD645 pinouts. Show main amplifier connected to collector of current mirror. Output of amplifier goes to pin 6. **(Diagram attached to this errata sheet).**

Figure 3.18: Delete resistor network connected to bottom of 1000MΩ summing resistor. Connect bottom of 1000MΩ resistor to a 100Ω resistor connected to ground. Connect a 1MΩ resistor to the junction of the 100Ω and 1000MΩ resistor. The other end of the 1MΩ resistor should go to the wiper of a 100kΩ pot which is connected between + and - 15V. **(Diagram attached to this errata sheet).**

Figure 3.19: Delete Rp. Change 1000MΩ resistor to Rp = 15.4MΩ. Connect bottom of 15.4MΩ resistor to a 100Ω resistor which goes to ground. Connect a 1MΩ resistor to the junction of the 100MΩ and 15.4MΩ resistor. The other end of the 1MΩ resistor should go to the wiper of a 100kΩ pot which is connected between + and - 15V. **(Diagram attached to this errata sheet.)**

Figure 3.21: Same correction as Figure 3.19.
(Diagram attached to this errata sheet).

Figure 3.24: Same correction as Figure 3.19.
(Diagram attached to this errata sheet).

Figure 3.28: In diagram, C2 should be 50pF, not 10pF.

Figure 3.30: "In^+" in second term of long equation for Von should be squared.

Figure 3.37: Same correction as Figure 3.19.
(Diagram attached to this errata sheet.)

Page 3.31: Second column, lines 5 and 6: "6" should be "5.6".
Second column, line 13, $\sqrt{2}$ should be $\sqrt{10}$.
Figure 3.41: R4 should be 900kΩ. Equation on left-hand side should read:

WITH '"T" NETWORK: $\frac{1}{\beta_T} = (1 + \frac{100}{1000})(1 + \frac{900}{100})$

$$= (1.1)(10) = 11.1$$

$$\frac{1/\beta_T}{1/\beta_1} = 5.6$$

Figure 3.48: Change third bullet point to read: "Minimize op amp input capacitance: Cin $\leq$ Cd."

Page 4.1: Add John Wynne, Faisal Ansari, Joe Buxton, Adolfo Garcia, and Steve Sockolov to the list of authors.

Figure 4.4: Reverse the polarity of the inputs of A2.

Page 4.5: Column 2, line 23: Change "goes" to "go".

Page 4.9: Last sentence: Change "control" to "compression".

Page 4.10: Last paragraph: "N-Channel" should be "P-Channel".

Figure 4.10: Add (A) to left-hand drawing and (B) to right-hand drawing.

Page 4.13: First column, line 11: Change "4.8(b)" to "4.10(b)".

Page 4.13: Second paragraph: "Figure 4.8(b)" should be "Figure 4.10(b)".

Figure 4.11: Delete "-5V". Connect bottom of this 10kΩ resistor to V- of the op amp.

Figure 4.15: Change 121kΩ resistor to 12.1kΩ.

Figure 4.16: Change offset voltage to 300µV max, Change supply current to 300µA max, change gain-bandwidth product to 85kHz.

Figure 4.17: Reverse the polarity of the inputs to the OP-295.

Figure 4.18: Reverse the polarity of the inputs to the OP-295.

Page 4.21: Upper right-hand paragraph should read "The amplifier is frequency compensated so that it can drive a 1µF to 10µF output capacitance without oscillation."

Page 4.21: Middle right-hand paragraph should read; "The OP-90/OP-290/OP-490 comes close to ......"

Figure 4.19: Change specs on OP-295 as follows: Max Vos = 300μV, Max Is/Amplifier = 150μA.

Add data for dual OP-213 into table as follows

Dual	OP-213	150μV	0.2μV/C	2mA

Figure 4.24: Reverse polarity of the inputs of the OP-27.

Page 4.31: Second column , line 1 should read: "...a few inches of conductor can have...."

Page 4.34: Add Reference: Fair-Rite Products, P.O. Box J, Wallkill, NY, 12589

Figure 4.31: Top trace is 100mV/div., Bottom trace is 5mV/div.

Figure 5.4: Invert the polarity of the inputs to U1.

Page 5.10: Second column, line 5: Change R4 to R2.

Figure 5.9: In diagram, change R3 to R1, R4 to R2, R1 to R3, and R2 to R4.
In table, change R1,R2 to R1,R3 and R3,R4 to R2,R4. Change 12kΩ under R2,R4 for SSM-2143 to 6kΩ.

Figure 5.16: Change arrows to grounds.

Figure 5.18: Change equation for Gain to GAIN = 1 + R1/R2

Page 5.22: Add Reference 3: Aavid Engineering Co., P.O. Box 400, Laconia, NH, 03247.

Page 6.19: Line 15 should read: ..." Furthermore, its success will still be limited by the number of parts that.....".

Page 6.21: Second column, line 15 should read: ..."They exist between......"

Figure 7.8: Change SFDR to 110 dBc.

Page 7.7: "Figure 710" in right-hand column should be "Figure 7.10".

Page 7.12: Last paragraph, third sentence should read: "The percentage change in closed loop gain, ΔA_{cl}, for a percentage change in open loop gain, ΔA, is approximately $\Delta A/|A_o\beta|$, where A_o is the nominal dc open loop gain at room temperature."

Figure 7.16: Change second bullet point to read: "Percentage Change in Open Loop Gain", and fifth bullet point to read: "Percentage Change in Closed Loop Gain".

Figure 7.27: Substitute curves from Figure 8.20. Table for Gain, BW, and Product remains the same.

Figure 7.85: Change 5.1kΩ resistors to 5.62kΩ. Change top 16kΩ resistor to 5.76kΩ. Parallel it with a 100pF capacitor. Change bottom 16kΩ resistor to 5.49kΩ. Parallel it with a 100pF capacitor. Change 270Ω resistors to 51Ω. Change differentially connected 0.01µF capacitor to 0.0047µF. Eliminate 120Ω resistors to ground. Label top input to AD1879 "-IN" and bottom input "+IN". **(Diagram attached to errata sheet).**

Page 7.61: First column: Change last sentence to read: "The differentially connected 0.0047µF capacitor supplies most of the differential-mode transient currents, while the 0.01µF capacitors connected to ground absorb spike currents which are common mode. The 51Ω series......."

Figure 8.20: First graph should be INVERTING FREQUENCY RESPONSE. Settling time photo should be the same as Figure 7.32.

Page 8.29: First column, line 19: "bully" should be "bulky".

Figure 8.36: R2 in the denominator of the equation for I_L should be changed to R4.

Figure 8.37: Reverse the input polarities for both AD9617s.

Figure 8.42: Show termination resistor between pins 1 and 2 of AD830. Do not connect to ground at AD830.

Page 9.19: Right-hand side of Equation 9.2.5 should be positive.

Figure 9.2.6: Change title to VCA WITH SQUARE LAW GAIN CONTROL USING THE AD539 MULTIPLIER. Input range should be 50dB, not 55dB.

Figure 9.2.11: Change "R_F" to "R8 = R9"

Page 9.38: Line 5 in first paragraph under 9.2.5: C1 should be C4.

Figure 9.2.25: First label on horizontal axis should be 0.1.

Figure 9.2.26: Extend horizontal axis back one decade to 100µV. The graph is basically flat back to this point.

Figure 9.2.28: Change label on vertical axis to mV RMS

Figure 9.2.29: Change vertical axis scale to Volts.

Page 9.51: Line 5 under 9.2.9: "increases" should be "decreases".

Page 9.71: Second paragraph, line 5: +100mV should be -100mV.

Page 9.72: The right-hand term of Eq. 9.3.24 should be negative. The phrase:"that is, a small *forward*-bias on the collector." should immediately follow the equation.

Page 9.82: In Eq. 9.4.13 the term"A^{N-1}" in the last fraction should be moved to the left under $E\sqrt{A}$.

Page 9.86: In first equation, N-2 should be N-1. In Eq. 9.4.20, N-2 should be N-1. In Eq. 9.4.22, N-3 should be N-2. In the sentence between Eq. 9.4.22 and Eq. 9.4.23, 6.6438 should be 6.6435.

Figure 9.4.9: Delete "(NOT USED)" from output of last stage.

Figure 9.4.11: Add load resistor R_Y to ground.

Page 9.91: In Eq. 9.4.39, and 9.4.40 change + to - after the number "1".

Page 9.100: Change title to "Some Aspects of Log-Amps Based on Bipolar Differential Stages".

Page 10.3: Second column, line 7: "cascade" should be "cascode".

Page 10.15: Second column, line 9: Change generation to degeneration.

Page 10.27: First column, line 5: change "transistor" to "resistor".

Figure 10.34: Change "BIFET" to "BIFET and PNP Input" for both bullet points.

Section 11 Title Sheet: Change "Effect" to "Affect"

Figure 11.7: For AD712, Change series resistor to 14kΩ and noise to $22nV/\sqrt{Hz}$

Page 11.11: In title, change "Effect" to "Affect".

Page 11.23: Last line of second column should read: "$1nV/\sqrt{Hz}$ in the best low noise op amps."

Page 11.26: First line should read: "If the impedance is resistive there is a..."

Figure 11.34: In equation F, change non-inverting to inverting.

Figure 11.35: RTI NOISE should be $nV/\sqrt{Hz}$.

Figure 11.36: Right-hand top graph should be for Rs = 10kΩ.

Figure 11.56: Allow space between "Conduction" and "Electrostatic", and space between "Induction" and "Electromagnetic".

Figure 11.58: Add low and high frequency decoupling capacitors to left-hand node. Remove connecting line between A and B in right-hand diagram.

Page 11.56: First column, line 15: insert the word "formula" after the word "reactance".

Page 11.58: Second column: Change last sentence to read: "If sensitive circuitry is located close to a switching supply, its performance may be devastated - if it is further away problems will be minimized. "

Figure 12.28: Insert space between "Mount" and "adhesive" on next to last line.

Page 12.26: Change Wainwright address to: Wainwright Instruments Inc., 7770 Regents Rd., #113, Suite 371, San Diego, CA 92122, Tel: 619-558-1057. Wainwright Instruments GmbH, Widdersberger Strasse 14, DW-8138 Andechs-Frieding, Germany. Tel: +49-8152-2245, Fax: +49-8152-5174.

Page 13.6: Second column, line 16: change gm5 and C5 to gm2 and C4.

Figure 13.7: C4 in the "Noiseless" column should be 159×10^{-9}F.

Page 13.10: Second column, line 17: Change "By" to "because".

Page 13.28: Change last sentence to read: "The complete list of all 300 models on the "Release F, 4/92 version of the diskette is shown in Figure 13.30.

Figure 13.30: Replace with Release F listing which contains 300 macromodels.
(Figure attached to errata sheet).

Index, Page 19: Add "monolithic thermocouple amplifiers, II.68-69"

Analog Devices Parts Index, Page 22: Add: AD594, AD595, AD596, AD597, pp. II.68-69.

(Put at end of Section II)

MONOLITHIC THERMOCOUPLE AMPLIFIERS WITH COLD JUNCTION COMPENSATION: THE AD594/AD595/AD596/AD597

The AD594/AD595 is a complete instrumentation amplifier and thermocouple cold junction compensator on a monolithic chip. It combines an ice point reference with a precalibrated amplifier to produce a high level (10mV/°C) output directly from a thermocouple signal. Pin-strapping options allow it to be used as a linear amplifier-compensator or as a switched output set-point controller using either fixed or remote set-point control. It can be used to amplify its compensation voltage directly, thereby converting it into a stand-alone Celsius transducer with a low-impedance output voltage.

The AD594/AD595 includes a thermocouple failure alarm that indicates if one or both thermocouple leads become open. The alarm output has a flexible format which includes TTL drive capability.

The AD594/AD595 can be powered from a single ended supply (including +5V) and by including a negative supply, temperatures below 0°C can be measured. To minimize self-heating, an unloaded AD594/AD595 will typically operate with a total supply current of 160μA, but is also capable of delivering in excess of ±5mA to a load.

The AD594 is precalibrated by laser wafer trimming to match the characteristic of type J (iron-constantan) thermocouples, and the AD595 is laser trimmed for type K (chromel-alumel) inputs. The temperature transducer voltages and gain control resistors are available at the package pins so that the circuit can be recalibrated for other thermocouple types by the addition of two or three resistors. These terminals also allow more precise calibration for both thermocouple and thermometer applications. The AD594/AD595 is available in two performance grades. The C and the A versions have calibration accuracies of ±1°C and ±3°C, respectively. Both are designed to be used from 0 to +50°C, and are available in 14-pin, hermetically sealed, sidebrazed ceramic DIPs as well as low cost cerdip packages.

The AD596/AD597 is a monolithic temperature set-point controller which has been optimized for use at elevated temperatures such as those found in oven control applications. The device cold junction compensates and amplifies a type J or K thermocouple input to derive an internal signal proportional to temperature. The AD596/AD597 can be configured to provide a voltage output (10mV/°C) directly from a type J or K thermocouple signal. The device is packaged in a reliability qualified, cost effective 10-pin metal can and is trimmed to operate over an ambient temperature range from +25°C to +100°C.

Operation over an extended ambient temperature range is possible with slightly reduced accuracy. The AD596 will amplify thermocouple signals covering the entire -200°C to +760°C temperature range recommended for type J thermocouples while the AD597 can accommodate -200°C to +1250°C type K inputs. The AD596/AD597 has a calibration accuracy of ±4°C at an ambient temperature of 60°C and an ambient temperature stability specification of 0.05°C/°C from +25°C to +100°C.

BiFET OP AMP SIMPLIFIED INPUT CIRCUIT

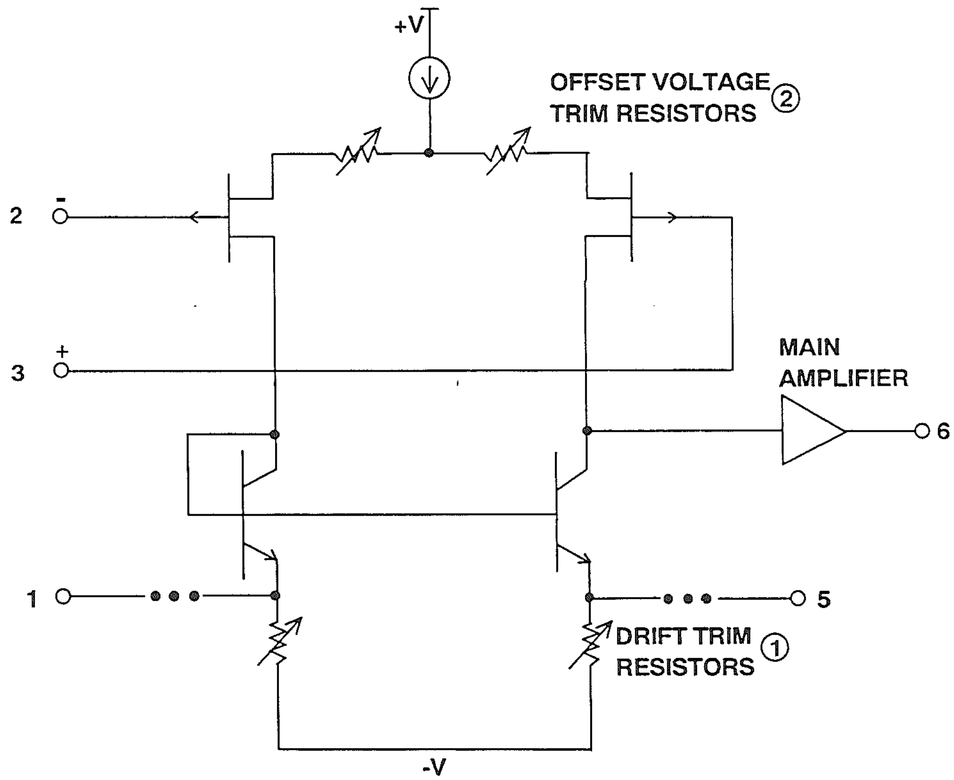

Figure 3.16

OFFSET VOLTAGE NULLING USING INVERTING INPUT

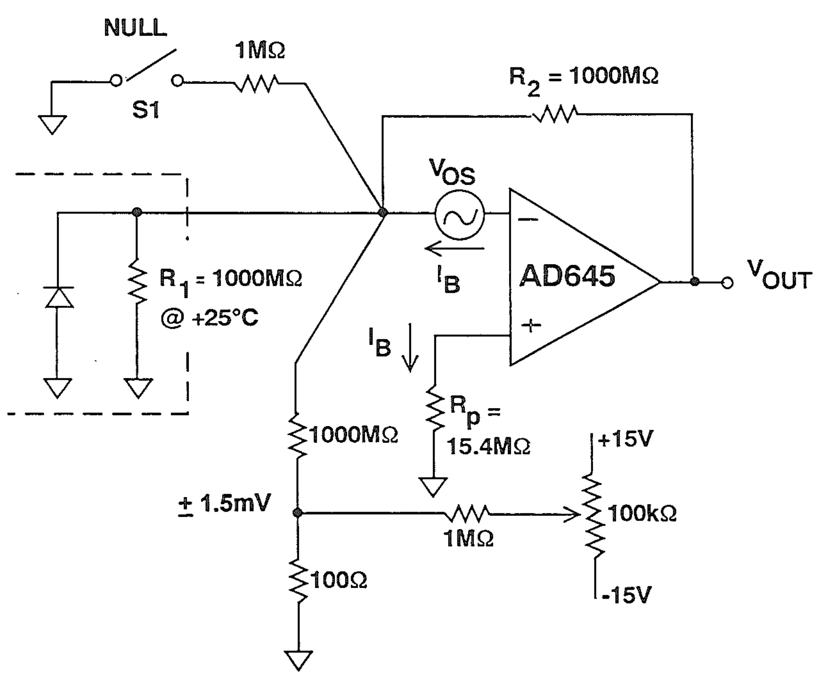

Figure 3.18

OFFSET VOLTAGE NULLING USING NON-INVERTING INPUT

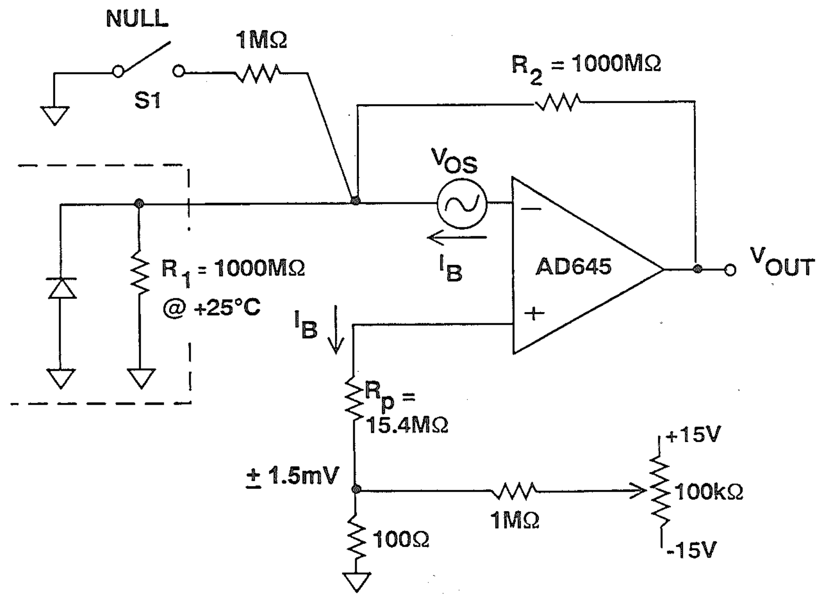

Figure 3.19

FINAL DC DESIGN FOR PHOTODIODE PREAMP

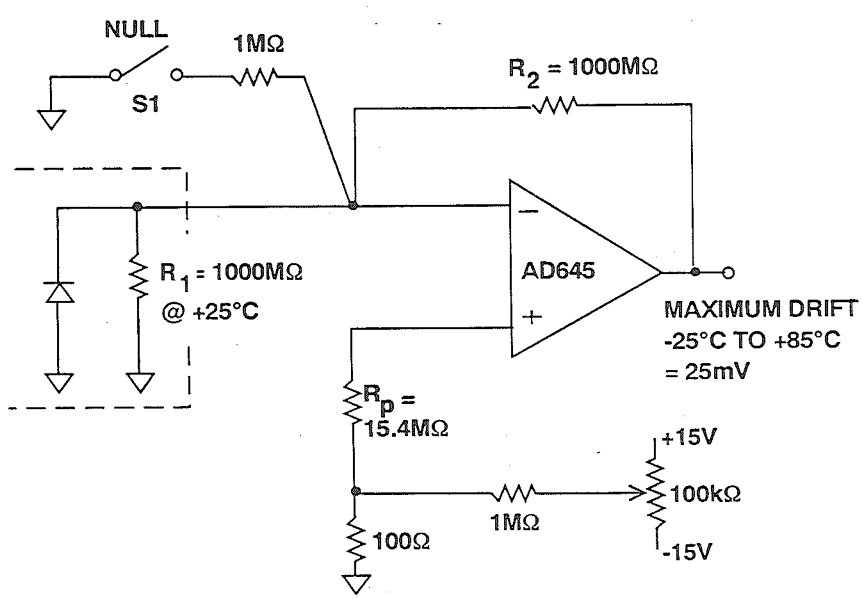

Figure 3.21

REACTIVE PORTION OF PHOTODIODE CIRCUIT

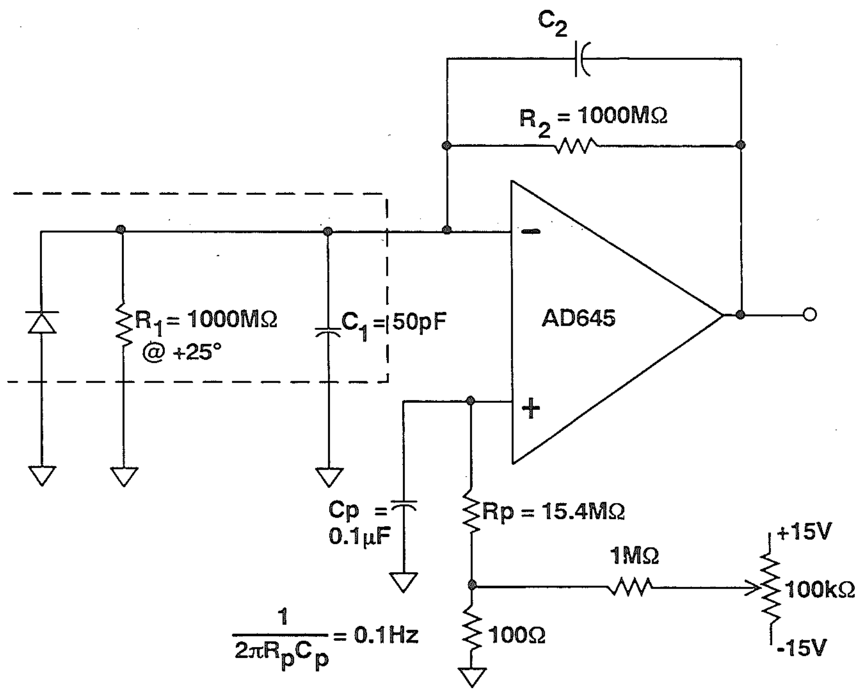

Figure 3.24

OPTIMIZED PHOTODIODE PREAMP

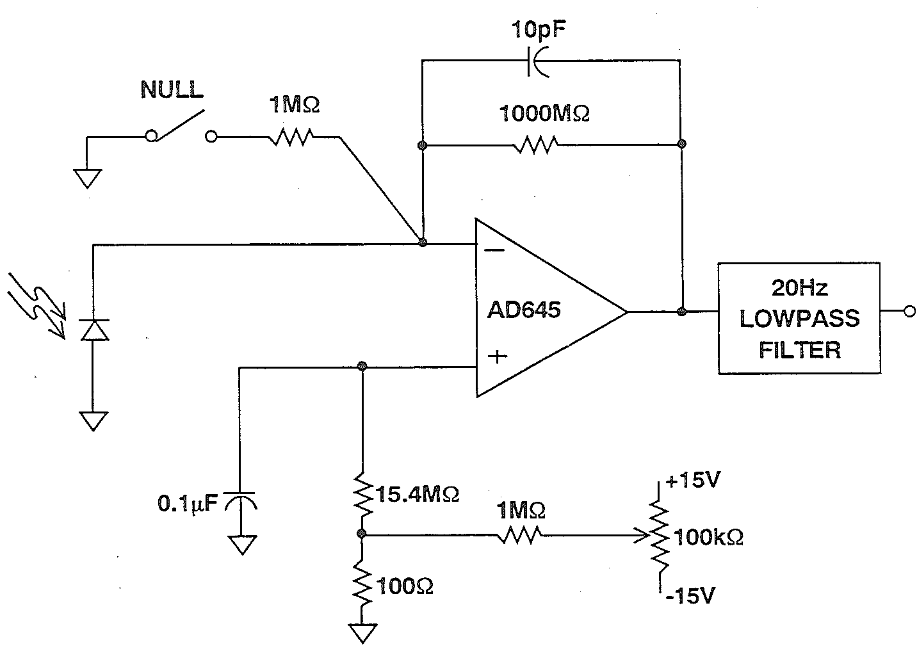

Figure 3.37

DIFFERENTIAL DRIVER (ONE CHANNEL) FOR AD1879 SIGMA-DELTA AUDIO ADC

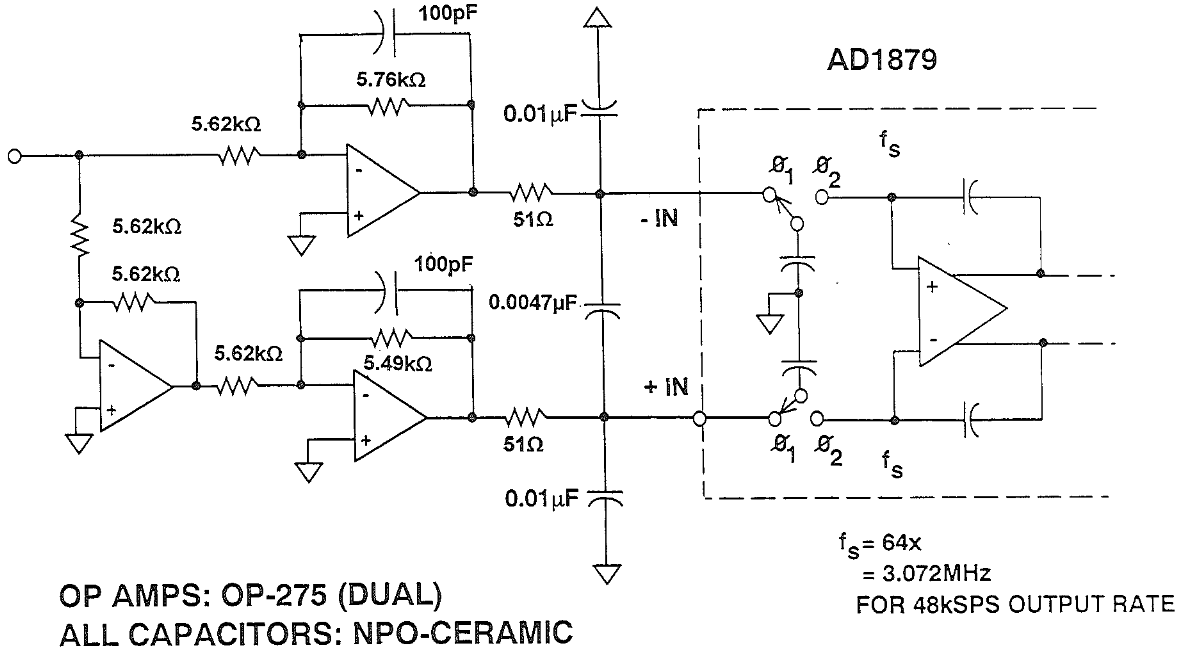

Figure 7.85

ADSpice Release F, 4/92

AD624
AD624A
AD624B
AD624C
AD624S
AD630 *
AD630A *
AD630B *
AD630J *
AD630K *
AD630S *
AD645 *(N)
AD645A *(N)
AD645B *(N)
AD645J *(N)
AD645K *(N)
AD645S *(N)
AD704
AD704A
AD704B
AD704J
AD704K
AD704T
AD705
AD705A
AD705B
AD705J
AD705K
AD705T
AD706
AD706A
AD706B
AD706J
AD706K
AD706T
AD711
AD711A
AD711B
AD711C
AD711J
AD711K
AD711S
AD711T
AD712 *(N)
AD712A *(N)
AD712B *(N)
AD712C *(N)
AD712J *(N)
AD712K *(N)
AD712S *(N)
AD712T *(N)
AD713
AD713A
AD713B
AD713J
AD713K
AD713S
AD713T
AD734
AD734A *

AD734B *
AD734S *
AD743 *(N)
AD743A *(N)
AD743B *(N)
AD743J *(N)
AD743K *(N)
AD743S *(N)
AD744
AD744A
AD744B
AD744C
AD744J
AD744K
AD744S
AD744T
AD745 *(N)
AD745A *(N)
AD745B *(N)
AD745J *(N)
AD745K *(N)
AD745S *(N)
AD746
AD746A
AD746B
AD746J
AD746S
AD811
AD829
AD829A
AD829J
AD829S
AD840
AD840J
AD840K
AD840S
AD843 *
AD843A *
AD843B *
AD843J *
AD843K *
AD843S *
AD844
AD844A
AD844B
AD844S
AD845
AD845A
AD845B
AD845J
AD845K
AD845S
AD846
AD846A
AD846B
AD846S
AD847
AD847A
AD847J
AD847S

AD848
AD848A
AD848J
AD848S
AD9617
AD9618
AD9630
AMP01
AMP02
MAT02
MAT03
MAT04
OP160
OP160A
OP160F
OP160G
OP177 (N)
OP177A (N)
OP177B (N)
OP177E (N)
OP177F (N)
OP177G (N)
OP200
OP200A
OP200E
OP200F
OP200G
OP20
OP20B
OP20C
OP20F
OP20G
OP20H
OP215
OP215A
OP215B
OP215C
OP215E
OP215F
OP215G
OP21
OP21A
OP21E
OP21F
OP21G
OP21H
OP220
OP220A
OP220C
OP220E
OP220F
OP220G
OP221
OP221A
OP221B
OP221C
OP221E
OP221G
OP249
OP249A

OP249E
OP249F
OP249G
OP260
OP27 (N)
OP27A (N)
OP27B (N)
OP27C (N)
OP27E (N)
OP27F (N)
OP27G (N)
OP275 *(N)
OP275G *(N)
OP282 *
OP282G *
OP290
OP290A
OP290E
OP290F
OP290G
OP297
OP297A
OP297E
OP297F
OP297G
OP37 (N)
OP37A (N)
OP37B (N)
OP37C (N)
OP37E (N)
OP37F (N)
OP37G (N)
OP400
OP400A
OP400E
OP400F
OP400G
OP400H
OP41
OP41A
OP41B
OP41E
OP41F
OP41G
OP420
OP420B
OP420C
OP420F
OP420G
OP420H
OP421
OP421B
OP421C
OP421F
OP421G
OP421H
OP42
OP42A
OP42E
OP42F

OP42G
OP43
OP43A
OP43B
OP43E
OP43F
OP43G
OP44
OP470
OP482 *
OP482G *
OP490
OP490A
OP490E
OP490F
OP490G
OP497
OP497A
OP497B
OP497C
OP497F
OP497G
OP61
OP64
OP77 (N)
OP77A (N)
OP77B (N)
OP77E (N)
OP77F (N)
OP77G (N)
OP90
OP90A
OP90E
OP90F
OP90G
OP97
OP97A *
OP97E *
OP97F *
PM1012
REF01 (N)
REF01A (N)
REF01C (N)
REF01E (N)
REF01H (N)
REF02 (N)
REF02A (N)
REF02C (N)
REF02D (N)
REF02E (N)
REF02H (N)
REF05 (N)
REF05A (N)
REF05B (N)
REF10 (N)
REF10A (N)
REF10B (N)
SSM2131
SSM2210
SSM2220

* Indicates new model since release E, 10/91
(N) Indicates noise model

Figure 13.30