Electronics front-end for sensors and signal transmission

Course on Analog Electronic Systems and Sensors

Laurea Magistrale Ingegneria Elettronica
Università di Firenze
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- Corso di laurea in INGEGNERIA ELETTRONICA (B066)
- Insegnamento B019736 - ELETTRONICA DEI SISTEMI ANALOGICI E SENSORI
- E-learning con Moodle

Topics

Direct transmission of signals.

•Methods of connecting sensors to electronic front ends:

•Connection with ground referenced or floating sources to single –ended or differential amplifiers, minimization of noise coupling with signal sources. Types of noise sources: conductive, magnetic, capacitive, radiative.

•Voltage to Current Converters: Howland current pump, application for 4-20 mA current loop.

•Converters Voltage to Frequency and Frequency to Voltage

Galvanically isolated transmission of signals.

Isolation of analog signals:

- •Isolation amplifiers with magnetic transformers
- •Optically isolated analog systems

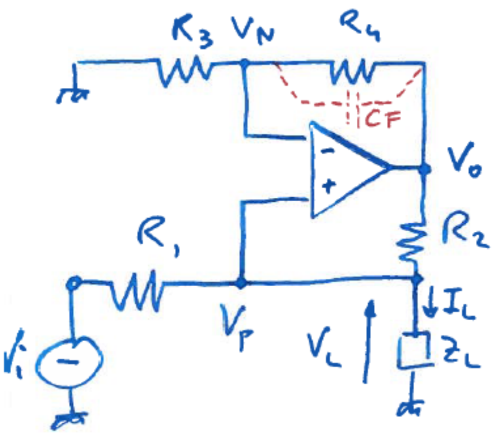
Isolation digital systems:

- Microtransformer technology on-chip
- Isolation serial and parallel interfaces

Direct transmission of signals

V to I converter (VCCS)

This circuit is also known as "HOWLAND CURRENT PUMP (1962, MIT)"



- LOAD Z_L is ground-referenced
- POSITIVE AND NEGATIVE FEEDBACK LOOPS PROVIDE AN OVERALL NEGATIVE FEEDBACK AND AMPLIFIER STABILITY
- C_F MAY BE NECESSARY FOR IMPROVING STABILITY MARGINS
- I_L DEPENDS (IDEALLY) ONLY BY V_i

1) $$I_L = \frac{V_i - V_L}{R_1} + \frac{V_o - V_L}{R_2} = \frac{V_i}{R_1} + \frac{1}{R_2}\left(1 + \frac{R_4}{R_3}\right)V_L - V_L\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

2) $$V_P = V_N = V_L \Rightarrow V_N = V_o \frac{R_3}{R_4 + R_3} = V_L \Rightarrow V_o = V_L\left(1 + \frac{R_4}{R_3}\right)$$

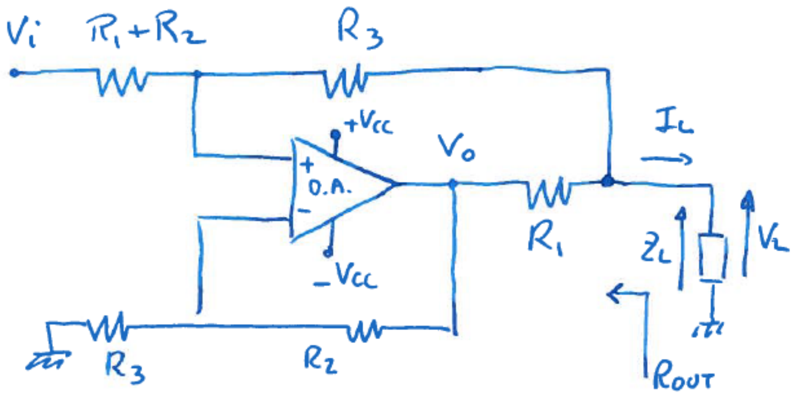
From 1):

$$I_L = \frac{V_i}{R_1} + \left[\frac{1}{R_2} + \frac{R_4}{R_2 R_3} - \frac{1}{R_1} - \frac{1}{R_2}\right] V_L$$

IF $\boxed{\frac{R_4}{R_3} = \frac{R_2}{R_1}}$ THEN $\boxed{I_L = \frac{V_i}{R_1}}$

Improved version of V to I converter

VOLTAGE CONTROLLED - CURRENT SOURCE (VCCS)



- The VCCS requires one more resistor (5 instead 4)
- The resistor matching is required by only two resistors

$$I_L = \frac{V_i}{R_1} + \frac{R_2^2 - R_3^2}{R_1 R_3 (R_2+R_3)} \cdot V_L$$

IF $\boxed{R_2 = R_3}$ $\Rightarrow$ $\boxed{I_L = \frac{V_i}{R_1}}$

Notes:

1) Generally $R_1 \ll R_2, R_3$ to minimize the difference $V_L - V_o$ and exploit full output voltage swing of OP. AMP.
2) Resistor matching $R_2 = R_3$ can be obtained with laser trimming or digital pot.
3) $$R_{OUT} = \frac{R_1 R_3 (R_2+R_3)}{R_3^2 - R_2^2}$$ POSITIVE OR NEGATIVE OUTPUT RESISTANCE CAN BE DESIGNED FOR A SPECIFIC VALUE (Remember PTC and NTC linearization circuit!)

Applications of V to I converters

- Measuring voltages with instruments having current input.
- S&H devices.
- Peak detectors.
- Triangular or saw tooth generators
- Dual ramp ADC
- Voltage to frequency converters
- Programmable/controlled current source for sensors or actuators

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Remember ACCURACY on generated I_L:

Accuracy strongly depends on resistors (accuracy better 1% is possible with special resistors) and overall accuracy on I_L is always worst than single resistor. (E.G.: 1% resistors accuracy provide 5% accuracy on I_L).
In applications for driving positioning systems with actuators, the position accuracy can be obtained at relatively low cost with position sensors and negative feed-back control.

Transmission of signal with Voltage controlled current source (VCCS)

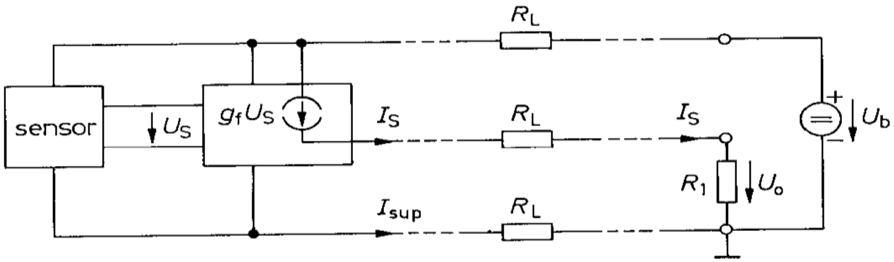


Fig. 26.58 Preamplifier with current output at the sensor eliminates errors in signal transmission. Example of a voltage-controlled IC current source: XTR 110 from Burr Brown

$$U_o = I_S R_1 = g_f U_S R_1 = A U_S$$

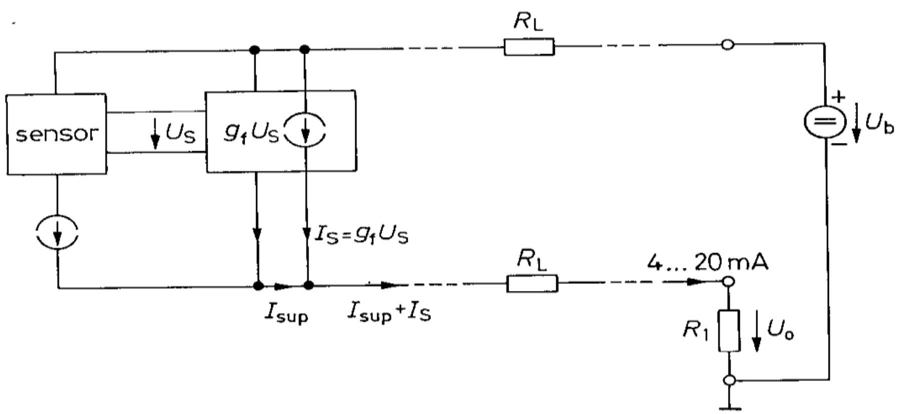


Fig. 26.59 Two-wire current loop for sensor signal transmission. IC types: XTR 101 from Burr Brown or AD 693 from Analog Devices

$$U_o = (I_{sup} + I_S) R_1 = R_1 I_{sup} + R_1 g_f U_S$$

The standard 4-20 mA current loop

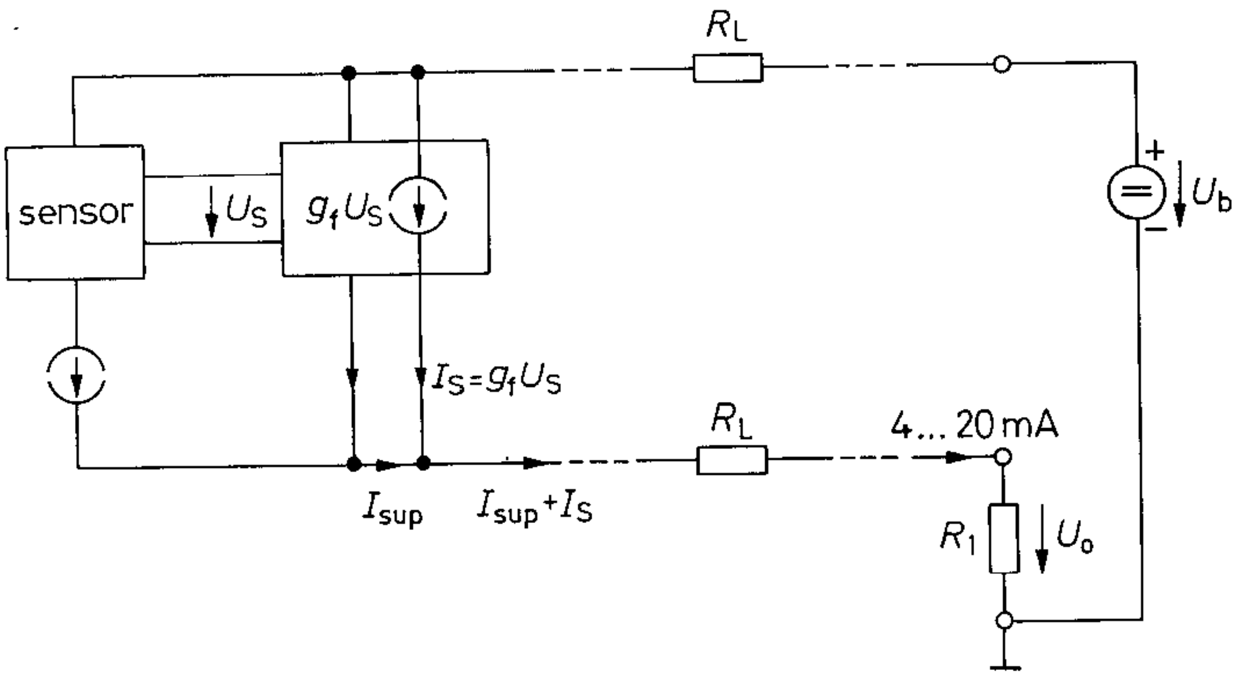


Fig. 26.59 Two-wire current loop for sensor signal transmission.
IC types: XTR 101 from Burr Brown or AD 693 from Analog Devices

$$U_o = (I_{sup} + I_S)R_1 = R_1 I_{sup} + R_1 g_f U_S$$

Active node for a 4-20 mA current loop

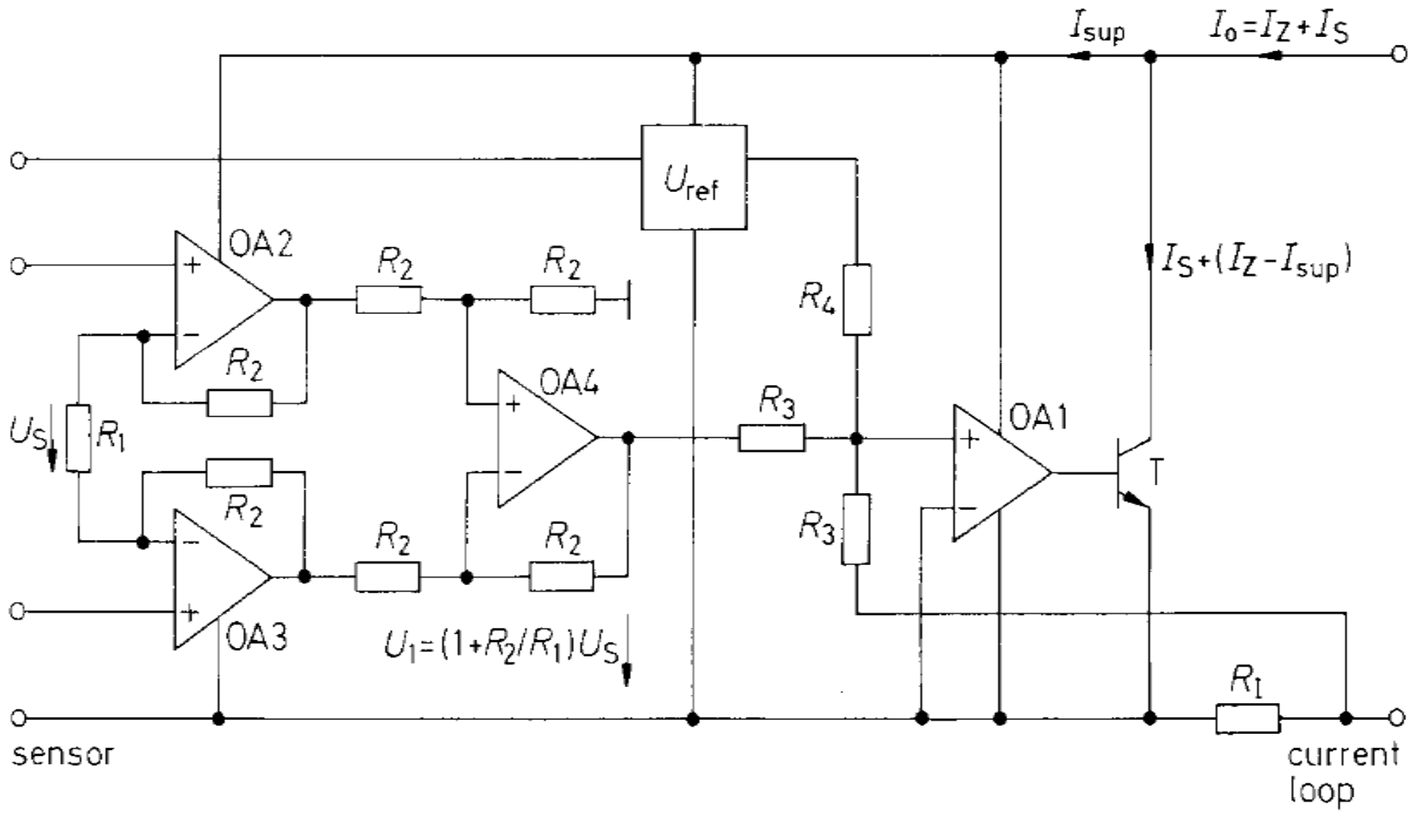


Fig. 26.60 Internal design of a current loop transmitter using the AD 693 from Analog Devices as an example

$$I_o = I_Z + I_S = \frac{R_3}{R_4}\frac{U_{ref}}{R_1} + \left(1 + \frac{R_2}{R_1}\right)\frac{U_S}{R_I}$$

Differential voltage measurements

In many cases Vcm is greater than Vd. Then are necessary op. amp. Featured by :

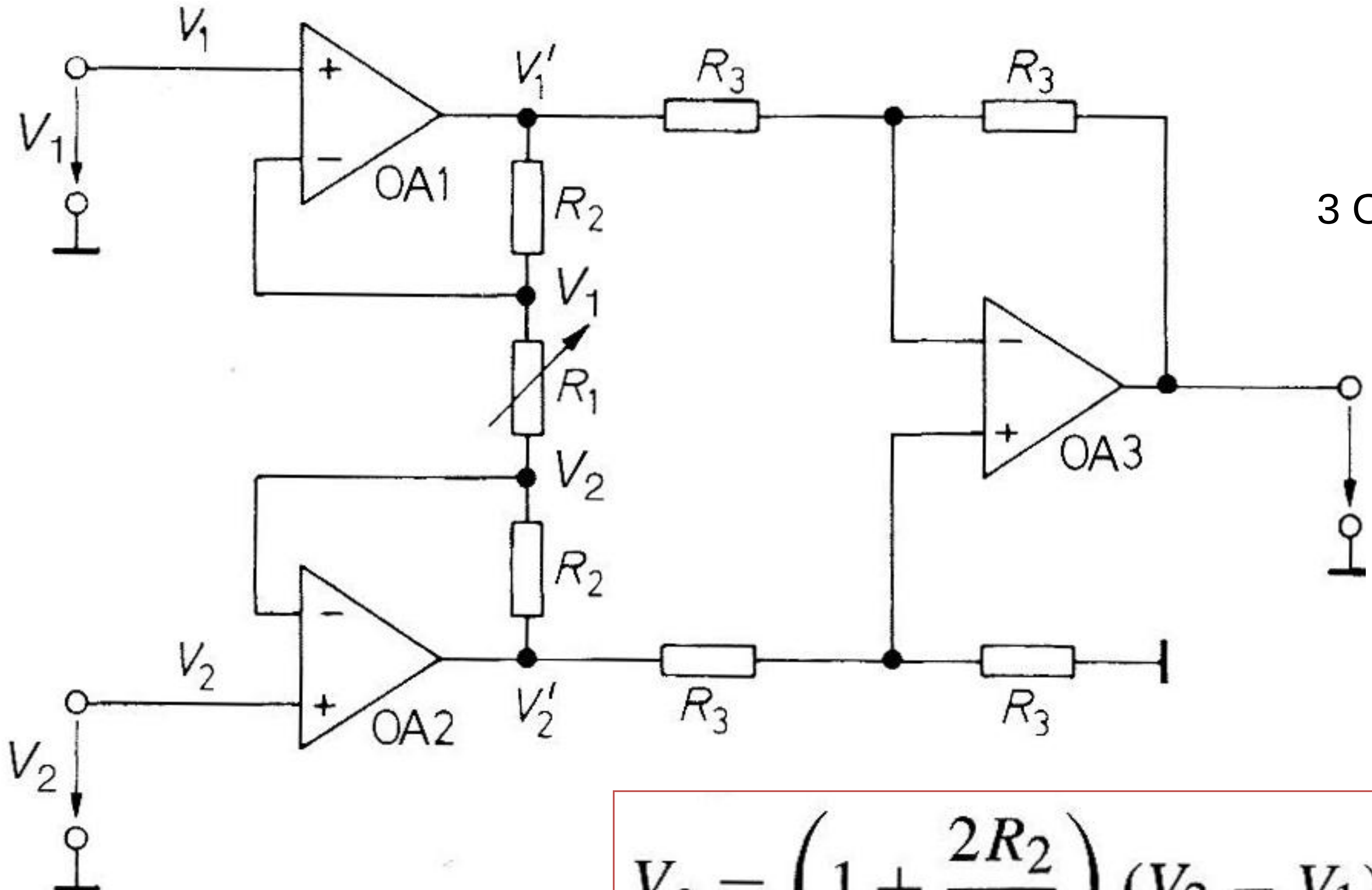
- High CMRR= Ad/Acm (> 80 dB)
- High Vcm range (10-200V)

Possible solutions:

- Subtractors with op. amp. Or differential amplifiers
- Instrumentation amplifiers
- Switched capacitors subtractors*

(Note * : not treated in this course)

Instrumentation Amplifier

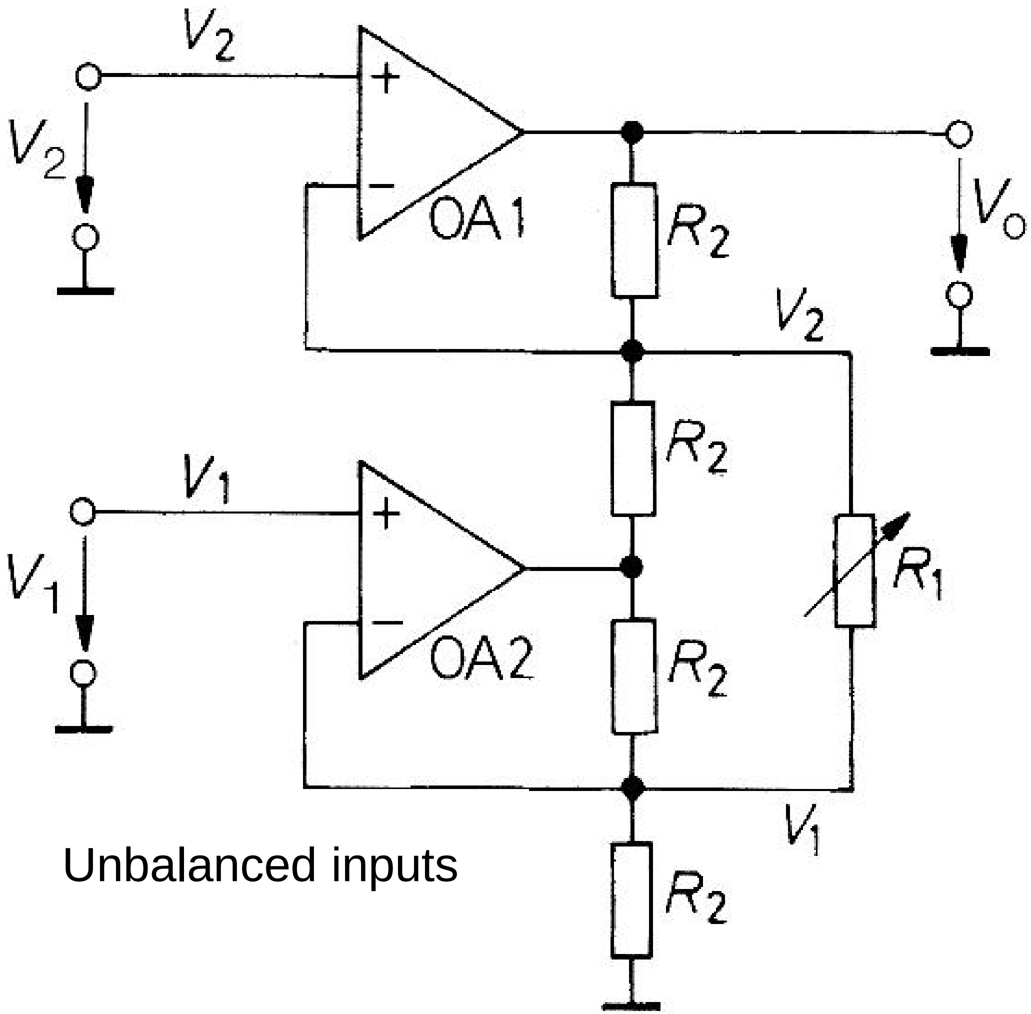


3 OP.AMP.

$$V_o = \left(1 + \frac{2R_2}{R_1}\right)(V_2 - V_1)$$

Balanced inputs,
Common mode gain OA1,OA2 =1

Two op. amp. subtractor



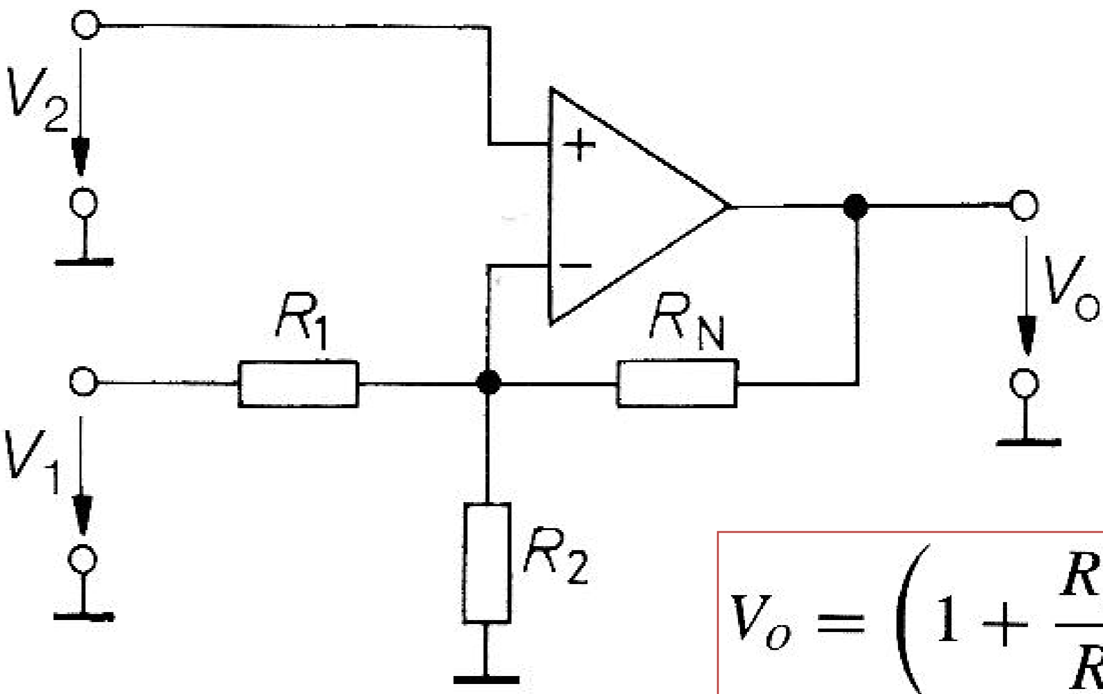
$$V_o = 2\left(1 + \frac{R_2}{R_1}\right)(V_2 - V_1)$$

Unbalanced inputs

2 OP.AMP.

This is a modified version of the electrometer amplifier!

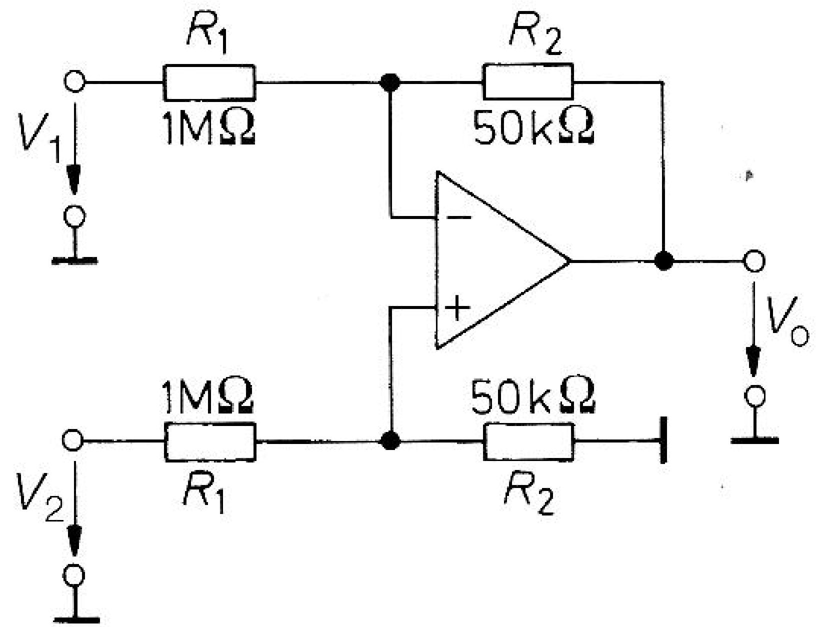
Subtractor with one Hi-Z input

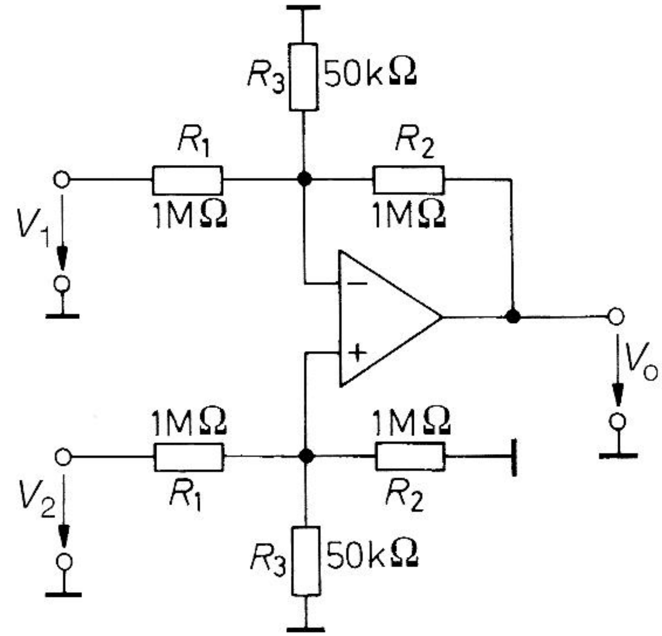


$$V_o = \left(1 + \frac{R_N}{R_1} + \frac{R_N}{R_2}\right) V_2 - \frac{R_N}{R_1} V_1$$

Simplified circuit with one Op Amp
Note : the two gain factors for V2 and V1 are different.

Subtractors for high Voltages





$$V_o = \frac{R_2}{R_1}(V_2 - V_1) = 0.05(V_2 - V_1)$$

$$V_{CM} = \frac{R_2 V_2}{R_1 + R_2} = 0.045 V_2$$

High attenuation for R1>>R2

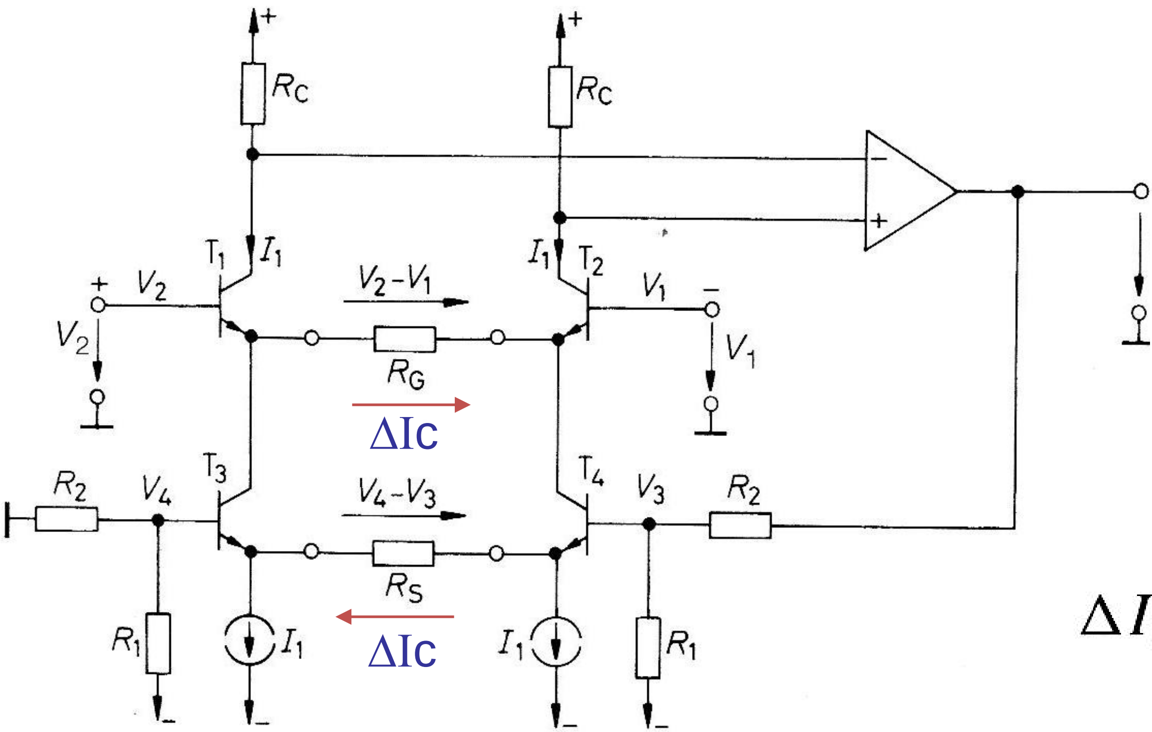
$$V_o = \frac{R_2}{R_1}(V_2 - V_1) = (V_2 - V_1)$$

$$V_{CM} = \frac{R_2|R_3}{R_1 + R_2|R_3} V_2 = 0.045 V_2$$

Good tolerance required for R2//R3

Typical values for V1 and V2 up to 200 V and small |Vcm|<10V

Subtractor with differential amplifier



$$V_o = \left(1 + \frac{R_2}{R_1}\right) \frac{R_S}{R_G} (V_2 - V_1)$$

$$\Delta I_C = \frac{V_2 - V_1}{R_G} = -\frac{V_4 - V_3}{R_S}$$

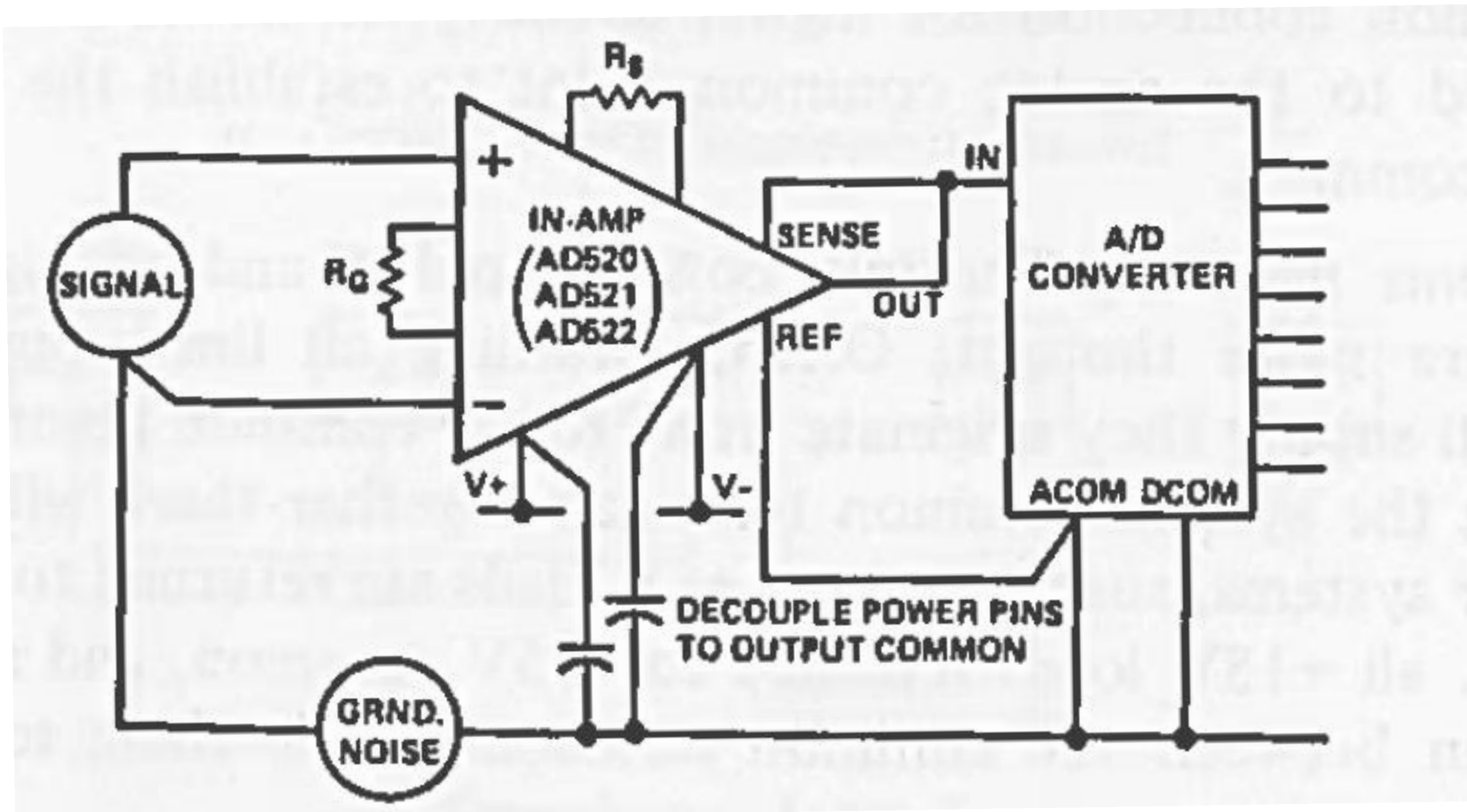
Note: the R1 and R2 pair are matched and fabricated with thick film technology on chip, Rs or Rg are designed for the required gain.
The differential structure allows a good balance of the amplifier and can provide high CMRR also for radiofrequency applications.

Commercial instrumentation amplifiers

Type	Manufacturer	Gain	Offset voltage	Supply voltage	Circuit figure	Pecularity
AD 620	Analog D.	1 . . . 1000	50 µV	±2/±18 V	20.10	cheap
AD 623	Analog D.	1 . . . 1000	100 µV	±3/± 6 V	20.4	RRO
AD 624	Analog D.	1 . . . 1000	25 µV	±6/±18 V	20.5	precision
AD 628	Analog D.	0.01 . . . 100	1000 µV	±2/±18 V	20.8	high V_{CM}
AD 8205	Analog D.	50	2000 µV	+ 5 V	20.10	high V_{CM}
AD 8221	Analog D.	1 . . . 1000	50 µV	±2/±18 V	20.10	high CMRR at RF
AD 8230	Analog D.	10 . . . 1000	5 µV	±4/± 8 V	20.11	autozero
AD 8553	Analog D.	1 . . . 10000	25 µV	+2/+ 5 V	20.4	autozero
LT 1101	Lin. Tech.	10, 100	50 µV	±3/±18 V	20.5	low power
LT 1102	Lin. Tech.	10, 100	200 µV	±5/±18 V	20.5	high speed
LT 1167	Lin. Tech.	1 . . . 10, 000	20 µV	±2/±18 V	20.4	precision
LT 1190	Lin. Tech.	1 . . . 10	800 µV	±2/±18 V	20.9	high V_{CM}
LTC 1100	Lin. Tech.	100	2 µV	±3/ ±9 V	20.5	autozero
LTC 2053	Lin. Tech.	1 . . . 1000	10 µV	±2/± 5 V	20.11	autozero
INA 103	Texas I.	1 . . . 100	50 µV	±9/±25 V	20.4	low noise
INA 106	Texas I.	10	50 µV	±5/±18 V	20.8	cheap
INA 110	Texas I.	1 . . . 500	50 µV	±6/±18 V	20.4	high speed
INA 116	Texas I.	1 . . . 1000	2000 µV	±5/±18 V	20.4	low bias current
INA 118	Texas I.	1 . . . 10, 000	20 µV	±2/±18 V	20.4	low offset voltage
INA 122	Texas I.	5 . . . 10, 000	100 µV	±2/±18 V	20.6	low power, RRO
INA 128	Texas I.	5 . . . 10, 000	50 µV	±2/±18 V	20.4	low offset voltage
INA 131	Texas I.	100	25 µV	±2/±18 V	20.4	accurate, cheap
INA 141	Texas I.	10, 100	20 µV	±2/±18 V	20.4	low offset voltage
INA 148	Texas I.	1	1000 µV	±2/±18 V	20.9	high V_{CM}
PGA 204	Texas I.	1 . . . 1000	50 µV	±5/±18 V	20.4	digit. gain sel.
PGA 207	Texas I.	1 . . . 10	1000 µV	±5/±18 V	20.4	digit. gain sel.

Fig. 20.12. Examples for instrumentation amplifiers. All amplifiers can be operated from a singl
supply voltage

Instrumentation amplifier for high CMRR and ADC interface



The ground noise acts as a common mode and is mitigated by the CMRR of the instrumentation amplifier.

Characteristics of AD620

AD620

Parameter	Conditions	AD620A Min	AD620A Typ	AD620A Max	AD620B Min	AD620B Typ	AD620B Max	AD620S[1] Min	AD620S[1] Typ	AD620S[1] Max	Unit
Common-Mode Rejection											
Ratio DC to 60 Hz with											
1 kΩ Source Imbalance	V_{CM} = 0 V to ± 10 V										
G = 1		73	90		80	90		73	90		dB
G = 10		93	110		100	110		93	110		dB
G = 100		110	130		120	130		110	130		dB
G = 1000		110	130		120	130		110	130		dB
OUTPUT											
Output Swing	R_L = 10 kΩ										
	V_S = ±2.3 V to ±5 V	$-V_S$ + 1.1		$+V_S$ − 1.2	$-V_S$ + 1.1		$+V_S$ − 1.2	$-V_S$ + 1.1		$+V_S$ − 1.2	V
Overtemperature		$-V_S$ + 1.4		$+V_S$ − 1.3	$-V_S$ + 1.4		$+V_S$ − 1.3	$-V_S$ + 1.6		$+V_S$ − 1.3	V
	V_S = ±5 V to ± 18 V	$-V_S$ + 1.2		$+V_S$ − 1.4	$-V_S$ + 1.2		$+V_S$ − 1.4	$-V_S$ + 1.2		$+V_S$ − 1.4	V
Overtemperature		$-V_S$ + 1.6		$+V_S$ − 1.5	$-V_S$ + 1.6		$+V_S$ − 1.5	$-V_S$ + 2.3		$+V_S$ − 1.5	V
Short Circuit Current			±18			±18			±18		mA
DYNAMIC RESPONSE											
Small Signal −3 dB Bandwidth											
G = 1			1000			1000			1000		kHz
G = 10			800			800			800		kHz
G = 100			120			120			120		kHz
G = 1000			12			12			12		kHz
Slew Rate		0.75	1.2		0.75	1.2		0.75	1.2		V/μs
Settling Time to 0.01%	10 V Step										
G = 1−100			15			15			15		μs
G = 1000			150			150			150		μs

Application of AD620 for pressure resistive sensors

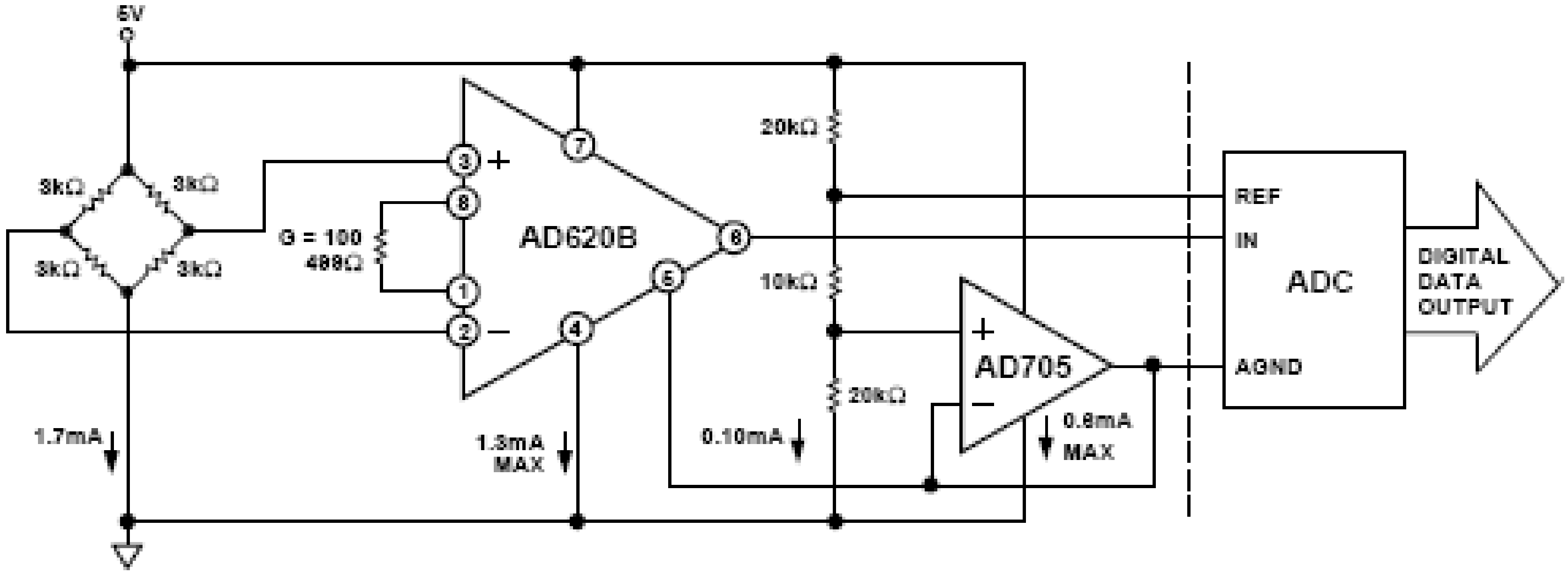
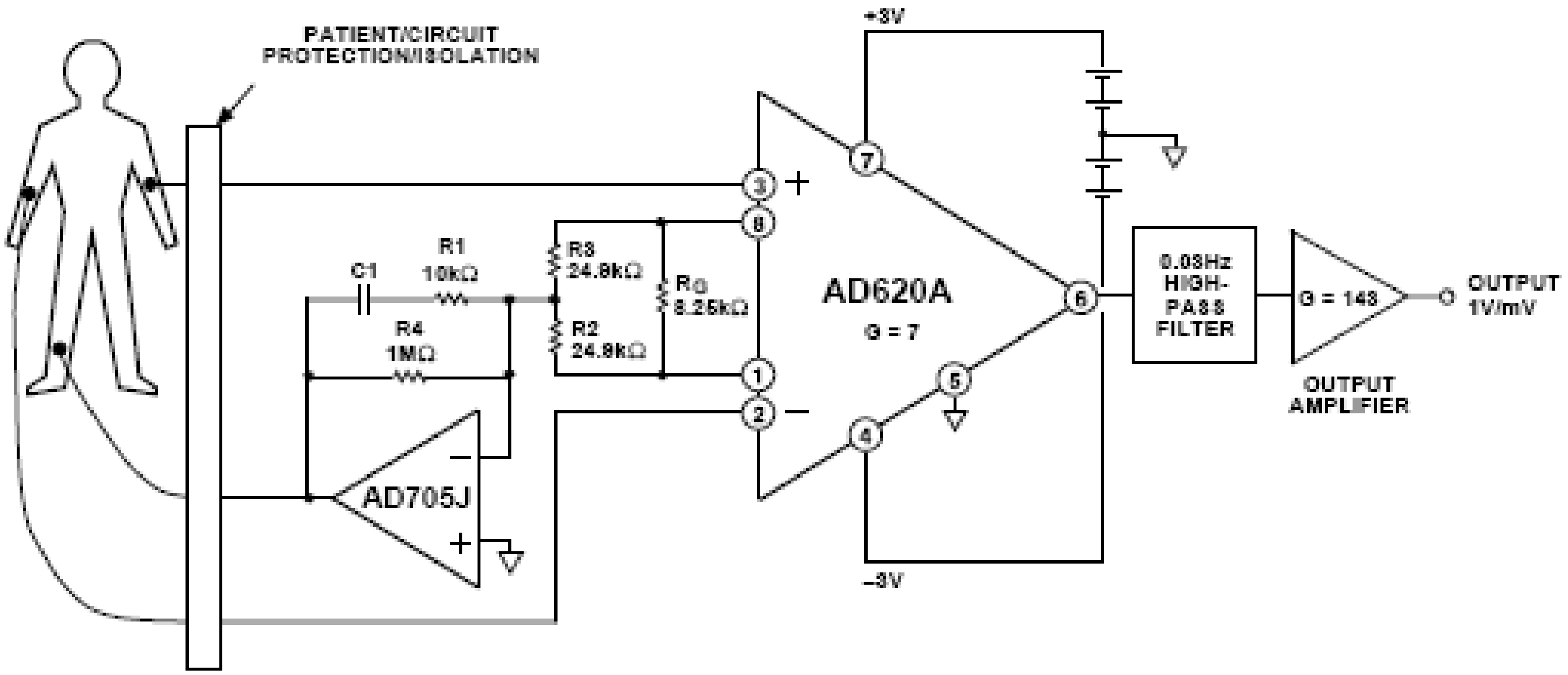


Figure 38. A Pressure Monitor Circuit that Operates on a 5 V Single Supply

Application of AD620 for a medical instrument ECG

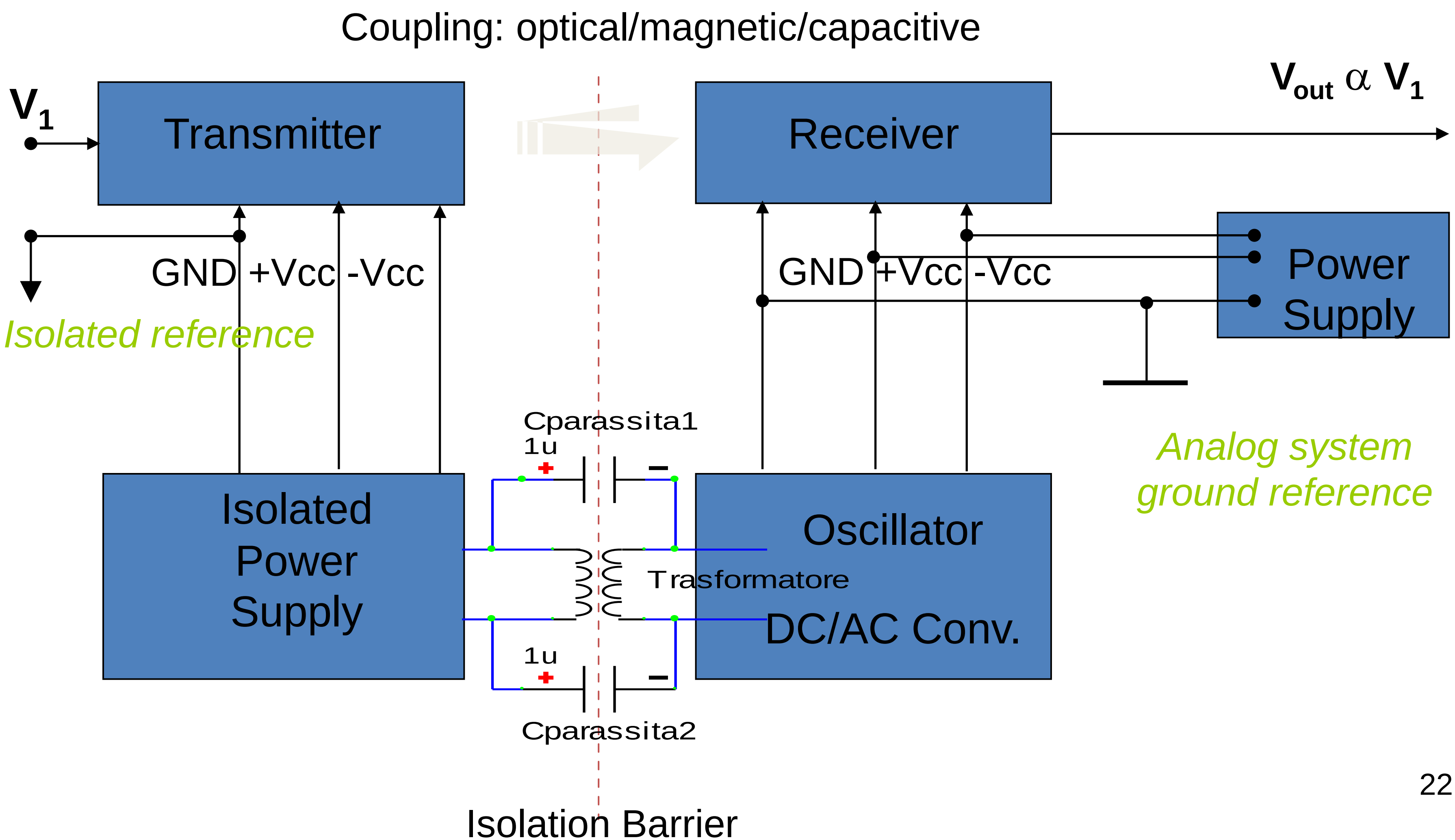


The common mode potential is controlled by an auxiliary amplifier that is connected to the leg electrode of the patient. Isolation circuits are needed if the instrument if the power supply is connected to the main.

Isolated transmission of signal

The galavanic isolation method is used when voltage differences are superimposed to very high common mode voltages in order of 100 - 1000 V, well above the absolute maximum rating voltages of integrated instrumentation amplifiers.

Block scheme of a galvanic isolated analog system



Galvanic Isolation

The galvanic isolation is adopted to obtain high CMRR at board design level. The sensors front-end can be isolated from the measuring circuit or ADC by ground references separation. This can be obtained by coupling the transmitting and receiving circuits with:

1. Optical coupling (LED and photodiode)
2. Magnetic coupling (transformer)
3. Electrostatic coupling(capacitors)

The isolated section of the analog system requires an isolated power supply obtained with switching power supply (DC-DC converters) or battery powered.

Static common mode voltage

In some cases the DC component of the common mode voltage ($V_{CM(DC)}$) is high and adequate insulating materials must be adopted to withstand the electric field. The minimum distance D_{min} between the isolated sections of the board or the device can be calculated:

$$D_{min} = V_{CM(DC)} / E_c$$

Where *Ec* is the *dielectric rigidity* of the material :

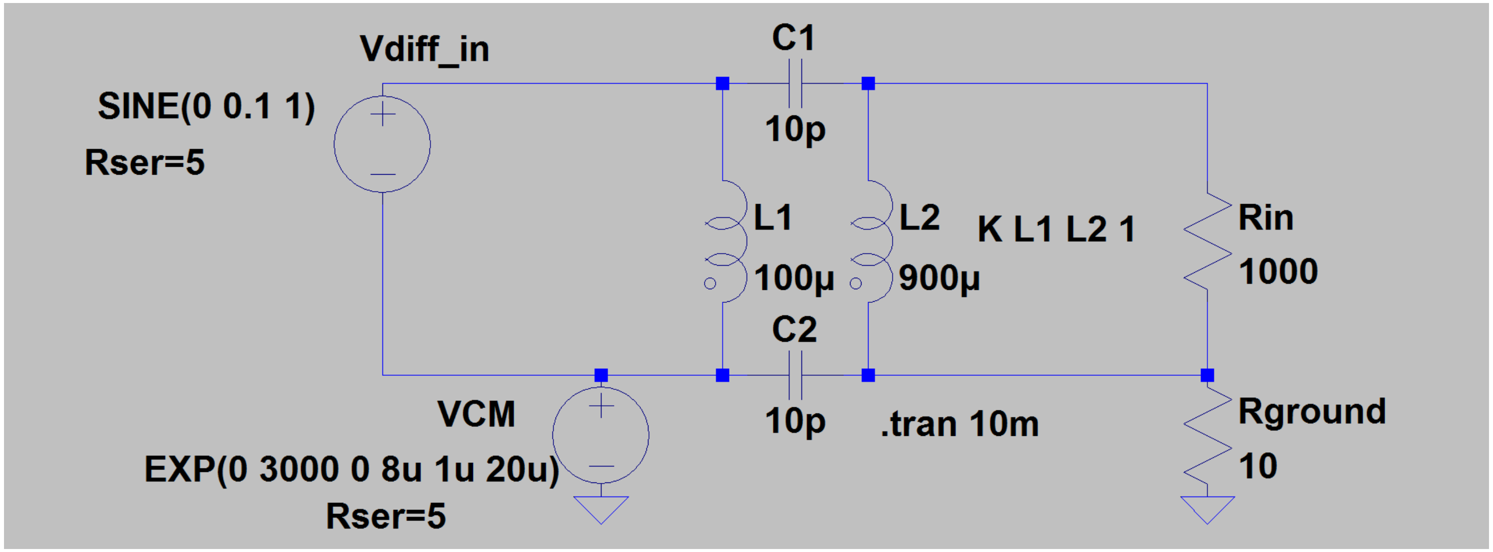
Air	*Ec*=30 kV/cm
Mica	*Ec*=2000 kV/cm
Teflon (PTFE)	***Ec*=300-400 kV/cm**
Polymide	***Ec*=2910 kV/cm**
Ceramic	***Ec*=3500 kV/cm**

Used in hybrid microcircuits

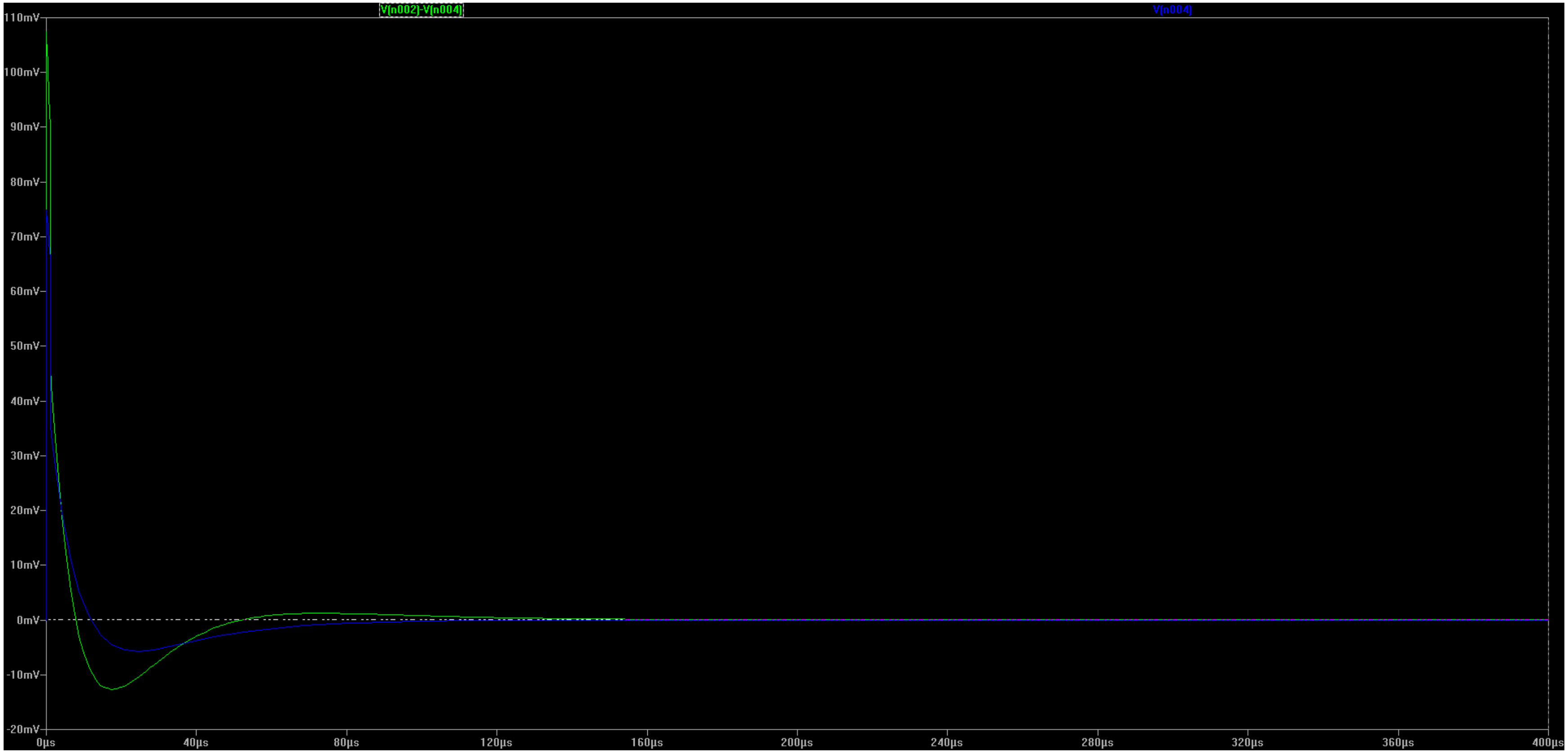
Dynamic common mode voltages

For transient of common mode voltages the magnetic transformer can be used but the effect of parasitic capacitances across the primary and secondary windings must be considered.

Example: Vcm: 3 kV peak, rise time 8 µs, Duration 1 µs, fall time 20µs, V_diff= 100 mV, 1 kHz



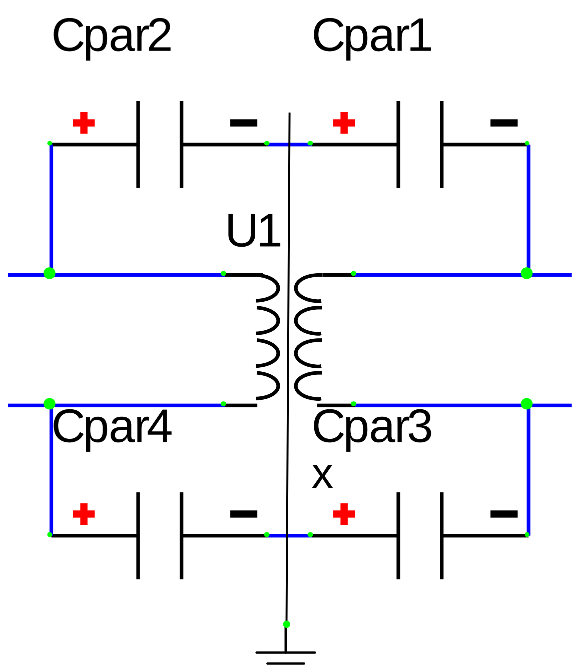
Differential voltage output

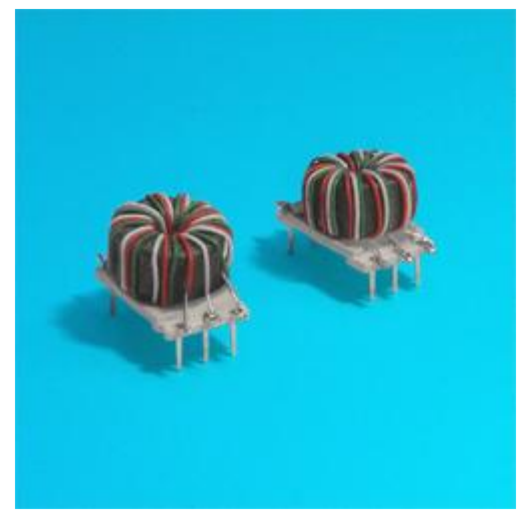


Transient noise of 120 mV pp and 160 us duration

Mitigation of the effects of parasitic capacitances of magnetic transformers

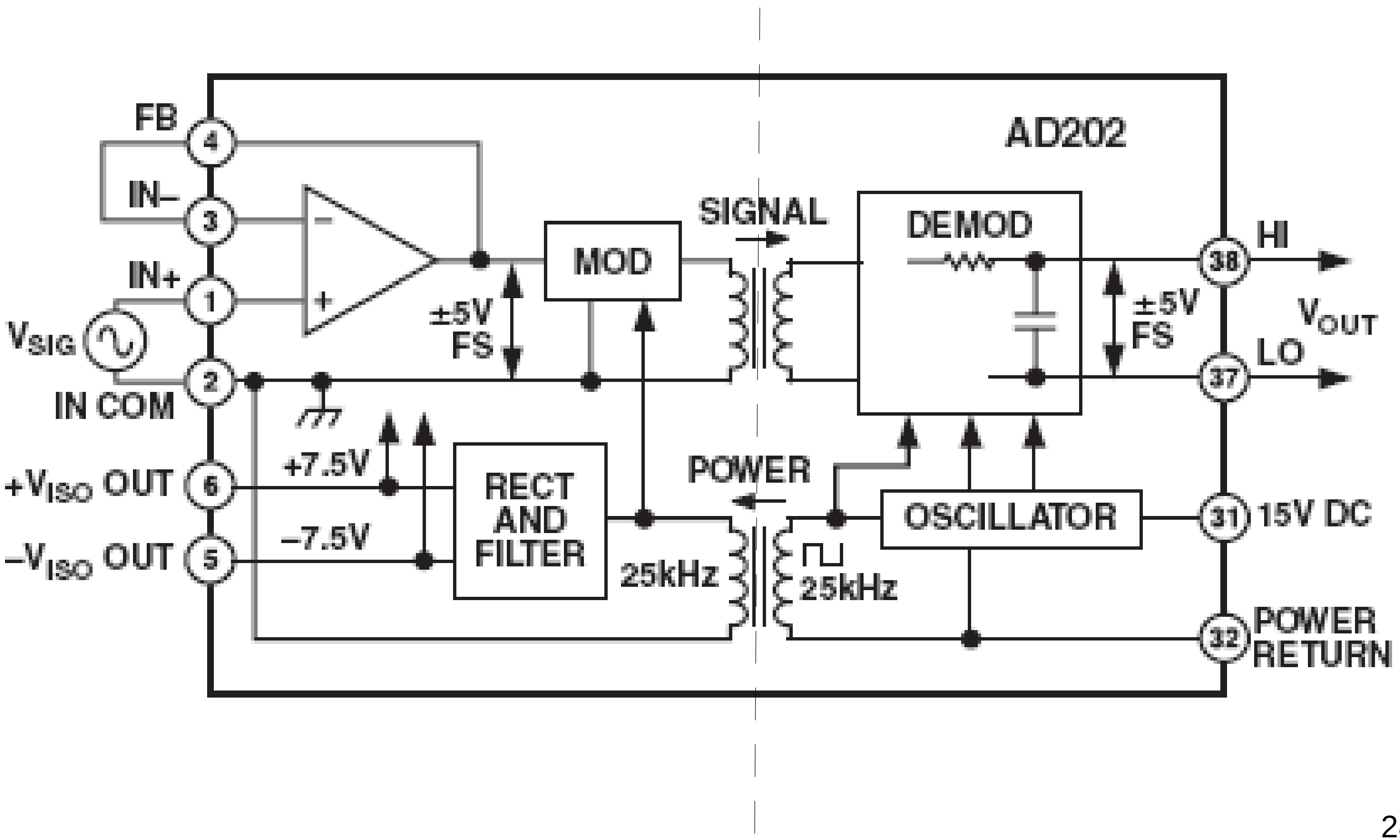
The parasitic capacitances can be reduced to about 10 pF by using toroidal transformer with shielded windings.





http://www.coilcraft.com/

Block scheme of Isolation Amplifier AD 202

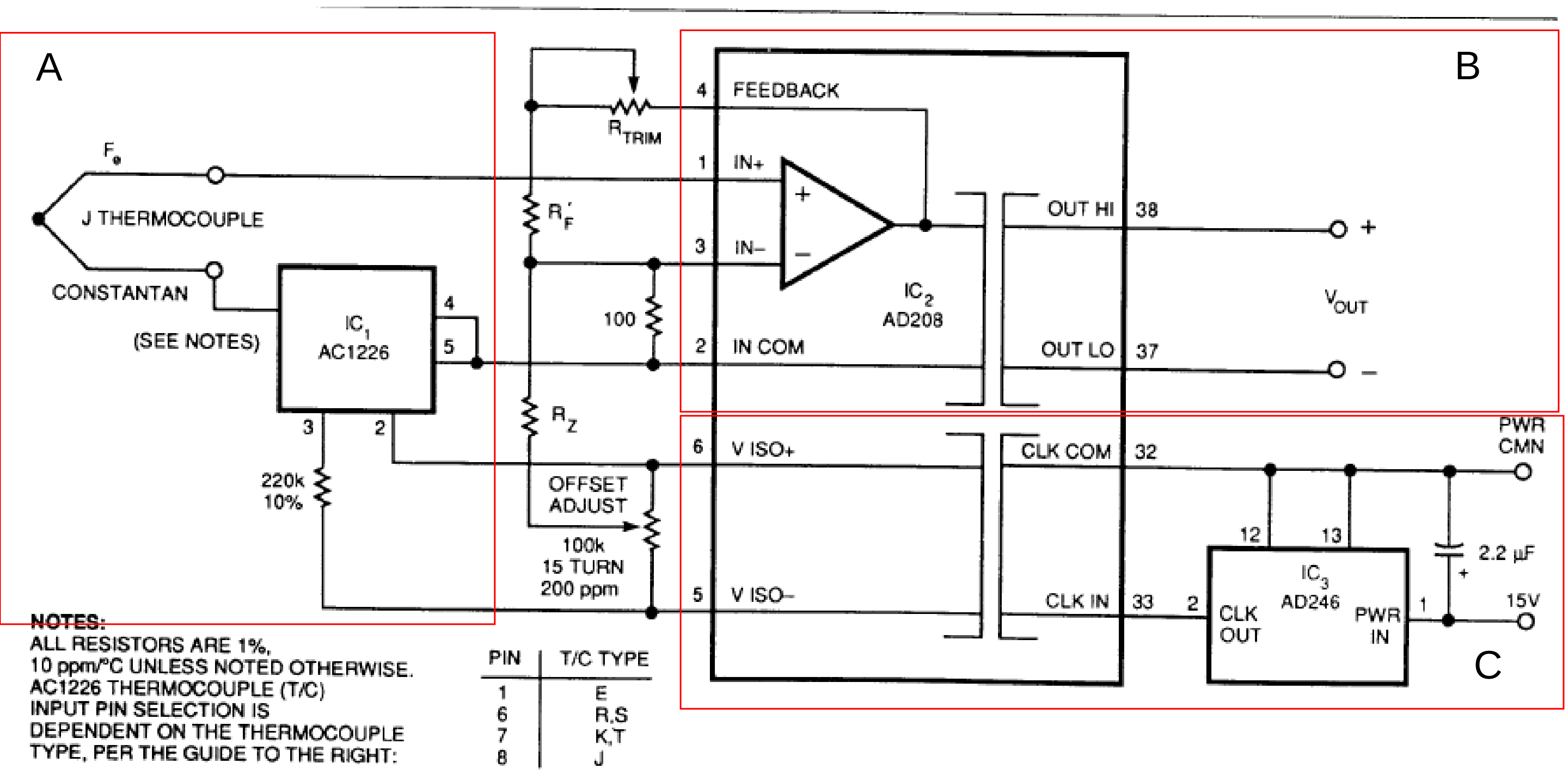


Comparison of Isolation Amplifiers

Type	Manufacturer	Signal transmission	Isolated power	Power bandwidth	Isolation voltage	Peculiarity
AD 202	Analog D.	transformer	for input	3 kHz	750 V	cheap
AD 210	Analog D.	transformer	input+output	20 kHz	2500 V	3 port isolation
AD 215	Analog D.	transformer	for input	120 kHz	1500 V	fast
ISO 103	Texas I.	capacitor	for input	10 kHz	1500 V	complementary power supply
ISO 113	Texas I.	capacitor	for input	10 kHz	1500 V	
ISO 122	Texas I.	capacitor	external	3 kHz	1500 V	cheap
ISO 124	Texas I.	capacitor	external	32 kHz	1500 V	cheap
HCPL 7510	Agilent	optocoupler	external	15 kHz	1500 V	iso: 15 kV/µs
HCPL 788J	Agilent	digit. opto	external	3 kHz	1500 V	iso: 15 kV/µs

Fig. 20.15. Examples for isolation amplifiers. Examples for isolated power supplies are the DCP 02-series from Texas Instruments or the HPR100-series from Power Convertibles

Thermocouple with isolation amplifier



A: Thermocouple Sensor and signal conditioning ; B: output ; C: power supply

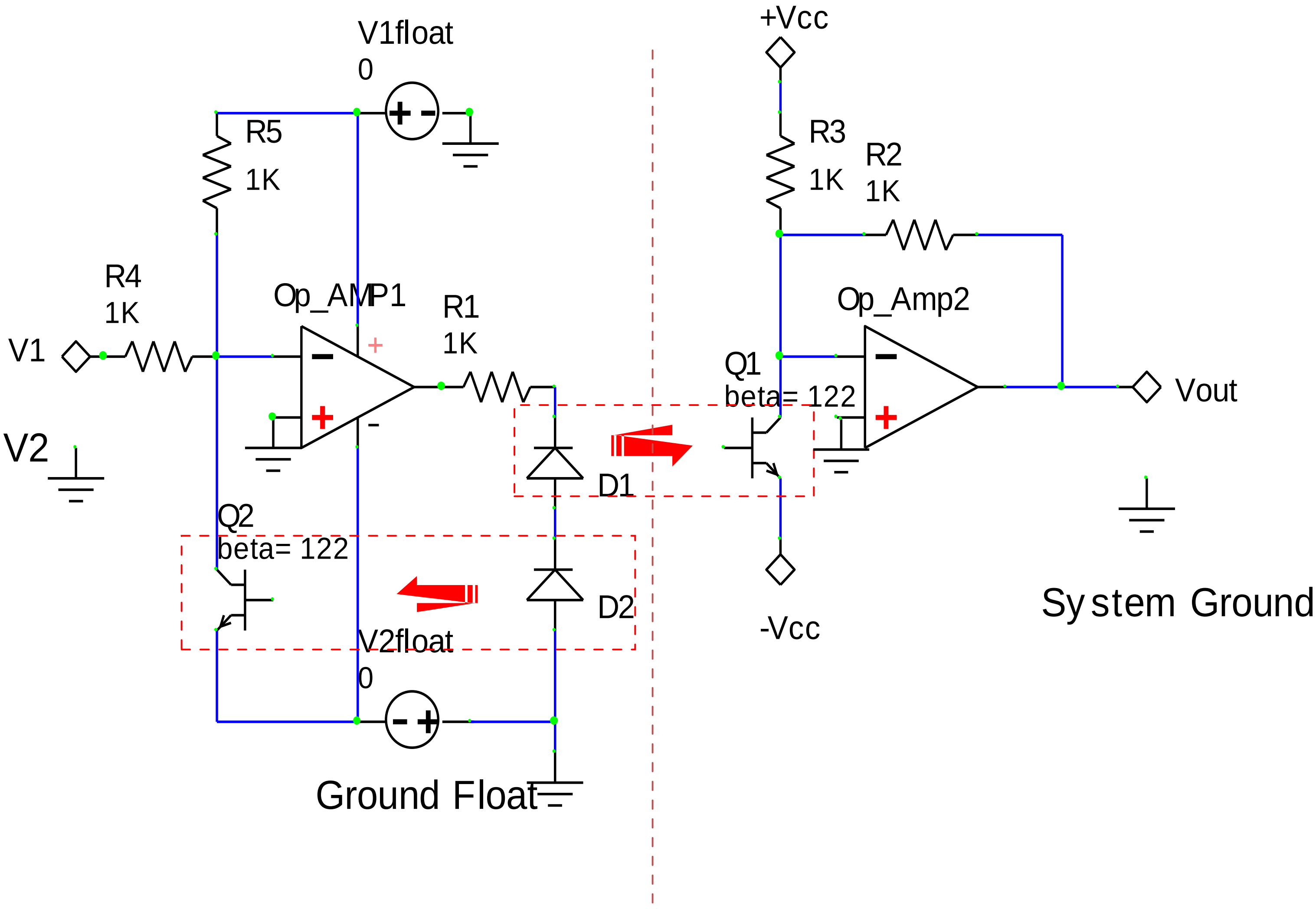
Ref: Data sheet Analog Devices – Isolation_Amplifier.pdf

Analog signal transmission by isolated optical coupling (1 of 3)

For the transmission of an analog signal an optical channel can be used to obtain high level of isolation. The voltage signal can drive a LED by a voltage to current (V to I) converter.

The non linear characteristic response of the LED *I=f(V)* needs to be corrected to avoid signal distortion and loss of information. Integrated optocouplers with negative feed back loop can provide linear response.

Schematic with optical couplers (2 of 3)



Transfer function (3 of 3)

$$Ic_{Q2} = \frac{V_{1float}}{R5} + \frac{V_1 - V_2}{R4} = \frac{V_{1float}}{R5} + \frac{V_1}{R4}$$

$$Ic_{Q1} = \frac{+Vcc}{R3} + \frac{Vout}{R2}$$

$$hp)\ Ic_{Q1} = Ic_{Q2}$$

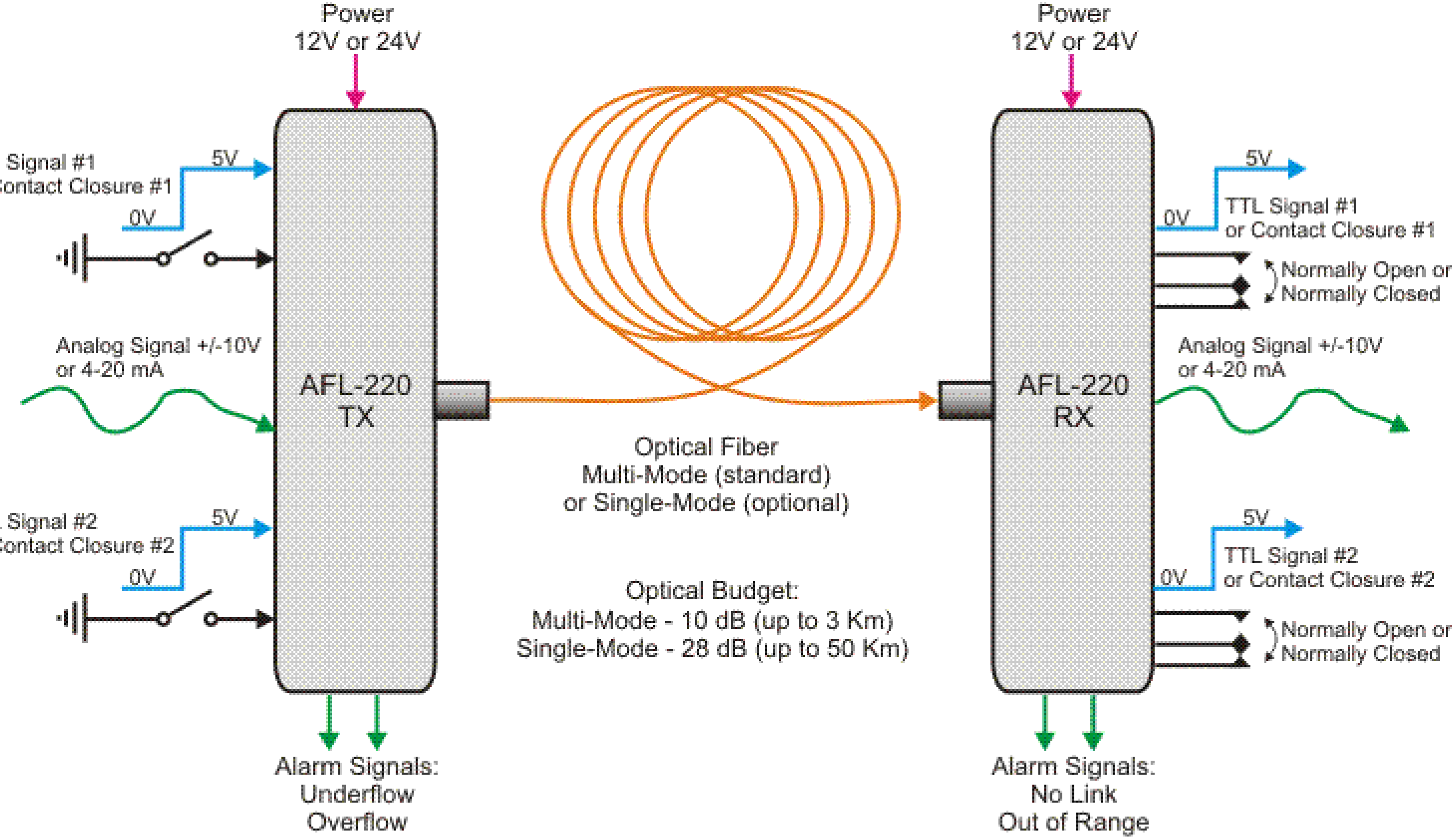
$$Moreover \quad if \ \frac{+Vcc}{R3} = \frac{V_{1float}}{R5} \ , then:$$

$$Vout = \frac{R2}{R4}(V_1 - V_2) = \frac{R2}{R4}V_1$$

$$hp) V_2 = 0$$

Transmission of voltage signals with long range connections

To mitigate the EMI for long range connections in harsh environments, the transmission channel can be fully optical, like optical fibers. With this solution isolation amplifier are not needed but local power supply system must be provided for the sensors and the front end.



Digital Modulation of a sensor signal with a Voltage to Frequency converter

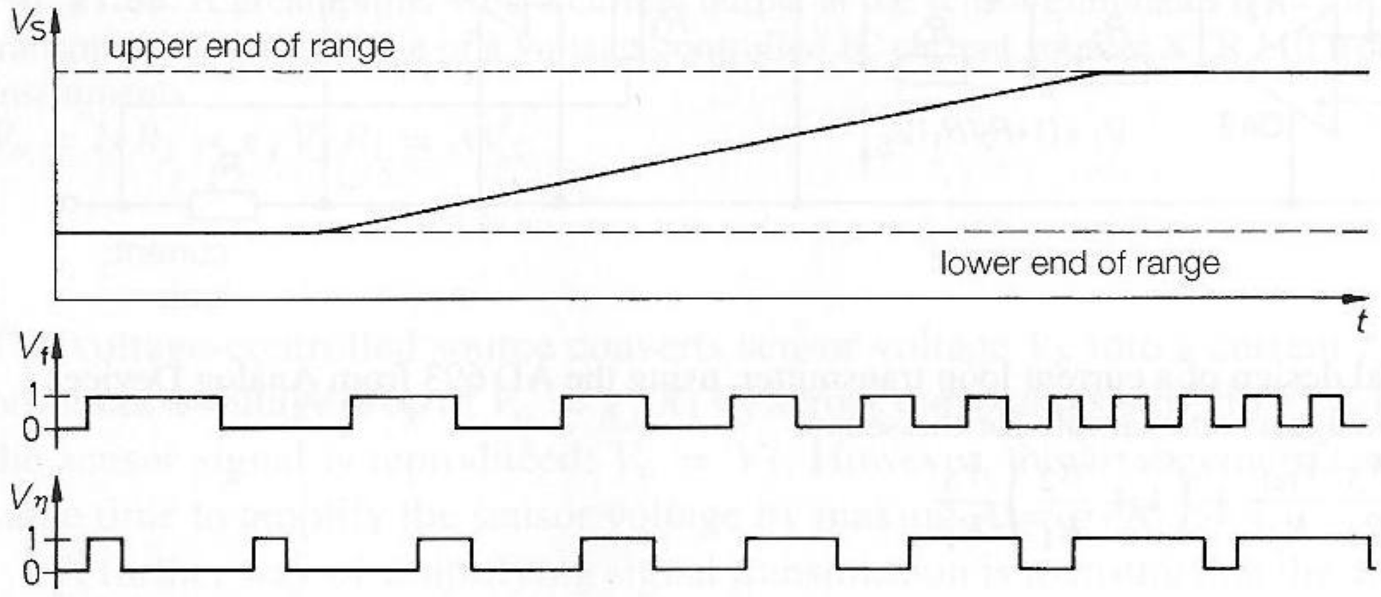


Fig. 21.62. Digital modulation of a sensor signal.
(*upper*): The analog sensor signal
(*middle*): voltage-to-frequency conversion
(*bottom*): voltage-to-duty factor conversion

V/F and F/V converters

The analog input voltage signal is converted in a frequency modulated square wave. The frequency (f_{osc}) of the square wave is proportional to the instantaneous input voltage amplitude.
The square wave drive the transmitting LED (or laser diode) .

The ideal Voltage to frequency converter function is:

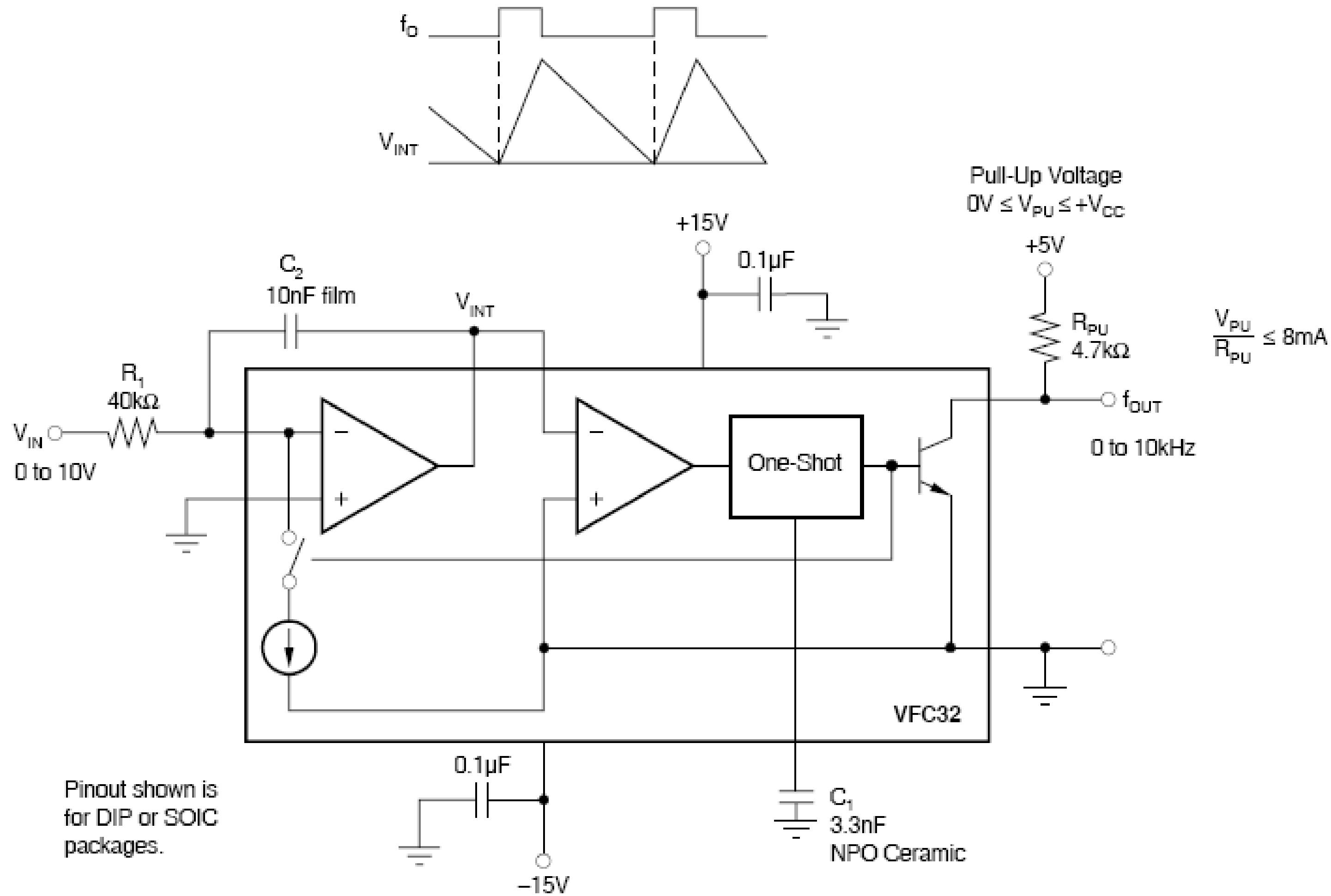
$$f_{osc}(t) = k\, V_1(t)$$

Where $V_1(t)$ is the input voltage. This circuit belong to the broad class of circuit called VCO (Voltage controlled Oscillator).
At the end of the fiber optic the voltage amplitude is restore with a inverse function that is a Frequency to voltage converter.

Main design issues for V/F and F/V converters are:

- Input dynamic voltage range
- Bandwidth
- Linearity
- Power consumption

Voltage to Frequency converter

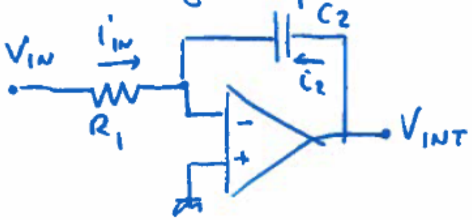


VFC32 TI data sheet : http://www.ti.com/lit/ds/symlink/vfc32.pdf

Voltage to Frequency converter

We assume a steady-state condition with $V_{IN}(t) \simeq$ const.
The voltage amplitude determines the output square wave frequency.

①



(see Figure 1 of VCF32 data sheet)

$$i_{IN} = \frac{V_{IN}(t)}{R_1}$$

$$i_2 = -i_{IN} = C_2 \frac{dV_{INT}}{dT}$$

$$-\frac{V_{IN}}{R_1} = C_2 \frac{dV_{INT}}{dT} \Rightarrow -\frac{V_{IN}}{R_1 C_2} = \frac{dV_{INT}}{dT} \Rightarrow$$

$$\Rightarrow -\int_0^{t_x} \frac{V_{IN}}{R_1 C_2}\, dt = \int_0^{t_x} dV_{INT}$$

$$\boxed{V_{PEAK} = +V_{IN} \frac{t_x}{R_1 C_2}}$$

hp) During t_x the switch is open

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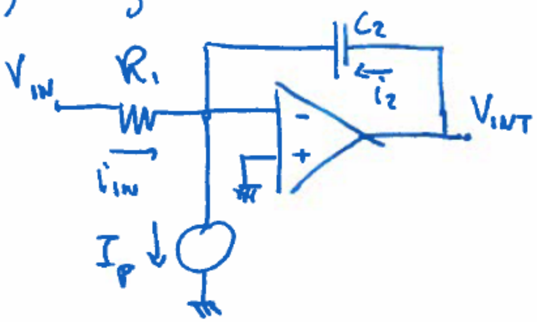
② hp) During t_{os} the switch is closed



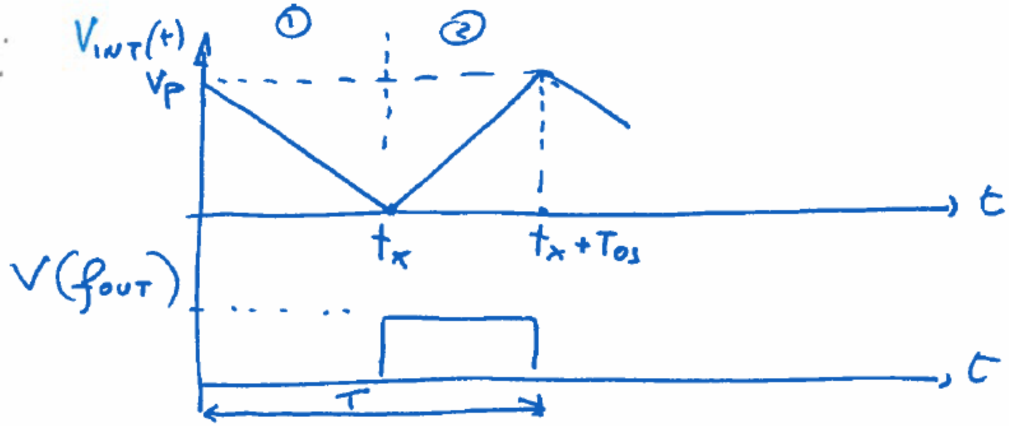
$$i_2 + i_{IN} = I_p \Rightarrow i_2 = I_p - i_{IN} = C_2 \frac{dV_{INT}}{dT}$$

$$\int_{T_x}^{T_x+T_{os}} \left(\frac{I_p}{C_2} - \frac{V_{IN}}{R_1 C_2} \right) dt = \underbrace{V_{INT}(T_x + t_{os})}_{V_p} - \underbrace{V_{INT}(T_x)}_{0V!}$$

$$V_p = \left[\frac{I_P}{C_2} - \frac{V_{IN}}{R_1 C_2} \right] t_{os} \quad > 0$$

because I_p is designed to be greater than $\frac{V_{IN}}{R_1 C_2}$

Voltage to Frequency converter



In steady state condition the $\Delta V_C(2) = \Delta V_C(1) = V_P$
We can equal the two voltage variation to find the relationship between V_{IN} and f_{OUT}.

$$V_{IN}\frac{t_x}{R_1 C_2} = \left(\frac{I_P}{C_2} - \frac{V_{IN}}{R_1 C_2}\right) t_{os} \Rightarrow \frac{V_{IN}}{R_1}\left(t_x + t_{os}\right) = I_P t_{os}$$

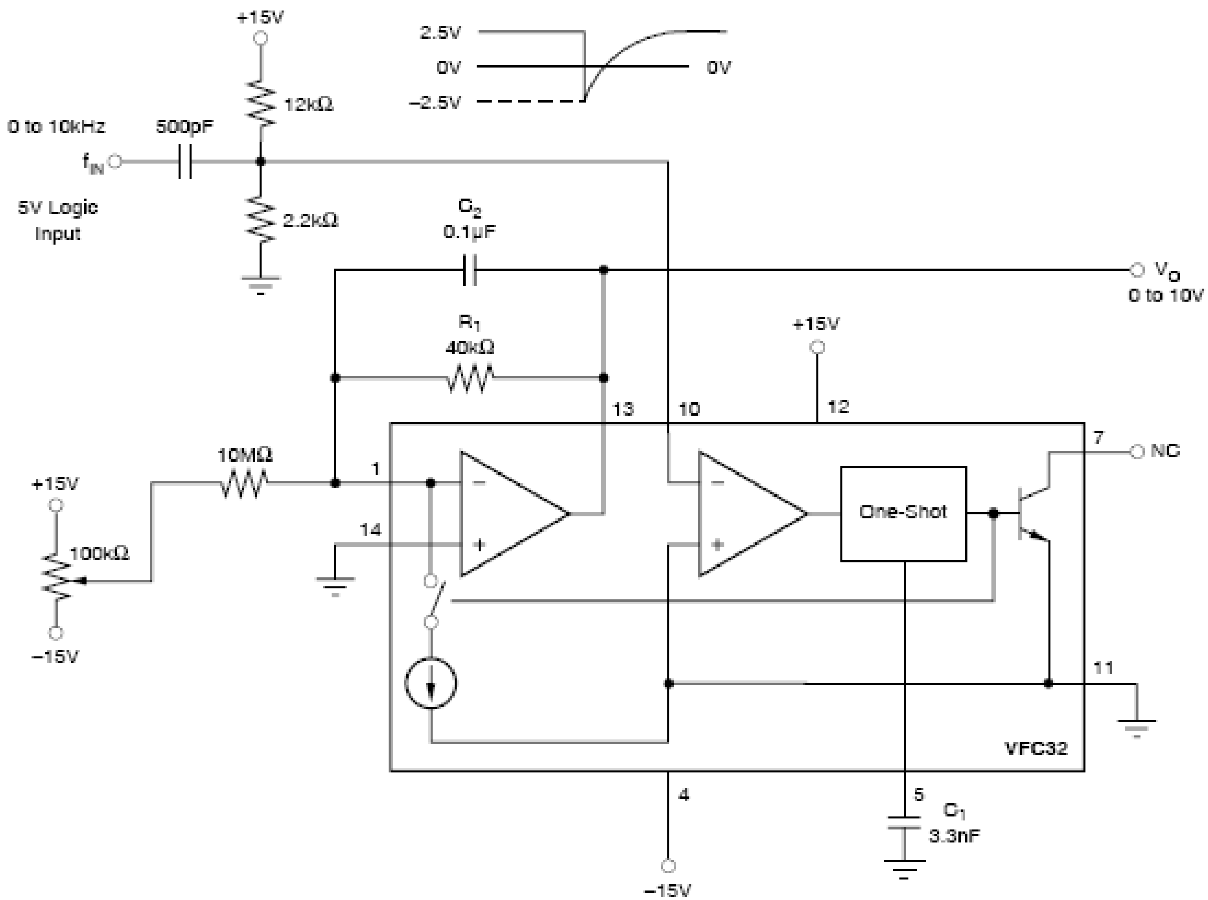
$$\Rightarrow \frac{V_{IN}}{R_1} T = I_P t_{os} \Rightarrow \frac{V_{IN}}{R_1}\frac{1}{f_{OUT}} = I_P T_{os}$$

$$V_{IN} = I_P t_{os} R_1 f_{OUT}$$

$$f_{OUT} = V_{IN}\frac{1}{I_P t_{os} R_1}$$

- $V_{IN} = f(f_{OUT})$
- $R_1 = \frac{V_{FS}}{0.25mA} \leftarrow i_1$ determines the full range.
- t_{os} depend from R_1 and C_2
- $I_P = 1mA$ (precision current generator in VCF32)

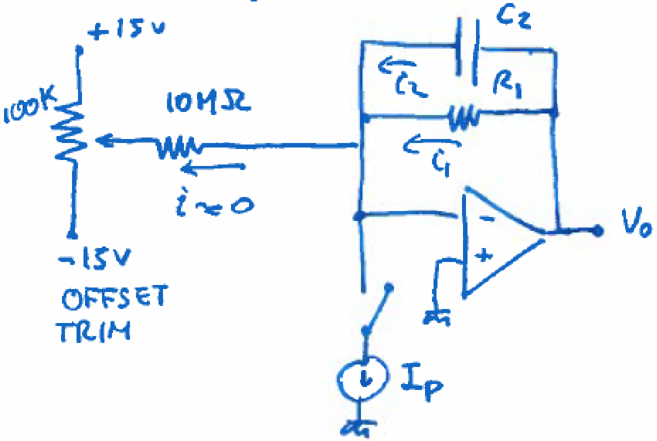
Frequency to Voltage converter

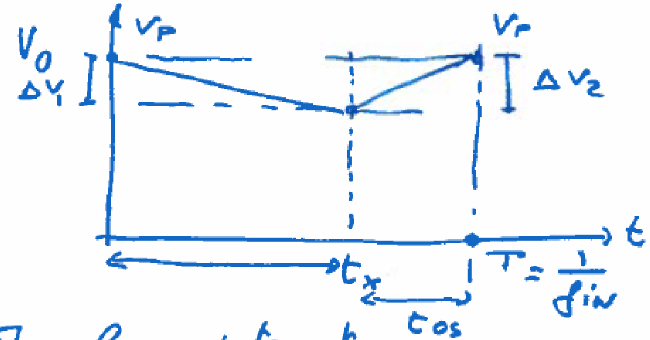


For each pulse, the capacitor charging is activated with a constant current for a predetermined time. The discharge constant is designed according to the value of the frequencies to be converted. The average value of the voltage on the capacity depends linearly on the frequency of the input pulses.

Frequency to Voltage converter

(see Figure 4 of VCF32 data sheet)





The lossy integrator has two operating condition depending on the one-shot circuit is on or off.

① One-shot OFF

We assume a linear discharge of C_2 as $R_1 C_2 \gg T$

$$V_0 = V_p \left(e^{-t/R_1C_2}\right) \simeq V_p \left(1 - \frac{t}{R_1 C_2}\right) \Rightarrow \boxed{\Delta V_1 = \frac{V_p}{R_1 C_2} t_x}$$

② One-shot ON

$$I_p = i_1 + i_2 = \frac{V_0}{R_1} + C_2 \frac{dV_0}{dt} \Rightarrow \frac{I_p}{C_2} - \frac{V_0}{R_1 C_2} = \frac{dV_0}{d\tau}$$

$$\int_{t_x}^{t_x + \tau_{os}} \left(\frac{I_p}{C_2} - \frac{V_0}{R_1 C_2}\right) d\tau = V(t_x + \tau_{os}) - V(t_x) = \Delta V_2$$

$$\Delta V_2 = \frac{I_p}{C_2} t_{os} - \frac{V_p}{R_1 C_2} t_{os}$$

Frequency to Voltage converter

By equating $\Delta V_1 = \Delta V_2$, the relationship between f_{in} and V_{OUT} can be obtained in a steady-state regime:

$$\frac{V_P}{R_1 C_2}(t_{os} + t_x) = \frac{I_P}{C_2} t_{os}$$

$$\frac{V_P}{R_1} T = I_P t_{os} \Rightarrow \frac{1}{f_{IN}} V_P = I_P T_{os} R_1$$

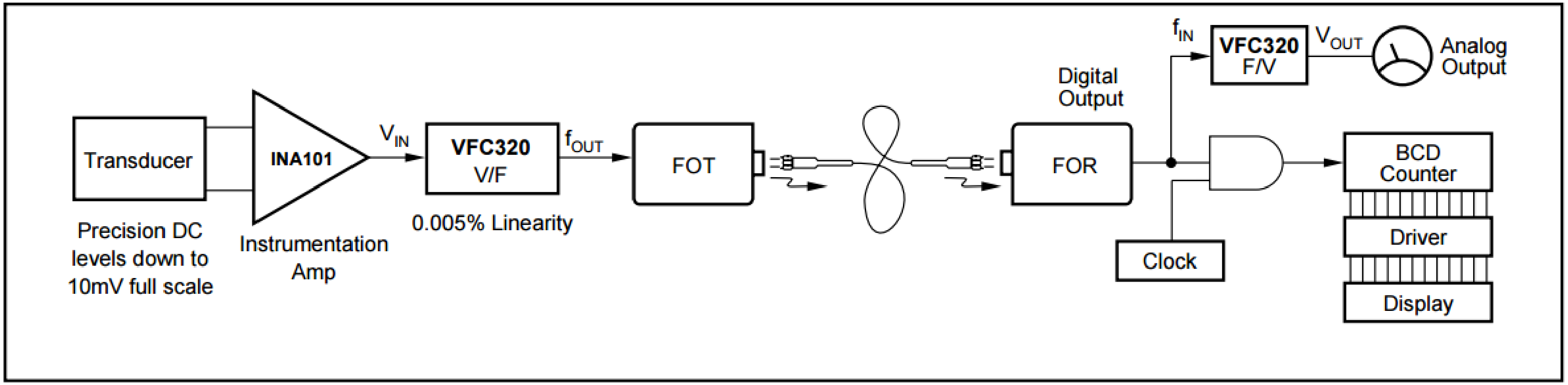
$$\boxed{V_P = (I_P T_{os} R_1) f_{IN}}$$

The f_{IN} activates the one-shot, and increasing f_{OUT} the V_P increases proportionally.

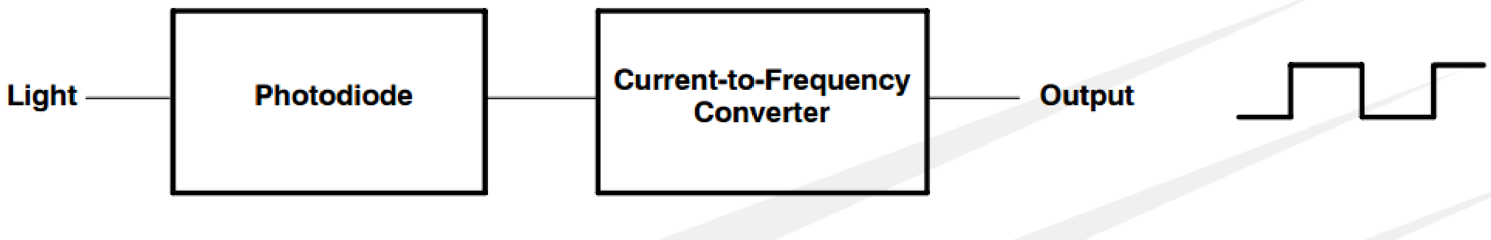
The fabrication of an accurate V/F or F/V converter requires passive components with values accurate and stable over time (aging) and temperature (temperature coefficient)

For example R_1 in thin film technology and C_1 high quality ceramic capacitor.

Remote Transducer Readout via Fiber Optic Link with analog and digital output



Typical applications of F/V converter with sensors



The integrated light-to-frequency converter outputs a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance).

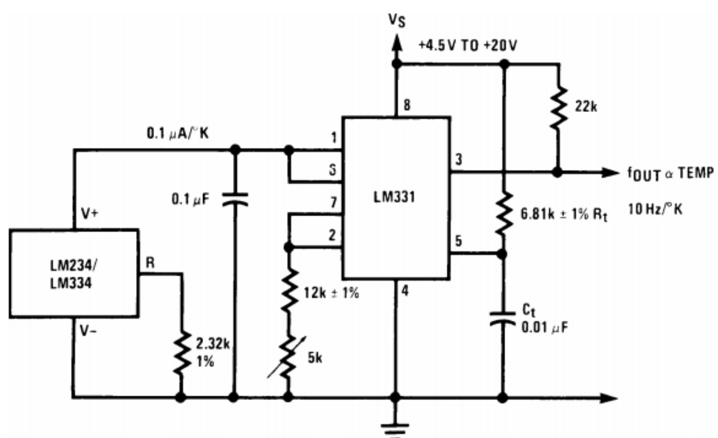
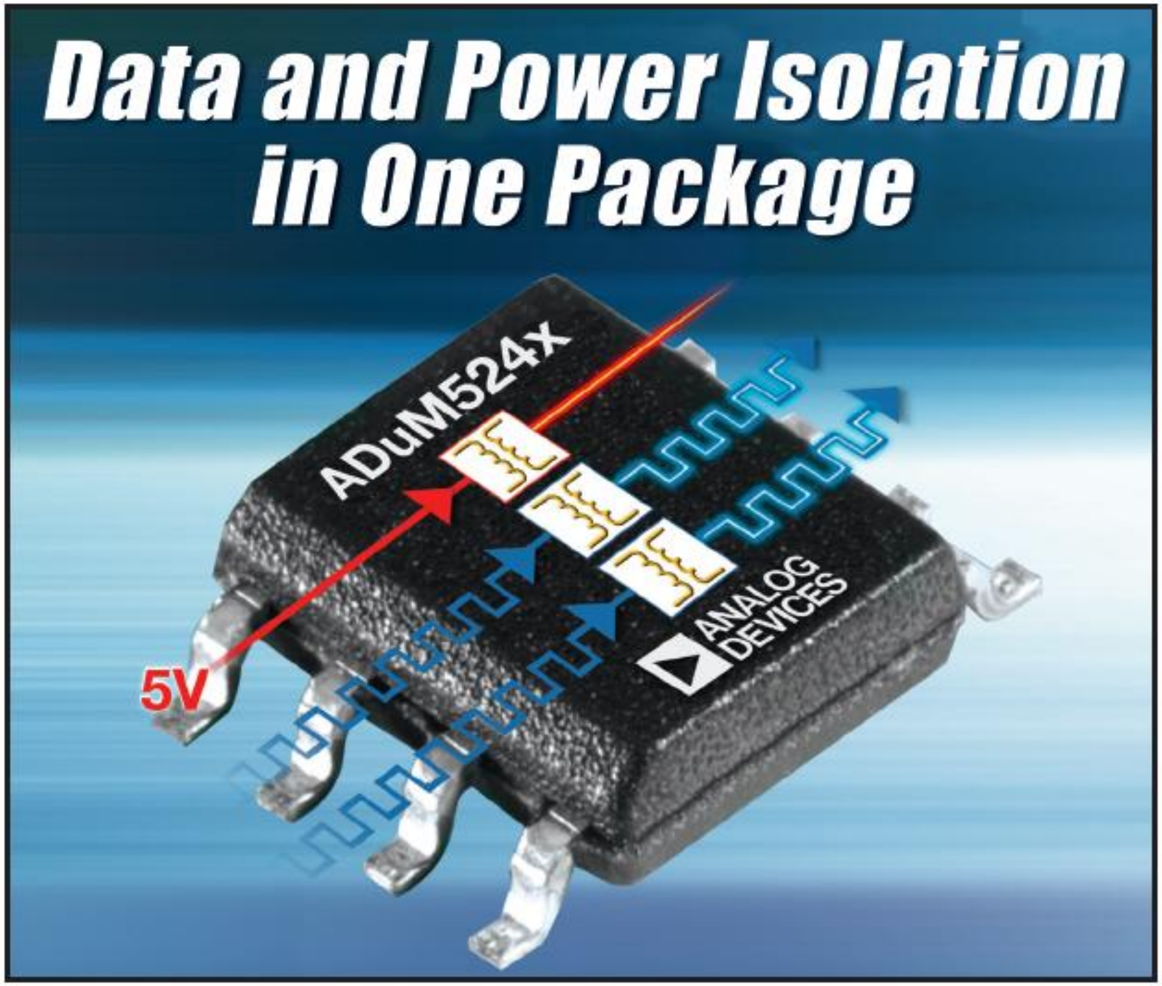


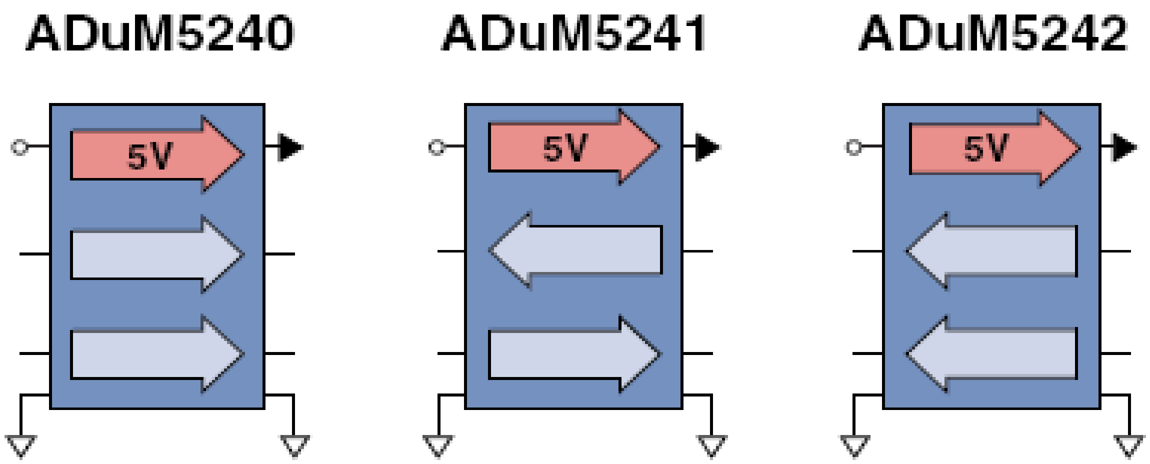
Figure 21. Temperature to Frequency Converter

Isolated digital systems with on-chip microtransformer



Ref: Data sheet Analog Devices – ADuM524x.pdf

Isolated digital systems with on-chip microtransformer



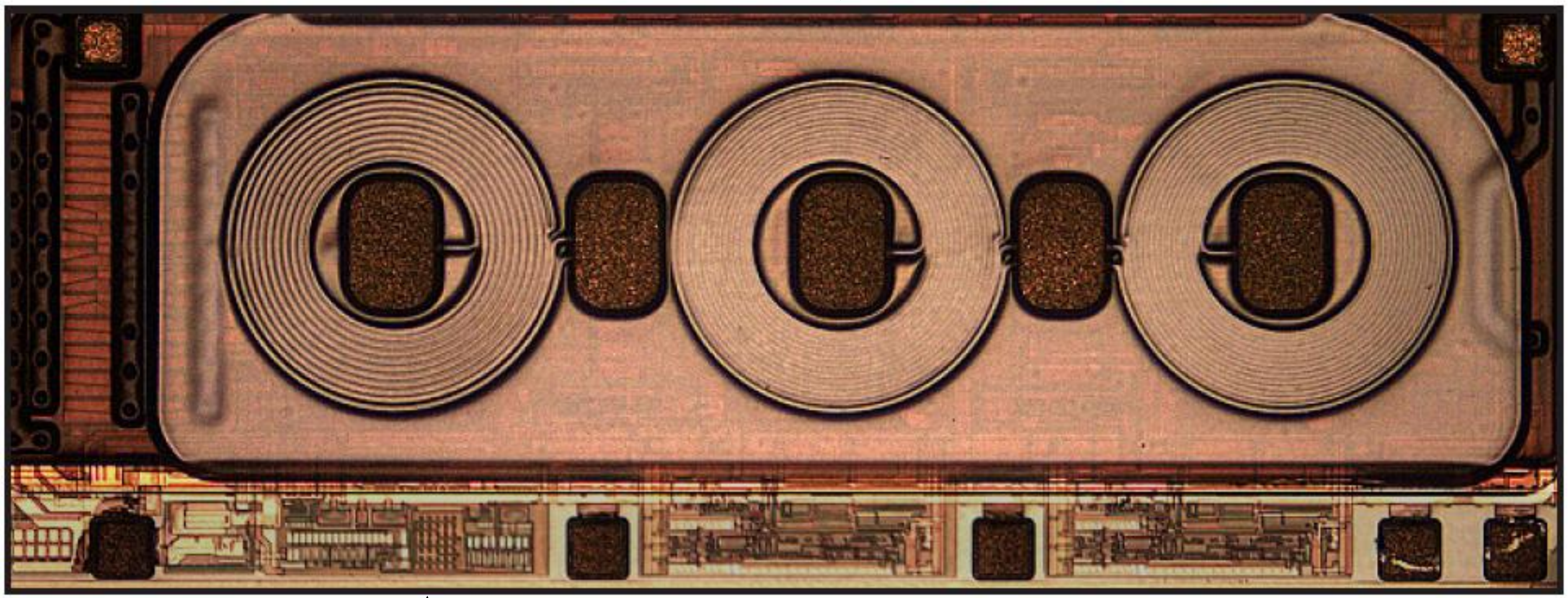
Pout_max=50 mW

The design of 3 on chip microtransformer has allowed to reduce the component dimension to be suitable for compact electronic systems.

On-chip microtransformer

1 power suppy microtransformer with lower number of turns and larger conductor sections

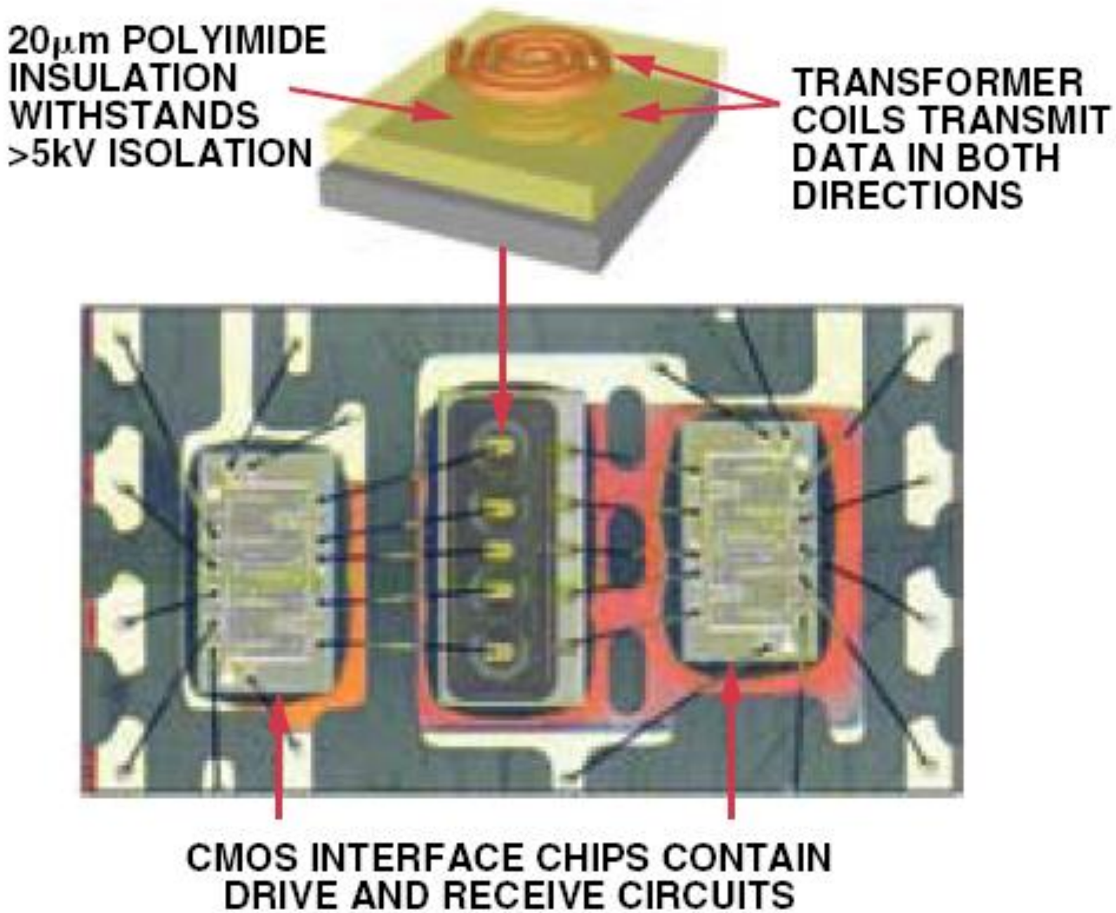
2 signal microtransrmers for two channels connections



On chip electronics for signal transmission (transformer driiver) and switched mode power supply

Technology of microtransforers

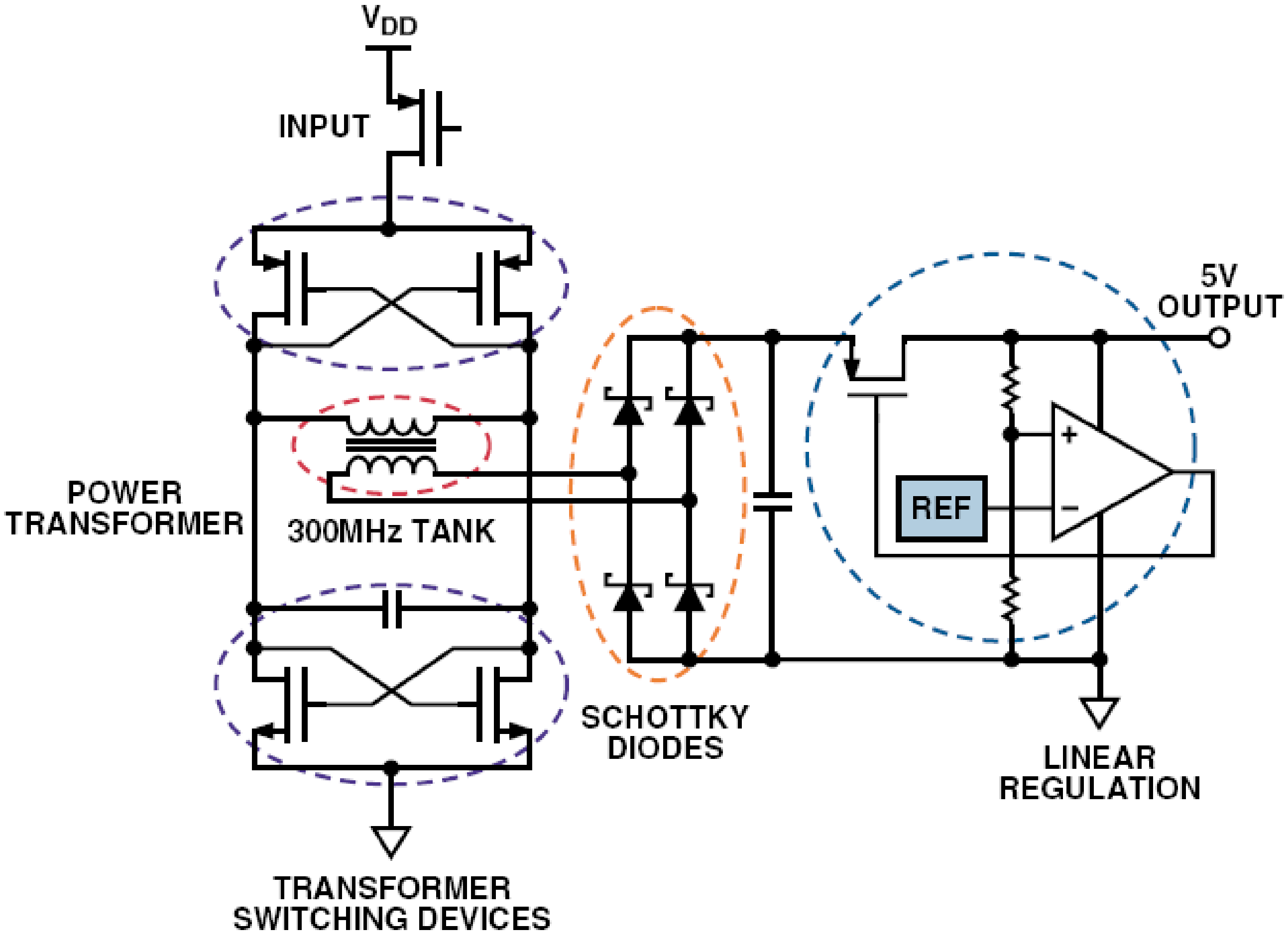
The wounds are metal deposition of (AlCu-Au) on a *polymide* insulation layer. This High Frequency transformers are characterized by a low L/R.



Ref: Data sheet Analog Devices – isoPower.pdf – Dec .2006

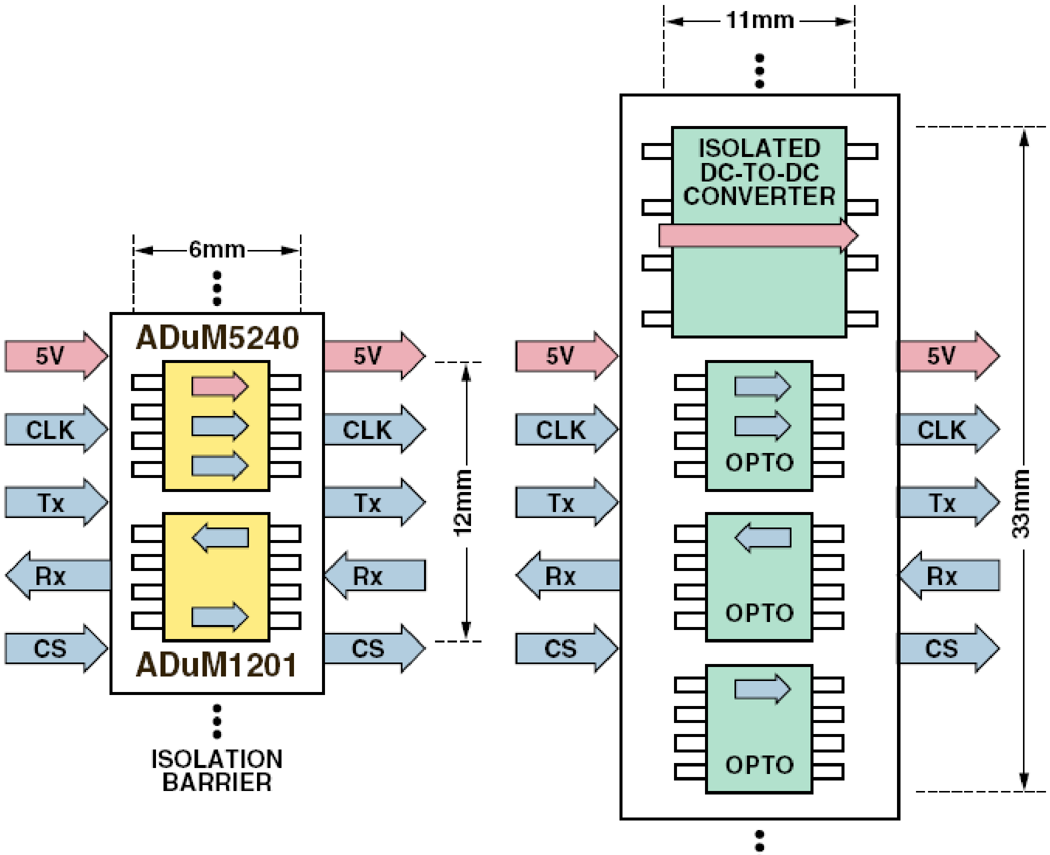
*iso*Power Technology

For a microtransformer with diameter 600 μm, the switching frequency is <u>300 MHz</u>, to achieve a high efficiency in power conversion.



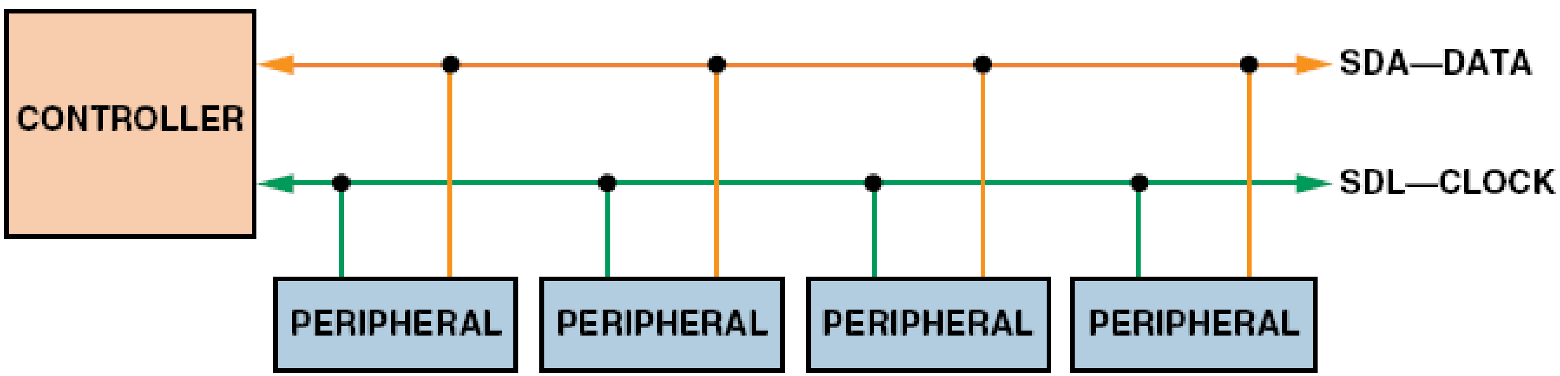
Isolated Serial/Parallel interfaces

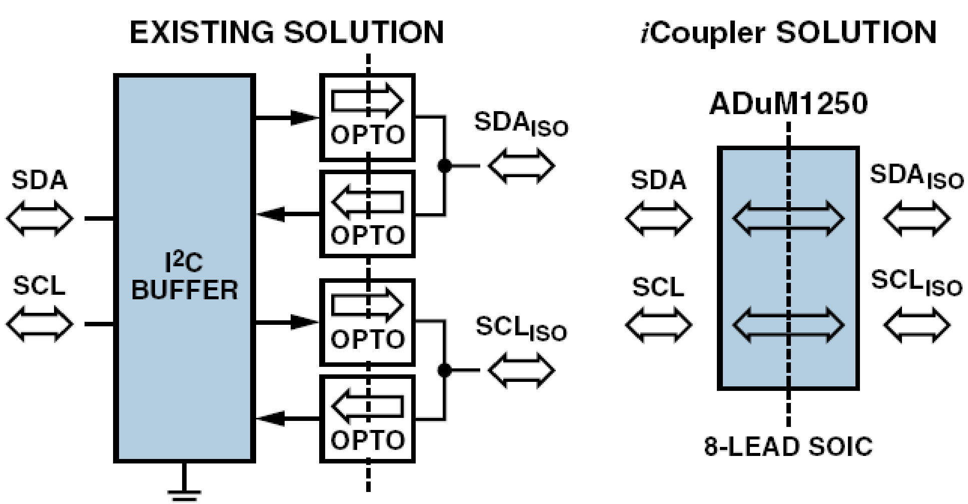
The integrated solution is more compact respect to the hybrid one (e.g. AD200x) for low power and isolation voltages of 5 kV.
Custom solutions for project spec's require longer times for realization, certification and testing.



Inter Integrated Circuits (I^2C) bus with galvanic isolation

I^2C is a standard bus for electronic systems for the communication between a master/control board and peripherals, through two active wires.
One wire is for data transfer and one for the clock. Typical data-rate 1 Mbps.





Dual-Channel Isolators with Integrated DC-to-DC Converter

Preliminary Technical Data

ADuM5210/ADuM5211/ADuM5212

FEATURES

*iso*Power integrated, isolated dc-to-dc converter
Regulated 3.15 V to 5.25 V output
Up to 150 mW output power
Dual dc-to-150 Mbps (NRZ) signal isolation channels
Soft start power supply
20-lead SSOP package with 5.3mm creepage
Supports SPI up to 15 MHz
High temperature operation: 105°C
High common-mode transient immunity: >25 kV/μs
Safety and regulatory approvals
- UL recognition (pending)
  - 2500 V rms for 1 minute per UL 1577
- CSA Component Acceptance Notice #5A (pending)
- VDE certificate of conformity (pending)
  - DIN V VDE V 0884-10 (VDE V 0884-10):2006-12
  - V_{IORM} = 560 V peak

FUNCTIONAL BLOCK DIAGRAM

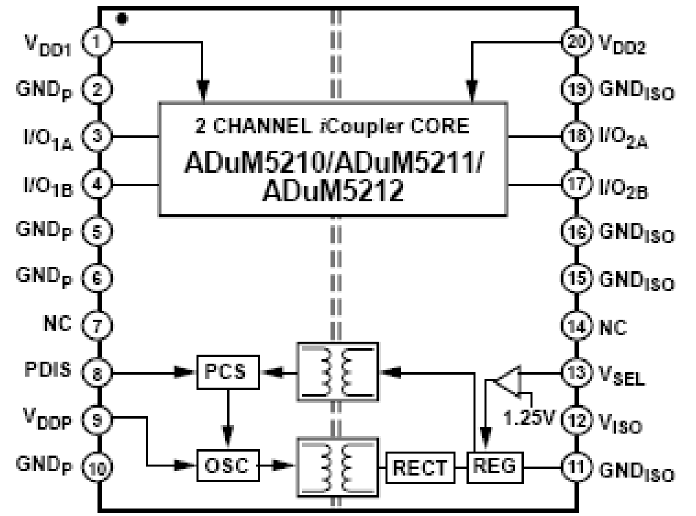


Figure 1. ADuM5210/ADuM5211/ADuM5212 Block Diagram

APPLICATIONS

RS-232 transceivers
Power supply start-up bias and gate drives
Isolated sensor interfaces
Industrial PLCs

References

- Sections 20.1.3 and 21.4 of Tietze-Schenk, Electronic Circuits, 2° Edition
- AD202/AD204, data sheet Analog Devices
- Isolating I2C interfaces, data sheet Analog Devices
- isoPower, data sheet Analog Devices
- LM131, data sheet National Semiconductor
- Trasformatori in Alta Frequenza, dispense prof Lorenzo Capineri