Keep Noise Out of Your System and Eliminate Ground Loops: How to Choose the Right Isolator

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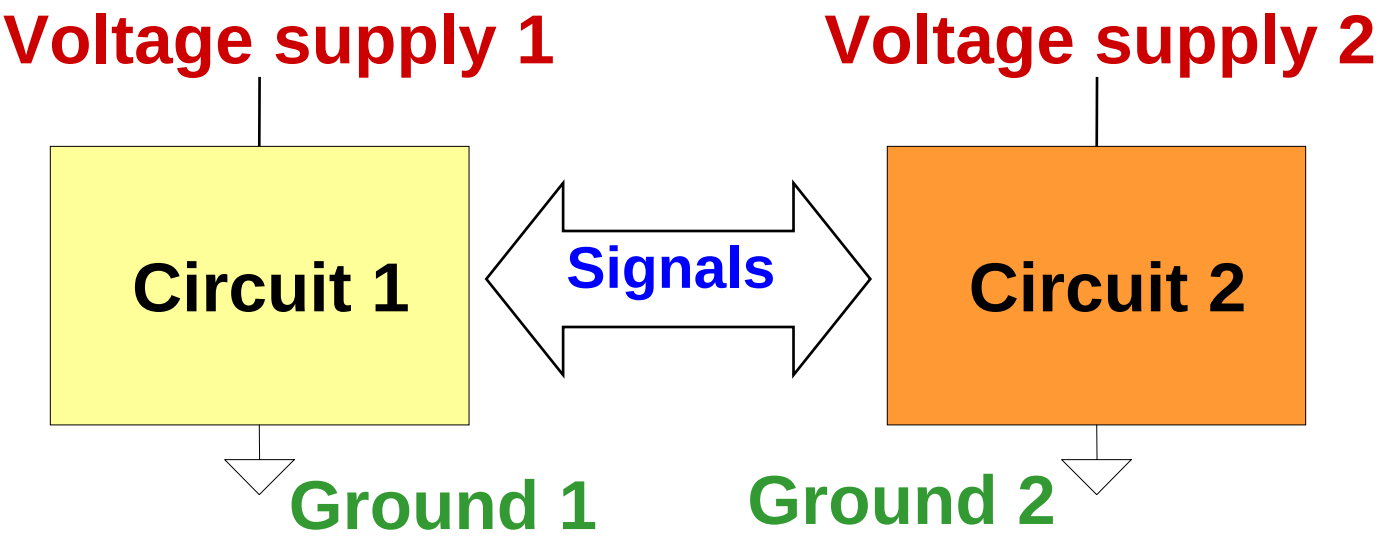
Agenda

- What is Isolation?
- Why is Isolation needed?
- Applications utilizing Isolation
- Introduction to various manufacturing techniques
  - Optical Isolation (opto-couplers)
  - Magnetic Isolation
  - Capacitive Isolation
- Comparing Isolation Solutions
- Summary

What is Isolation?

Galvanic isolation:

Although Circuit 1 and Circuit 2 exchange signals, no current (electrons) pass from Circuit 1 to Circuit 2.



Why is Isolation needed?

- Safety
- Level translation
- Common Mode noise rejection
- Break ground loops
- Standard compliance

They can replace relays:
+ faster switching speeds
+ no contact bounce
+ better reliability
+ better electrical isolation.

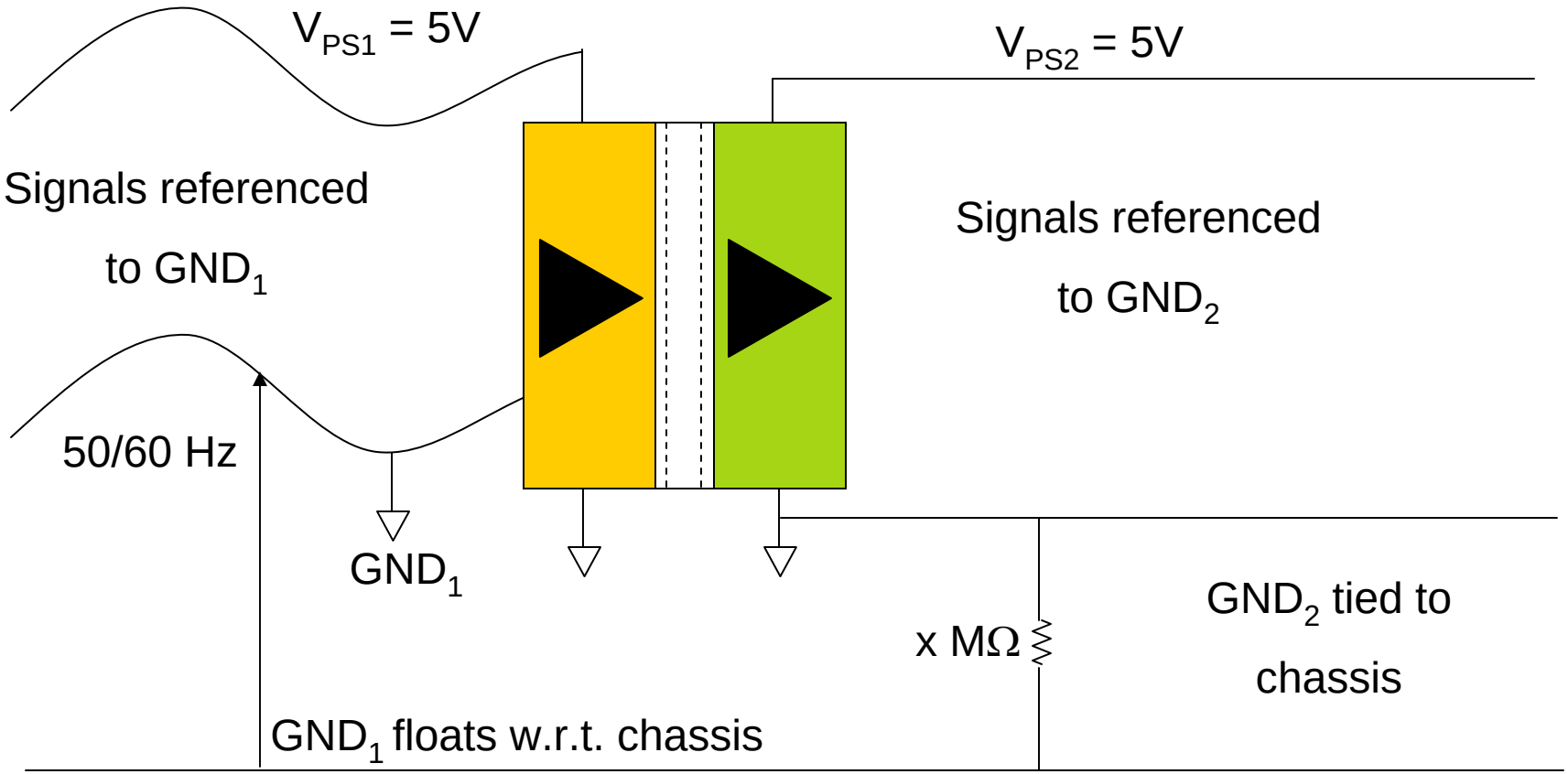
Can eliminate the effects of electrical noise caused by crosstalk, power glitches, interference, etc.

Can replace pulse transformers in many floating apps:
+ isolators transmit DC & AC components.

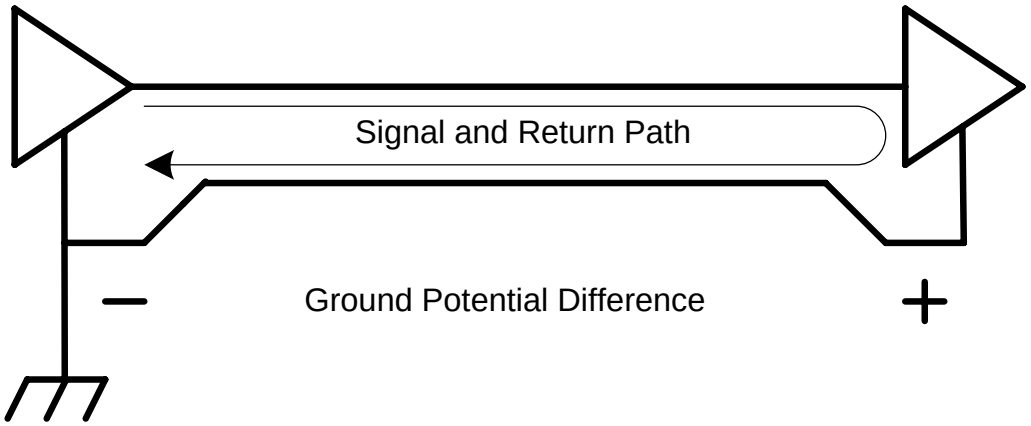
Used for shifting logic levels.

Provide high voltage isolation allowing safe interface between high and low voltages in electrical circuits.

Common Mode Noise



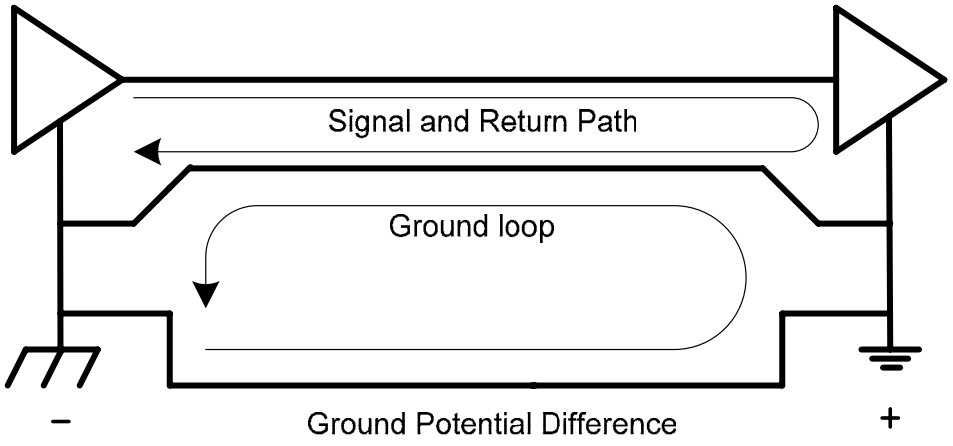
Ground Loops



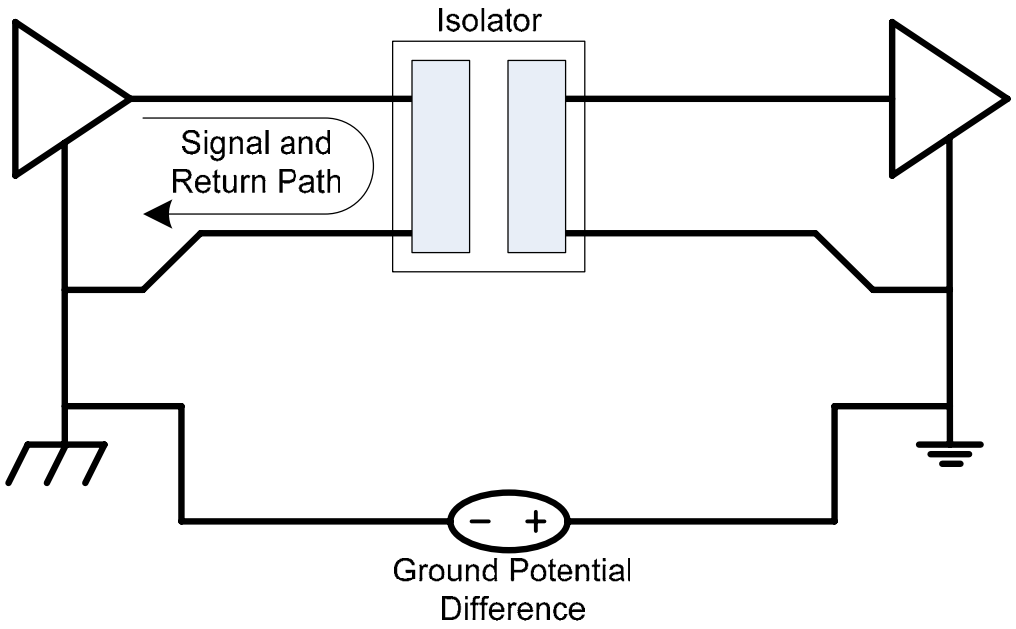
Ground potential differences arise due to the finite impedance of the current path and the return or ground current.

A ground loop exists whenever there is more than one conductive path between two circuits. The existence of multiple ground paths may lead to unintended current paths which can impact system performance.

In higher speed applications, it is necessary to reduce the ground impedance with multiple grounds.



Ground Loops



- **The ground loop can be broken by simply disconnecting the grounds, or by more sophisticated means: common-mode chokes, frequency selective grounding, differential amplifiers, and galvanic isolators.**

- **Of these solutions only galvanic isolation provides protection for very large potential differences between grounds, breaks the ground loop, and provides galvanic isolation.**

Applications utilizing Isolation

Many applications ranging from power supplies & motor control circuits to data communications & digital logic interface circuits.

Industrial:

- Panel switches
- Remote meter reading
- Robotics
- PLC input/output isolation
- NC machines
- Industrial networks
- Motor control
- Test equipment
- Power dist. protection systems
- Air conditioning
- Switch mode power supplies

Communications:

- PBX and central office
- Digital cross connect
- Telephone terminal equipment
- Telephone switching equipment
- Modems
- ISDN

Applications utilizing Isolation

Consumer Electronics:

- Video (TV, VCR, etc.)
- Alarm systems
- Fitness equipment
- Plasma displays
- Electronic gaming
- Home appliances

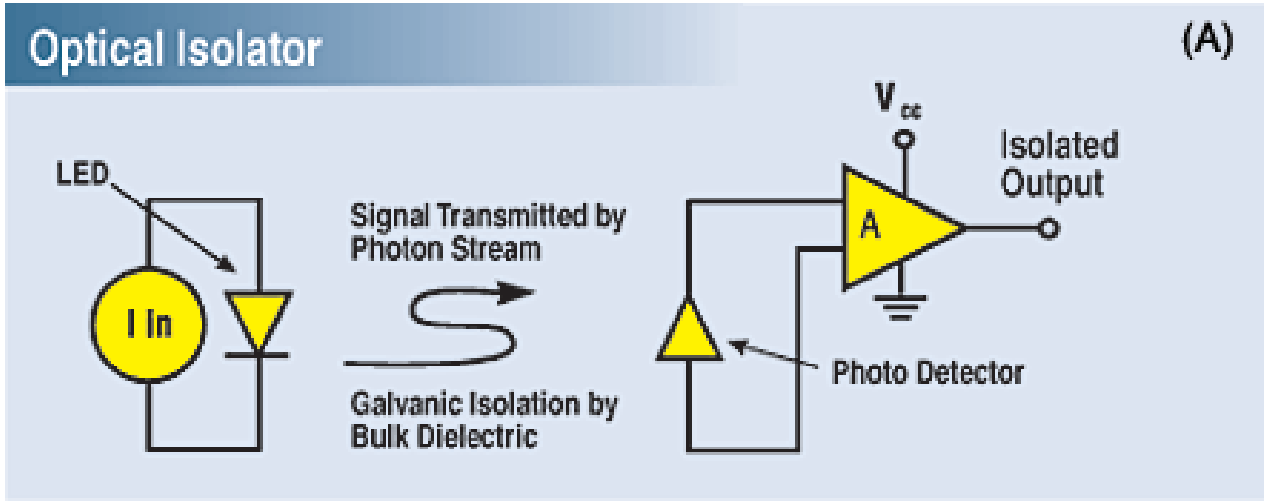
Medical:

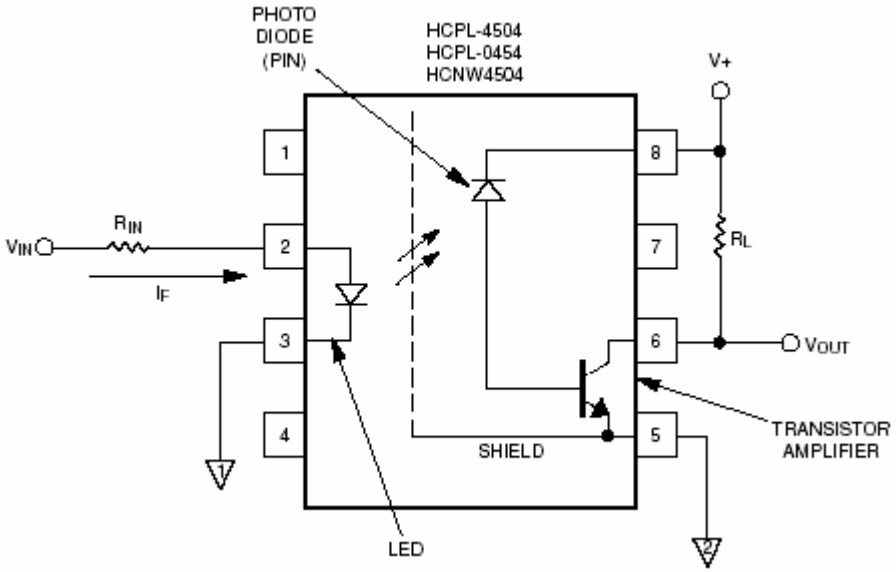
- Microwave therapy
- Patient monitoring
- Electrocardiographs
- Defibrillators

Computers & Office Equip:

- Isolated I/O
- Printers and plotters
- Fax machines

Optical Isolation (Opto-couplers)

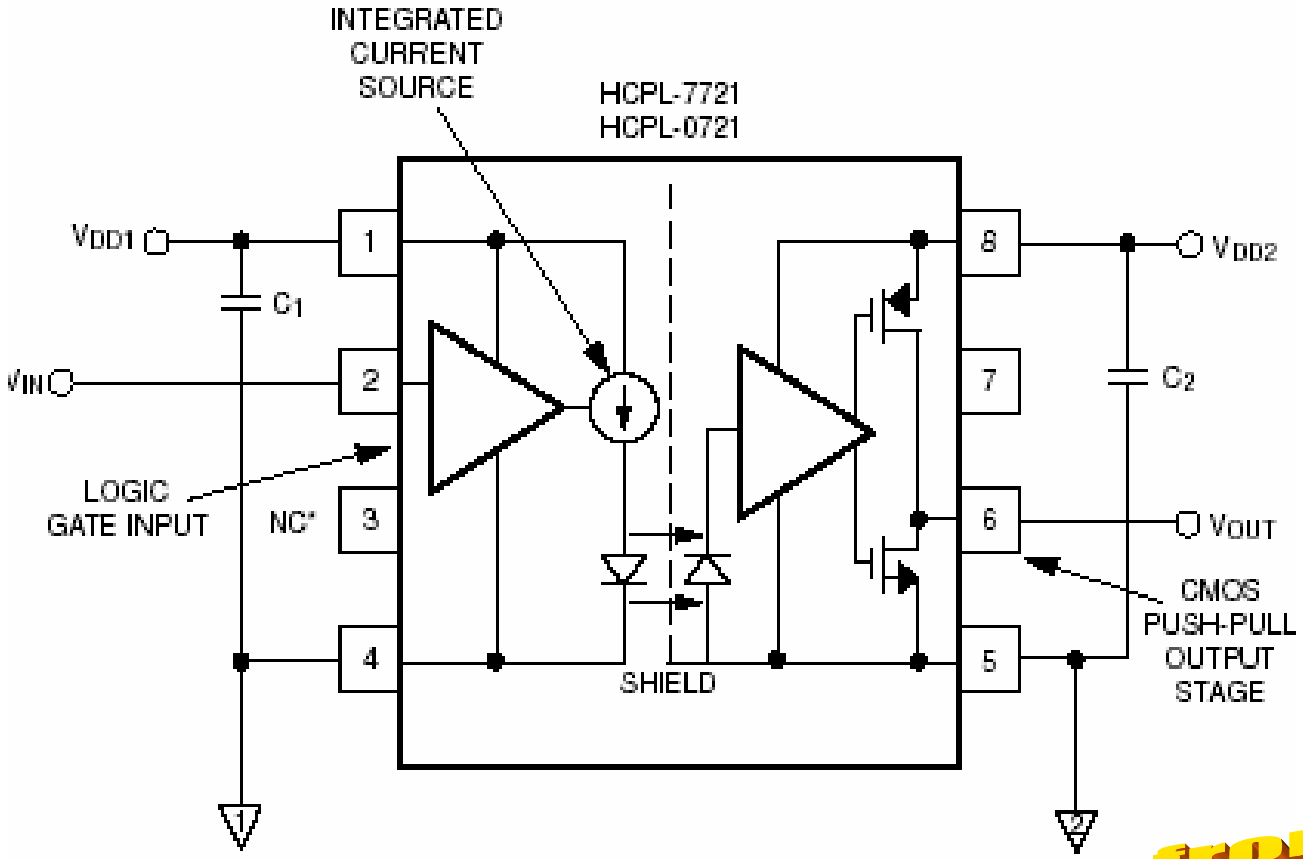




Type of Opto-Isolators:

- Photodiode/Transistor
- Split Darlington Transistor
- Cascaded Amplifier
- Totem Pole Output
- High Speed CMOS

HCPL—0721 Optical Isolator

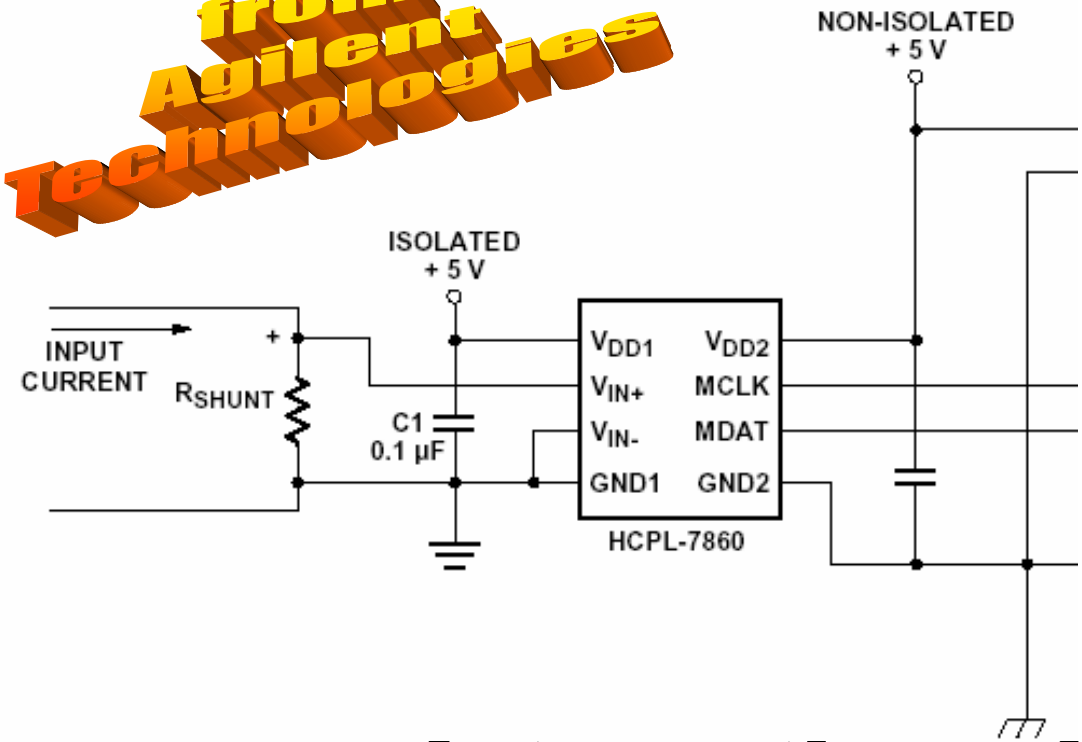


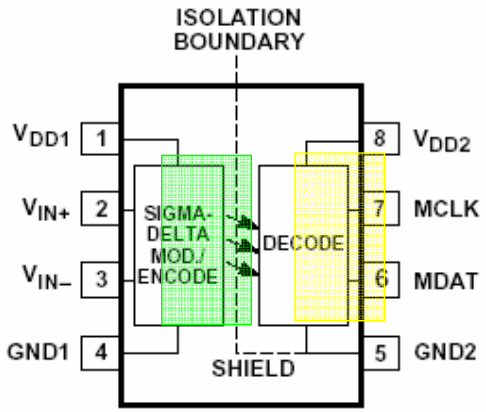
High Speed CMOS Opto-isolators

from Agilent Technologies

HCPL-7860 Functional Diagrams

from Agilent Technologies

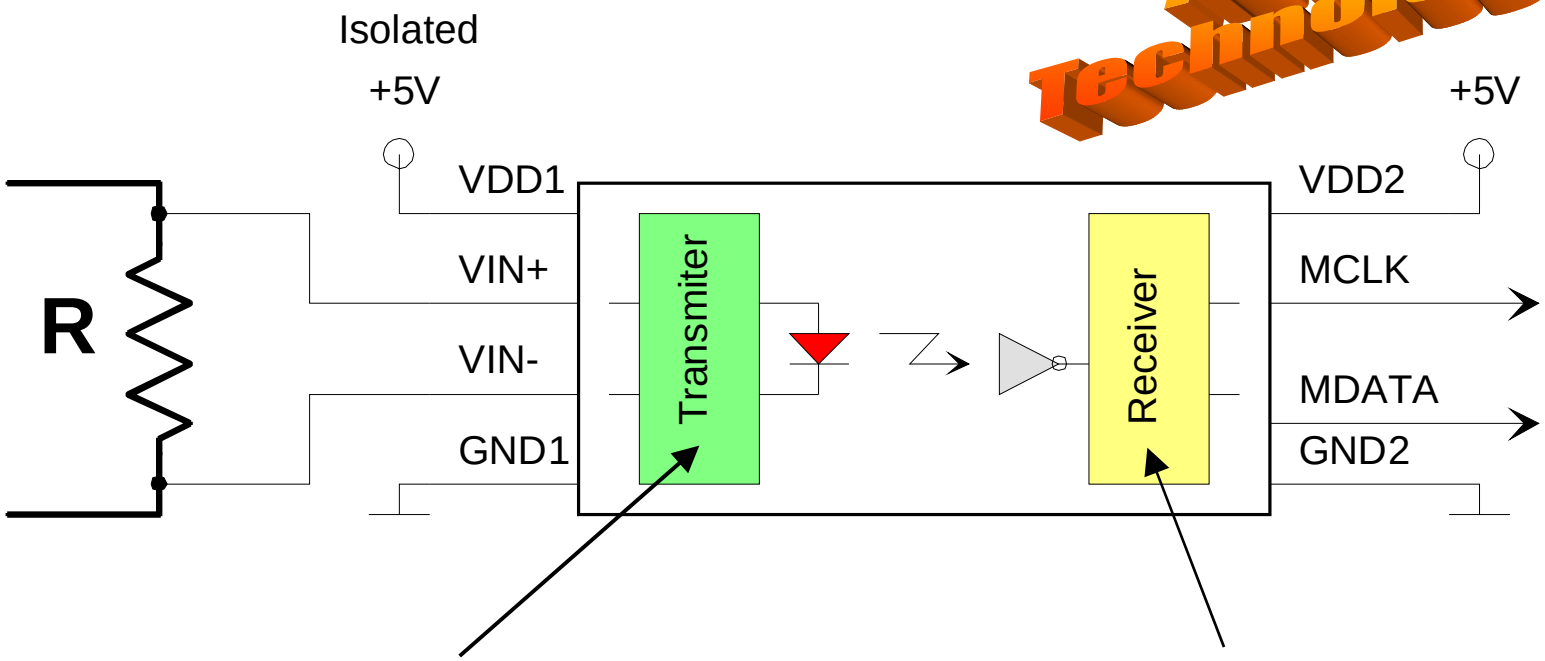




HCPL-7860 Isolated Modulator

Integration with other components: Data-Converters, Transceivers, Amplifiers, Power …

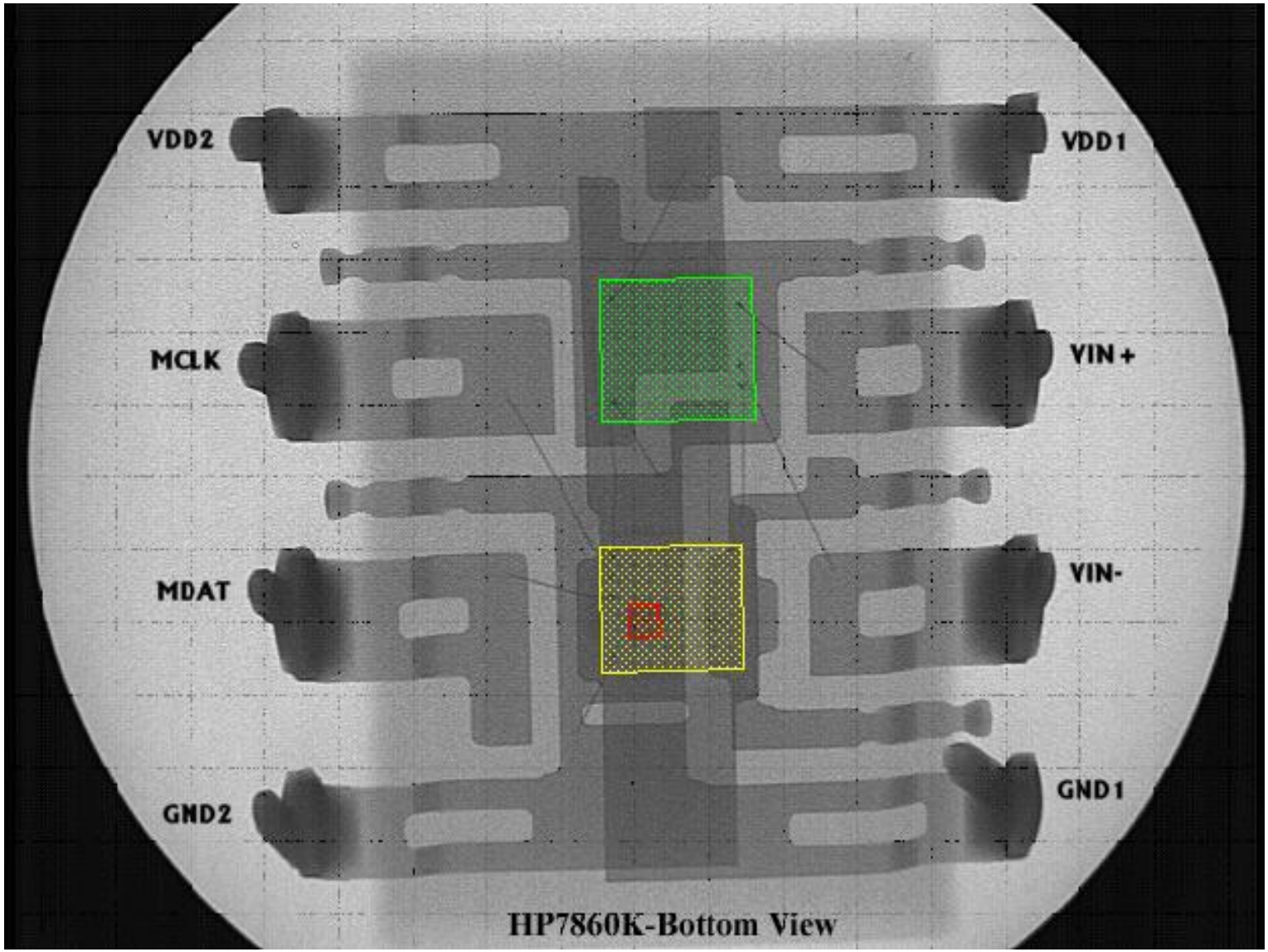
HCPL-7860 Structure



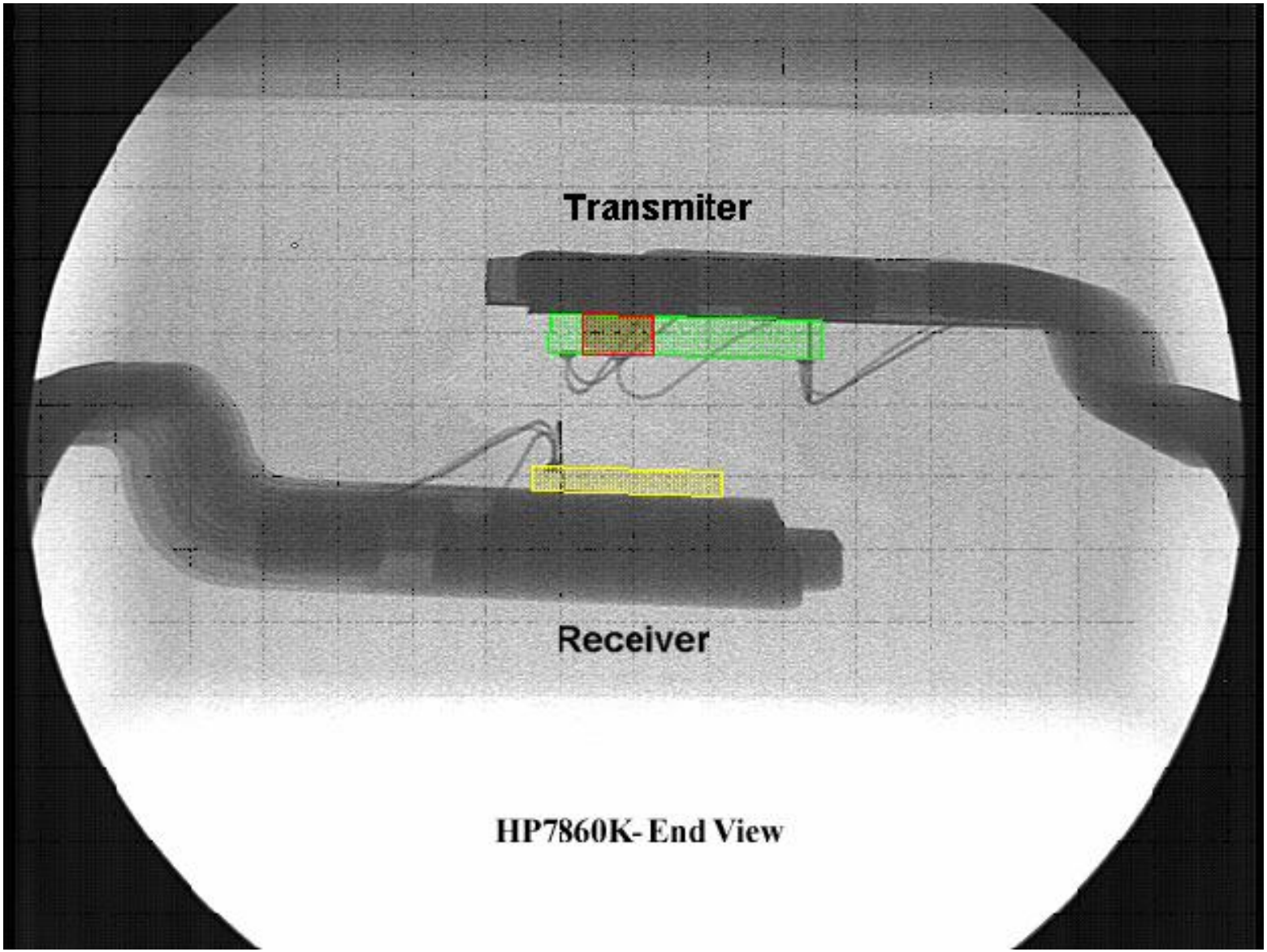
- Delta-Sigma Modulator
- Voltage Reference
- Clock Generator
- Encoder
- Led drive Circuit

- High speed optocoupler
- Detector Circuit
- Self-synchronization
- Clock Recovery

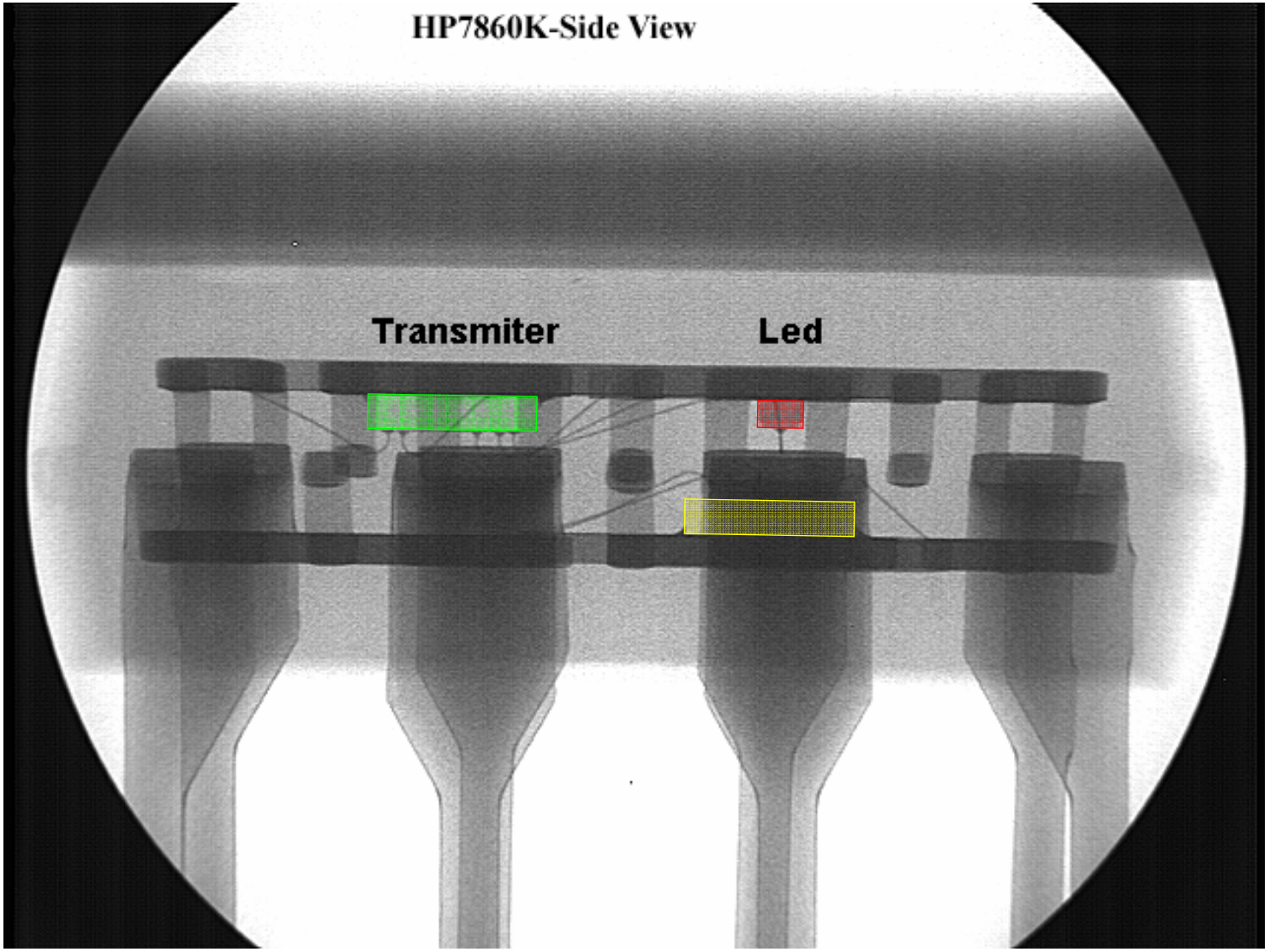
HCPL-7860 X-Ray Bottom View



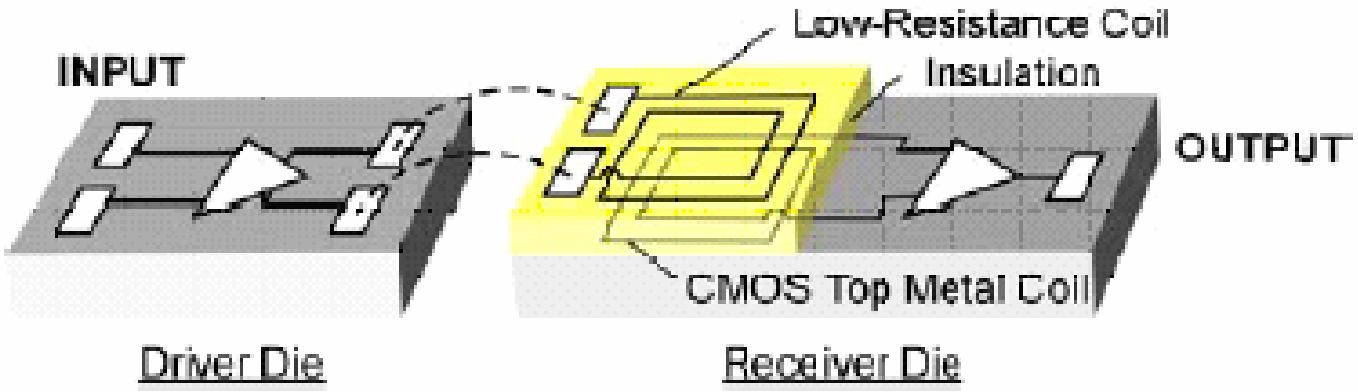
HCPL-7860 X-Ray End View



HCPL-7860 X-Ray Side View



Magnetic Isolation - 1



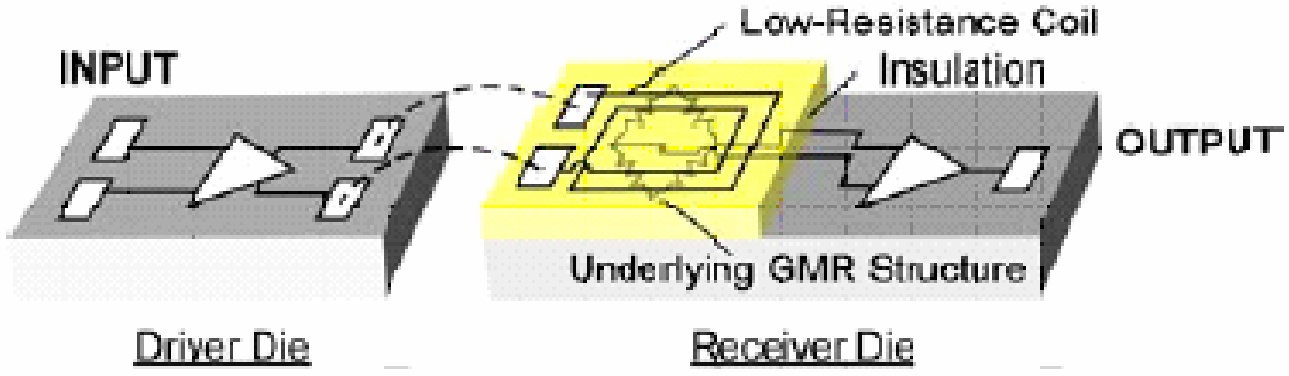
Analog Devices *i*Coupler Technology

Analog Devices' iCoupler technology uses chip scale transformers to transmit data across an isolation barrier.

Key Features:

- Transmission triggered by input logic transition
- Driver refresh function ensures dc correctness in absence of input logic transitions
- Correct output upon start-up guaranteed within 1 us
- Input filter prevents false triggering due to input noise
- Fail-safe output state upon loss of input power
- Sensitive to external dc magnetic field

Magnetic Isolation - 2



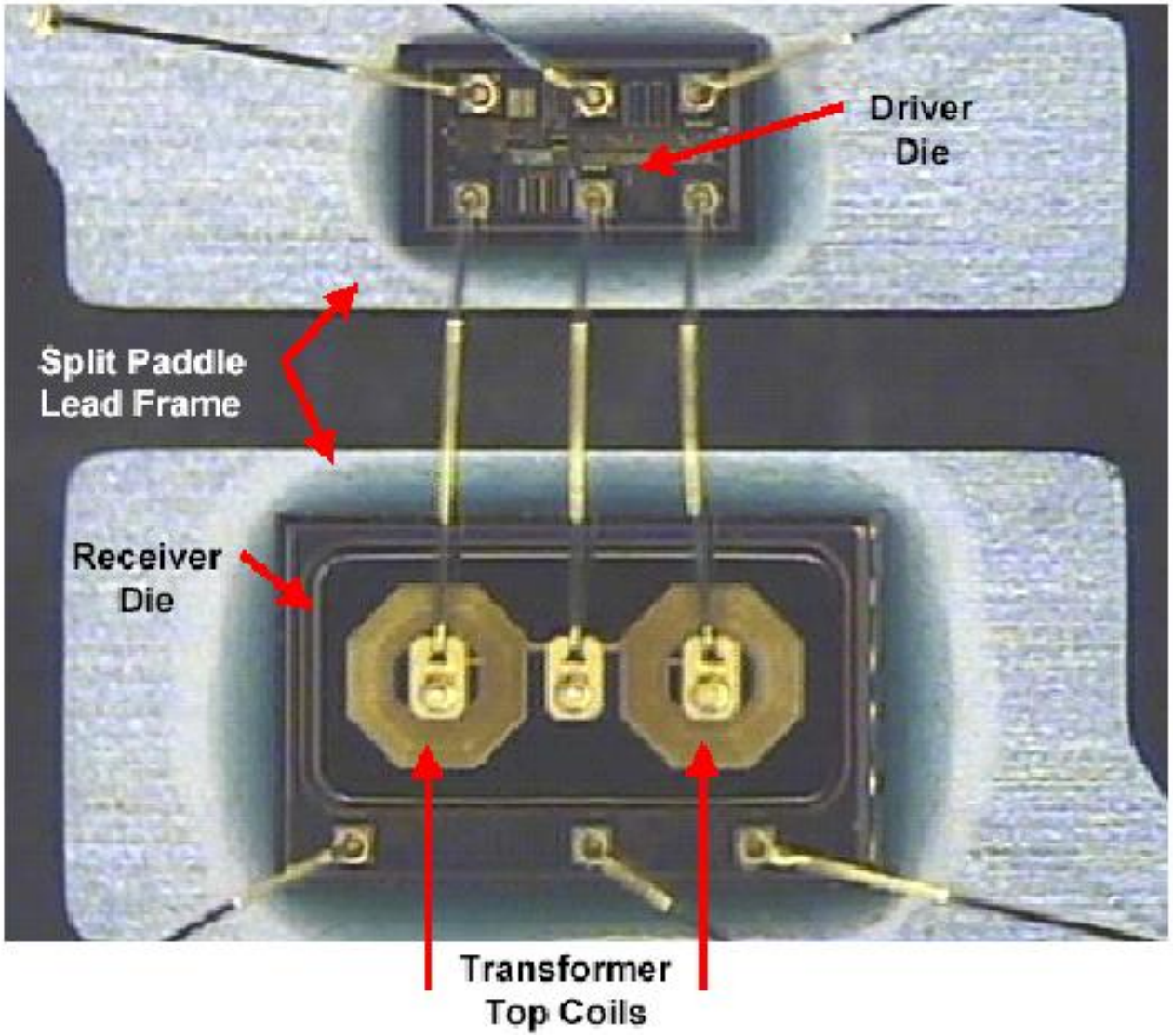
NVE IsoLoop Technology

NVE's IsoLoop Technology uses a coil and GMR (giant magnetoresistive) structure to do the same.

Key Features:

- Transmission triggered by input logic transitions
- DC correctness not ensured
- Correct output upon start-up not guaranteed
- Susceptible to false triggering by input noise
- Retains last state upon loss of input power
- Very sensitive to external dc magnetic field

ADuM1100 Digital Isolator



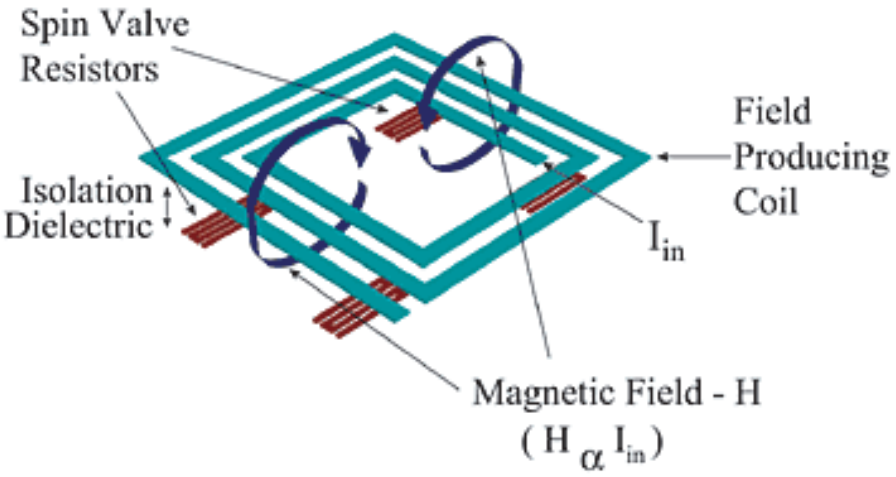
Driver circuitry sends short pulses to transformers upon receipt of input logic transitions

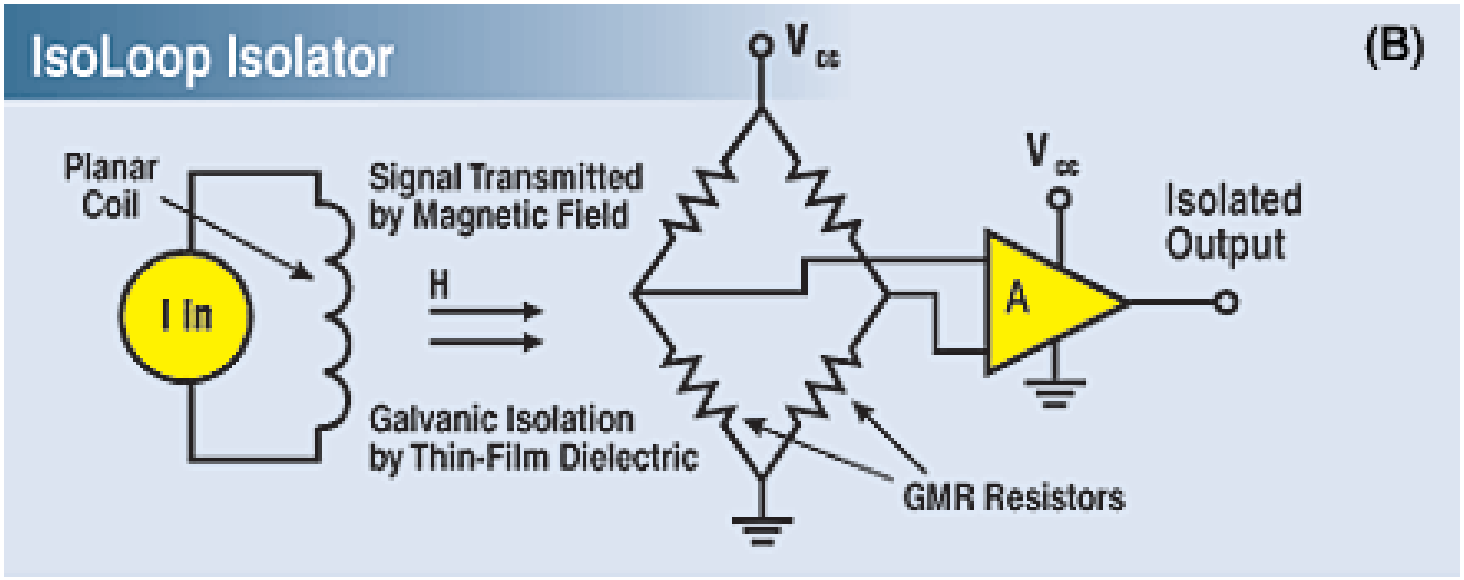
Driver "refresh" circuit initiates pulse transmittal with low data rate or DC signals.

Two transformers used to distinguish between input rising and falling transitions

Receiver circuitry reconstructs digital signal upon receipt of coupled transformer pulses

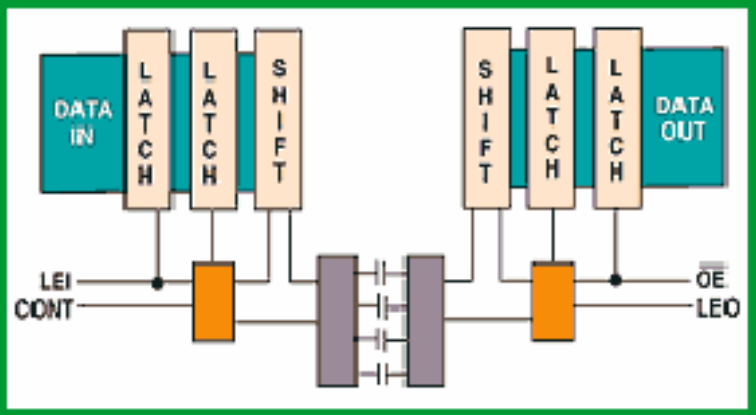
GMR Close-up


Spin Valve
Resistors
Isolation
Dielectric
Field
Producing
Coil
I_{in}
Magnetic Field - H
($H \alpha I_{in}$)

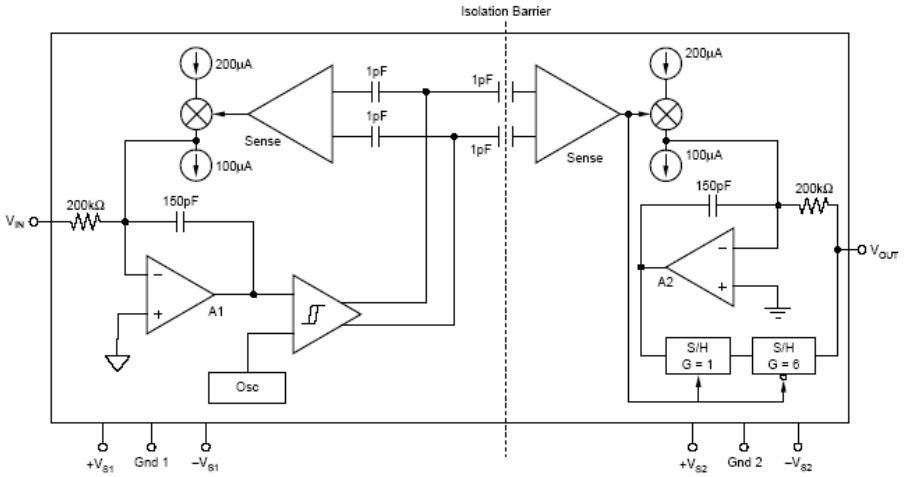

IsoLoop Isolator
(B)
V_{cc}
V_{cc}
Planar
Coil
I In
Signal Transmitted
by Magnetic Field
H
Galvanic Isolation
by Thin-Film Dielectric
A
Isolated
Output
GMR Resistors

Capacitive Isolation - Legacy

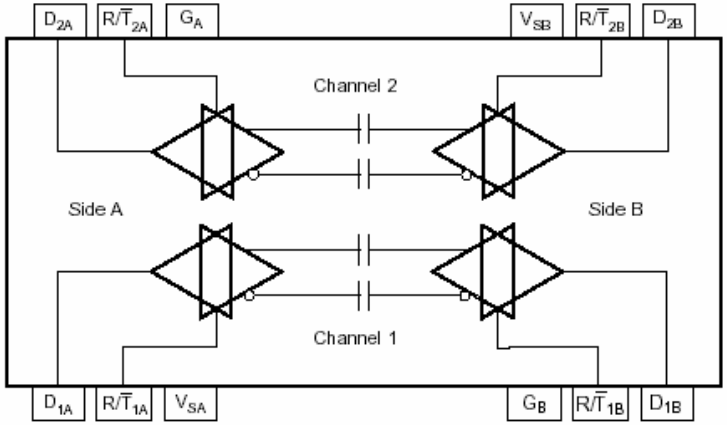
The signal modulates a high-frequency carrier and is capacitively coupled from input to output. Either duty-cycle or frequency modulation techniques are used, and the signal is passed differentially across the barrier.



The signal and control information are passed differentially across the capacitive barrier. The double-buffered architecture and three-state outputs allow easy integration into bus-based systems.

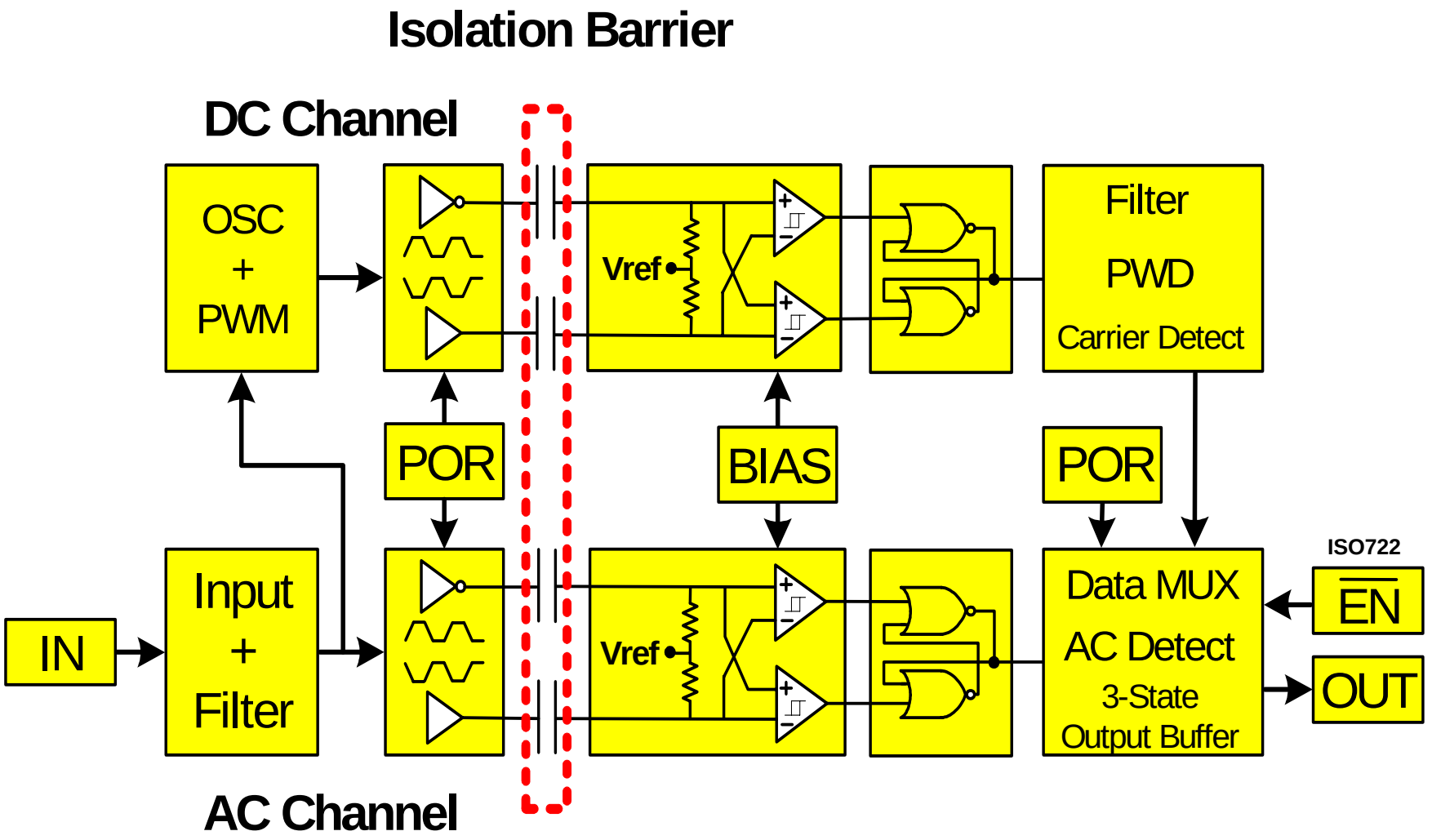


ISO124 - Precision Lowest-Cost Isolation Amplifier



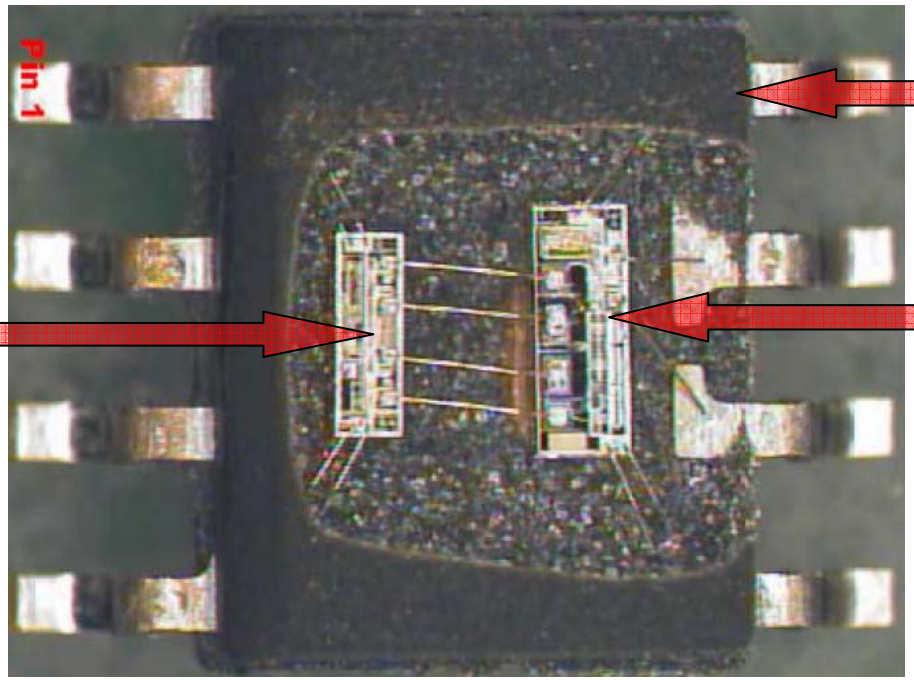
ISO150 - Dual, Isolated, Bidirectional Digital Coupler

New Generation Capacitive Isolation



ISO721 High-Speed Digital Isolator

PREVIEW



SOIC-8

Transmitter (TX) die with signal conditioning

Receiver (RX) die with differential capacitive coupling

Product:

2-die Multi Chip Module with transmit (TX) die and receive (RX) die; in-between capacitive isolation barrier

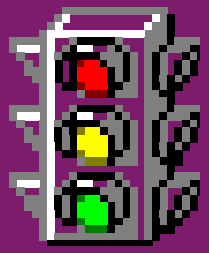
Certification:

Isolation standards certified per UL/VDE/CSA *(VDE, IEC 60747-5-2)*

Comparing Isolation Solutions

- Optical
  - **Well established in market**
  - **Cost-effective solution for low speed**
  - **High speed switching for LED's is difficult**
  - **Power hungry, low volt operation with degraded performance**
  - **Drive current performance degradation over lifetime**
- Magnetic (Inductive/Transformer/GMR)
  - **New technology approved by industry leaders**
  - **Low power over optos (ADI)**
  - **Inherent low immunity to electro-magnetic noise**
  - **No ESD protection (ADI)**
  - **Data integrity issues at power up/down, failsafe (NVE)**
- Capacitive
  - **High immunity to electro-magnetic noise**
  - **Low voltage operation**
  - **Power lower than opto, higher than Inductive**

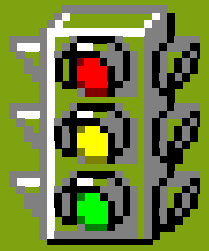
Comparing Isolation Solutions



Magnetic

Capacitive & Optical

Immunity:

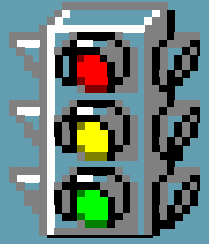


Optical

Capacitive

Magnetic

Power:



Optical

Capacitive & Magnetic

Degrading With age:

Summary

- No one-size fits all
- Optical-isolation (opto-couplers) are ideal for low signaling-rate applications and power isolation
- Capacitive and Magnetic isolations are perfect fit for high data-rate applications due to power and ageing issues associated with optical solution
- Immunity concerns about magnetic solutions, especially in harsh environments such as next to a motor (magnetic coupling)
- Old generation capacitive isolation solutions are not cost competitive
- New generation capacitive isolation solution will be cost competitive and low-power

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