ANALOG DEVICES

Evaluation Board for
Loop Powered 4-20mA DAC

EVAL-AD421EB

FEATURES

Loop Powered

5V, 3.3V and 3V Modes of Operation

Direct Hook-Up to Printer Port of PC

PC Software for Control of Loop Current

INTRODUCTION

This Application Note describes the evaluation board for the AD421, loop powered 4-20mA DAC. The AD421 is a complete, loop-powered, digital to 4-20mA converter, designed to meet the needs of smart transmitter manufacturers in the Industrial Control industry. It provides a high precision, fully integrated, low cost solution in a compact 16-pin package. The AD421 is ideal for extending the resolution of smart 4-20mA transmitters at very low cost.

The AD421 includes a selectable regulator which can be used to power all other devices in the transmitter. This regulator provides either a +5 V, +3.3 V or +3 V regulated output voltage. The part also contains +1.25 V and +2.5 V precision references. The AD421 thus eliminates the need for a discrete regulator and voltage reference. The only external components required are a number of passive components and a pass transistor to span large loop voltages. Full data on the AD421 is available in the AD421 data sheet available from Analog Devices and should be consulted in conjunction with this Application Note when using the Evaluation Board.

Included on the evaluation board, along with the AD421, are a DN2535/DN2540, an N-Channel depletion mode FET which is used as part of the regulator loop to regulate the supply for the board from the externally supplied loop voltage applied between the loop(+) and loop (-) inputs, digital buffers to buffer and level shift the input signals from the printer port edge connector and a number of passive components required to achieve optimum performance from the AD421.

Interfacing to the AD421 board is provided via a 36-Pin Centronics Connector.

OPERATING THE AD421 EVALUATION BOARD

Power Supplies

The evaluation board operates from a single power supply connected between the LOOP PLUS and LOOP MINUS terminals on the board. This loop power supply must be floating with respect to the computer ground and have a minimum limit of V_{CC}+2 V and a maximum limit of the breakdown voltage of the external pass transistor. The pass transistor used on this board is a DN2535/DN2540, N-Channel Depletion mode transistor available from Supertex inc.., this facilitates the use of loop voltages up to 350V. This pass transistor in association with the regulator loop of the AD421 regulates the supply voltage for the AD421 itself and for the digital buffers on the board. The regulated voltage is referenced to the COM pin on the AD421. A link option on the board selects the operating mode for the board to be either 5V, 3.3V or 3V.

The regulated voltage on the AD421 V_{CC} pin is decoupled with 10µF tantalum and 0.1µF ceramic disc capacitors.

The loop current can be measured in either the LOOP PLUS or LOOP MINUS lines.

FUNCTIONAL BLOCK DIAGRAM
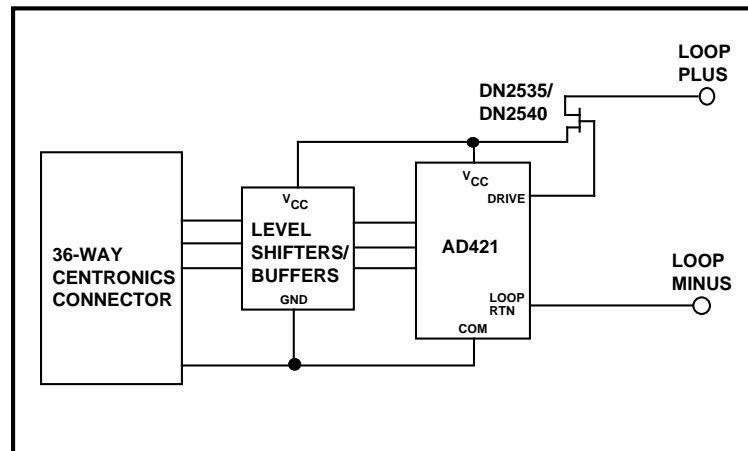
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Link Options

There is one link option on the evaluation board which should be set for the required operating setup before using the board. The function of this link option is described below.

LK1	Function
	This option is used to control the selectable regulator on the AD421 that is used to power the AD421 itself and the digital buffers on the board.

Position	Function
A	With this link in position A, the LV pin on the AD421 is connected to COM, in this position the regulated voltage for the AD421 and the digital buffer is set to 5V.
B	With this link in position B, the LV pin on the AD421 is connected to V_{CC}, in this position the regulated voltage for the AD421 and the digital buffer/level shifter is set to 3V.
C	With this link in position C, the LV pin on the AD421 is connected through a 0.01uF capacitor to V_{CC}, in this position the regulated voltage for the AD421 and the digital buffer/level shifter is set to 3.3V.

EVALUATION BOARD INTERFACING

Interfacing to the evaluation board is via a 36-pin Centronics connector, SKT1 using a standard parallel printer port cable. The pinout for the SKT1 connector is given in Figure 1 and its corresponding pin designations are given in Table I. The evaluation board should be powered up before a cable is connected to the connector.

The digital interface on the AD421 consists of just three wires: DATA, CLOCK and LATCH. The interface connects directly to the serial ports of commonly-used microcontrollers without the need for any external glue logic. On this evaluation board the PC via the printer port is used to emulate a microcontroller. Data is loaded MSB first into the input shift register of the AD421 on the rising edge of the CLOCK signal and is transferred to the DAC latch on the rising edge of the LATCH signal. This data can take two forms; normal 4-20mA data and alarm current data. The first form is where the AD421 operates over its normal 4mA to 20mA output range with 16-bits of resolution between these end-points. The second form allows the user to program a current value outside this range as an indication from the transmitter than there is a problem with the transducer i.e. tranducer burnout. The AD421 counts the number of clock pulses which it receives between LATCH signals as a means of determining whether the data clocked in is 4-20mA data or alarm current data.

If there are 16 rising clock edges between successive LATCH pulses then the data to be loaded to the input shift register is assumed to be normal 4-20mA data.

If there are more than 16 rising clock pulses between successive LATCH pulses then the data to be loaded to the input shift register is assumed to be alarm current data.

Table I. SKT1 Pin Designations

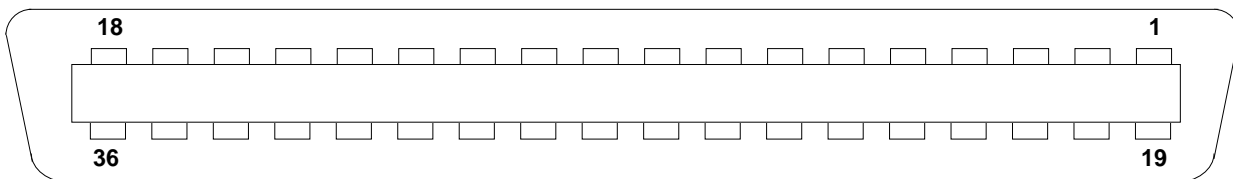|		
1	NC	No Connect. This pin is not connected on the evaluation board.
2	NC	No Connect. This pin is not connected on the evaluation board.
3	LATCH	Latch Input. The signal on this pin is buffered in 5V operating mode and level translated in both 3.3V and 3V modes using a 74HC4050 before being applied to the LATCH pin of the AD421. On the rising edge of the latch signal data is loaded from the input register to the DAC register and the DAC output is updated.
4	NC	No Connect. This pin is not connected on the evaluation board.
5	CLOCK	Serial Clock. The signal on this pin is buffered when using a V_{CC} of 5V and level translated when V_{CC} is 3.3V or 3V before being applied to the CLOCK pin of the AD421. Data on the DATA pin is clocked into the AD421 shift register on the rising edge of this clock input.
6-8	NC	No Connect. These pins are not connected on the evaluation board.
9	DATA	Serial Data Input. Data applied to this pin is buffered when using a V_{CC} of 5V and level translated when V_{CC} is 3.3V or 3V before being applied to the AD421's DATA pin. The serial data applied to the DATA pin is written to the input shift register on the part. Data from this input shift register is transferred to the data register on the rising edge of the LATCH signal.
10-18	NC	No Connect. These pins are not connected on the evaluation board.
19-25	DGND	Ground reference point for digital input signals. Connects to the COM plane on the evaluation board.
26-36	NC	No Connect. These pins are not connected on the evaluation board.

Figure 1. SKT1 Pin Configuration, Pin View.

RUNNING THE AD421 INTERFACE SOFTWARE

Included in the evaluation board package is a PC-compatible disk which contains software for controlling and evaluating the performance of the AD421 using the printer port of a PC. There are a total of thirteen files on the distribution disk.

To use the software, the user must have an IBM-compatible PC and Windows 3.1 must be installed. Start Windows and, using either the RUN command or the file manager, start the program called SETUP.EXE on the distribution disk. This automatically installs the application and sets up a window called ANALOG DEVICES. The application ICON is found here. To start the application, double click on the ICON.

PRINTER PORT SELECTION

When the program starts, a window as shown in Figure 2 appears and the user is asked to select a printer port. The user can select the port they wish to use by cliciking on the appropriate option button and then clicking OK. The hexadecimal numbers displayed beside each option correspond to the memory address of the port in question. The correct selection depends on what type of computer is being used (Desktop, Laptop etc). LPT1 works for most machines and is the default selection. When using a Compaq laptop, select PRN. A different port can be selected at any time from the MAIN MENU.
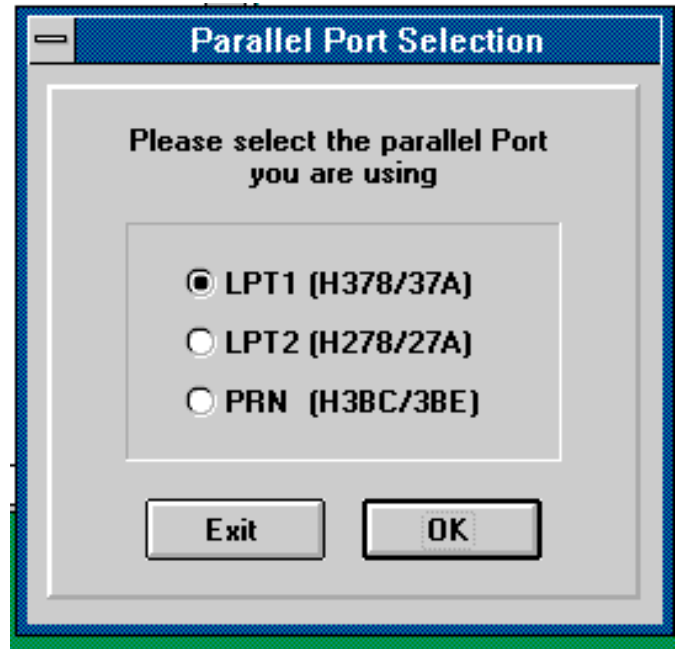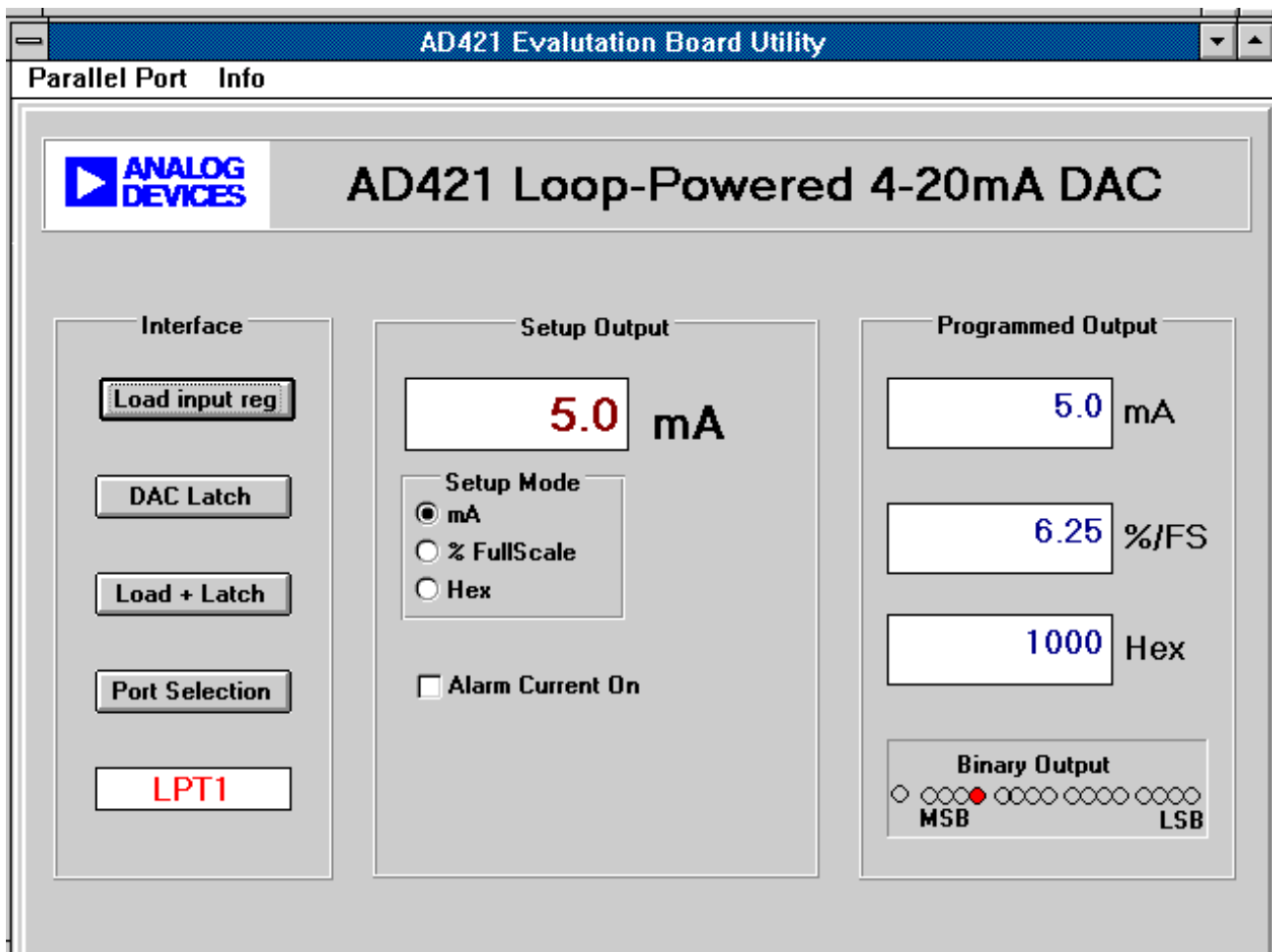

Figure 2. Parallel Port Selection.

Figure 3. Main Window.

The evaluation software does not allow another application running under Windows to access the printer port while it is running. Control of the printer port is returned when the AD421 application program is quit.

MAIN MENU WINDOW

Once the OK button of the port selection window has been pressed the user is presented with the Main Menu Window for the application. The window is called AD421 Evaluation Board Utility and is as shown in Figure 3. This utility contains the following sections: interface, setup output and programmed output.

INTERFACE SECTION

The interface section contains buttons that control the method in which data is loaded to the AD421 and also the printer port selection. The following is a description of these buttons.

Load Input Reg

When this button is clicked the input register of the AD421 is loaded with the data as programmed in the Setup Output section. Data is only loaded to the input register and is not transferred to the DAC register. No output update takes place in this case.

DAC Latch

When this button is clicked the data in the input register of the AD421 is transferred to the DAC register and an output update takes place. This basically activates the LATCH input to the AD421.

Load + Latch

When this button is clicked the input register of the AD421 is loaded with the data as programmed in the Setup Output Section and the LATCH signal is also activated updating the output of the AD421. This is a combination of the previous two buttons.

Port Selection

This button returns the user to the previous menu on Parallel Port Selection. The selected port appears in the box at the bottom on the interface section.

SETUP OUTPUT SECTION

This section allows the user to select one of three current output setup modes and also allows the selection of either 4-20mA normal mode of operation or the selection of an alarm current mode where the current range is from 3.5-24mA. The following is a description of these buttons.

Setup Mode

There are three selections in this setup, the programmed output current can be programmed as a straight mA by selecting the mA button.

The second button, % Fullscale, allows the output current to be programmed as a percentage of the fullscale output.

The third selection allows the user to enter the HEX data value to be loaded to the input register as the method of programming the output current.

Alarm Current On

This button is used to select between the normal 4-20mA output and the alarm current output. When this button is not selected the normal 4-20mA output range is selected. When the alarm current on is selected an "x" appears in the box and the output range can be programmed from 3.5mA to 24mA.

PROGRAMMED OUTPUT

This section shows the programmed output current as a current in mA, as a % of Fullscale and as the HEX value that has been written to the input register. The Binary Output Box shows in the form of a LED display the data that has been loaded to the AD421.
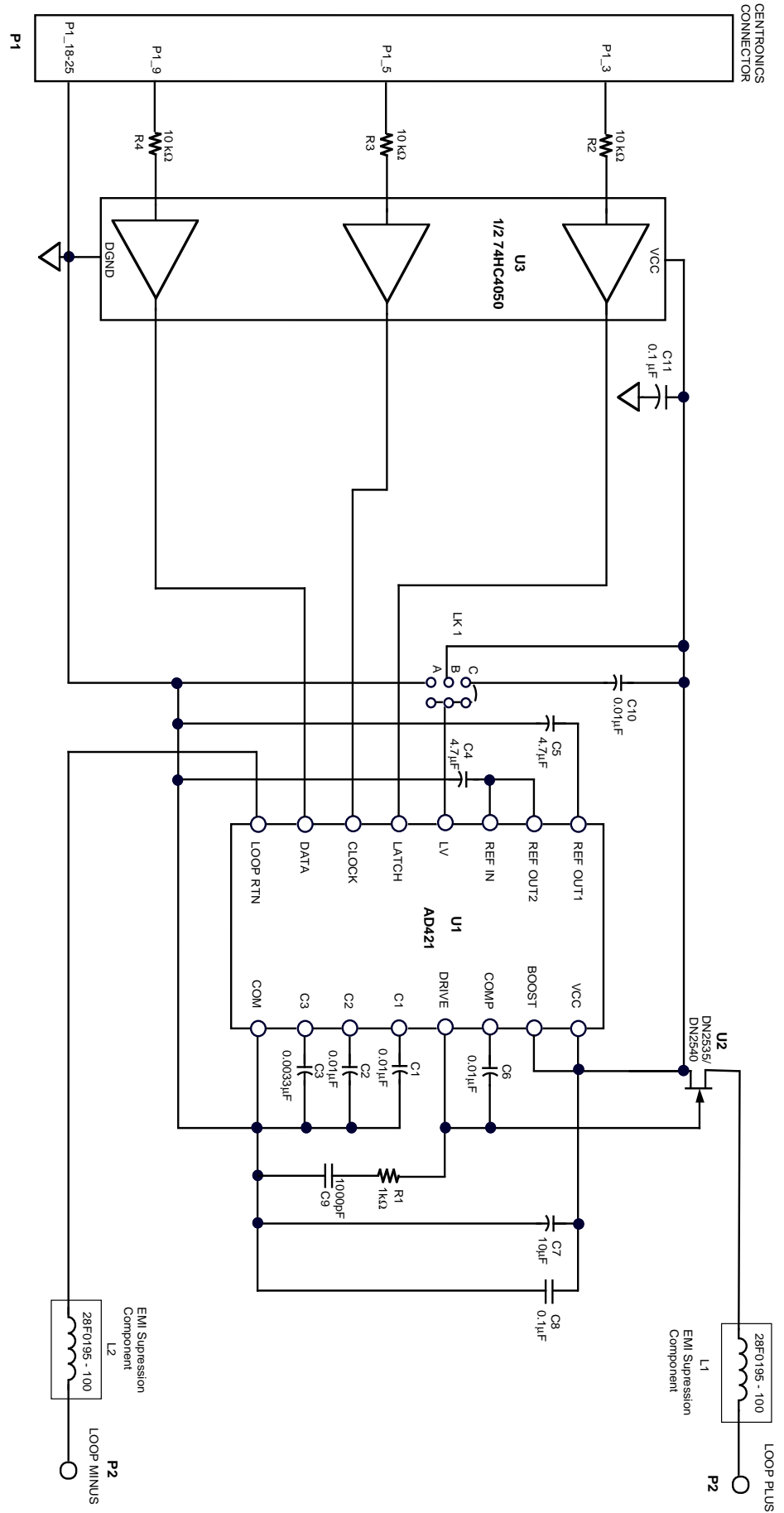
Figure 4. AD421 Evaluation Board Circuit Diagram.

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COMPONENT LISTING AND MANUFACTURERS

Intergrated Circuits

Component	Location	Vendor
AD421	U1	Analog Devices
DN2535/DN2540	U2	Supertex[1]
74HC4050	U3	Philips

Capacitors

Component	Location	Vendor
0.01μF Ceramic	C1, C2	Philips Mftrs No. CW20C 103M
0.0033μF Ceramic	C3	
4.7μF ± 20% Tantalum (16 V)	C4, C5	AVX- Kyocera Mftrs No TAG106MO16
0.01μF Ceramic(X7R ±20%)	C6, C10	Philips Mftrs No. CW20C 103M
10μF ± 20% Tantalum (16 V)	C7	AVX- Kyocera Mftrs No TAG106MO16
0.1μF Ceramic(X7R ±20%)	C8, C11	Philips Mftrs No. CW20C 104M
1000pF Ceramic	C9	Philips Mftrs No. CW15A102M

Resistors

Component	Location	Vendor
1kΩ ±5% 0.25W Carbon Film Resistor	R1	Bourns
10kΩ ±5% 0.25W Carbon Film Resistor	R2, R3, R4	Bourns

EMI/EMC Ferrites

Component	Location	Vendor
28F0195-100 Ferrites	L1,L2	Steward[2]

Link Options

Component	Location	Vendor
Pin Headers	Lk1 (3x2 way)	Harwin Mftrs No. M20-9993606
Shorting Plugs	Pin Headers (1 required)	Harwin Mftrs No. M7571-05

Sockets

Component	Location	Vendor
36 Pin Centronics Connector	P1	Fujitsu Mftrs No. FCN785J036G0
16-Pin IC Socket	U1,U2	Harwin Mftrs No. D2816-01
PCB Mounting Terminal Block	P2 (LOOP PLUS, LOOP MINUS)	Lumberg Mftrs No. KRM2

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[1] Supertex inc., 1350 Bordeaux Drive, Sunnyvale, California 94089. Tel No. 408 744 0100
[2] Steward, 1200 East 36th Street, P.O. Box 510, Chattanooga, Tennessee 37401-0510. Tel No. 423 867 4100.

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EMI/EMC CONSIDERATIONS

On the AD421 board care was taken with the layout, grounding and decoupling to reduce any effects that electromagnetic disturbances might have on the AD421. Two ferrites, L1 and L2 are included on the AD421 board to provide an extra level of security against EMI disturbances that come in on the loop(+) and loop(-) lines. EMC susceptibility tests were carried out on the AD421 board to check the level of performance obtained from this board when subjected to various electromagnetic disturbances. The aim of the susceptibility tests is to ensure that the product has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended. The EMI/EMC directive 89/336/EEC only applies to products or systems and not to individual components. The AD421 evaluation board acts as a system in this test procedure. The immunity tests performed included conducted immunity and radiated immunity. Conducted immunity is a fast transient burst test where fast transients are coupled onto the 4-20ma loop twisted pair cable using a 1m capacitive clamp. Radiated immunity testing involves subjecting the board under test to various electric fields with frequencies varying from 30MHz to 1GHz.

Radiated Immunity (IEC 1000-4-3)

This set of experiments looked at the performance of the AD421 when subjected to various electric fields. Class B approval for use in residential/commercial light industrial environments requires the system to remain functional in a field of 3V/m from 30MHz to 1GHZ. Class A approval for use in industrial environments requires the system to remain functional in a field of 10V/m. This test is carried out in a stripline cell which is essentially two metal plates placed in parallel, the AD421 board is placed between these plates where it is subjected to an electric field applied to the plates. The results obtained from this test with the AD421 in its normal operating mode with Vcc =5V and controlling the current in the loop to 10mA are as follows.

Board in Horizontal Orientation:

Field Strength	Results	Comments
3V/m	PASS	Range from 30MHz to 1GHz
5V/m	PASS	Range from 30MHz to 1GHz
10V/m	PASS	Range from 30MHz to 1GHz

This is class 1 performance, i.e. normal operation maintained during application on the field.

Board in Vertical Orientation:

Field Strength	Results	Comments.
3V/m	PASS	Range from 30MHz to 1GHz
5V/m	PASS	Range from 30MHz to 1GHz
10V/m	FAIL	Device resets to 4mA at 860MHz

This is class 1 performance, ie normal operation maintained during application of the fields of 3V/m and 5V/m. The classification is class 3 at 10V/m as user intervention is required to get the AD421 back to its programmed conditions.

Conducted Immunity (IEC 1000-4-4 Fast Transient Burst Test)

This set of experiments involved the coupling of fast transients onto the current loop unshielded twisted pair cable through a 1m capacitive clamp. The fast transient burst is specified to have a rise time of 5ns and a duration of 50ns and is supplied from a 50Ω source. Bursts of 15ms duration of these pulses at a repetition rate of 5kHz are applied every 300ms. The voltage level of the pulse is controlled from 250V to 5kV. Coupling onto the cable is via a capacitive clamp which is essentially two metal plates which sandwich the line under test to provide a distributed coupling capacitance. This clamp is fed from the transient generator which is constructed with a spark gap driven from an energy storage capacitor which enables the high voltages to be generated with the fast rise times. The AD421 is programmed so that 10mA flows in the loop during the experiments. The results from this test were as follows:

Burst Amplitude	Results	Comments.
500V Positive	PASS	Normal Operation.
500V Negative	PASS	Normal Operation.
1kV Positive	FAILS	Loop current resets to 4mA.
1kV Negative	FAILS	Loop current resets to 4mA.
2kV Positive	FAILS	Loop current resets to 4mA.
2kV Negative	FAILS	Loop current goes to 20mA.

The board achieves class 1 performance for application of a burst of 500V, ie it continues to work as normal. For all other bursts the operation can be classified as class 3 where user intervention is required to restore the part back to normal operation after the burst has been removed.

Further development work on the AD421 evaluation board is being planned to see if the above performance can be improved upon.