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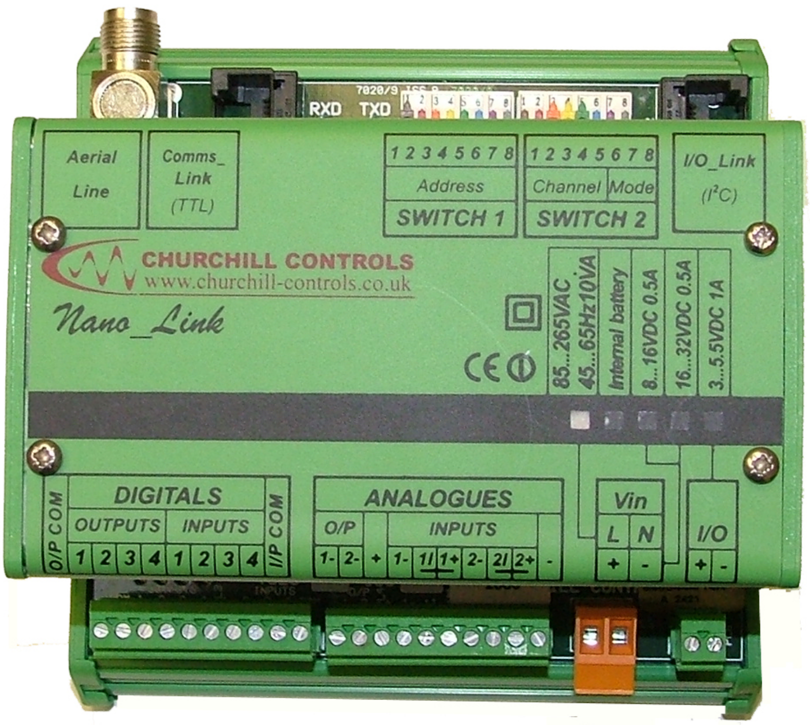
Nano_Link

Nano_Link

TECHNICAL MANUAL

RADIO/LAND LINE TELEMETRY & TELECONTROL SYSTEM WITH BATTERY-POWER OPTION



Issue	Date	Revision
1	05/05/99	
2	20/10/00	Adds Exception Reporting
3	21/01/02	Enhances exception reporting and adds 1 sec transducer warm-up
4	08/06/04	Adds 4 sec warm-up & new radio test modes, plus various corrections
5	02/02/09	Adds rotation sensor and analogue averaging modes

As part of our policy of continuous improvement we would welcome any suggestions for changes to the document.

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1. Preface

This manual is intended to give the installer, user and maintenance personnel all the information they are likely to need for implementing telemetry systems from the ***Data_Link 2000*** product range.

The ***Data_Link 2000*** product is based on ***Nano_Link*** (which is a simple, low power, self-contained unit) and ***Micro_Link*** (which is a more complex product with considerable expansion capacity and many configurable functions). This manual concentrates on ***Nano_Link***. If a system uses both ***Nano_Link*** and ***Micro_Link***, this manual should be read in conjunction with the '***Data_Link 2000*** **Technical Manual**'.

The ***Data_Link 2000*** product range is subject to continuous evolution, so new features are constantly being added by a combination of software enhancements and new hardware modules. This manual describes the features of ***Nano_Link*** software version 2.24. Some of the features described may not be available, or may function slightly differently, in earlier software versions. However, it is Churchill Control's policy to ensure that wherever possible software is backwards-compatible. This means that wherever possible the features described will be present in all future software issues.

The software version fitted within ***Nano_Link*** can be found by removing the cover and examining the label on the EPROM, or by connecting an alphanumeric display to it.

Every attempt has been made to lay out this manual in a logical sequence. Chapter 2 describes the features of ***Nano_Link***, and should be read before designing a system around ***Nano_Link***.

Chapter 4 explains the method of installation.

Chapter 5 describes the method of configuring ***Nano_Link*** for each specific application, and chapters 6, 7, 8 and 9 describe the functionality in detail.

Chapter 10 describes the Alphanumeric Display Module, which provides a user interface if required.

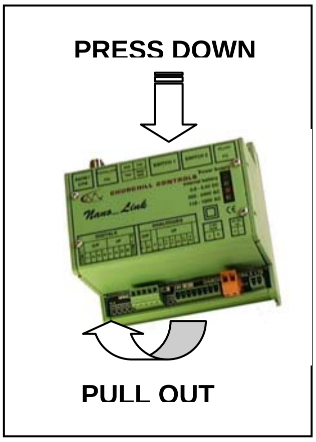
Before shipping any ***Nano_Link*** system, Churchill Controls configure it to their best understanding of the specific application requirements, and test it as a complete system. However, because the internal power supply has battery back-up which would run down during shipping. To overcome this the configuration switches on each ***Nano_Link*** are set to the power down mode immediately prior to shipping. After installation the system should begin operation immediately if the user sets the switches to the position marked on the label attached to the unit.

2. Common Features

2.1 Mechanical

2.1.1 Housing

All modules (except the ***Nano_Link IP67***) are housed in plastic cases, which can be clipped onto either G or ‘top hat’ DIN rails. The housings measure 125mm H x 125mm W x 110mm D (when mounted on a vertical surface). All electrical connections are made through two part screw terminals along the top and bottom edges. Connections between modules and with other devices are made through FCC68 RJ11 and RJ45 jacks. No internal circuitry is accessible without removing the top cover.



The top cover is retained by internal clips, and can be removed by inserting a fingernail or screwdriver into the centre of the gap at each side of the cover and pulling outwards. Some modules also have screws.

To unclip modules from ‘top hat’ rails on a vertical surface, press down on the top of the module and lift it out from the bottom.

2.1.2 Nano_Link IP67

This is a form of mechanical housing that can be used when ***Nano_Link*** has no ancillary equipment around it. It is a lower cost option than a conventional unit in a polycarbonate enclosure.

As shown in the illustration, a leased line unit can also incorporate a surge protection unit. All variants can also include any of the power supply options and a rotation sensor.

A label is attached to the inside of the lid to show the I/O connections. It also identifies the type of power supply fitted, and can be used to identify the required DIPswitch settings.

2.1.3 Polycarbonate Enclosures

A range of polycarbonate enclosures is available for applications requiring wall-mounting. They range in size from 190mm x 190mm x 135mm (suitable for a single module) up to 380mm x 560mm x 135mm (for up to 4 modules). The smallest enclosure is rated IP68 (submersible for 24 hours to a depth of 2m), whilst all others are IP67 (resistance to temporary submersion to a depth of 1m). The enclosures are fitted with DIN rails to which the unit can be clipped and a cable to extend the aerial connector to a TNC aerial socket on the top of the enclosure. It is assumed that the user will fit any glands needed to bring plant I/O into the enclosure.

It should be noted that the IP rating is dependent on the lid being screwed down tightly, and all glands being correctly fitted and secured.

Larger systems can be supplied in steel enclosures if required.

2.2 Network Communications

2.2.1 Radio

Both ***Micro_Link*** and ***Nano_Link*** can be equipped with synthesised VHF or UHF transceivers which are approved to ETSI standard EN 300 220-1 and can thus be used so can be used in all the European Community member states (subject to national requirements). In the UK the de-regulated bands are designated MPT1328 (VHF) or MPT1329 (UHF) bands. Any of 32 channels can be selected to avoid conflict with other users.

The UHF MPT1329 band is the most popular, since it allows for transmit powers of up to 500mW ERP (Effective Radiated Power), but doesn't require a licence. There are 32 channels at 12.5KHz spacing, in the band 458.500MHz to 458.925MHz.

The radio range depends on the aerials used and the topography of the area, but will typically be up to 8Km in urban environments and up to 25Km with elevated aerials.

There are two adjustments on the radio modules, Modulation Level and Transmit Power, both of which are factory set:

The Modulation Level trimmer sets the transmitter frequency deviation, and should never be changed.

The Transmit Power trimmer sets the output power in the range 20mW to 1W, and is pre-set to 500mW. *It can only be changed by qualified personnel equipped with a calibrated UHF power level meter*. The output level can be set below 500mW to minimise power consumption and reduce potential interference with other users. It must be set below 500mW if the aerial has gain. It can only be set above 500mW if the aerial and/or aerial feeder has an overall gain of less than unity, and then only to compensate for the losses. ***The ERP must never be set to more that 500mW when using MPT1329.***

Other versions can be supplied to operate within the regulated MPT1411 band of 457.5MHz to 458.5MHz and 463.0MHz to 464MHz at power levels up to 5W, or the unregulated MPT1328 band of 173.20MHz to 173.35MHz at a power level of 10mW.

2.2.2 Leased Line

Nano_Link can alternatively be equipped with modems for use on leased telephone lines supplied by national network providers such as BT and Mercury. The modems are approved for use through the European Union.

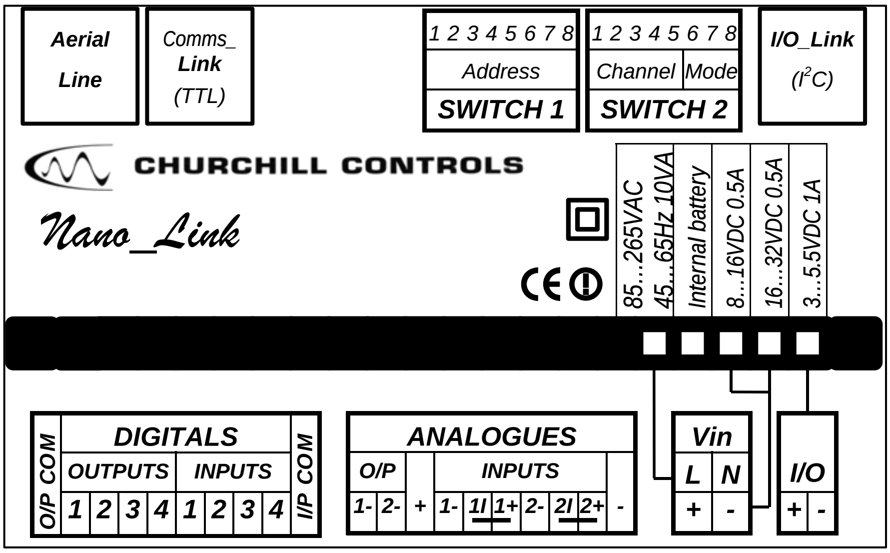
The modems are capable of operating with an end-to-end loss of up to 27dB, and provide correct impedance matching in accordance with the regulations. Normal telephone wires have a loss of about 1.5dB per Km, giving a range of typically 18Km. However, if more than one outstation is used, the line becomes mismatched, thus increasing the loss and effectively reducing the maximum line length. This can be overcome by adding line amplification and/or impedance matching pads. The network provider will normally arrange this.

2.2.3 Private Wire

Private wires are cable pairs similar to leased lines, but owned by the user. The user is thus responsible for maintenance of the cable, but does not have to pay rental charges.

Over short distance the characteristics of the cable are unimportant. However, for distances greater than around 2Km the cable should be matched to the terminating impedance of the modems, namely 600Ω. The modems are capable of operating with an end-to-end loss of up to 27dB. Normal telephone wires have a loss of about 1.5dB per Km, giving a range of typically 18Km. However, if more than one outstation is used, the line would become mismatched, due to the additional load impedance. This increases the loss and effectively reduces the maximum allowable line length. A high impedance version of the modem is available to overcome this and allow large numbers of outstations to be connected across a single pair of wires, with appropriate terminations at each end of the cable.

3. Product Description



3.1 General

Nano_Link is housed in a compact plastic enclosure, which includes an internal power supply and radio or modem, and can be clipped onto a standard DIN rail. It can be supplied in waterproof polycarbonate enclosures if required.

The internal power supply can be three 'D' alkaline batteries, a mains power supply with battery back-up or an external 12VDC source (such as a solar power supply). The module has been optimised for low power consumption, to the extent that it will operate for over 2 years on low-cost Duracell batteries. Battery operation has the advantage of significantly lower installation and running costs.

The internal communications device can be either a radio or a modem. The radio is normally operated on a de-regulated UHF band, so doesn't need a licence. The modem can use either a leased line (owned by a national network provider) or a private wire (owned by the user). ***Nano_Link*** can also be used with external communications devices connected to the ***Comms_Link*** port.

Nano_Link has 4 digital inputs, which can each be used to monitor alarm or status conditions, and also to count pulses from totalised flow transducers. Pseudo digital inputs flag communications fail alarm and battery low alarm conditions. It also has 2 analogue inputs, which can be used with low-cost millivolt transducers or conventional current loop transmitters. A pseudo analogue input monitors the battery voltage and another monitors the radio receive signal strength.

Nano_Link can also be equipped with 4 digital outputs, each comprising a volt-free relay contact, and two 0…20mA analogue outputs. The state of each output can be monitored by LED indicators located adjacent to the relevant terminals.

The capacity can be increased by a further 16 digital inputs and/or 16 digital outputs by adding optional digital expansion modules.

Although ***Nano_Link*** is intended primarily for use as an outstation or repeater, it can be configured as a base-station to provide a simple point-to-point link to another ***Nano_Link***, transferring up to 2 analogues and 20 digitals in both directions.

However, to access pseudo inputs, use repeaters, or use more than one outstation, a ***Micro_Link*** base-station should be used. This is described in the '***Data_Link 2000*** Technical Manual'

3.2 Indicators

All ***Nano_Link***'s include four LED's, designated RXD, TXD, Test and Heartbeat.

TXD and RXD monitor communications between the main processor and the radio or modem. It should be noted that the radio acknowledges each character sent to it, so whenever the TXD LED flashes on a ***Nano_Link*** equipped with a radio, the RXD flashes in sympathy. This does not happen on ***Nano_Link***'s equipped with other communication interfaces. In all cases incoming data will cause the RXD LED to flash on its own. Commands to the communications interface (such as setting the radio channel or enabling the transmitter) are also sent on TXD and acknowledged through RXD, although they may not result in any transmitted data.

The Test LED lights in normal operation whenever the transmitter is enabled. However, it is also used to indicate when the unit is in test mode (see 9.3).

The Heartbeat LED flashes to indicate that ***Nano_Link*** is 'alive'. The flashing sequence indicates its status:

- When flicking on very briefly every second, ***Nano_Link*** is asleep, in its power-down mode.
- When flashing continuously at the rate of 4 flashes per second, ***Nano_Link*** is awake, communicating correctly, and its power supply is good.
- When flashing three pulses out of every four, ***Nano_Link*** is awake, but has lost communication with the remote device.
- When flashing two pulses out of every four, ***Nano_Link*** is awake and has communication with the remote device, but its battery is running low.
- When flashing one pulse out of every four, ***Nano_Link*** is configured as a base-station, has communication with the remote device, and its battery is good, but the remote outstation is reporting a low battery.

Nano_Link's equipped with digital outputs also have 4 LED's to monitor the state of these outputs. These LED's are located adjacent to the relevant terminals.

3.3 Power Supply

Nano_Link works from an input supply of 3.0…5.5VDC, which may be derived from a variety of sources via an internal power supply unit.

The current consumption is less than 50µA when asleep, increasing to about 20mA when awake, and about 1A when the radio transmitter is active. ***Nano_Link*** incorporates is a power converter that generates a stable +5Vsupply when required for the modem or radio receiver, expansion modules and other digital circuitry, and another that generates +12VDC when required to power the radio transmitter, modem and/or external analogue transducers. If ***Nano_Link*** is set to power save mode (see 7.1) both converters are disabled when not required to conserve power. However, in constant power mode (see 7.1) they both remain active at all times.

The output of the internal power supply is accessible through the terminals marked 'I/O', which can also be used as the power input if no internal supply is fitted. The input to the internal power supply is accessible through the terminals marked 'Vin'. The label is marked to indicate the type of supply fitted:

3.3.1 Internal Batteries

An internal battery pack can be fitted which holds three D alkaline cells (typically Duracell Procell batteries). These have a capacity of 18 ampere-hours, which is sufficient to power the unit for at least two years if it is scanned every 15 minutes.

When fitting new batteries, ensure that the negative end (flat) goes to the coil spring in the battery holder.

Battery power is only intended to be used for an outstation that is interrogated relatively infrequently (typically every 15 minutes) or uses exception reporting, and is not intended to support digital or analogue outputs. Furthermore it will not support expansion modules.

Nano_Link monitors the battery voltage as an analogue value that can be read by the base-station. It also generates a digital alarm if it drops below a defined level. The outstation should continue working for several days after generating this alarm (assuming it is interrogated every 15 minutes).

3.3.2 Universal Mains Power Supply

An internal mains power pack can be fitted, which derives a 5.3V supply from any input in the range 80…260VAC. The supply includes rechargeable Ni-Cad batteries, which will support the unit in the event of a mains power failure. ***Nano_Link*** monitors the battery voltage as an analogue value that can be read by the base-station, and generates a digital alarm if it drops below a defined level. If a mains fail indication is required a mains-operated relay can be used externally, with its contacts connected to one of ***Nano_Link***'s digital inputs. The period for which the batteries will support ***Nano_Link*** depends on the mode of operation, but will typically be at least 8 hours.

The power supply is double insulated, so does not require a safety earth. The power input is through a two-part screw connector that is different both in size and colour from all other terminals, to ensure it cannot be incorrectly fitted.

Mains power should be used for any ***Nano_Link*** used as a base-station, a repeater or an outstation that is interrogated continuously, used analogue or digital outputs or is fitted with expansion modules. It can also be used for an outstation that is interrogated relatively infrequently.

3.3.3 External 12/24VDC Source

Two variants of this supply are available, one operating from a supply in the range 8…16VDC and the other for 16…32VDC. They are intended for operation from station supplies of nominally 12V and 24V respectively. If the user wishes to monitor the battery voltage, and/or generate a battery low alarm, the 7041 Solar Power Controller described below can be used by connecting the station battery to it and omitting the solar panel.

3.3.4 Solar Supply

Solar power requires an external solar panel, a solar controller and a lead-acid battery. The battery is required to maintain the system overnight and during bad weather. Its size has to be calculated, along with that of the solar panel, to ensure that the system continues operation throughout the year. Factors influencing the size of the panel and battery include the electrical load, the location and the ambient temperature range. The controller ensures that the battery is not overcharged during bright sunlight, and does not discharge into the panel at night.

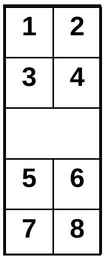
Nano_Link 's supplied for solar operation are fitted with an internal 12VDC power supply, and use an external 7041 Solar Power Controller and battery. The controller is fitted in a small housing that clips onto DIN rail adjacent to ***Nano_Link***. The battery is normally fitted at the bottom of the enclosure. An important feature of the 7041 Solar Power Controller is its very low internal power dissipation. Some commercially-available solar controllers are designed for us with large solar panels and batteries, and consume more current than ***Nano_Link***! They therefore significantly reduce battery life when used on small systems.

As well as controlling charge to the battery, the 7041 Solar Power Controller also provides a digital Battery Low Alarm output that can be connected directly to one of the digital inputs on ***Nano_Link***. There is also a voltage monitor which provides a level of 0…100mV for a battery voltage range of 0…20V. This output can be connected to one of the analogue inputs on ***Nano_Link*** if required.

The 7041 Solar Power Controller has two LEDs, marked 'Charging' and 'Charged'. The Charging LED flashes when the battery is being charged by the solar panel. If the battery attains a fully-charged state the 'Charged' LED lights, and the controller shorts out the solar panel to prevent further charging. In the quiescent state both LEDs will flash alternately as a trickle charge is fed to the battery to maintain equilibrium.

Whenever the solar panel is not charging the battery (e.g. at night) the Charged LED will flash and the Charging LED will remain off. If the battery voltage drops below 11V the flash rate will slow to about 1 pulse/second and the Battery Low Alarm will be generated.

Connections to the 7041 controller are via screw terminals, as follows:



1	Solar Panel –ve	2	Solar Panel +ve
3	Battery –ve	4	Battery +ve
5	Battery Low Alarm	6	Battery monitor
7	Output –ve	8	Output +ve

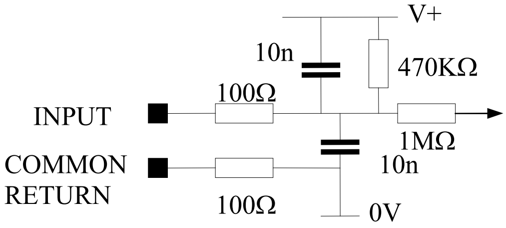
Terminals 7 and 8 should be connected to Vin – and + respectively on ***Nano_Link***. Terminal 5 can be connected to any of the digital inputs on ***Nano_Link*** if required. Terminal 6 can be connected to Analogue 1+ on ***Nano_Link*** if the battery volts is to be monitored remotely, with analogue 1- connected to the Analogue – terminal. Do not fit a link between 1I and 1-. Analogue input 2 can still be used for 0…100mV or 0…20mA signals.

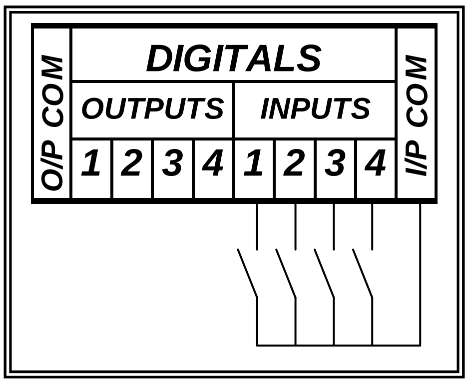
3.3.5 External 5V Source

Nano_Link can alternatively be operated from an external source of 3.0…5.5V. The supply must be capable of supplying 1A surge currents.

3.4 Plant I/O

All plant I/O on ***Nano_Link*** is via screw terminals on two-part connectors. This provides universal connectivity whilst allowing the unit to be easily replaced if necessary. One connector is allocated for digital I/O and another for analogue I/O. The pin functions are marked on the top cover.





3.4.1 Digital Inputs

Nano_Link has 4 identical digital inputs, with a common return, intended for use with volt-free contacts. The input circuit is as follows:

The inputs are intended for use with volt-free contacts, but can also be used to monitor DC voltages in the range 0…24V. A closed contact (or a voltage less than approx. 1V) is treated as logic '1', and an open contact (or a voltage greater than approx. 4V) is a logic '0'.

The series resistors give protection against EMI and excessive voltages in input terminals. The capacitors serve the dual purpose of providing a surge wetting current when the input contact first closes and providing switch bounce filtering, whilst allowing pulses of up to 10pps to be counted.

V+ is equal to the raw input voltage (i.e. 3.0...5.5V) when ***Nano_Link*** is asleep, and 5.0V when it is awake.

Nano_Link records the current state of each digital input. In addition, it maintains an internal 16-bit counter for each input, which is incremented each time the contact closes. Each input can therefore be used to monitor a digital state or to count input pulses. The count is copied into non-volatile memory every 10 minutes, so in the event of a total power failure in the worst case only 10 minutes of counts will be lost.

The counters can be reset to zero using a special test mode (see Chapter 0).

3.4.1.1 Pseudo Digital Input 1 – Comms Fail alarm

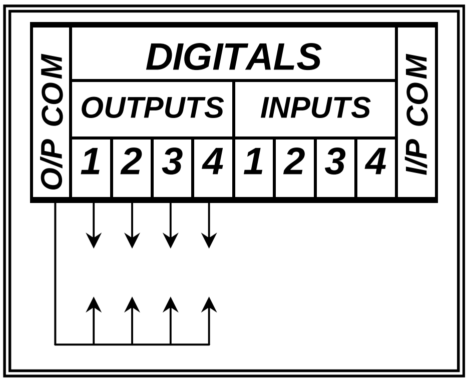
This is set to '1' under normal conditions, but changes to '0' in the event of loss of communications. It is described in more detail in Sections 7.2 and 8.2.

3.4.1.2 Pseudo Digital Input 2 – Battery Low alarm

This is set to '1' under normal conditions, but changes to '0' when ***Nano_Link*** senses that the supply voltage is dropping to the point where failure is imminent. It is described in more detail in Sections 7.2 and 8.2.

3.4.2 Digital Outputs

Digital outputs, if equipped, use volt-free relay contacts rated 125VAC/0.5A/60VA max. or 24VDC/1A/30W max. The four outputs share a common return, but are fully isolated from the internal circuitry.



Note that the digital outputs copy the state of the corresponding remote digital inputs, combined with alarm flags as described in 7.2 and 8.2.

Although the relay contacts are rated up to 125VAC, the user must exercise due caution to ensure that the safety requirements of the Low Voltage Directive are not breached by the application of an unsafe voltage from an external source.

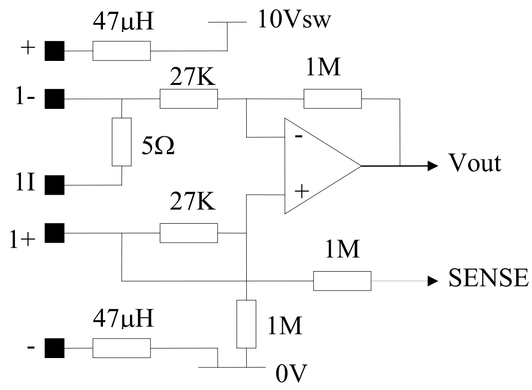
If the relays are used to switch inductive loads, such as interposing relays, the load must include transient suppression to prevent excessive voltages during switching. If the load is DC, this is most easily achieved by connecting a reverse-biased diode across the load. If it is AC, a bi-directional suppressor such as transorb or a voltage dependent resistor should be used

3.4.3 Analogue Inputs

Nano_Link has two real inputs and two pseudo inputs (which read the battery voltage and the radio received signal strength):

3.4.3.1 Real Inputs:

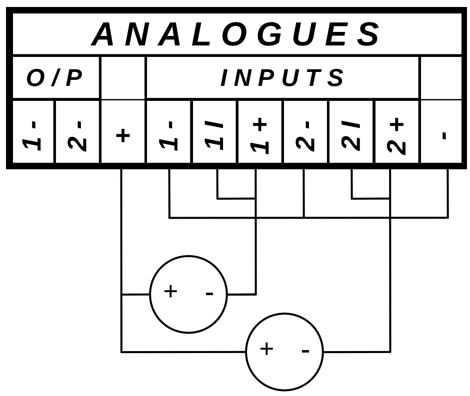
The two real inputs are very similar, and are read to a resolution of 12-bits (i.e. 0…4095). The equivalent circuit of input 1 is as follows:



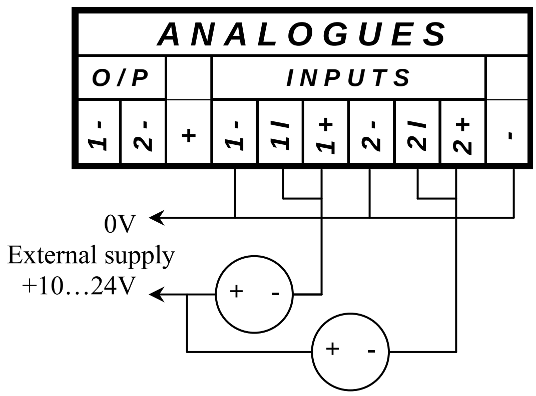
Analogue input 2 is identical, but omits the SENSE detector.

Nano_Link generates an internal 12V supply, which is present all the time if the unit is configured for mains power, but switched off in battery-powered units when not needed, to conserve power. It is used to power the analogue input and output circuits, and the radio transmitter. It is also available for powering transducers if required.

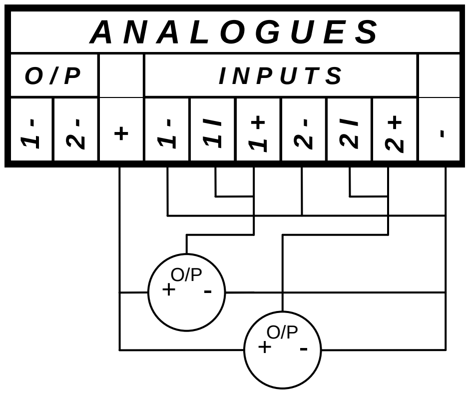
If SENSE is within 1V of either 0V or 12V the input sensitivity is set to 0...100.0mV. Linking 1I to 1+ converts this to a current input of 0...20.00mA. This is compatible with both 0…10mA and 4…20mA transducers, and can detect both over-range and under-range errors. The means of connecting current transducers is thus:



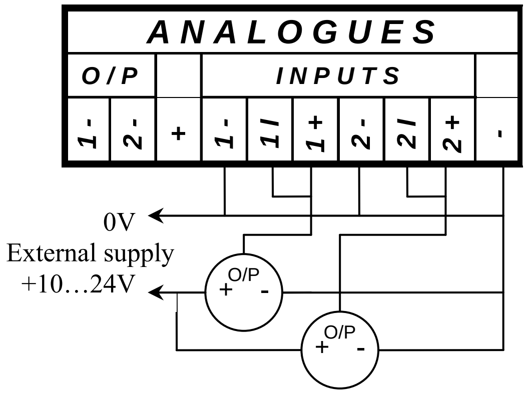
2-wire current transducer input, powered by *Nano_Link*



2-wire current transducer input, externally powered



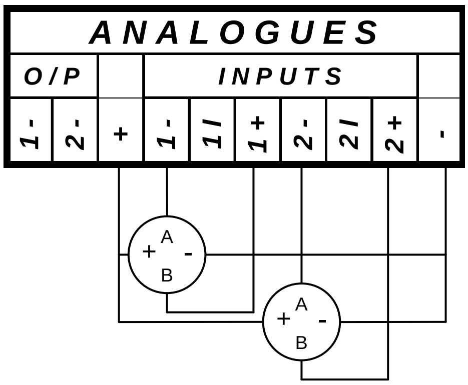
3-wire current transducer with common 0V, powered by *Nano_Link*



3-wire current transducer with common 0V, externally powered

The calibration means that a reading of 4000 corresponds to full scale. A reading between 4001 and 4095 indicates that the input is over-range.

If SENSE is midway between 0V and 12V, ***Nano_Link*** assumes the transducer to be a strain gauge pressure sensor. These give an output voltage that is proportional to the supply voltage and to the pressure, and are normally calibrated to give 100mV FSD when powered from 12VDC. ***Nano_Link*** accommodates this by changing the reference to 1.00% of 12V. It thus self-adjusts for tolerances on 12V:



4-wire strain gauge transducer, powered by *Nano_Link*

Note that the 12V supply from *Nano_Link* is only present when the station is awake. A base-station is constantly awake, as is an outstation in Constant Power Mode. However, a battery-powered outstation conserves power by only energising the transducers when needed. It will thus activate the 12V supply only when it receives a command requesting an analogue reading. The supply is then raised for a short period before sampling the analogue, to give the transducer time to stabilise. Power is switched off immediately after the response has been sent to the base-station.

If the user wishes to test transducers at a battery-powered site, he should set the station to constant power mode for the duration of the tests, remembering to return it to normal afterwards to conserve the battery.

For more information on operating modes refer to Chapters 7 and 8.

3.4.3.1.1 Potentiometer Interface

Some transducers incorporate a potentiometer that needs to be energised by a stable voltage, and returns a voltage that varies from 0 to 100% of the energising voltage. A small interface module, designate 7023-1 is available to power a potentiometer from a stable supply derived from the analogue + & - output from ***Nano_Link***, and convert the potentiometer reading to a 0…100mV signal compatible with the analogue inputs on ***Nano_Link***. The module is fitted in a small housing that clips onto DIN rail adjacent to ***Nano_Link*** and incorporates Span and Offset adjustment.

Details of connections to this module, and the method of calibrating it, are given in Application Note AN009.

3.4.3.1.2 Voltage Output Transducers

A small number of transducers generate a voltage output, typically scaled 1…5VDC. A small interface module, designate 7023-2 is available to convert this to a voltage in the range 0…100mV, compatible with the analogue inputs on ***Nano_Link***. The module is fitted in a small housing that clips onto DIN rail adjacent to ***Nano_Link*** and incorporates Span and Offset adjustment.

Details of connections to this module, and the method of calibrating it, are available on request.

3.4.3.2 Pseudo Analogue Input 1 - Supply Volts

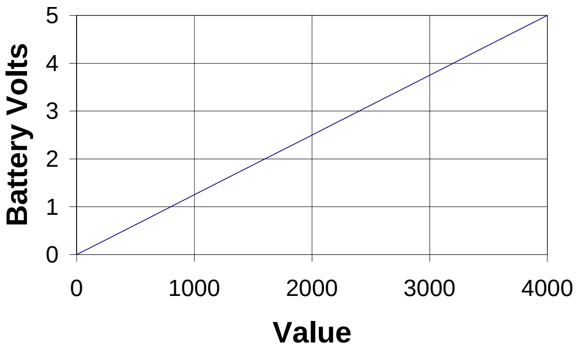
Nano_Link measures the internal battery voltage, and stores it as if it was an additional analogue input. This register be accessed in two ways:

1. Using the Alphanumeric Display Module (described in section 10). This scales the register contents and displays the actual voltage.
2. By configuring ***Nano_Link*** as an outstation and interrogating it with a ***Micro_Link*** base-station. The method of accessing the register via ***Micro_Link*** is given in the '***Data_Link 2000*** Technical Manual'.

The battery voltage can be calculated from the reading using the formula

Battery = Value / 800V

This can be illustrated graphically as follows:



The reading is limited to the range 0…4080, corresponding to a voltage range of 0…5.10V.

Battery-powered units use 3 alkaline batteries giving a nominal 4.5V (i.e. reading of 3600). When they are nearing the end of their life the voltage drops to 3.65V (corresponding to a reading of 2920). At this point a battery-powered ***Nano_Link*** will generate a Low Battery alarm.

Mains powered units derive a supply of 5.5V when mains is present, giving a full-scale reading of 4080. If the mains supply fails the unit continues operating from internal trickle-charged Nickel Cadmium batteries, but the voltage will drop to about 4.5V (reading 3600). When the batteries are approaching the end of their life the voltage will drop to 4.0V (3200). At this point a mains-powered ***Nano_Link*** will generate a Low Battery alarm.

3.4.3.3 Pseudo Analogue Input 2 - Radio Received Signal Strength Indicator (RSSI)

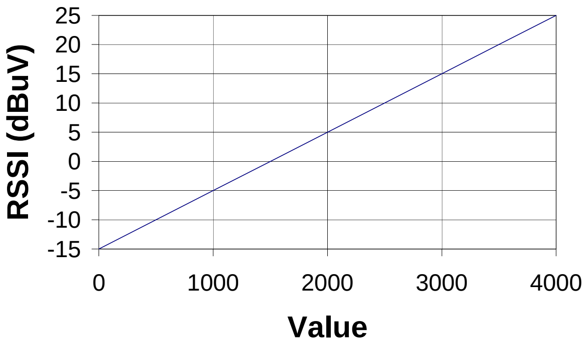
If ***Nano_Link*** uses radio communication, it measures the received signal strength, and stores it as if it was an additional analogue input. This register be accessed in three ways:

1. Using the Alphanumeric Display Module (described in section 10). This scales the register contents and displays the actual RSSI level in dBμV.
2. By setting a ***Nano_Link*** base-station to the radio commissioning mode described in Chapter 8.1.2. The value will then be presented on an analogue output.
3. By configuring ***Nano_Link*** as an outstation and interrogating it with a ***Micro_Link*** base-station. The method of accessing the register via ***Micro_Link*** is given in the '***Data_Link 2000*** Technical Manual'.

The RSSI can be used to deduce the margin by which the path can deteriorate before communication will be lost. RSSI is measured in dBμV, according to the following formula:

RSSI = Value / 100 - 15 dBμV

This can be illustrated graphically as follows:

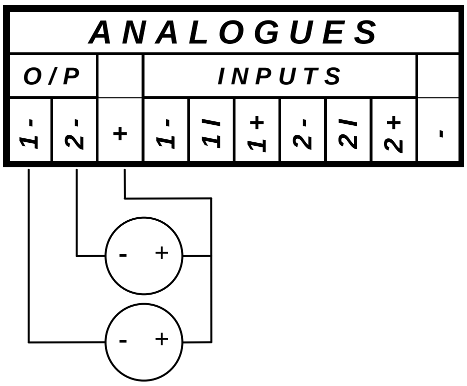


The calculated value can be read via ***Micro_Link***. If using method 3 above. However, if using method 1 or 2 the value will be scaled appropriately.

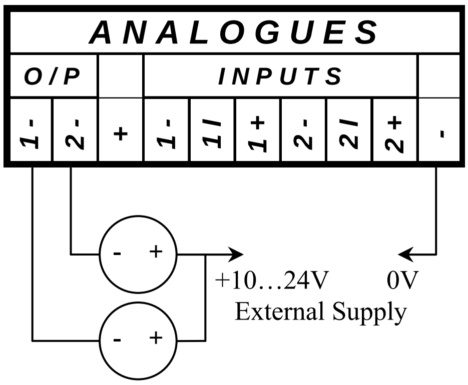
The radio receiver has a sensitivity of about -10dBµV, and a good radio path should have a margin of at least 10dBµV so the RSSI should ideally read at least 0dBµV, or 1500.

3.4.4 Analogue Outputs

Analogue outputs, if equipped, sink a current of 0…20.00mA to the internal 0V rail. The current can be sourced from either the internal 12V supply on the + terminal of the analogue connector, or from an external supply of up to 24V DC. Analogue outputs are only available when the 12V supply is active, so ***Nano_Link*** must be set to continuous power (switch 2.8 closed):



Outputs powered by *Nano_Link*
Load 0…450Ω



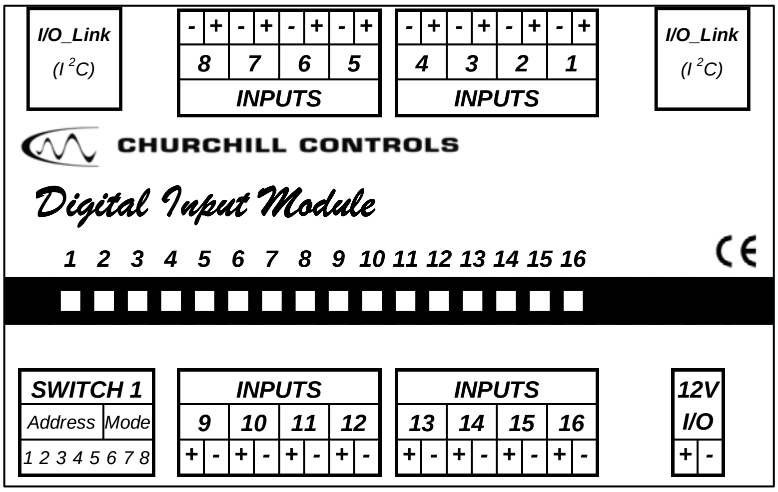
Outputs powered by external supply
Load 0…((V-1)*50)Ω

Although the outputs are calibrated to give 0…20.00mA, they can produce up to 20.40mA to indicate fault conditions.

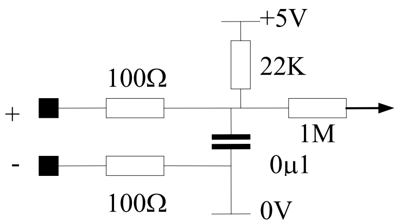
3.4.5 Expansion Capability

Nano_Link includes an ***I/O_bus port*** that can be used to access expansion modules from the ***Data_Link 2000*** product range. Its capacity is limited to one 16-way digital input module (must be set to address 0, so S1.1…S1.5 all open), one 16-way digital output module (must be set to address 1, so S1.1…S1.4 all open, S1.5 closed) and/or an Alphanumeric Display Module. Digital expansion modules cannot be used on battery-powered ***Nano_Link***'s. The Alphanumeric Display Module is described in Chapter 10.

3.4.5.1.1 7150-1 Digital Input Module



This module has 16 inputs, each with two terminals marked '+' and '-'. The input circuit of each is as follows:



The inputs are designed for use with volt-free contacts, which are supplied a wetting current of 50mA on closing, with a normal sense current of 250µA. However, they can also be used to monitor a DC voltage of up to 24V relative to 0V.

The module usually generates a logic '0' state when the contact is open or the monitored voltage is greater than 3.5V, and a logic '1' state when the contact is closed or the voltage is less than 1.5V. However, the sense can be inverted if required by setting switch 8 of the DIPswitch ON. This can be summarised as follows:

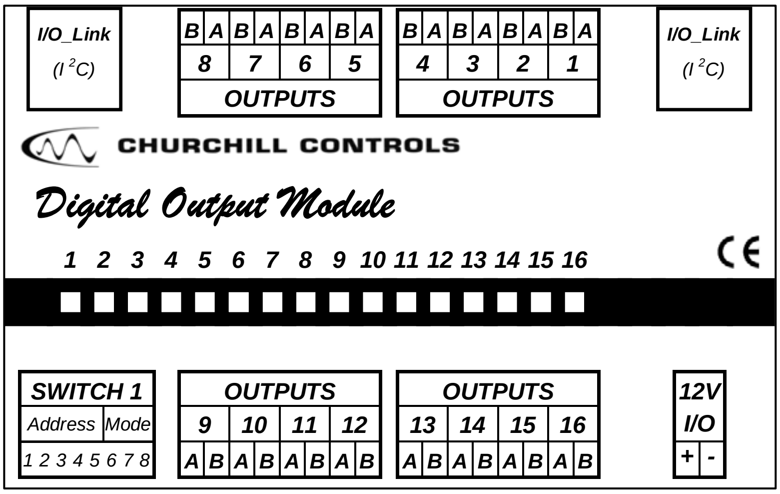
Input State	Logic State	
	Switch 8 OFF	Switch 8 ON
Volt-free contact open	0	1
Volt-free contact closed	1	0
Sense voltage > 3.5V	0	1
Sense voltage < 1.5V	1	0

The module draws minimal current from the power supply.

Specifications

CURRENT CONSUMPTION:	12V:	0mA
	5V:	10mA max.
INPUT VOLTAGE:	Logic 0:	min. -24V max. +1.5V
	Logic 1:	min. +3.5V max. +24V
ENERGISING CURRENT:	50mA wetting current, 250µA continuous	

3.4.5.1.2 7150-2 Digital Output Module



This module has 16 fully isolated outputs. Each comprises a volt-free relay contact rated 125VAC/1A/60VA max. 60VDC/1A/30W max. A 120V transient suppressor is fitted across each contact to prevent damage and/or interference when switching inductive loads. Each contact is isolated to 500V min from all other contacts and from 0V.

Although the switch contacts are rated at up to 125V, it is the user's responsibility to ensure that external power sources do not compromise the operator's safety.

The module usually closes the contact for logic '1' state and opens it for logic '0'. However, the sense can be inverted if required by setting switch 8 of the DIPswitch ON. This can be summarised as follows:

Logic State	**Output State**	
	Switch 8 OFF	**Switch 8 ON**
0	OFF	ON
1	ON	OFF

The module draws a maximum of 240mA from the power supply when all outputs are on.

Specifications

CURRENT CONSUMPTION:	12V:	225mA max. (All outputs on)
	5V:	10mA max.
SWITCH RATING:	125VAC/1A/60VA max. 60VDC/1A/30W max.	
ISOLATION:	500VAC	

4. Installation

4.1 Mechanical

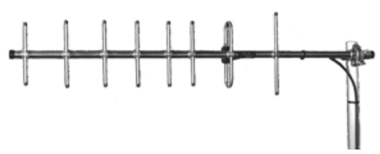
Data_Link 2000 outstations and base-stations are usually supplied in either steel or polycarbonate enclosures that can be attached to a wall using conventional fixings. The smaller polycarbonate enclosures provide a high degree of protection against water ingress, and care is needed to ensure this isn't compromised by the method of installation.

Most enclosures include cable glands, which are supplied with blanking plugs to maintain a seal. The sealing plugs must be removed before feeding cables through the glands, and the glands should be tightened around the cables to maintain the seal. Blanking plugs should be left in any unused glands.

4.2 Aerials

The four types of aerial commonly used on ***Data_Link 2000*** are whips, end-fed dipoles, folded dipoles and yagis. Whips and end-fed dipoles are omni-directional (radiate equally in all directions), so their orientation is not important. Whip aerials are usually attached directly to ***Nano_Link*** or ***Micro_Link***, or to the top of the enclosure in which they are mounted. ENF450 end-fed dipole aerials fit into the top of a 2" (OD) pole mounted externally. CDF450 centre-fed dipoles are useful for mounting on the side of a pole when the top is not available for an ENF450. Although they radiate in all directions, the signal is slightly stronger in the direction in which the balun is pointing (i.e. out of the page, towards the reader, in the illustration shown).

CDF450



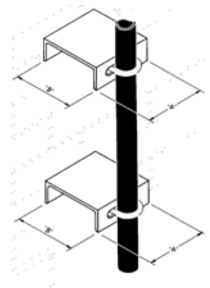
UHF8

Yagis are similar to end-fed dipoles, but with reflectors which focus the signal in the direction in which they are pointing (i.e. to the left in the illustration shown). This results in signal gain in one direction, at the expense of loss in all other directions. The directivity and hence gain is related to the number of elements. A typical yagi, the UHF8, has 8 elements and a gain of 10dB.

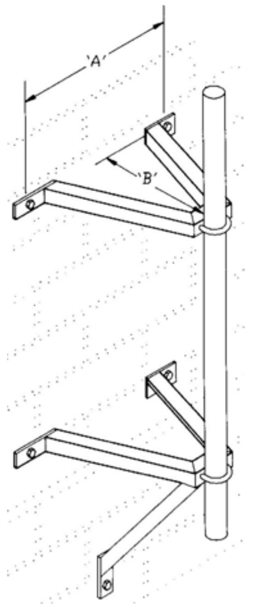
Note that approval regulations limit the maximum effective radiated power (ERP) that can be emitted from a transmitter. If a yagi is used the transmitter output power should be reduced to compensate for the aerial gain. The aerial gain, however, effectively increases the sensitivity of the receiver, hence increasing the permissible path loss. Since ***Data_Link 2000*** uses two-way radio communication, there will be no operational benefit in fitting a yagi at one end and an omni-directional aerial at the other, since this would only improve transmission in one direction.

All aerials should be vertically polarised (i.e. the elements should be vertical, not horizontal). Yagis and end-fed dipoles also have a defined top and bottom. They must be installed in the orientation marked by labels attached to them.

External aerial poles can be fixed to walls using either CS6 or SAB brackets. CS6 brackets space the pole 6" from the wall. SAB brackets allow the poles to be spaced further from the wall to clear soffits and gutters, as well as providing a stronger fixing capable of supporting longer poles.



CS6



STOCK CODE	A	B
SAB 3/12	365mm	305mm
SAB 3/18	460mm	460mm
SAB 3/24	620mm	600mm
SAB 3/36	900mm	900mm

SAB

4.3 Surge Protection

Any external cables are susceptible to surges induced from lightning and electrical power distribution faults. Cables at exposed sites on high ground (such as water reservoirs) is particularly susceptible.

Lightning is caused by a build up of static charge in the atmosphere which ultimately causes a flashover. A lightning strike dissipates enormous amounts of energy. A direct hit will discharge tens of thousands of amps at many kilovolts for several milliseconds. Nothing can withstand this amount of energy. More widespread damage is done, however, by surges induced in cables from nearby strikes. These affect both overhead and underground cables, and will typically be a few hundred amps at a few hundred volts. Equipment can be protected against these by fitting surge arrestors.

A surge arrestor works by diverting the transient to earth and thus limiting the maximum voltage that can be passed to the equipment. The main component used is a gas discharge tube (GDT), which is normally an open circuit, but will typically ionise at around 150V. In its ionised state it will clamp the line to around 10V for transient currents of up to 10,000A, then return to the open circuit state when the current drops below a threshold of around 50mA. Special zener diodes are used to limit the maximum voltage presented to the equipment to typically 30V **relative to the surge arrestor's earth terminal**.

Surge arrestors are very effective in protecting equipment against induced transients, **provided they are correctly installed**. The most important aspect is the provision of a good earth to which the transient can be diverted. Figure 1 below graphically illustrates the potential problem caused by an incorrect installation. Figure 2 illustrates the correct method of installation.

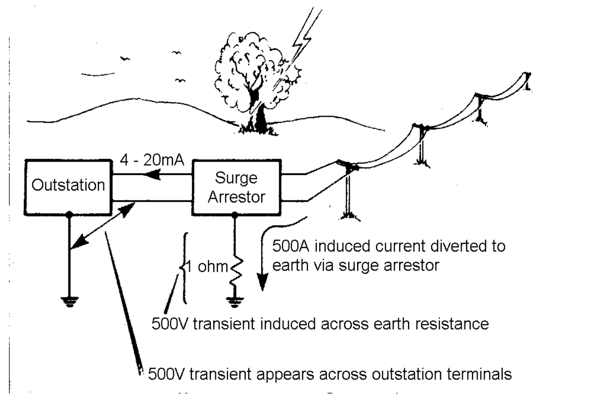


Figure 1 – Poor installation

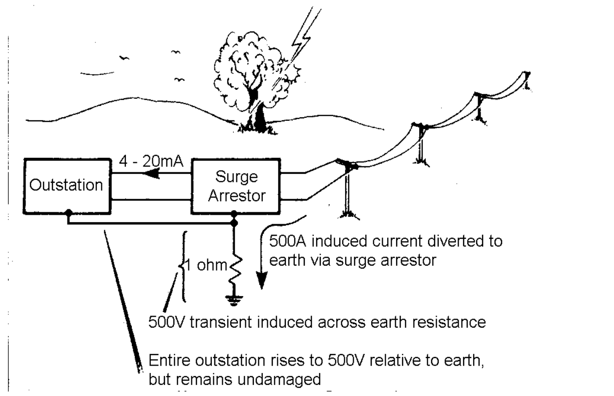


Figure 2 – Correct installation

This illustration correctly indicates that the integrity of the earth connection is irrelevant, provided there is no other path to earth. However, there will inevitably be other paths, via other equipment connected to the outstation, or ultimately by arcing. The earth connection should therefore be as low impedance as possible. Mains earth is not adequate, since it is only designed to take fault current of tens of amps.

Ideally the earth connection should be to a buried copper mat, or at least a substantial earth stake. The connecting cable should be at least $10mm^2$, and should be braid or copper strip to minimise its inductance.

Surge arrestors should be mounted close to the equipment being protected, but the cables should be kept apart to prevent electromagnetic coupling.

The only other means of protecting against lightning is to dissipate the static charge in the atmosphere before it reaches a high enough level to flashover. This is achieved by fitting lightning conductors to any elevated points. Unfortunately, radio aerials form very effective lightning conductors! They are thus prone to receive power surges before lightning occurs. They should thus ideally also be protected by surge arrestors. The above comments regarding earthing are equally applicable.

5. Configuration

Switches S1 and S2 are used to set all configurable parameters in ***Nano_Link***. The software checks the switches every second. If there are any changes the processor will be reset to action the new state. All switches are defined as logic 0 when open or off, and logic 1 when closed or on.

5.1 Switch S1 - Station Address

Each ***Nano_Link*** can be allocated any station address between 0 and 255 on switch S1. The software reads the switch in binary coding, where S1.1 has a weighted value of 1, S1.2 has a weighted value of 2, through to S1.7 with a weighted value of 128. The station address is the sum of the weighted values:

Switch S1 12345678	**Decimal Value**	**Function**
00000000	0	Base-station interrogating outstation address 1 **(see Chapter 8)**
11111111	255	Power down **(see 9.4.1)**.
01111111	254	Radio receiver test **(see 9.4.2)**.
10111111	253	Radio transmitter test **(see 0)**
00111111	252	Hardware I/O test **(see 9.4.4)**
nnnnn111	224…251	Base-station interrogating outstation address nnnnn000 **(see Chapter 8)**
nnnnnnnn	1…223	Outstation address nnnnnnnn **(see Chapter 7)**

5.2 Switch S2 - Mode

In base-station and outstation modes the functionality is further defined by S2, in accordance with the following tables:

5.2.1 S2.1 ... S2.5 - Radio Versions – Set Channel

If the ***Nano_Link*** is equipped with an internal de-regulated radio, these switches set the operating frequency. The transmission baud rate is fixed at 1200 baud.

Channel Selected	**Switch 12345**	**Frequency (MHz)**	**Actual Channel No**
0	00000	458.5000	0
1	10000	458.5125	1
2	01000	458.5250	2
3	11000	458.5375	3
4	00100	458.5500	4
5	10100	458.5625	5
6	01100	458.5750	6
7	11100	458.5875	7
8	00010	458.6000	8
9	10010	458.6125	9
10	01010	458.6250	10
11	11010	458.6375	11
12	00110	458.6500	12
13	10110	458.6625	13
14	01110	458.6750	14
15	11110	458.6875	15
16	00001	458.7000	16
17	10001	458.7125	17

18	01001	458.7250	18
19	11001	458.7375	19
20	00101	458.7500	20
21	10101	458.7625	21
22	01101	458.7750	22
23	11101	458.7875	23
24	00011	458.8000	24
25	10011	458.8125	25
26	01011	458.8500	28
27	11011	458.8625	29
28	00111	458.8750	30
29	10111	458.8875	31
30	01111	458.9125	33
31	11111	458.9250	34

These switches are only relevant if ***Nano_Link*** is equipped with an internal UHF radio. Note that the channels are at 12.5KHz spacing, but omit frequencies of 458.8250MHz, 458.8375MHz and 458.9000MHz, in accordance with MPT1329.

5.2.2 S2.1 ... S2.5 - Modem Versions – Set Data Rate

If the ***Nano_Link*** is not equipped with an internal de-regulated radio, these switches set the transmission data rate. If it has an internal modem the data rate should be set to 1200 baud. If using an external modem the data rate should be set as required.

Switch 12345	Transmission Data Rate
0xxxx	1200 baud
1xxxx	300 baud

5.2.3 S2.6…S2.8 - Operating Mode

Switch 678	Outstation	Base-station
000	Power-save mode with 250ms transducer settling time **(see 7.1.2)**	Normal, continuous scan **(see 8.1)**
100	Power-save mode with 30 second transducer settling time **(see 7.1.5)**	
010	Power-save mode with 250ms transducer settling time, using digital outputs **(see 7.1.6)**	Normal, slow scan **(see 8.1.1.2)**
110	Power-save mode with 1 second transducer settling time **(see 7.1.3)**	
001	Continuous operation **(see 7.1.1)**	Radio commissioning **(see 8.1.2)**
101	Power-save mode with 4 second transducer settling time **(see 7.1.4)**	
011	Analogue averaging **(see 7.1.7)**	Radio Path Test Set **(see 8.1.3)**
111	Rotation Sensor **(see 7.1.8)**	

Unused modes are available for future expansion and should not be selected.

6. Specifications

POWER SUPPLY:	a) 3 x Alkaline D cells giving 2 years operation*
	b) 230/240V AC @ 10VA, max. with 8 battery back-up
	c) 110/120V AC @ 10VA, with battery back-up
	d) External 10…15V DC @ 1A max.
	d) External 3.0...5.5V DC @ 1A max.
	* Battery life based on power-save mode with 100ms transducer settling time, interrogated every 15 minutes
HARDWARE I/O:	
Digitals:	
Inputs:	4 digital / count inputs compatible with external volt free contacts
Energising voltage:	Supply voltage (3.0…5.5V) when asleep 5.0V when awake
Switching current:	50mA wetting current, 10µA continuous
Maximum count rate:	50 pulses/second
Outputs:	Optionally 4 digital volt free contact outputs rated 125VAC/1A/60VA max. 60VDC/1A/30W max. with common return.
Analogues:	
Inputs:	2 Analogue inputs (non isolated).
Range:	0…20mA into 5Ω or 100mV strain gauge
Accuracy:	± 1%
Energising voltage V+:	9.5…10.0V @ 40mA max. (only available when awake)
Common mode range:	0…V+
Pseudo inputs:	Battery volts (0…10V ±1%)
	RSSI (0…100%).
Outputs:	Optionally 2 Analogue outputs (non isolated).
Range:	0-10mA or 0-20mA @ 9V max.
Accuracy	±1%

7. Nano_Link as an Outstation

When configured as an outstation (S1 not set to 00000000), ***Nano_Link*** can be interrogated by either a ***Micro_Link*** or a ***Nano_Link*** base-station. It can operate continuously or in a power-saving mode. In continuous mode the power consumption is too high for operation from internal batteries for extended periods, so it is assumed to be mains-powered (although it could be operated from a solar panel or from external batteries). In power-save mode ***Nano_Link*** will run for typically 2 years on an internal alkaline battery pack, or indefinitely on a small solar panel. Variants of the power-save mode allow special features to be enabled as described below, but reduce battery life.

7.1 Operating Modes

7.1.1 Continuous operation (S2.6…S2.8 = 001)

In this mode the outstation is permanently active, so able to respond to base-station commands at any time. Its radio receiver is constantly powered, so the power consumption is significant. Although the battery back-up within a mains power supply will keep the outstation running for several hours, this mode is not suitable for long-term operation from batteries.

A ***Nano_Link*** operating as a repeater must be configured in this mode, since it has to be able to respond both to commands directed to itself and to commands to be forwarded to more distant outstations.

Analogue and digital outputs can normally only be used in this mode.

7.1.2 Power-save mode with 250ms transducer settling time (S2.6…S2.8 = 000)

Power drain within ***Nano_Link*** is mainly due to the radio receiver and the radio transmitter. Minimising the time each of these is on minimises power consumption. In power-save mode the receiver is only switched on when a message is expected from the base-station, and the base-station only requests as much data as it needs (e.g. if it is not reading analogues, it does not request them) to minimise the time the transmitter is on. If there is no power at the outstation site, there will be no plant to control, so the outstation will not be equipped with digital or analogue outputs, and the base-station will not send data to it.

The ***Nano_Link*** outstation can be supplied with an internal battery pack, which can also be used to energise transducers connected to it. The outstation will only switch them on when needed, again to avoid unnecessary power drain.

In this mode the outstation will be in one of the following states:

7.1.2.1 Sniff mode

The outstation switches on its radio receiver every two seconds for just long enough to sense a valid data signal. If no signal is detected it will switch the radio off and repeat the cycle. If a signal is detected it changes to the Receive Mode.

7.1.2.2 Receive Mode

The outstation enters this mode two seconds before it expects to receive a command from the base-station. If it receives a valid command it will change to Transmit Mode:

7.1.2.3 Transmit Mode

The outstation first switches on its 12V supply, then, waits 250ms. It then reads the analogue inputs, compiles the relevant response, sends it, then drops the 12V supply.

The normal command to an outstation configured for a low-power mode requests data, but also defines the delay before the outstation will next be interrogated. If such a command is received, the outstation changes to Receive Mode for a defined ‘Stay Awake’ period. The Stay Awake period is normally 5 seconds, which is sufficient time for the base-station to send another command if the response to the first was corrupted in transmission. However, if the base-station detects that the outstation is also used as a repeater, it will modify each command sent to the outstation, instructing it to remain in receive mode for an extended Stay Awake period (typically 30 seconds). During this time it can send further commands to it for passing on to more distant outstations. Each time a command is received the outstation re-starts the Stay Awake period.

When the Stay Awake period lapses, the outstation will switch to Sleep Mode:

7.1.2.4 Sleep Mode

The outstation switches off all internal functions, except for a very low power timer, so power consumption is minimised. Every second it briefly wakes to check switches S1 and S2. If either has been changed the outstation will reset itself.

If any digital input changes state the outstation will briefly wake up and increment the relevant counter. If digital exception reporting is enabled for the relevant digital input (see 9.3) the outstation will transmit an unsolicited message to the base-station, repeated at random time intervals until the base-station acknowledges receipt.

If analogue exception reporting is enabled the outstation will periodically wake from sleep mode, read the analogue inputs and compare them with the last values sent to the base-station. If a significant change has occurred it will transmit an unsolicited message to the base-station, repeated at random time intervals until the base-station acknowledges receipt.

Two seconds before the next command is due the outstation will wake up and change to Receive Mode. It will stay in this mode for up to 30 seconds, during which time the base-station should send its next command. If no command is received the outstation will return to Sniff Mode.

7.1.3 Power-save mode with 1 second transducer settling time (S2.6…S2.8 = 110)

This mode is intended for use with transducers that take more than 250ms to stabilise, such as fast ultrasonic probes. It is identical to the normal power-save mode described above, except that the outstation raises 12V when it enters Receive mode, so the transducers are powered for at least 1 second before the next command is received. The 12V supply remains raised during the Stay Awake period. If analogue exception reporting is enabled the outstation will raise

Note that while the outstation is in sniff mode (i.e. when it has lost sync with the base-station) the transducer is not powered. Its response to the first request will thus not contain the correct analogue values. The next request from the base-station will receive the correct response.

Obviously, the power consumption in this mode is slightly higher than in normal power-saving mode.

7.1.4 Power-save mode with 4 second transducer settling time (S2.6…S2.8 = 101)

This mode is similar to the normal power-save mode described above, but power is applied to the transducer 4 seconds before exiting Sleep Mode to allow more time for the transducer to settle. It should be apparent that the longer power is applied to the transducer the higher the overall power consumption.

7.1.5 Power-save mode with 30 second transducer settling time (S2.6…S2.8 = 100)

This mode is similar to that described above, but allows even more time for the transducer to settle. It should be apparent that the longer power is applied to the transducer the higher the overall power consumption.

7.1.6 Power-save mode, using digital outputs (S2.6…S2.8 = 010)

Outstations at sites without power are usually input-only, since by definition there is no power to operate any plant that they could be used to control. The base-station optimises the outstation power consumption by only requesting the input states it uses, so the outstation does not waste power transmitting unused data.

However, there is one exception, where battery-powered valves are used. These can be controlled by a two-way switch, to set them fully open or fully closed. In this mode the ***Nano_Link*** outstation needs to be fully-equipped, so its digital outputs can be used to control a magnetically-latching relay to switch the valve. (The ***Nano_Link*** digital outputs de-energise when the outstation enters Sleep Mode, so their state must be stored magnetically).

A ***Micro_Link*** base-station can be configured to send data to the outstation as well as reading data from it. A ***Nano_Link*** base-station cannot be configured to enable or disable sending of data to the outstation, so normally only sends data to continuously-powered outstations. However, if the outstation reports that it uses digital outputs, a ***Nano_Link*** base-station will automatically send data to it as well as reading from it.

Obviously, the power consumption in this mode is higher than in normal power-saving mode.

7.1.7 Power-save mode, analogue averaging (S2.6…S2.8 = 011)

This mode is similar to the other power saving modes described above, but makes provision for 'noise' on the analogue inputs.

All other modes take a snapshot of the analogue level at the time it is transmitted to the base-station. If there is any variation in the input signal (for example, if a depth transducer is affected by waves on the surface) the level sent may be in error, depending on the height of the wave at the instant the reading is taken.

The analogue averaging mode minimises this by applying power to the transducer 35 seconds before the outstation is next due to be called. It waits 5 seconds for the transducer to stabilise, then takes continuous readings at one second intervals. Thus when the outstation is called it will have taken 30 samples, and it returns to the base-station the average of these. The effect of any fluctuations due to waves on the surface will thus be minimised, at the expense of a slightly higher overall power consumption.

7.1.8 Power-save mode, Rotation Sensor (S2.6…S2.8 = 111)

This mode should only be set if a 7062-1 magnetic field sensor is connected to analogue input 2.

The magnetic field sensor is a very sensitive resistive bridge which is unbalanced when a magnetic field is applied. It is sensitive enough to detect the earth's magnetic field, so the output varies from a maximum when the sensor points north to a minimum when it points south.

When the outstation is configured for use with a rotation sensor it will power the analogues at regular intervals for 250ms then read analogue input 2. It compares the new reading to the last. If the new reading is greater than the last it knows that the sensor is rotating from south towards north. Conversely, if the new reading is less than the last it knows that the sensor is rotating from north towards south. Therefore it knows that when the ramp changes from positive to negative the sensor has passed north, and when it changes from negative to positive the sensor has passed south.

From these sample readings the outstation calculates the total of the number of revolutions and the time per revolution (in seconds). These are stored in Count 1 and Count 2 respectively (when in this mode, digital inputs 1 and 2 cannot be used for totalising pulses).

To calculate the ramp direction the outstation must sample the sensor at least twice in each half-revolution. It therefore uses the time per revolution to define the sample rate. If it finds there are less than 4 samples per half-revolution or more that 8 it will recalculate the sample rate to achieve nominally 6 samples per half-revolution. If it was sampling at 4 per half-revolution and the speed suddenly doubled it would only take two samples in the next half-revolution, but this still is enough to correctly track the movement. The sample rate will then adjust to ensure it is able to track future speed changes. If the speed increases by a factor of more than 2 in a half-revolution there is a possibility that the system could temporarily lose synchronisation.

If the outstation detects that the rotation speed has reduced to less than one fifth of the previous rate it will assume that the sensor has stopped rotating and will raise an alarm. For example, if it was rotating at 1 revolution per minute it will raise an alarm if no changes are detected for 5 minutes. The rotation alarm can be read at the base-station in the alarm flag position allocated for ***Bus_Link*** fail (since this is not normally used on a ***Nano_Link*** outstation).

The sampling period automatically adjusts in the range 1…60 seconds, to try to keep the sampling rate in the range 8…16 samples per revolution. There must be at least 2 samples per revolution, so the maximum rotation speed that can be tracked is 4 seconds per revolution, and the minimum is 512 minutes per revolution.

7.2 Outstation Alarm Handling

As well as indicating fault conditions on the Heartbeat LED (as described in section 3.2), a ***Nano_Link*** outstation also indicates them on digital outputs (if equipped). It does this by logically ANDing the digital inputs sent to it by the remote station with the alarm flags. The outputs are thus as follows (digital state 1 = contact closed, 0 = contact open):

Digital Output	State	Meaning	Heartbeat LED
1	1	Base-station digital input 1 = 1 **and** No comms alarm	Flashes continuously @ 4 flashes per second
	0	Base-station digital input 1 = 0 **or** Lost communication with base-station	If comms alarm: Flashes 3 out of every 4
2	1	Base-station digital input 2 = 1 **and** Outstation battery/mains supply is good	Flashes continuously @ 4 flashes per second
	0	Base-station digital input 2 = 0 **or** Outstation battery/mains supply is low	If battery/mains supply low: Flashes 2 out of every 4
3	1	Base-station digital input 3 = 1	
	0	Base-station digital input 3 = 0	
4	1	Base-station digital input 4 = 1	
	0	Base-station digital input 4 = 0	

All outputs can therefore be used to replicate the corresponding input at the remote end, with the proviso that outputs 1 and 2 will de-energise under fault conditions. (In the event of a comms failure, outputs 3 and 4 will hold their last valid state).

If the user wants dedicated alarm outputs, he must insure that inputs 1 and/or 2 at the remote site are permanently energised, so only digitals 3 and 4 are usable.

8. Nano_Link as a Base-station

Nano_Link configured as a base-station (S1 = 00000000) can only interrogate one outstation. The default base-station address is 0, which will interrogate outstation address 1. However, in areas of dense usage there could be more than one ***Nano_Link*** system operating on the same radio channel. To prevent the risk of interference the base-stations could be set to address nnnnn111, which will configure them to interrogate outstation address nnnnn000. By selecting different values for nnnnn on each system the risk of interference is obviated.

A ***Nano_Link*** base-station can operate either in normal mode or in special modes for testing radio communications:

8.1 Operating Modes

8.1.1 Normal operation

There are two variants of normal operation:

8.1.1.1 Continuous transmission (S2.6…S2.8 = 000)

In this mode the base-station will continuously scan the outstation, thus transferring data as quickly as possible. This is the recommended mode for leased-line systems. It can also be used for testing radio systems, but they should not be left continuously in this mode, since it results in unnecessary power consumption, and is against the spirit of the use of de-regulated radio.

8.1.1.2 Slow Scan (S2.6…S2.8 = 010)

In this mode the base-station will initially scan every 10 seconds. This slows the system response, but reduces the channel usage to less than 10%, allowing the radio channel to be shared with other users in accordance with the requirements of de-regulated radio.

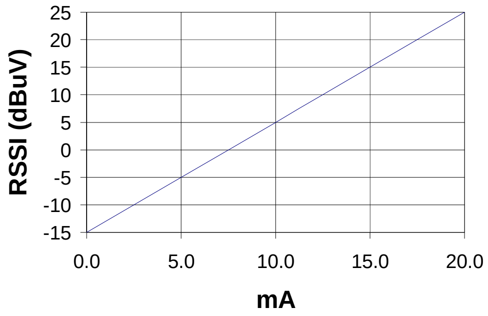
However, if the outstation reports that it is battery-powered, the base-station automatically converts to scanning it every 15 minutes to conserve the outstation battery. Since the outstation goes to sleep between scans, it will not normally be equipped with digital outputs, so the base-station normally only reads data from the outstation. However, if the outstation reports that it is battery-powered but using digital outputs (see 7.1.6), the base-station will send data to it as well.

8.1.2 Radio Commissioning (S2.6…S2.8 = 001)

This mode is particularly for commissioning a radio telemetry system when it is first installed, or at any subsequent time when the communications integrity needs to be checked.

The base-station will attempt to interrogate the outstation every 5 seconds, copying its digital and analogue inputs to the outstation's digital and analogue outputs, and the outstation's digital inputs to its digital outputs. However, instead of copying the outstation's analogue inputs to its analogue outputs, it will copy the local RSSI to analogue output 1 and the remote RSSI to analogue output 2. They can thus be read using a conventional multimeter set to read 0…20mA. If an alphanumeric display (as described in Chapter 10) is plugged into the ***I/O_Link*** socket, they can be read directly.

The relevant RSSI levels can be deduced from the output currents using the following graph:



The radio receiver has a sensitivity of about -10dBµV, and a good radio path should have a margin of at least 10dBµV so the RSSI should ideally read at least 0dBµV, or 7.5mA, in each direction.

8.1.3 Radio Path Test Set (S2.6…S2.8 = 011)

This mode is identical to the Radio Commissioning mode described above, but the base-station ***must*** be fitted with an Alphanumeric Display Module. The base-station is assumed to run from an internal battery, and to be used in conjunction with a battery-powered ***Nano_Link*** outstation, making the test set portable.

The base-station is normally asleep, to conserve battery power. Every 10 seconds it interrogates the pushbuttons on the display module. If any is pressed it wakes up and starts polling the outstation every 5 seconds. The display module can be used to monitor the RSSI in both directions.

For added confidence, the base-station simulates activity on its digital inputs, which should be replicated at the outstation. If the outstation's digital outputs are fed back to its digital inputs, the activity should also be replicated on the base-station digital outputs.

The system can be activated by pressing the ENABLE button on the display (or closing a switch connected in parallel with it). The display remains active for 15 seconds after the switch is opened, following which the base-station goes to sleep to conserve batteries.

8.2 Base-station Alarm Handling

As well as indicating fault conditions on the Heartbeat LED (as described in section 3.2), a ***Nano_Link*** base-station also indicates them on digital outputs (if equipped). It does this by logically ANDing the digital inputs sent to it by the remote base-station with the alarm flags. The outputs are thus as follows (digital state 1 = contact closed, 0 = contact open):

Digital Output	State	Meaning	Heartbeat LED
1	1	Outstation digital input 1 = 1 **and** No comms alarm	Flashes continuously @ 4 flashes per second
	0	Outstation digital input 1 = 0 **or** Lost communication with outstation	If comms alarm: Flashes 3 out of every 4
2	1	Outstation digital input 2 = 1 **and** Outstation battery/mains supply is good **and** Base-station battery/mains supply is good	Flashes continuously @ 4 flashes per second
	0	Outstation digital input 2 = 0 **or** Outstation battery/mains supply is low **or** Base-station battery/mains supply is low	If battery/mains supply low: If base-station low: Flashes 2 out of every 4 If outstation low: Flashes 1 out of every 4
3	1	Outstation digital input 3 = 1	
	0	Outstation digital input 3 = 0	
4	1	Outstation digital input 4 = 1	
	0	Outstation digital input 4 = 0	

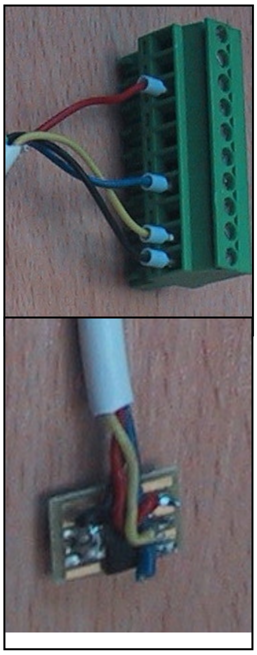
All outputs can therefore be used to replicate the corresponding input at the remote end, with the proviso that outputs 1 and 2 will de-energise under fault conditions. (In the event of a comms failure, outputs 3 and 4 will hold their last valid state).

If the user wants dedicated alarm outputs, he must insure that inputs 1 and/or 2 at the remote site are permanently energised, so only digitals 3 and 4 are usable.

9. Special Features of Nano_Link

As described in Section 0, ***Nano_Link*** can be configured in a number of special modes that set it to particular functions. All configuration is carried out via the switches S1 and S2, with the exception of shaft encoders, which rely on the use of an Alphanumeric Display Module, as described below.

9.1 Rotation Sensor



The rotation sensor is a small module that can be connected externally to analogue input 2. It has a self-adhesive backing so can typically be stuck to the inside of the enclosure.

The connections to the ***Nano_Link*** analogue input terminals are as illustrated

The sensor detects the earth's magnetic field, so it is important that it is mounted in the correct orientation and away from any magnets or steel items that could interfere with its functionality.

The correct orientation is with the longest edge of the module horizontal, as shown in the illustration. It can therefore be mounted on a horizontal surface of on a vertical surface.

The sensor cannot be used inside a steel enclosure, and should be mounted as far a practicable from any steelwork. Steel will reduce its sensitivity, but not necessarily prevent it from working.

.The sensor can be tested by connecting an alpha-numeric display and monitoring the value of analogue 2. The absolute reading is not relevant, but it should change by at least 1% (i.e. 0.2mA) when the sensor is rotated.

When a rotation sensor is used the mode must be set accordingly (See 7.1.8)

9.2 Shaft Encoder Interface

9.2.1 General

An incremental shaft encoder can be typically used to measure water level to a resolution of 1mm over a range of several metres. It comprises a float and a counterweight attached to opposite ends of a cord that passes over a pulley. An optical sensor is attached to the shaft of the pulley to give a typically 400 output pulses for each revolution of the shaft. The pulley diameter is set such that each pulse represents a float movement of 1mm.

The optical sensor comprises two sets of LEDs and photocells that detect rotation of 'spokes' on a wheel attached to the shaft. The use of two sensors allows the direction of rotation to be detected. There are thus two digital outputs from the sensor.

A variant of ***Nano_Link*** is available which, in conjunction with an Alphanumeric Display Module, is optimised for operation with a shaft encoder in battery-powered applications:

9.2.2 Implementation

This variant of ***Nano_Link*** interface to the shaft encoder through digital inputs 1 and 2 (which are then read as logic 1 state). Pulses from the shaft encoder are accumulated in the counter allocated to digital input 1 (i.e. Count 1). Count 2 is invalid, and digital inputs 3 and 4 are available for normal use.

This variant of ***Nano_Link*** can also interface to two shaft encoders, using all digital inputs. Pulses from the second shaft encoder are accumulated in Count 2. Counters 3 and 4 are invalid.

In both cases, ***Nano_Link*** sources power to the shaft encoder(s), using digital outputs 3 and 4.

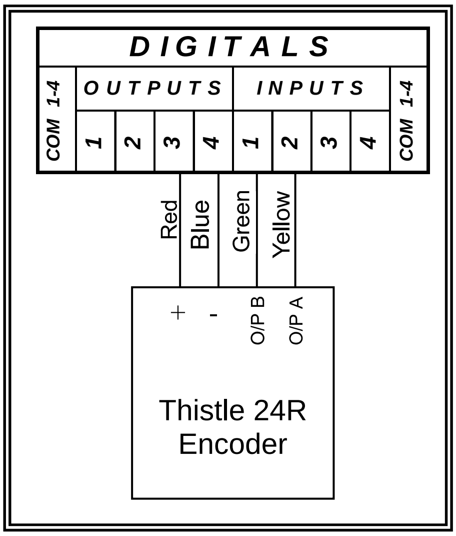
The encoder power consumption imposes additional drain on battery-powered outstations, so it is optimised by pulsing power when the shaft is stationary. If movement is detected power is maintained until the shaft again becomes stationary. By this means the average power consumption of the shaft encoder is reduced to approximately that of ***Nano_Link*** itself. This means that the battery life will be about halved if ***Nano_Link*** is powering a shaft encoder, and reduced to one third if it is powering two shaft encoders.

The signals from an incremental shaft encoder only indicate movement up and down from an arbitrary starting point. A shaft encoder does not have an in-built zero reference. The facility to set the zero is therefore built into the outstation, as described below

Digital and analogue outputs are not available on versions with a shaft encoder interface.

9.2.3 Hardware Configuration

Nano_Link sources 5VDC at 100mA max to the shaft encoder via digital outputs 3 and 4. Special hardware in ***Nano_Link*** changes the function of these from volt-free contacts to power outputs. Connections to a Thistle 24R series encoder are as shown:



9.2.4 Software Configuration

A ***Nano_Link*** outstation with a shaft encoder interface must be fitted with an Alphanumeric Display Module. Shaft encoders are enabled and disabled through the display module, and the zero is set through it. The means of doing this is described in sections 10.2.1 and 10.2.2.

9.3 Exception Reporting

Nano_Link outstations fitted with software version V2.0 or later support exception reporting. This feature is configured via commands sent to the outstation from a ***Micro_Link*** base-station, not by configuration of the outstation. The method of implementing exception reporting at the base-station is described in the ***Data_Link 2000*** **Technical Manual**.

The outstation can be configured to exception report the following conditions:

1. **Digital input changes**

   Nano_Link monitors digital inputs even when it is asleep. If a change occurs while it is asleep, ***Nano_Link*** will briefly wake up to process the change, then go back to sleep. Part of the processing is to check if it has been configured to exception report on change of the relevant input. If it has, ***Nano_Link*** will initiate an exception report.

2. **Totalised count increments**

   The processing of digital input changes described above included incrementing a totalised counter. ***Nano_Link*** also checks if the counter has been configured to exception report on change of the relevant input. If it has, and the count has incremented by more than a defined number since the last count reported to the base-station, then ***Nano_Link*** will initiate an exception report.

3. **Analogue input changes**

   Nano_Link normally only reads analogue inputs when it is interrogated by the base-station. If the base-station configures a ***Nano_Link*** outstation to exception analogue changes, it must also define the rate at which analogues are to be sampled. If the outstation is set to low power mode it will wake up each time a sample is due, apply power to the analogues, wait for them to stabilise, then read them and compare them to the last value reported to the base-station. If any analogue has changed by more than the defined margin, then ***Nano_Link*** will initiate an exception report.

4. **Powered digital input changes**

   Some digital transducers require power to function (for example, optical detectors). The base-station can configure ***Nano_Link*** to treat digital input 1 and/or 2 as powered transducers. It will then process these in the same way as described above for analogue inputs, and initiate an exception report if the input state differs from that last reported to the base-station.

In cases (3) and (4) the time allowed for the analogues/digitals to stabilise is defined by the configuration switches (see 7.1).

When an exception report has been initiated, ***Nano_Link*** will send an unsolicited message to the base-station. If the base-station does not acknowledge receipt of the message ***Nano_Link*** will keep re-transmitting it at random time intervals (in the range 2…9 seconds), for 60 seconds or until the base-station acknowledges receipt. This feature is active even when ***Nano_Link*** is asleep. It therefore allows battery life to be considerably extended, since background polling is only required as a confidence check, to prove that the outstation is still working. The poll rate could therefore be reduced to, say, once per day whilst still ensuring that digital changes are reported immediately.

Further details of the operation of exception reporting are provided in the ***Data_Link 2000*** **Technical Manual**.

9.4 Test Modes

Selecting an address on switch S1 above 251 puts the module into a test mode. In the following the switch positions are given in the sequence 12345678, with logic '1' representing a switch closed:

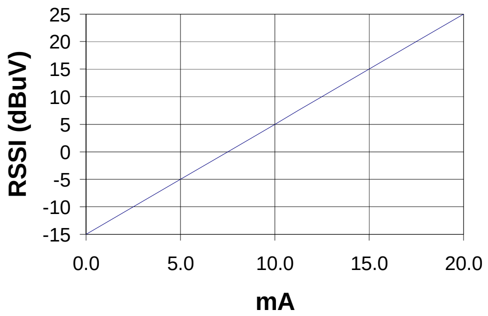
9.4.1 Address 255 (S1 = 11111111) - Power down

In this mode all functions of ***Nano_Link*** are switched off, except for a low power timer. Every second it wakes up to check for changes on the switches S1 and S2.

Power consumption in this mode is minimal, so the unit is in effect switched off. This mode is intended for storing and transporting ***Nano_Link***.

9.4.2 Address 254 (S1 = 01111111) - Test Receiver

The radio receiver is permanently energised, and the RSSI level is copied to analogue output 1 in accordance with the following graph:



9.4.3 Address 253 (S1 = 10111111) - Test Communications Device

This mode allows various aspects of the communications device to be tested. The following description assumes the unit is fitted with a radio, but the test modes apply equally to an internal leased line modem or an external communications device:

The radio transmit and receive frequency will be as set by switches S2.1…S2.5 as defined in section 5.2.1. The actual test mode is defined by switches S2.6…S2.8 as follows:

Switch 678	Test Mode
000	Transmit unmodulated carrier
100	Transmit carrier modulated with the Mark state
010	Transmit carrier modulated with the Space state
110	Transmit carrier modulated with alternate Marks and Spaces
001	
101	
011	
111	Test receiver. RSSI is copied to analogue output 1. The Test LED flashes in sync with the Heartbeat if no carrier is detected, and out of sync when a carrier is detected.

9.4.4 Address 252 (S1 = 00111111) – Calibrate Analogues / Test Hardware Outputs / Reset Counters

Setting this address will carry out an action defined by the state of switch S2. Note that calibration of analogues requires an accurate current source and an accurate ammeter, and must follow the procedure listed below.

S2 12345678	
Reset Counters:	
01010101	Reset all counters
Calibrate analogues:	
10000001	Record analogue input reading for 20.00mA.
01000001	Record analogue input reading for 2.000mA, calculate correction factors and save in NOVRAM
00100001	Record value needed to give 20.00mA on analogue output 1
00010001	Record value needed to give 2.000mA on analogue output 1, calculate correction factors and save in NOVRAM
00001001	Record value needed to give 20.00mA on analogue output 2
00000101	Record value needed to give 2.000mA on analogue output 2, calculate correction factors and save in NOVRAM
10000011	Record RSSI reading for a signal level of +25dBµV
01000011	Record RSSI reading for a signal level of -15dBµV, calculate correction factors and save in NOVRAM
…THEN…	
Test inputs/outputs:	
xxxxxx00	Sequence all digital outputs from all off to all on, and all analogue outputs in 20% increments
xxxxxx10	Sequence all digital outputs from all off to all on, and analogue output 2 in 20% increments. Copy corrected RSSI to analogue output 1. Flash TEST LED in opposite sync to HEARTBEAT if radio is receiving a valid carrier.
xxxxxx01	Copy digital inputs to digital outputs and uncorrected analogue inputs to analogue outputs. Flash TEST LED in opposite sync to HEARTBEAT if analogue or RSSI maximum value has been recorded.
xxxxx011	Copy digital inputs to digital outputs and uncorrected analogue input 2 to analogue output 2. Copy uncorrected RSSI level to analogue output 1. Flash TEST LED in opposite sync to HEARTBEAT if analogue or RSSI maximum value has been recorded.

Calibration:

To calibrate analogues, S2 should initially be set to 00000001.

To calibrate analogue inputs, apply a full scale signal (i.e. 20.00mA) to both inputs, then select 10000001 on S2. The TEST LED should flash in opposite sync to the HEARTBEAT to indicate that the reading has been recorded. Change S2 back to 00000001. Next, change the input current to 10% of full scale (i.e. 2.000mA), then select state 01000001. The TEST LED should revert to flashing in sync with the HEARTBEAT to indicate that the calibration has been completed. Change S2 back to 00000001.

To calibrate analogue output 1, apply a a full scale signal (i.e. 20.00mA) to both inputs, and monitor the current on analogue output 1. Adjust the input current until the output reads full scale (i.e. 20.00mA), then select state 00100001. The TEST LED should flash in opposite sync to the HEARTBEAT to indicate that the reading has been recorded. Change S2 back to 00000001. Next, adjust the input current until the output reads 10% of full scale (i.e. 2.000mA), then select state 00010001. The TEST LED should revert to flashing in sync with the HEARTBEAT to indicate that the calibration has been completed. Change S2 back to 00000001.

To calibrate analogue output 2, repeat the above procedure, using test states 00001001 and 00000101.

Calibration of RSSI is not possible without the use of a radio test set, so is normally only carried out in the factory.

10. Alphanumeric Display Module

10.1 General

The Alphanumeric Display Module Mk2 comprises a 4 line by 20 character LCD display, with an ***I/O_Link*** interface, plus 3 pushbuttons. The pushbuttons are marked ▲,▼ and ►. It is housed in an ABS enclosure, which can be hand-held, fitted behind a control panel, or clipped to a DIN rail.

The display module can be used as an optional diagnostic tool, but it is essential when using shaft encoders (see 9.1) and when using ***Nano_Link***'s for radio path testing (see 8.1.3)

The module derives all its power from the ***I/O_Link*** bus. The host can put the module in a sleep state, which reduces the power consumption to almost zero. This is of particular relevance when it is used with a battery-powered ***Nano_Link***. In this mode the host can still interrogate the module at regular intervals to read the state of the pushbuttons.

The alphanumeric display is fixed at address 127 on the ***I/O_Link*** bus, and only one module can be used on any given host.

10.2 Operation

The Alphanumeric Display Module Mk2 can be configured by pressing the ▼ and ► ▼ buttons simultaneously. The configuration allows the module to be set to Continuous or Low Power mode, with the backlight either on or off. In continuous mode the display is permanently active, and keeps the host ***Nano_Link*** permanently powered (even if is is set to a power save mode). In low power mode, if the host is set to a power save mode it will put itself and the display module to sleep after 30 seconds of inactivity on the buttons. The host will then check the buttons on the display every 2 seconds and wake up if a button is pressed.

The ▲ and▼ buttons are used to select the required display mode, and the ► button moves through relevant states within a given mode. Some modes automatically scroll through display screens. In these modes the ► button can be used to freeze and unfreeze the scrolling. Other modes allow the operator to change configuration parameters. In these modes the ► button can be used to highlight the relevant parameter and the ▲ and▼ buttons to change the value.

10.2.1 Update Number of Shaft Encoders

This mode is only displayed if ***Nano_Link*** is configured as an outstation, and allows shaft encoders to be enabled or disabled (see 9.1). The module displays:

```
No shaft encoder
Enabled. Change?
```

Pressing the ► button will change the display to:

```
No shaft encoder
Enabled. OK?
```

Pressing the ▲ and▼ buttons will allow the user to sequence through

```
1 shaft encoder
Enabled. OK?
```

```
2 shaft encoders
Enabled. OK?
```

Pressing the ► button will accept the number of shaft encoders displayed and return to, for example:

```
1 shaft encoder
Enabled. Change?
```

10.2.2 Zero Shaft Encoders

This mode will only be displayed if ***Nano_Link*** is configured as an outstation and has one or two shaft encoders enabled.

```
Set 0 for shaft
Encoder ?
```

Pressing the ► button will change the display to:

```
Set 0 for shaft
Encoder No?
```

The ▲ and▼ buttons scroll between `No`, `1` and `2`. Selecting a shaft encoder will reset its count to zero.

10.2.3 Radio Path Test mode

The display sequences through the following (note that the display can be 'frozen' on any given state by pressing the ► button. Pressing it again will resume sequencing):

```
  RSSI:-15.0dBuV
Remote:-15.0dBuV
```

```
Dig i/p:00000000
Dig o/p:00000000
```

```
  Batt:4.50V
Remote:4.49V
```

10.2.4 Update Radio Channel

This mode allows the radio channel to be changed without the need to access switch S2. It is particularly intended for use in the radio path test configuration. It should not be used for permanent changes, since after any subsequent power down (e.g. changing batteries) will cause ***Nano_Link*** to revert to the channel selected on S2.

The module displays:

```
Radio channel:31
 Change?
```

Pressing the ► button will change the display to:

```
Radio channel:31
OK?
```

The ▲ and▼ buttons allow the user to sequence through channels 0…31. Pressing the ► button will accept the currently-displayed value.

This channel will remain until either:

- A new value is selected through the display OR
- Any pole of switch S1 or S2 is changed OR
- Power is removed from ***Nano_Link***.

In the latter two events, the channel will be as set on switches S2.1…S2.5.

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