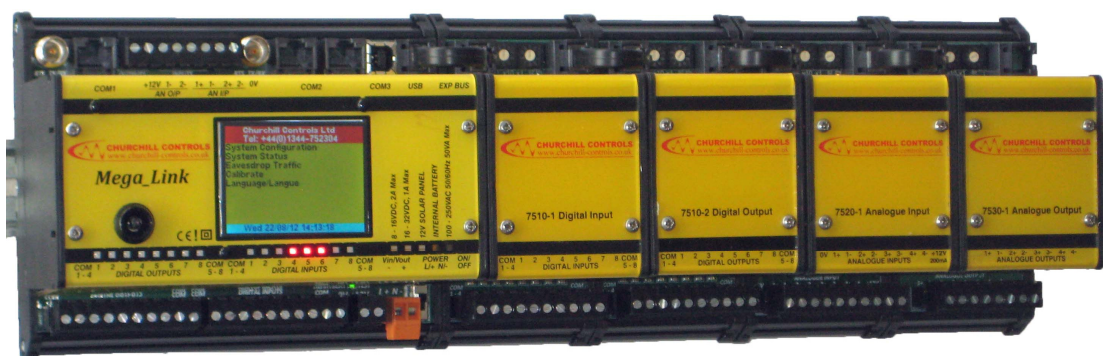


Mega_Link

Telemetry Communication System

Technical Manual - Issue 6.



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6	09/02/16	General update. Corrections to 16.4, remove Ethernet. compass and compatibility mode. Added examples for scaling RSSI and Battery Volts. Added radio channel frequencies.

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

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DECLARATION OF CONFORMITY WITH **EC DIRECTIVES**

Directives covered by this Declaration:

EC Directive 1999/5/EC (R&TTE Directive)

EC Directive 2006/95/EC (LVD Directive)

Products covered by this Declaration:

Mega_Link module, incorporating any combination of the following internal modules:

7500-1	Mega_Link PCB Assembly
7501-1	458MHz Radio PCB Assembly
7501-2	868MHz Radio PCB Assembly
7502-1	GPRS Radio Modem
7509-2	LED Display PCB Assembly
7680-1	Mains Power Supply
7681-1	Alkaline Battery Pack
7582-1	24V Regulator

and used in conjunction with any combination of the following expansion modules:

7610-1	Digital Input Module
7610-2	Digital Output Module
7620-1	Analogue Input Module
7630-1	Analogue Output Module

Basis on which Conformity is Declared:

ETSI EN 300 220-2 V2.4.1 (2012-05)

Electromagnetic compatibility and Radio spectrum Matters (ERM);

Short range devices (SRD);

Radio equipment to be used in the 25 MHz to 1 000 MHz
frequency range with power levels ranging up to 500mW;

Part 1: Technical characteristics and test methods

Part 2: Harmonized EN covering essential requirements
under article 3.2 of the R&TTE Directive

ETSI EN 301 489-1 V1.9.2 (2011-09)

Electromagnetic compatibility and Radio spectrum Matters (ERM);

ElectroMagnetic Compatibility (EMC) standard for radio equipment and services;

Part 1: Common technical requirements

ETSI EN 301 489-3 V1.4.1 (2002-08)

Electromagnetic compatibility and Radio spectrum Matters (ERM);

ElectroMagnetic Compatibility (EMC) standard for radio equipment and services;

Part 3: Specific conditions for Short Range Devices (SRD) operating on frequencies between 9KHz and 40GHz

BS EN 61326-1:2006

Electrical equipment for measurement, control and laboratory use

EMC requirements

BS EN 60950-1:2006 + A12:2011

Information technology equipment – Safety

Part 1: General Requirements

ERC/REC 70-03:

ERC Recommendation 70-03 (Tromsø 1997 and subsequent amendments)

Relating to the Use of Short Range Devices (SRD)

Recommendation adopted by the Frequency Management, Regulatory Affairs and
Spectral Engineering Working Groups

Version of 9 February 2011

ERC/DEC/(01)04:

ERC Decision of 12 March 2001

on harmonised frequencies, technical characteristics and
exemption from individual licensing of
Non-specific Short Range Devices
operating in the frequency bands
868.0 – 868.6 MHz, 868.7 – 869.2 MHz, 869.4 – 869.65 MHz and 869.7 – 870.0 MHz

IR 2030:

UK Interface Requirements 2030
Licence Exempt Short Range Devices
Dated October 2010

02/71R5:

Permitted Short Range Devices in Ireland

The technical documentation required to demonstrate that the above product satisfies the requirements of the above directives has been compiled by the signatory below, and is available for inspection by the relevant enforcement authorities.

The CE mark was first applied in 2014.

Signed on behalf of Churchill Controls Limited

_____ **Date:** _____

Mr D Pearce (Managing Director)

ATTENTION!

The attention of the specifier, purchaser, installer or user is drawn to any special measures and limitations to use specified in the product manuals. Failure to observe these measures and limitations may result in the product no longer conforming with the directives specified above.

SAFETY CONSIDERATIONS



Mega_Link and all associated parts conform with EC Directive 2006/95/EC (LVD Directive) and are certified to comply with BS EN 60950-1:2006 + A12:2011 / IEC 60950:2005+A12:2011. However, the performance is dependent on some aspects of the way in which it is installed and operated:

1. If a variant incorporating a mains power supply is used the orange connector is the power input and carries potentially lethal voltages. It is therefore imperative that this connector is protected from accidental contact by housing the equipment within an enclosure that protects the user from accidental contact. Maintenance and service personnel are expected to use their training and skill to avoid possible injury to themselves and others due to obvious hazards that exist.
2. If a variant incorporating a mains power supply is used the supply should be derived from a switched spur incorporating a 3A fuse.
3. The line connections of any communications devices (such as modems or Ethernet interfaces) are normally safe but should be treated as possible sources of unsafe voltages.
4. All plant I/O is from unknown sources could potentially be a source of unsafe voltages.
5. The enclosure in which the product is mounted must provide mechanical protection in accordance with clause 4 of BS EN 60950-1:2006+A12:2011 / IEC 60950:2005+A12:2011

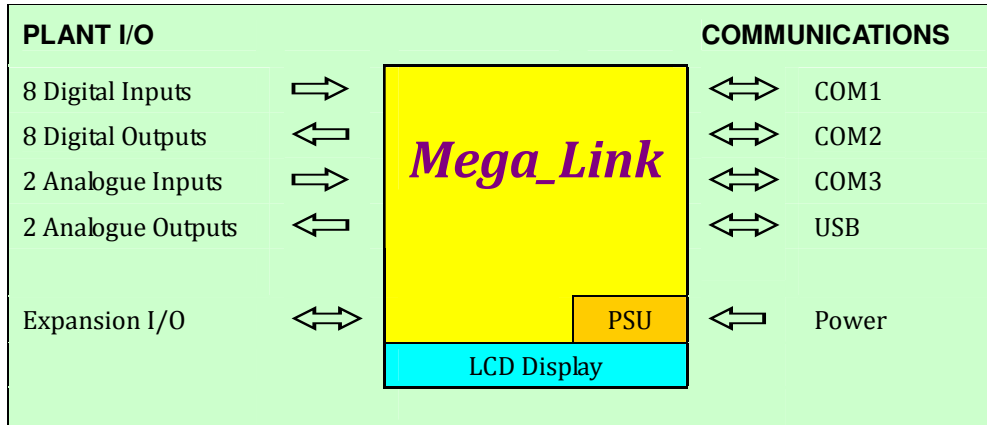
EMC CONSIDERATIONS

Mega_Link may incorporate one or more radio transmitters which, while complying with all relevant standards, could cause interference to other equipment. Furthermore, while it has a high degree of immunity to external interference, interfering signals above the levels specified in the relevant standards could cause it to malfunction. The following points should therefore be considered:

1. **Mega_Link** should not be configured to operate on the same radio channel as any other nearby equipment.
2. Any equipment that is susceptible to electrical interference should not be located near to the aerials.
3. Any equipment that could be a source of high level electrical interference should not be located near to **Mega_Link**. Examples include high power switchgear, switched mode power supplies and even cameras used for flash photography.
4. If digital outputs are used to control inductive loads there is the potential for them to generate high levels of interference when switching. **Mega_Link** Incorporates a high degree of surge suppression on the digital outputs, but high voltage high inductance loads may cause the equipment to malfunction.

1 Introduction

Mega_Link is a communications system that can pass two way instrumentation, measurement and control data between industrial plant and equipment distributed over wide geographical areas, typically by radio.



COM1 & COM2 INTERFACES

De-regulated long-range radio 458MHz, 500mW
De-regulated long-range radio 869MHz, 500mW
GSM/GPRS cellular radio, 3G Quad band
Leased line V23 modem

COM3 INTERFACES

RS232
RS485

The plant I/O interfaces are compatible with a wide range of digital and analogue instruments and would typically be connected to equipment such as volt-free contacts, depth transducers, flow meters and electrical switchgear etc.

8 Digital Inputs (volt-free contact).

8 Digital Outputs (relay contact rated to 120VAC/0.3A, 24VDC/1A).

2 Analogue Inputs (fully isolated, 0...20mA into 10 Ω).

2 Analogue Outputs (0...20mA into 500 Ω).

The I/O expansion port provides additional plant interfaces via a range of expansion modules.

COM1, COM2 and COM3 can be used for connecting distributed **Mega_Link** units together via the radio, GSM/GPRS and wired interfaces listed above, or for linking to intelligent industrial equipment such as SCADA systems, PLC's, sensors or third party telemetry systems.

COM1 and COM2 can each be fitted with any of the interface modules listed above.

COM3 has an RS232 / RS485 interface. Each COM port can use any protocol.

FIELDBUS PROTOCOL OPTIONS

Modbus
Allen-Bradley DF1
Mitsubishi Melsec FX
Mitsubishi Melsec non-FX

PSU OPTIONS

AC mains (with battery-back-up)
Alkaline battery
12VDC
24VDC
Solar panel

Mega_Link is configured using DUCX software, which can be down-loaded at no charge and will run on any PC and interfaces via USB. The USB port implements two virtual serial COM ports for use with the DUCX Windows PC based user interface software:

DUCX user interface

Configuration – create, edit, upload, download and save the system configuration

Diagnostics - examine and monitor all aspects of operation

Upgrade – upgrade the firmware

Mega_Link provides a high degree of system integrity by incorporating features such as battery back-up (to maintain operation during power failures) and extensive user-configurable fault monitoring.

The integral back-lit LCD display allows the user to examine and modify the system configuration, monitor all inputs and outputs, eavesdrop all data being transmitted and received, view the system status and diagnose operation.

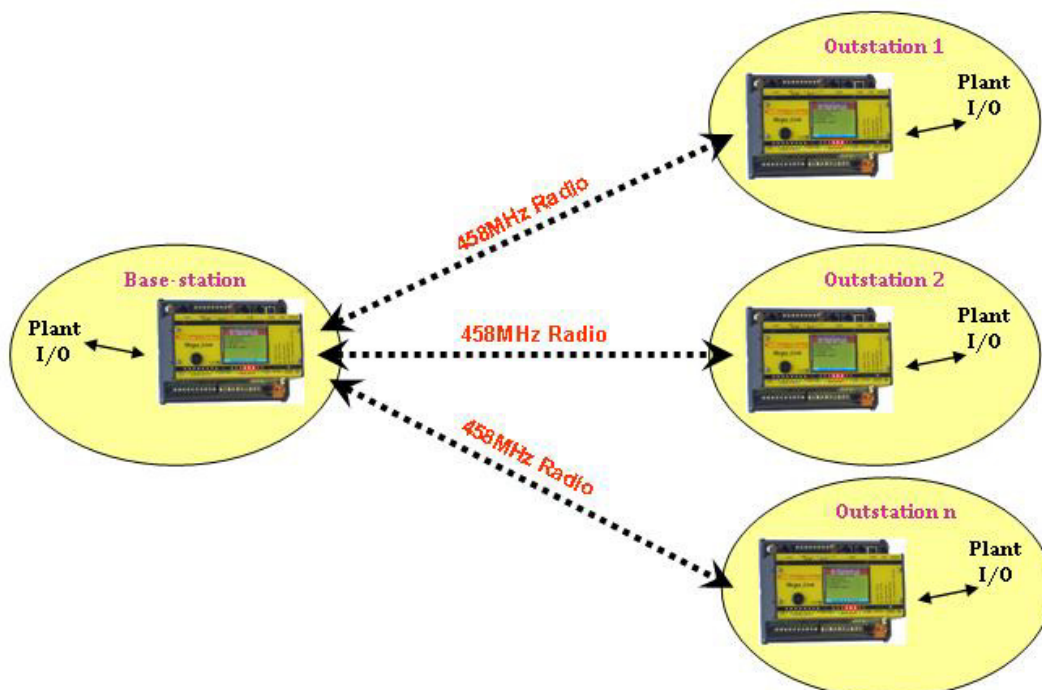
Mega_Link operates using a secure proprietary protocol optimised for radio telemetry and can function as a base-station, an outstation, a Fieldbus master or a Fieldbus slave.

Each Mega_Link maintains a large database of analogue and digital values. Local plant I/O is mapped into the database. The **Mega_Link** protocol ensures that the database is replicated at each site. The user can configure each unit to copy registers within the database, and to copy registers to/from Fieldbus devices.

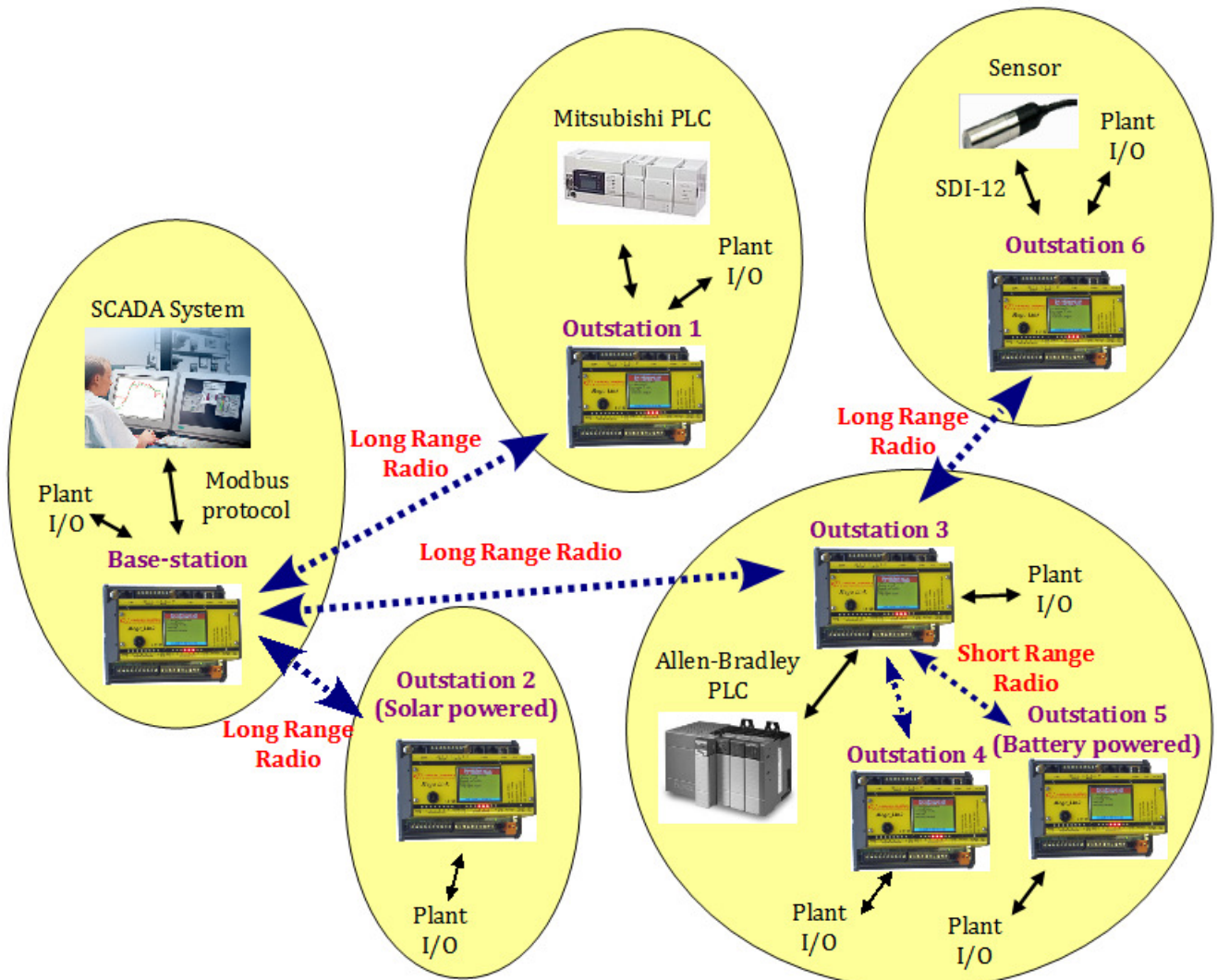
A simple low cost single-point to single point telemetry system, where inputs from plant at the outstation are replicated as outputs at the base-station and vice versa could be:



A simple low cost multipoint to single point telemetry system could be:



A more complex system might be:



In this example the main communication is by long range de-regulated radio, allowing the sites to be separated by up to 20 km.

The base-station links to a SCADA system as a Modbus slave.

Outstations 1 & 3 link to PLC's as masters.

Outstations 2 and 5 are at unpowered locations.

Outstation 3 is configured to act as a repeater between the base-station and outstation 6 (assuming there is no direct radio path between them).

Outstation 3 also acts as a base-station on a second COM port, gathering data from local outstations 4 and 5 via short-range radio.

Note that this illustration shows the base-station communicating with a SCADA system. It could alternatively be linked to a third-party telemetry outstation to provide a low-cost satellite system to expand the range of the host network. This configuration is widely used with regional telemetry schemes.

2 Specifications

Mechanical:	Size 150w x 125h x 110d, DIN rail mounting
Power Supply:	Mains: 100...250VAC, 50VA max (including 15WH battery back-up) Battery: 4 x Alkaline D cells (giving up to 3 years battery life) 12VDC: 10...16VDC, 24W max 24VDC: 20...32VDC, 30W max Solar: Solar panel and lead acid battery
Electrical Connections:	Pluggable 2.5mm ² screw terminals
Current Consumption:	From 12V supply: Awake: < 250mA Asleep: < 25uA
Power Output:	12V +/-0.5V @ 100mA to power external transducers (switched off to conserve power when not needed)
Digital Inputs:	Two groups of 4, each from volt-free contact to common 0V return
Digital Outputs:	Two groups of 4 volt-free relay contacts to common return, each rated 120VAC/0.3A, 24VDC/1A
Analogue Inputs:	Two fully isolated inputs calibrated 0...20mA into 10Ω, 0.025% resolution, 0.1% accuracy
Analogue Outputs:	Two outputs with common +12VDC return, calibrated 0...20mA into 500Ω max, 0.025% resolution, 0.1% accuracy
COM1, COM2:	De-regulated radio: UHF 458MHz, 500mW, range up to 20km UHF 869MHz, 500mW, range up to 10km GSM/GPRS cellular radio modem (Quad band) V23 Leased line modem
COM3:	Configurable RS232 or RS485
Display:	320 x 240 colour TFT with adjacent joystick
Expansion Modules:	Module size: 57w x 125h x 110d, DIN rail mounting Max number: 32 Digital Input: Two groups of 4, each from volt-free contact to common 0V return Digital Output: Two groups of 4, volt-free relay contacts to common return each rated 125VAC/0.3A, 24VDC/1A Analogue Input: Four fully isolated inputs calibrated 0...20mA into 10Ω, 0.025% resolution, 0.1% accuracy Analogue Output: Four fully isolated outputs calibrated 0...20mA into 500Ω max, 0.025% resolution, 0.1% accuracy
XTP Protocol:	No of outstations: 249 max per base-station No of repeaters: 8 max on any path No of base-stations: No limit
Fieldbus Protocols:	Modbus RTU Allen Bradley DF1 half duplex Mitsubishi Melsec FX Mitsubishi Melsec non-FX
Technical:	Processor: 32-bit ARM Cortex-M Clock Speed: 72MHz CPU Memory: 512KB Flash, 64KB RAM, 64KB NOVRAM Additional Memory: 256KB RAM, 1MB NOVRAM, 4GB Flash, 4GB SD Card

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3 Part Numbering System

Mega_Link can be configured with a variety of power supplies and communication interfaces.

The part number defines the build variant.

The basis part number is 7600, but this is followed by a suffix of 4 characters to define the options.

The complete part number is thus **7600-abcd**:

a	Power Supply	A	AC mains
		B	Alkaline Battery
		S	Solar
		1	12V
		2	24V
b c	COM1 Interface COM2 Interface	4	458MHz Digital UHF Radio
		8	868MHz Digital UHF Radio
		G	GPRS
		L	Leased line modem
		0	No interface
d	Display	D	LCD display fitted
		0	No display

4 System Concept

4.1 Hardware

Mega_Link is a modular telemetry system comprising a main module and optional expansion modules. The main module houses a powerful microprocessor system which has the following features:

- Eight digital inputs, capable of monitoring external volt-free contacts such as trip switches, limit switches or pushbuttons.
- Eight digital outputs, each comprising a volt-free relay contact capable of switching external loads such as interposing relays or indicator lamps.
- Two fully-isolated analogue inputs, calibrated to read 4 – 20mA current loop signals from instruments such as depth transducers or pressure gauges.
- Two analogue outputs, calibrated 4 – 20mA, capable of driving loads such as meters or variable drives.
- Up to two COM ports that can be fitted with any of a range of interface modules, as described in section 6.2.
- A serial port that can be configured as an RS232 or an RS485 interface.
- A power supply chosen from the following: AC mains with battery back-up, in-built solar regulator, 12VDC, 24VDC or Alkaline battery pack.
- A USB port for connection to a PC to configure the system and diagnose operation and status.
- A colour LCD display and joystick. This allows the user to monitor various aspects of the system configuration, status and operation. For cost-sensitive applications the display can be omitted and replaced by a handheld unit that can be plugged in externally when required.
- A port for connecting expansion modules to increase the I/O count. The following are available:
 - 8-channel digital input
 - 8-channel digital output
 - 4-channel analogue input
 - 4-channel analogue output

4.2 Software

Mega_Link maintains an internal array of 250 input files and 250 output files. Each file contains eight 16-bit registers and 32 digitals. Inputs from the integral analogue and digital inputs, as well as any expansion modules fitted, are copied to input files, and output files are copied to the analogue and digital outputs. In addition to this, Fieldbus protocols can be used to copy data between the input and output files and external devices such as PLC's or SCADA systems.

Multiple **Mega_Links** can be used to create a telemetry system. The modules will communicate with each other via any of their communication interfaces. At least one module will be configured as a base-station, but all will act as outstations and/or repeaters.

The user can configure the system via the DUCX software to map any inputs to any outputs. This allows great flexibility in passing data around the network, and all data routing configuration is done at the base-station.

Each **Mega_Link** incorporates extensive system monitoring, and maintains a number of alarm flags that can be passed to outputs to indicate various fault conditions.

A unique feature of **Mega_Link** is its ability to communicate via dual paths. For example, it could be configured to communicate via radio and leased line. A base-station will then send each command via both paths. The outstation will process a command received on either path, but log a partial comms failure if the command is not received on both paths. It will send its response on both paths. The base-station will process a response received on either path, but will flag an alarm if either the outstation reports a partial comms failure or if it fails to receive the response on both paths.

4.3 Protocols

Any devices that communicate with each other must use the same protocol, as well as the same hardware interface.

Mega_Link is aware of a number of industry standard protocols, including Modbus, Allen-Bradley DF1 and Mitsubishi, which are collectively known as Fieldbus protocols. These can be used for communicating with third-party systems such as PLC and SCADA systems, and are explained in detail in section 16.

If **Mega_Link** receives a message on any of its COM ports it tests it against all its known protocols. If it is a valid message it will act on it and respond on the same COM port.

When **Mega_Link** is configured as a base-station it will communicate with outstations using XTP protocol, but the user must define the COM port(s) on which it is to send.

When **Mega_Link** is configured as a Fieldbus master the user must define the protocol it is to use to send commands to slave devices, and the COM port on which it is to send.

4.3.1 XTP Protocol

Mega_Links communicate with each other using XTP protocol, which is proprietary to Churchill Controls. XTP protocol incorporates unique features to optimise it for radio communications:

1. Repeaters: A base-station can be configured to route all messages to a given outstation via other outstations, to allow it to reach outstations that may be beyond normal radio range. In fact, up to 7 repeaters can be used, effectively extending the radio range by a factor of 8.
2. System Address: In addition to a station address, each unit is configured with a system address. **Mega_Link** will only act on messages containing the correct station address and system address, thus eliminating the risk of interference from any adjacent systems that may be operating on the same radio channel.
3. Time Synchronisation: Commands sent from a base-station include the time, according to the real-time clock within the base-station. Each outstation synchronises its clock to that of the base-station.

4.4 Configuration and Diagnostics

Mega_Link is configured using DUCX, which is an application that will run on any computer running Microsoft Windows. DUCX is provided free-of-charge, and in addition to allowing the user to configure **Mega_Link** it also allow him to upgrade the firmware and to carry out diagnostics.

Diagnostics is a very powerful and useful feature of **Mega_Link** and it allows the user to monitor all aspects of operation, and is very helpful both in setting up a system and in identifying fault conditions.

4.5 Display

In addition to the facilities offer by DUCX, **Mega_Link** also incorporates various LED's and a colour LCD (Liquid Crystal Display) and joystick. The LED's give an immediate indication of the status of the system.

The LCD display emulates many of the features provided by DUCX without the need to connect a PC.

It also facilitates additional features, such as system calibration.

5 Quick Start

This chapter is intended for anyone who needs to install or fault-find a system without needing to know how the system operates.

5.1 Safety Considerations

The equipment is designed to comply with all relevant safety regulations. The only conductors that are at an unsafe voltage are the power input cables when operating from a mains power supply. These are on the orange connector on **Mega_Link**. It is the user's responsibility to ensure they are adequately insulated, and that the equipment is installed such that they are not accessible without the use of a tool (for example, it could be housed in an enclosure that can only be opened with a tool).

All other conductors should be at safe potentials, but since they may be connected to external electrical equipment they should be treated with care.

5.2 System Configuration

The system configuration is a combination of the hardware and software:

5.2.1 Hardware Configuration Summary

5.2.1.1 Power Supply

Mega_Link incorporates an internal power supply. The type of power supply is indicated by a marker on the cover. Note that there is an ON/OFF switch between the output of the power supply and the internal circuitry.

Power supplies generally include battery back-up so the system can continue operation through power failures.

The output of the power supply is fed internally to the **Mega_Link** motherboard, via an ON/OFF switch. The motherboard will operate from any supply in the range 4...16VDC, and derives from this its internal power rails and a switched 12V supply which powers the analogues and the digital outputs. This supply is also capable of powering external transducers.

5.2.1.2 Display

Mega_Link incorporates various LED's and an optional LCD (Liquid Crystal Display). Note that if the system is in PowerSave mode the display will blank 20 seconds after the last movement of the joystick. It can be re-activated by moving the joystick.

If no display is fitted a hand-held display can be used when needed.

5.2.1.3 Communication Interfaces

One or two communication interfaces can be fitted inside **Mega_Link**. The type communication interfaces can be viewed via the LCD display, or via a label fitted in place of the display.

5.2.1.4 Expansion Modules

Mega_Link can be expanded by adding I/O expansion modules. These connect to it through short jumper leads. Each expansion module has two rotary switches that define its address in the range 00 to 99. Each module must be set to a unique address and the addresses must be contiguous, starting from 00.

5.2.2 Software Configuration Summary

Mega_Link is configured from a PC running DUCX software. This is provided on a disc supplied with each system, or can be downloaded from our website at www.churchill_controls.co.uk. The method of installing it is described in Appendix A.

DUCX allows numerous features to be configured including:

5.2.2.1 Base-station Mode

In Base-station Mode **Mega_Link** will instigate communications with outstations via a defined COM port and respond to replies from them.

In Base-station Mode the user must define which outstations are in use, and the data to be passed between them.

Mega_Link will always inherently function as an outstation, so will respond to any commands received from a base-station on any COM port.

5.2.2.2 Fieldbus Master Mode

In Fieldbus Master Mode **Mega_Link** will instigate communications with Fieldbus slave devices via a defined COM port and respond to replies from them. Part of the configuration is to define the protocol to be used.

In Fieldbus Master Mode the user must define which slave devices are in use, and the data to be passed between them.

Mega_Link will always inherently function as a Fieldbus slave, so will respond to any commands received from a Fieldbus master on any COM port, in any protocol.

5.2.2.3 PowerSave Mode

If **Mega_Link** is not configured as a base-station or a Fieldbus master it can be configured in PowerSave mode. It will minimise power consumption by switching off all hardware that is not used. Until it has synchronised with a base-station it will power itself down, but wake every 2 seconds to sense the presence of a radio carrier. In this Sniff mode the power consumption is low (but not as when **Mega_Link** is asleep). If it detects a carrier it will remain awake until it receives a command from the base-station. The base-station will recognise that the outstation is in PowerSave mode and send it a command indicating when it will next call. The outstation will then go to sleep, minimising its power consumption, until it is next due to be called.

5.2.2.4 Miscellaneous Parameters

Numerous other parameters need to be configured, such as radio channel, baud rate and TCP/IP addresses.

5.3 Diagnostics

5.3.1 Indicator LEDs

Mega_Link has a number of LED indicators to show its functional state:

5.3.1.1 COM Port Monitor LEDs

There are two LED's adjacent to each COM port (COM1, COM2 and COM3). One lights red when the port is receiving data and green when it is sending data. The other lights yellow when the transmitter is active.

5.3.1.2 Heartbeat/Test LED

This LED is adjacent to the power input connector and serves several functions:

- When power is supplied to the COM port interfaces this LED lights green. If the system is not set in PowerSave mode it should continually show green.
- If the system is not set in PowerSave mode it flashes red every second to indicate that the system is functional.
- If the system is set in PowerSave mode it very briefly flashes red every second

5.3.1.3 12V Monitor LED

This LED is adjacent to the analogue outputs, and lights green when the internal 12V rail is active. Analogue inputs and outputs, and digital outputs, can only be used when this rail is active. The power output is provided on the analogue connector for powering external transducers if required.

5.3.1.4 Digital Input/Output Monitor LEDs

An array of 16 LEDs in the top cover displays the state of each of the digital inputs and outputs.

5.3.2 LCD Display

The LCD Display works in conjunction with the joystick. Clicking up or down generally navigates through menus while clicking right selects the highlighted item. Clicking left reverts back to the previous menu.

All menus display a title bar at the top and a diagnostic bar at the bottom. The diagnostic bar normally shows the time and date but if any faults exist it alternates between the time/date and an alarm banner.

5.3.3 DUCX Diagnostics

When a PC is plugged into the USB port and DUCX is opened on it, selecting Diagnostic Terminal on it will open a new window that allows the user to select various diagnostic modes. Pressing Return shows a list of the available commands.

5.3.4 Diagnostics in PowerSave Mode

If **Mega_Link** is configured in PowerSave mode, power to the COM port interfaces will be switched off to conserve power when they are not needed, and the COM port monitoring LED's will be extinguished. The display will continue to function until 20 seconds after the last movement of the joystick. It will then be blanked and the Digital I/O monitor LEDs will be switched off. The Heartbeat LED will briefly flash red every second.

Any movement of the joystick will wake the system, re-activating the display and the Digital I/O LEDs. The Heartbeat LED will give a brighter flash every second to indicate that the system is no longer asleep, but the power rails and COM ports will still only be activated when needed.

When a PC is plugged into the USB port **Mega_Link** partially wakes, as indicated by the Heartbeat LED, but the COM ports will still only be switched on as required, and the LCD display will still be blanked.

5.4 I/O Connections

All I/O connections are via two-part connectors, so the equipment can be readily removed or replaced without exposing the wiring.

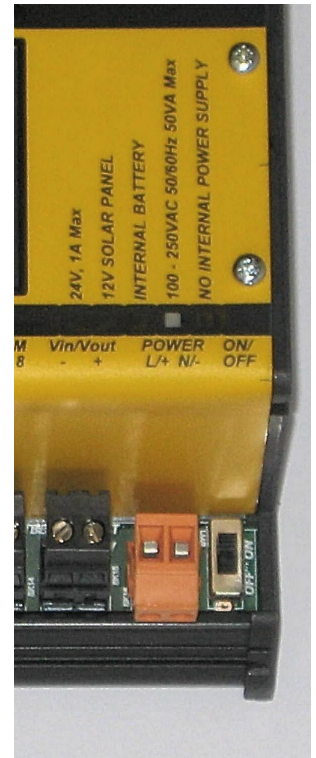
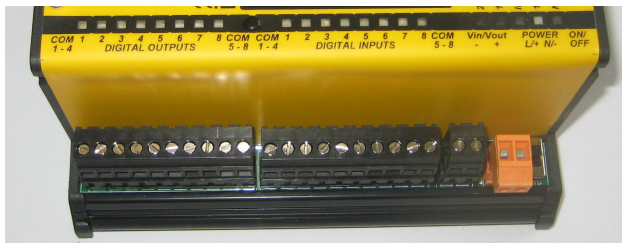
5.4.1 Power

The supply used must match the marker in the top cover. Power is connected via the orange connector. The output of the internal power supply is fed through the ON/OFF switch to the internal circuitry and to the Vin/Vout connector. The voltage on this connector could be anywhere in the range 4.0V...16.0V. If using a solar regulator an external 12V lead acid battery should be connected to the Vin/Vout connector.

If a mains power supply is fitted it should be connected via a switched fused spur, so the equipment can be easily isolated for maintenance. The fuse should be rated at 3A.

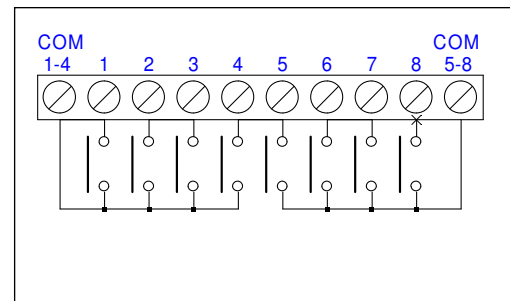
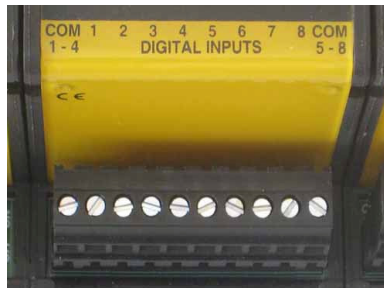
5.4.2 Digital I/O

The digital inputs and outputs are identical on **Mega_Link** and expansion modules:



5.4.2.1 Digital Inputs

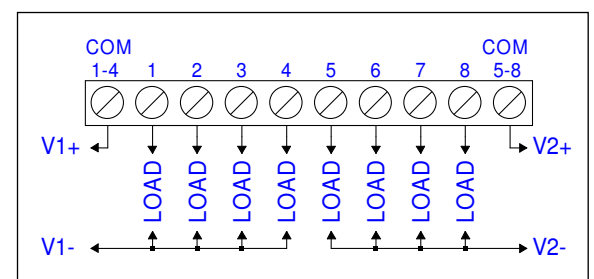
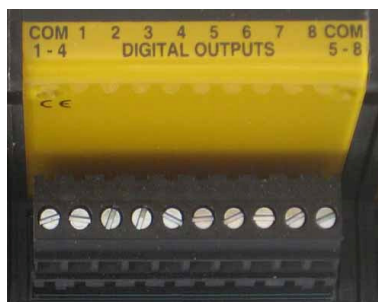
There are eight digital inputs, in two groups of four. Each group shares a common return terminal which is connected to the system 0V rail. The inputs are designed for operation from volt-free contacts.



5.4.2.2 Digital Outputs

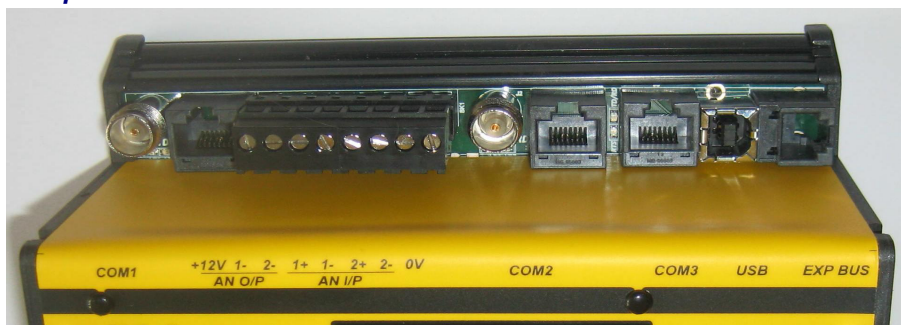
There are eight digital outputs, in two groups of four. Each group shares a common return terminal which is floating. In the illustration V1 and V2 can be either polarity, AC or DC.

All outputs are volt-free relay contacts rated 125VAC @ 0.3A, 24VDC @ 1A. All contacts include surge protection devices which clamp the maximum voltage across open contacts to 170V to prevent arcing when switching inductive loads. However, it is recommended that any DC inductive loads (e.g. interposing relays) are fitted with catching diodes.

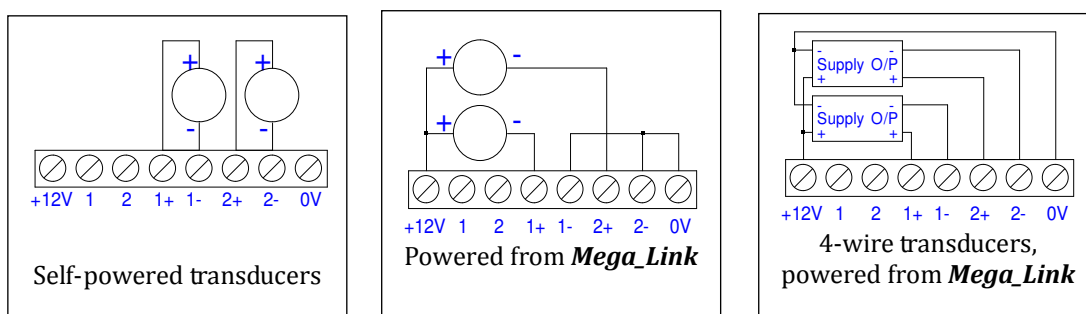


5.4.3 Analogue I/O

5.4.3.1 Analogue Inputs



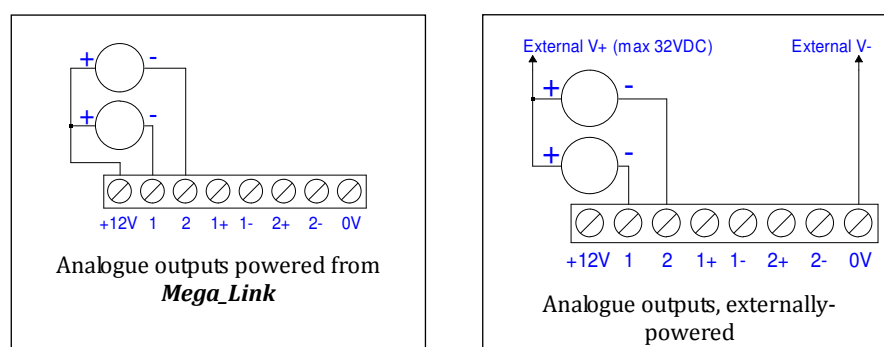
There are two analogue inputs, each with an input resistance of 10Ω , calibrated $0\ldots 20\text{mA}$. Both inputs are fully isolated and can withstand common-mode signals of up to $\pm 240\text{V}$. Note that high common mode AC voltages may give reading errors so should be avoided by ensuring that current loops are referenced to 0V .



The 12VDC output can be used for powering external transducers, if required. An LED adjacent to the connector shows when 12V is available.

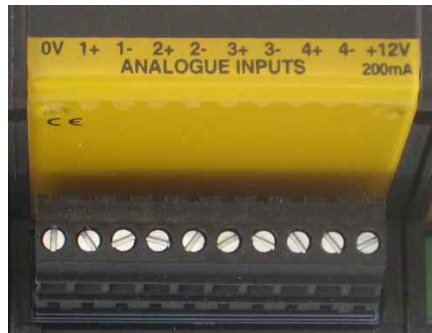
5.4.3.2 Analogue Outputs

There are two analogue outputs, each calibrated $0\ldots 20\text{mA}$ into loads of up to 500Ω . Both outputs sink current to the internal 0V rail, so the external loads must be commoned to a positive supply (normally the system's 12VDC supply, but an external voltage source can be used if required).



5.4.3.3 Expansion Analogue Inputs

All analogue inputs are fully isolated both from each other and from the power supply. Note that high common mode AC voltages may give reading errors so should be avoided by ensuring that current loops are referenced to 0V. The analogue input module incorporates a power regulator that provides a stable 12VDC supply capable of sourcing 200mA that can be used to power transducers.



5.4.3.4 Expansion Analogue Outputs

All analogue outputs are fully isolated both from each other and from the power supply. Each is capable of sourcing 0...20mA into an external load of up to 500Ω. They can thus each be connected to passive loads.



5.4.4 Aerial

If **Mega_Link** is fitted with one or more radio interface then an aerial must be connected to the relevant TNC socket. If an external aerial is used it is strongly recommended that a lightning protection unit is included. The LPU must be earthed to the same reference earth point as **Mega_Link** using the largest practical cable size. A lightning strike can result in currents of several thousand amps flowing through this cable, so the earth terminal may rise to a significant potential. However, no damage will be done, provided all equipment and instruments are earthed to the same point.

5.5 System Configuration

Any given system will comprise at least one base-station and at least one outstation. Each is physically identical, but its mode of operation is defined by a System Configuration file downloaded to it from a PC running DUCX software.

5.5.1 DUCX Configuration

DUCX can be used to create configuration files, save them to disc, download them to a **Mega_Link** or upload them from **Mega_Link**. It can also be used for diagnostics, as outlined above.

For convenience it is often practical to use DUCX to create configurations in the office, then save them to disc before going to site to download them into **Mega_Link**. The method of creating configuration files is described in chapter (Note that this is not included in the Quick Start Manual).

5.5.2 DUCX Diagnostics

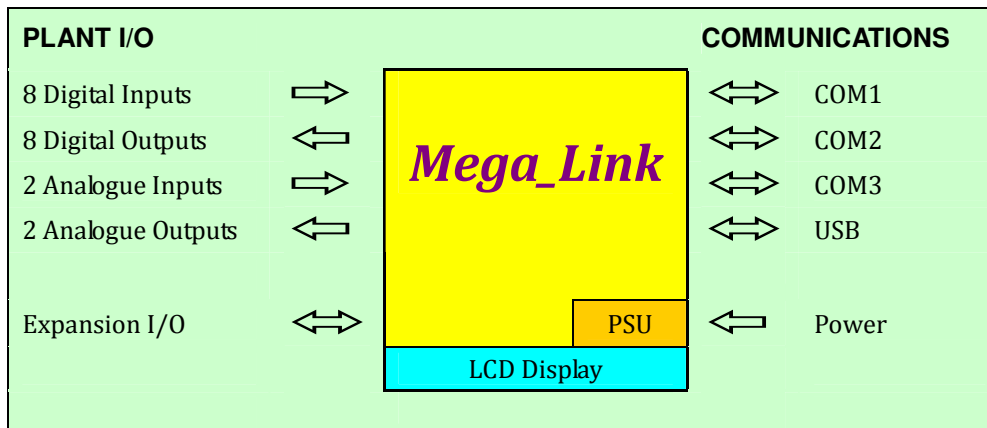
DUCX Diagnostics are relatively easy to use, and can be used to confirm the correct operation of a system and to pinpoint faults. Enter diagnostics mode by selecting Tools:Diagnostic Terminal, clicking on the Diagnostic Terminal icon or typing Ctrl/D.

Pressing Return will terminate the existing diagnostics mode and display a list of available commands. Useful commands include:

- EX is for monitoring all XTP communications between a base-station and outstation. It will display any message originating from the **Mega_Link** or received by it. It will also indicate the port on which the message is sent/received.
- EF is a similar command to monitor all Fieldbus messages.
- SC produces a summary of the system configuration, defining the type of interfaces fitted in each COM port, the power supply fitted and details of any expansion modules
- SS shows a continually-updated list of the status of all hardware I/O ports.

6 Communication Interfaces

The modular construction of **Mega_Link** provides four communication ports, designated as COM1, COM2, COM3 and USB:



COM3 provides a serial interface that can be configured to use either RS232/V24 levels or RS485.

The USB port provides two serial connections to a PC, one of which is configured for use by the DUCX configuration software and the other is for use by the diagnostic functions of DUCX.

COM1 and COM2 can each be fitted with any of a variety of communication interfaces. The type fitted will depend on the application, and will usually be determined from a site survey. The available interfaces are described in section 6.2.

6.1 Radio Standards

A number of radio standards are available for telemetry use, all of which define maximum transmit power levels, and allowable bandwidths. As a general rule the range achievable reduces as the frequency increases, and narrower bandwidths increase receiver sensitivity and immunity from interference.

There are limits on the maximum Effective Radiated Power (ERP), which determines the maximum allowable transmit power. (Note that the transmitter power needs to be reduced if used with a directional aerial that provides gain).

A range of communication interface modules are available for use with **Mega_Link** allowing the following radio networks to be used:

6.1.1 CEPT Recommendation 70-03

This is a pan-European standard that provides specific radio channels for various applications. No licences are required, provided the equipment complies with the appropriate ETSI technical specification, so there are no recurring costs.

The sub-band most suitable for medium-range telemetry applications is Annex 1 band g3, which is 869.400MHz...869.650MHz and allows transmit powers of 500mW (+27dBm) at 25KHz channel spacing. The applicable ETSI standard is ETSI EN 300 220. **Mega_Link** can be configured to use this band by fitting a 7506-2 UHF radio in one or both of its COM ports.

6.1.2 IR2030/2/6

This standard was originally created by the UK Radiocommunications Agency specifically for telemetry applications, designated MPT1329. It was subsequently incorporated into the Ofcom document "UK Interface Requirements 2030 Licence Exempt Short Range Devices IR2030" as a National Licence-Exempt Band. It provides a band from 458.500MHz to 458.950MHz divided into 32 channels at 12.5KHz spacing and allows transmit powers of up to 500mW (+27dBm). No licences are required, provided the equipment complies with ETSI EN 300 220.

Mega_Link can be configured to use this band by fitting a 7506-1 UHF radio in one or both of its COM ports.

6.1.3 Licensed Radio

Most European countries have radio bands allocated for licensed use, permitting transmit powers of up to 20 watts to be used. The equipment used must comply with generic ETSI standard EN 300 113, which specifies tighter parameters than EN 300 220. The UK standard is OfW49 which provides two bands, 457.5 to 458.5MHz and 463.0 to 464.0MHz. The radio used in **Mega_Link** can be configured to operate in this band, albeit at a maximum power level of only 0.5W.

The Irish Republic don't offer a licence-free band, but they permit end-users to buy licences which given them exclusive use of defined channels which fall into the OfW49 bands.

6.1.4 GPRS

GPRS is an enhancement to GSM.

GSM is a standard for voice and data mobile telephone systems adopted by 80% of the countries of the world. It generally operates at around 900MHz or 1800MHz, and is built around a network of base-stations that are positioned to give global coverage. Network providers such as Vodafone, O2 and Orange supply and maintain the base-stations and the infra-structure. It is a circuit-switched network, where the operators charge based on the duration of each call. SMS is a special feature of GSM that allows text messages to be sent.

GPRS lays on top of GSM and provides an always-on packet switching link, where a terminal may be permanently connected to the network, and the operator charges only for the amount of data sent over it. GPRS uses the internet standard TCP/IP protocol for communication, so any device can establish contact with any other device that has access to the internet.

Mega_Link can be configured to use interface by fitting a 7502-1 GPRS Radio Modem in its COM1 port position.

6.2 Available Interfaces

COM3 has an on-board interface that can be configured to either RS232 or RS485. It is intended for communicating with other systems via relatively short wires, or with external communications interfaces such as high-power radios.

COM1 and COM2 can each be fitted with any of the following:

6.2.1 7501-1 458MHz Digital UHF Radio

This is a fully digital radio that can be operate at up to 500mW (+27dBm) on any channel at 12.5KHz spacing in the frequency bands 457.5000...458.4250MHz, 457.5000...459.9250MHz or 463.0000...463.9250MHz. It can achieve a range of up to 10km, and complies with EN 300 220.

It can be configured to operate at any of 30 channels in the band 458.5125...458.9250MHz, (except for channel 20), as designated in the UK standard IR2030/2/6, so can be used licence-exempt anywhere in the UK.

The other two bands listed above are for licensed use in the UK or the Republic of Ireland:

In the Republic of Ireland companies can purchase a licence to give them exclusive use of a number of channels throughout the country. Each licence owner does not expect anyone else to be able to access his channels, so they are password-protected within **Mega_Link**.

In the UK licences are issued for particular applications re sold to for telemetry use. However, a PIN number code must be entered by the user to select any non-IR2030/2/6 channels. The relevant PIN details will only be given to customers who are authorised to use the relevant channel.

When a system is configured the user must define the type of aerial used and the type and length of cable.

Mega_Link then calculates the maximum transmit power that can be used to keep the ERP (Effective Radiated Power) within the regulation limits.

Channel	Frequency
1	458.5125MHz

2	458.5250MHz
3	458.5375MHz
4	458.5500MHz
5	458.5625MHz
6	458.5750MHz
7	458.5875MHz
8	458.5600MHz
9	458.6125MHz
10	458.6250MHz
11	458.6375MHz
12	458.6500MHz
13	458.6625MHz
14	458.6750MHz
15	458.6875MHz
16	458.7000MHz
17	458.7125MHz
18	458.7250MHz
19	458.7375MHz
20	Not available
21	458.7625MHz
22	458.7750MHz
23	458.7875MHz
24	458.8000MHz
25	458.8125MHz
26	458.8500MHz
27	458.8625MHz
28	458.8750MHz
29	458.8875MHz
30	458.9125MHz
31	458.9250MHz

6.2.2 7501-2 869MHz Digital UHF Radio

This is a fully digital radio that can operate on any channel at 25KHz spacing in the band 869.4000...869.6500MHz at up to 500mW (+27dBm) and complies with CEPT Recommendation 70-03 and EN 300 220. It can therefore be used in any country that is a member of the European Union with no recurring costs. It can be configured to work on any of 10 channels shown in table below and depending on aerials employed it can achieve ranges of up to 8km.

When a system is configured the user must define the type of aerial used and the type and length of cable. **Mega_Link** then calculates the maximum transmit power that can be used to keep the ERP (Effective Radiated Power) within the regulation limits.

Channel	Frequency
1	869.4125MHz
2	869.4375MHz
3	869.4625MHz
4	869.4875MHz
5	869.5125MHz
6	869.5375MHz
7	869.5625MHz
8	869.5875MHz
9	869.6125MHz
10	869.6375MHz

6.2.3 7502-1 GPRS Radio Modem

This radio modem operates on the cellular phone network, so provides unlimited range in most countries of the world. **Mega_Link** uses the modem in GPRS mode, which allows data to be sent over the network using TCP/IP internet protocol. GPRS modems use SIM cards similar to those used in a cellular phone to allow access to a defined GPRS network (e.g. Vodafone). However, standard GPRS SIMs allocate an IP address that may change each time the device is powered up. **Mega_Link** needs to use fixed IP SIMs so each device has a known IP address that can be used to route data to it.

The modem transmit power is automatically adjusted to achieve reliable communications with the nearest GSM base-station. If an **Mega_Link** is not near a GPRS base-station, or it has a poor aerial, the transmit power could be up to 2 watts, which may be detrimental to battery life. It is recommended, therefore, that an elevated aerial is used.

In addition to the station address and system address used to identify outstations, **Mega_Link** also needs to know the IP address so messages can first be routed via the GPRS network. When an outstation receives a command from a base-station it can derive the base-station's IP address from the message content, so it can route responses back to it. However, the base-station needs to be programmed with the IP address of each outstation (see section 7.6).

6.2.4 7504-1 V23 Leased Line Modem

This allows **Mega_Links** to communicate with each other via leased telephone lines or private wires.

6.3 Aerials

Every radio variant needs an aerial. The overall performance depends on the radio, the aerial type and location and the topology of the surrounding area.

The aerial must be matched to the frequency at which the radio operates. In general the higher it is mounted the longer the range. Omni-directional aerials give unity gain in all directions so can be used at base-stations and any outstation that needs to communicate with others. Directional aerials give gain in one direction at the expense of loss in other directions, so can only be used at stations which communicate with only one other station. However, because regulations define the maximum ERP (effective radiated power) the transmitter power must be reduced to compensate for the gain. Directional aerials therefore offer no benefit to radio transmitter other than reducing 'pollution'. They do, however, effectively increase the sensitivity of radio receivers.

For more details see section 13.4.

7 Configuration

Each **Mega_Link** needs to be configured via a PC running DUCX software, connected to the USB port. Outstations need minimal configuration, since all data routing is configured through the base-station. DUCX is described in detail in section 15.

The parameters that require configuration can be summarised as follows:

7.1 System configuration

Mega_Link automatically detects the interface modules fitted in COM1 and COM2 positions, but the user needs to define the characteristics of each, depending on the type of interface:

- 458MHz or 868MHz UHF Radio: Channel, aerial type, cable type, cable length
- GPRS: APN, User Name, Password (for use in COM1 position only)

COM3 also needs some configuration:

- RS232 or RS485: Interface type, baud rate, data format and time delays

7.2 Fieldbus

Every **Mega_Link** automatically functions as a Fieldbus slave device, but if it is used as a slave the user must define its slave address.

Mega_Link can also be configured as a Fieldbus master, in which case the user must define the COM port to be used, the protocol and timing requirements.

7.3 XTP Configuration

7.3.1 Outstation Mode

Every **Mega_Link** automatically functions as an XTP outstation, but the user needs to configure a system address and a station address. These addresses are used by both the outstation and the base-station functions. The user can also configure it to operate in PowerSave mode, where it will minimise the current consumption to optimise it for operation from batteries. In PowerSave mode it provides a switched output to energise external transducers, and the user can configure the time required for the transducers to stabilise.

7.3.2 Base-station

If **Mega_Link** is to function as an XTP base-station the user must define following:

The COM port(s) through which it is to communicate. Note that two COM ports can be defined to enable dual comms operation.

Timing parameters, such as outstation scan rate.

7.4 Data Routing

If an **Mega_Link** is configured as an XTP base-station or as a Fieldbus master the user must define the data routing required. The data routing table comprises a list of up to 512 lines, each defining a route such as:

Outstation 10 Digital Inputs 1 – 4 >>> Outstation 20 Digital Outputs 5 – 8

The data routing table is also used to pass data to/from a slave Fieldbus device via entries such as:

Outstation 20 Analogue Inputs 1 – 2 >>> Fieldbus Address 1 Input Register 101 – 102

Data routing can also be used to copy alarm flags to outputs:

Outstation 20 Battery Low Alarm >>> Local Digital Output 8

Finally, data routing can be used for basic data manipulation:

Local Analogue Output 1: Value on Comms Fail = 0

Local Digital Outputs 1 – 4: State on Comms Fail = 1

Invert Outstation 10 Digital Outputs 2 – 4

For more details on configuring data routing see section 15.

7.5 Repeater Comms Routing Configuration

If a **Mega_Link** is configured as an XTP base-station and it uses radio to communicate with outstations, there is a possibility that some outstations may be out of radio range. If this is the case the base-station can direct commands to them via other outstations, which will act as repeaters. The response will follow the same route. The route is configured by defining the last repeater needed to reach the outstation, for example:

Outstation 20: Last repeater = 10, Total Path = 10

Outstation 30: Last repeater = 20, Total Path = 10, 20

If there are no entries in the table for a given outstation the base-station will assume it can be contacted directly.

7.6 GPRS

Systems using GPRS communications need some special attention. The destination of every message sent over the GPRS network is defined by the IP address that is embedded within it. A **Mega_Link** that is using GPRS must therefore define each station not only by station address but also by IP address.

The SIM's used in conventional cellular telephones and modems request their IP address from the network, and it may change if the modem is powered down then re-started. **Mega_Link** must instead use Fixed IP SIM's, which route each message through a Radix server. The Radix server will allocate the SIM a fixed IP address which will be given to the user by the network provider.

Mega_Link needs to know how to access the Radix server, so must be configured with the relevant APN, User Name and Password (see section 15.1.1.3). These details will also be given to the user by the network provider

If a base-station is to communicate with outstations via the GPRS network it needs to know the IP address of the SIM fitted in each outstation. The user must therefore include in the base-station configuration a list of the IP addresses for each outstation (see section 15.1.6). When an outstation receives a command from a base-station it derives the base-station IP address from the message content, so doesn't need to be configured.

Mega_Link has no means of reading its own SIM IP address, so if the documentation from the SIM supplier is lost the user would have no means of finding it. The convention used in **Mega_Link** is therefore to save the station's own IP address as outstation 0. This is not normally used as a valid outstation address so the value stored here is used only as a means of recording.

8 Polling

Each base-station interrogates all its outstations at a defined rate. Each interrogation comprises a command to the outstation followed by a response from it. If the base-station fails to receive a response from the outstation it will retry a number of times before eventually giving up and raising a Comms Fail alarm for the outstation.

The poll rate is configurable, so the user can define the rate at which outstations are scanned. However, some radio bands impose limits on the maximum duty cycle, so the system may over-ride invalid settings.

Each command includes the current time, which is used to synchronise all clocks. The outstation response includes flags that notify the base-station of its configuration and its firmware version. The base-station therefore knows, for example, the type of power supply fitted in the outstation. It can therefore be configured with two distinct polling methodologies, one for battery-powered outstations and another for normal outstations. If it detects a mix of outstation types it will interlace the two polling sequences:

8.1 Normal Outstations

Normal outstations are defined as stations that have a power supply that does not need to conserve power (such as an AC mains supply). They can be continuously polled at a user-defined rate that may, for example, be one outstation polled every 10 seconds or continual polling.

8.2 PowerSave Outstations

Outstations configured to operate in PowerSave mode conserve power by switching off all peripherals when not needed, including the communication interfaces. They switch on the communication interfaces just before they expect the next command from a base-station.

A base-station polls PowerSave outstations using a slower scan rate. The PowerSave scan rate and scan window are user configurable, where the scan rate must be greater than the scan window multiplied by the number of outstations. For example, the scan window may be set to 10 seconds and the scan rate to 15 minutes (provided there are not more than 90 outstations). The base-station can make multiple attempts to call an outstation during its allocated scan window, and will call the outstation at the rate defined by the scan rate.

PowerSave mode is explained in detail in section 12.2.

8.3 Exception Reporting

A base-station can configure outstations to exception-report changes as they happen. This means that the outstation will send an exception message to the base-station when it detects a change on one of its inputs. Each digital input at an outstation can be individually configured to exception report whenever it changes state. Each analogue input can be configured to exception report when it changes more than a defined amount from the last value reported to the base-station.

The base-station can also be configured to exception-report changes to outstation outputs. It will then interrupt its normal poll sequence to send changes to outstations as they happen. This feature can't be used with PowerSave outstations.

For more details see section 12.2 .

8.4 GPRS

When GPRS modems are used the outstation or base-station needs to register on the GPRS network before it can start communications. This can take several minutes, so special consideration needs to be given to PowerSave outstations (see section 12.1.2). There is also a network usage cost consideration, so a slower poll rate may be preferred.

9 Data Routing

Every **Mega_Link** maintains a database of 2000 16-bit input registers, 2000 16-bit output registers, 8000 digital inputs and 8000 digital outputs. For convenience these are grouped into data files, where each file contains 8 registers and 32 digitals:

Input File	
Register 0	Digital 0
Register 1	Digital 1
.	.
.	.
Register 7	Digital 31

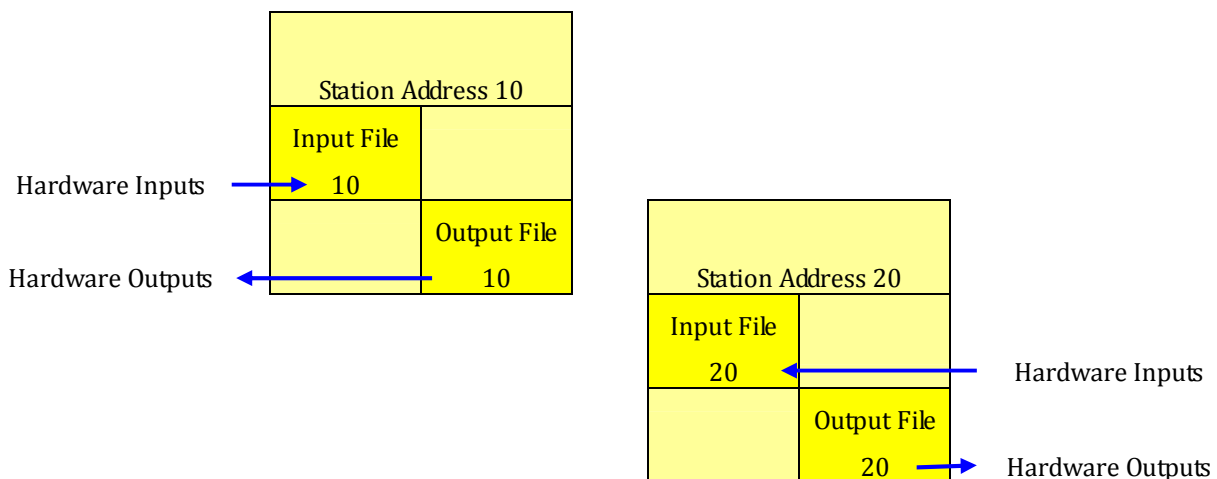
Output File	
Register 0	Digital 0
Register 1	Digital 1
.	.
.	.
Register 7	Digital 31

The database can therefore be viewed as 250 input files and 250 output files:

Input File 0
Input File 1
.
.
Input File 250

Output File 0
Output File 1
.
.
Output File 250

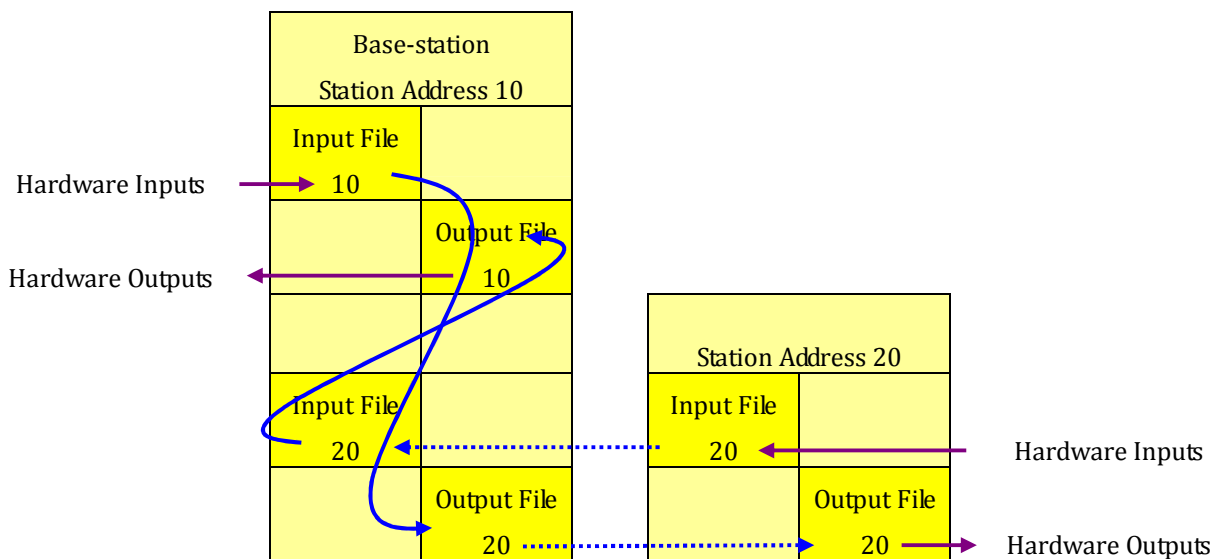
Every **Mega_Link** is configured with a station address. It maps its hardware inputs and alarm flags to the input file corresponding to its station address, and copies the corresponding output file to its hardware outputs. The databases of a system of two stations could be visualised as follows:



Unused database files are omitted for clarity. Each station continually copies its hardware inputs to its input file, and copies data from its output file to its hardware outputs. At this stage there is no communication between stations, and all outputs remain at their reset value of 0.

9.1 Example 1 – Simple point-point system

To transfer data between stations one must be configured as an XTP base-station. The system could be configured as follows:



The additions from the last example are shown in blue:

- Station 10 has been configured to function as a base-station on one of its COM ports. Station 20 must have a matching communication interface on one of its COM ports. It is assumed for the examples that follow that both stations are fitted with GPRS modems on COM1.
- Data routing has been configured in the base-station to copy data from outstation 20 to its local outputs. XTP protocol will automatically poll outstation 20 to populate Input File 20 with data from the outstation inputs. All stations inherently work as outstations so Station 20 recognises commands received on COM1 and responds to them.
- Data routing has also been configured in the base-station to copy some of its local inputs to outputs at outstation 20. XTP protocol will automatically poll outstation 20 to copy the data to it.

It should be apparent that by configuring Station 10 as a base-station and configuring data routing within it the system now functions as a simple telemetry system.

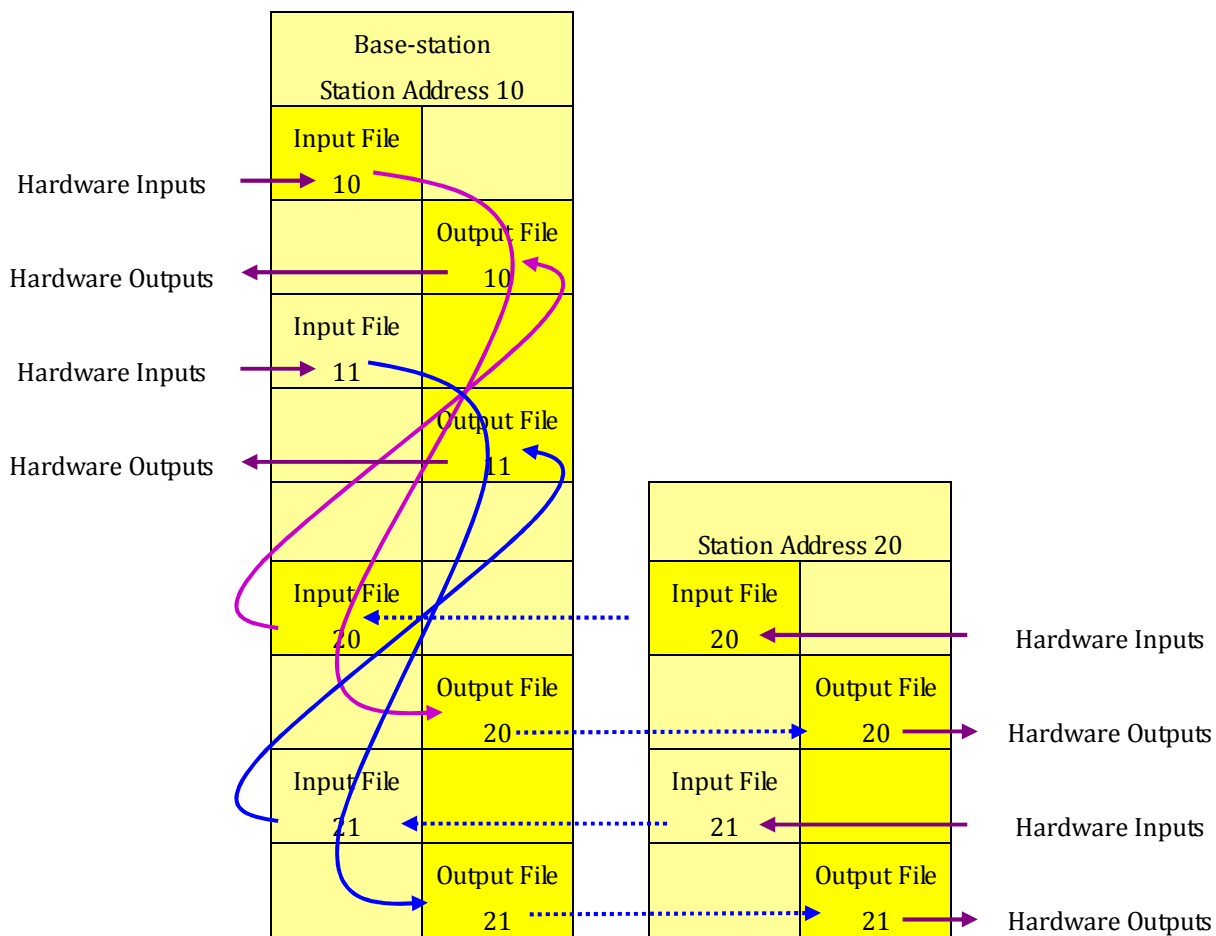
The entries in the base-station data routing table could typically include:

Local Analogue Input 1	>>>	Outstation 20 Analogue Output 1
Local Digital Input 1 – 8	>>>	Outstation 20 Digital Output 1 – 8
Outstation 20 Digital Input 1 – 4	>>>	Local Digital Output 1 – 4
Outstation 20 Comms Fail Alarm	>>>	Local Digital Output 5

No entries are needed in Station 20 data routing table

9.2 Example 2 – Adding Hardware Expansion

The I/O capacity of every **Mega_Link** can be increased by adding expansion modules:

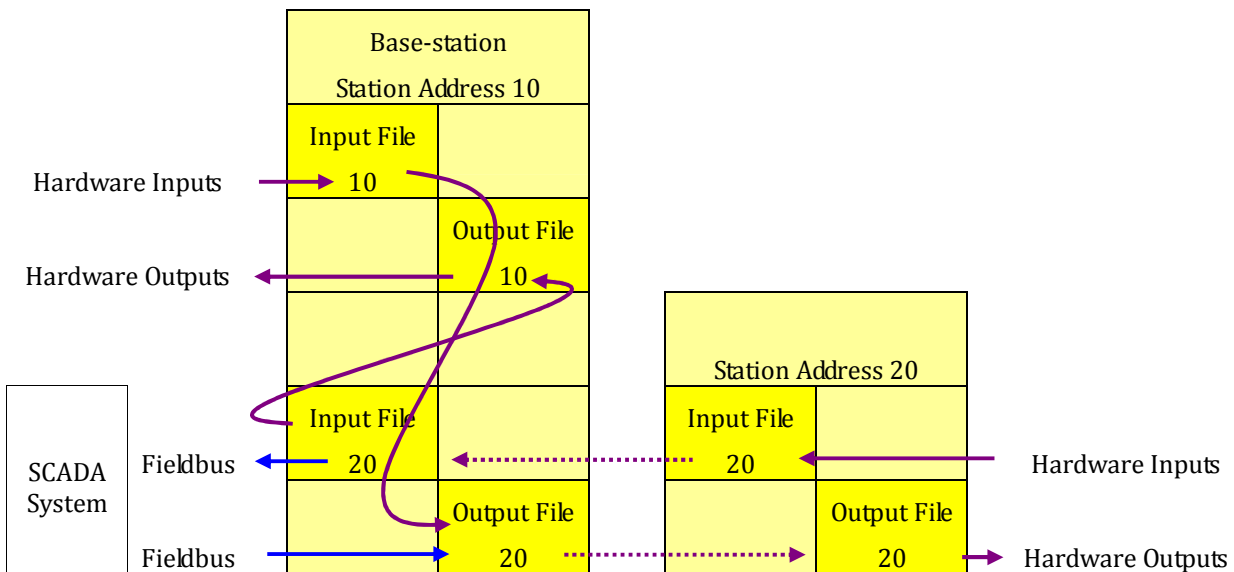


The additions from the previous example are shown in blue:

- Input expansion modules have been added to the base-station. **Mega_Link** automatically maps these to be appended to the internal inputs, so they may spill over into input file 11.
- Output expansion modules have been added to the base-station, which could similarly spill over into output file 11.
- Outstation 20 has been similarly expanded
- The data routing table has been expanded to access the new I/O

9.3 Example 3 – Adding Fieldbus at the Base-station

The database can also be accessed via Fieldbus devices. Suppose the base-station is connected to a SCADA system using Modbus protocol via an RS232 link to COM 3:

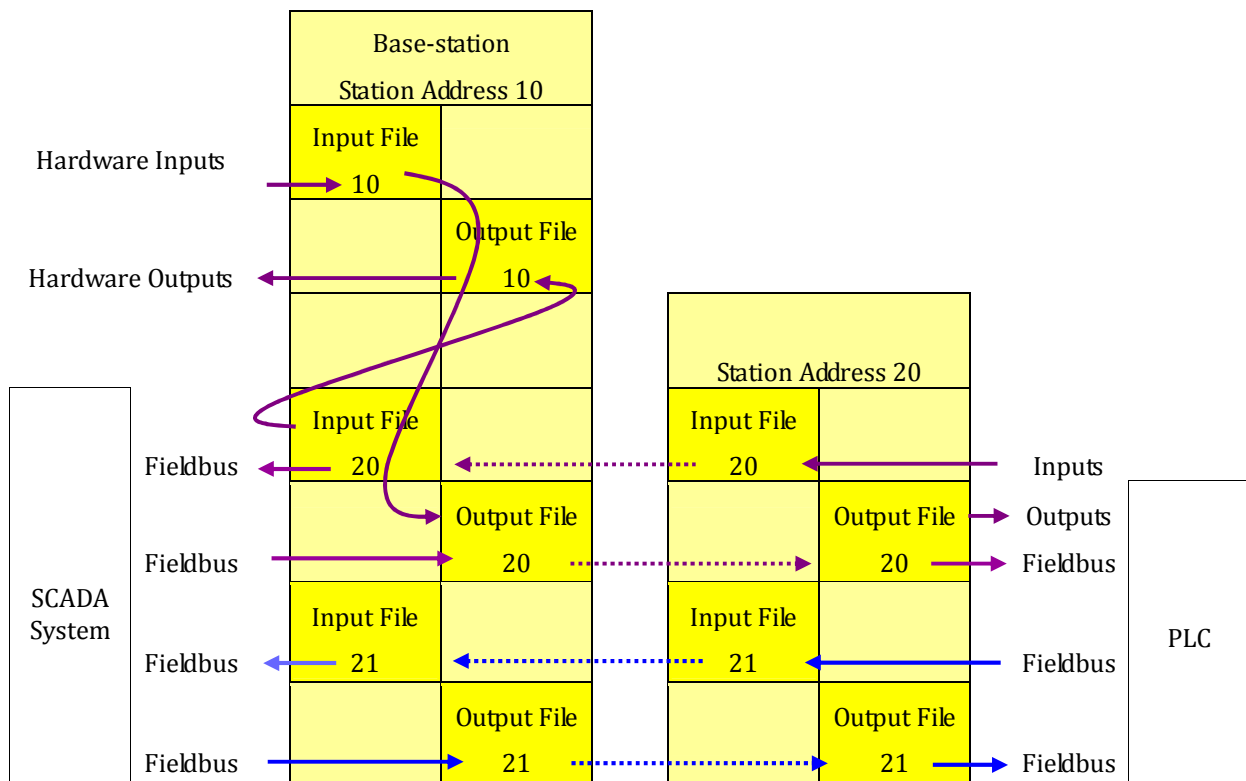


The additions from the previous example are shown in blue:

- A connection has been established between the base-station and a SCADA system using Fieldbus on COM3, at RS232 levels. It is assumed that the SCADA system functions as a Modbus master. Every station inherently functions as a Fieldbus slave device, so the base-station will respond to commands from the SCADA system.
- The SCADA system has been configured to read from registers in Input Files 20. Every **Mega_Link** inherently functions as a Fieldbus slave device, so the base-station will respond to these commands. Note that the SCADA system can read the same registers as used by internal routing, since data can be read by multiple devices.
- The SCADA system has been configured to write to registers within Output File 20. It is assumed that it is writing to different registers within file 20 than those already accessed via internal data routing.

No changes are needed in the data routing table.

9.4 Example 4 – Adding Fieldbus at the Outstation



The additions from the previous example are shown in blue:

- Station 20 has been linked to a PLC via COM3 at RS485 levels. It has been configured to act as a Mitsubishi master, copying data from registers within output files 20 and 21 to the PLC, and copying data from the PLC into registers in input file 21.
- The SCADA system configuration has been expanded to also read from registers in Input File 21 and write to registers in Output File 21. This will automatically cause the base-station to poll for these files. Outstation 20 will recognise that it is using these files so it will respond.

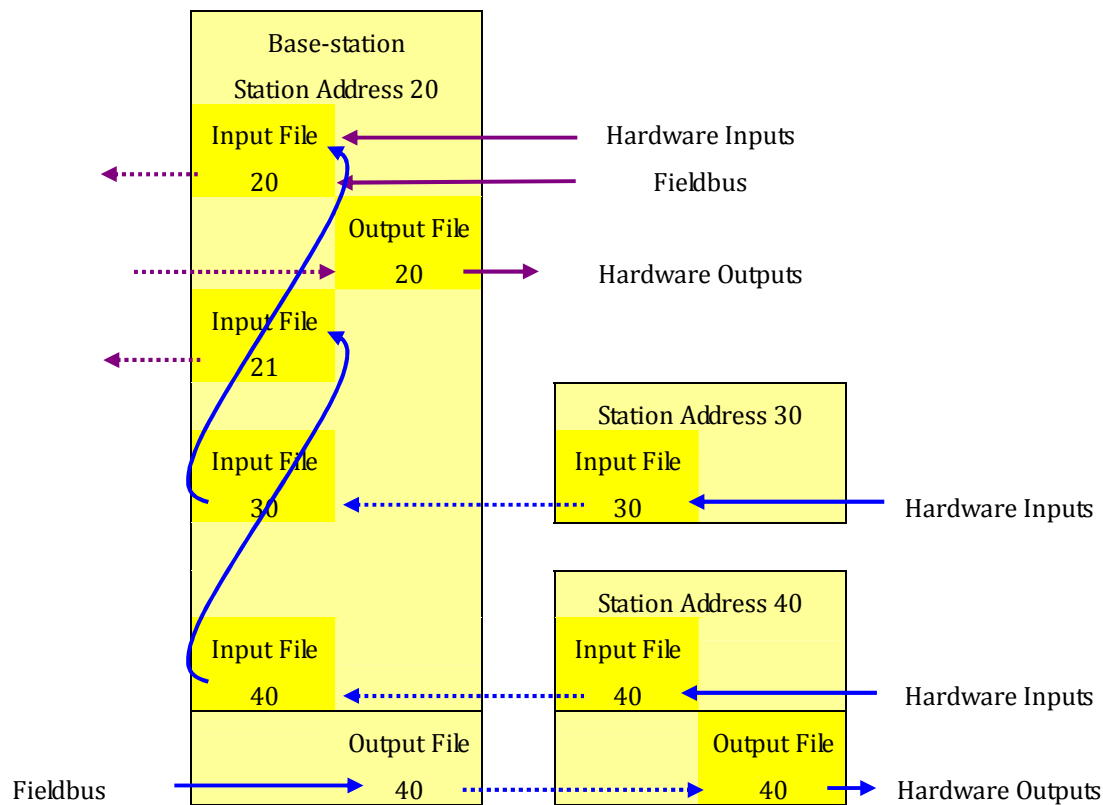
Since outstation 20 is now configured as a Fieldbus master it also needs data routing entries to configure the data transfers between it and the PLC's to which it is connected. For example, it could include:

Fieldbus Address 1 Input Digital 256 – 263 >>> Local Digital Input 9 – 16

(NB Digital inputs 1 – 8 are mapped to the hardware inputs on **Mega_Link** so cannot be used by Fieldbus. If digital input expansion modules were fitted they would use inputs starting from 9, so those used by Fieldbus would have to be modified accordingly).

9.5 Example 5 – Using an outstation as a second base-station

Outstation 20 could be configured to also function as a base-station on a different COM port:



For the sake of clarity this illustration shows only outstation 20 from the previous example, and omits the other stations. The additions from the previous example are shown in blue:

- A short-range radio has been fitted to one of the unused COM ports on Station 20. Since the previous examples are already using COM1 and COM3 the radio must be fitted to COM2.
- Station 20 has been configured to function as an XTP base-station on COM2. This does not affect its existing functionality as an XTP outstation on COM1.
- Data routing has been configured in Station 20 to copy registers from within input files 30 and 40 to input files 20 and 21. The base-station in the previous examples (i.e. Station 10) can be enhanced to read these additional registers from outstation 20.
- New stations have been added, configured to addresses 30 and 40, each fitted with a communication interface matching that of station 20. For this example they are assumed to have short-range radios fitted to COM1. Note that there are now two stations on the system set to address 30, but there is no interaction since they are fitted with different communication interfaces.

The main base-station (Station 10) can effectively access the new stations via Station 20.

To achieve this, outstation 20 must also be configured via DUCX to function as a base-station on a different COM port to that used by its outstation function. The data routing table should copy inputs from outstations 20 and 30 to local inputs other than those used by Hardware I/O or Fieldbus. For example, it could include:

```
Outstation 30 Digital Input 1 - 4 >>> Local Digital Input 17 - 20
Outstation 40 Digital Input 1 - 4 >>> Local Digital Input 21 - 24
```

(NB Digital inputs 1 – 8 are mapped to the hardware inputs on **Mega_Link**. From the previous example digital inputs 9 – 16 are used by Fieldbus. Therefore the first digital input that can be used by the base-station is 17).

The main base-station will now be able to read 24 digital inputs from outstation 20.

9.6 File Mapping

The database within **Mega_Link** comprises a linear array of 250 input files and a linear array of 250 output files. Each file contains 8 registers and 32 digitals. The main **Mega_Link** module provides 2 analogue inputs, 2 analogue outputs, 8 digital inputs and 8 digital outputs, which are all accommodated within the file number corresponding to the station address, defined as the local input file and the local output file. Inputs and outputs on hardware expansion modules are appended to these.

There are three means of reading from and writing to input and output files:

1. Hardware inputs are automatically copied to the input file corresponding to the XTP station address. This applies both to the inputs integral within **Mega_Link** and any expansion input modules that may be fitted. Similarly data from the output file corresponding to the XTP station address is automatically copied to hardware outputs.
2. Data routing (configured via DUCX) can be used to copy data between files at a base-station.
3. Fieldbus can be used to copy data between **Mega_Link** files and external devices.

Whichever method is used, the following rules apply:

1. Data written to an output file at a base-station other than those used for local outputs will automatically be sent via XTP protocol to the corresponding outstation. (If no outstation acknowledges receipt of the data an XTP Comms Fail alarm will be generated).
2. If data is read from an input file at a base-station other than those used for local inputs it will send commands to the corresponding outstation to request it to send the relevant data.
3. Data written to an input file at an outstation will be available for reading by the base-station.
4. If data is read from an output file at an outstation it is assumed that the base-station will write to this file to update the data.

Mega_Link maps its hardware inputs and outputs to defined locations within the relevant input and output files. The user doesn't generally need to know the relevant locations, since the DUCX configuration software makes all necessary calculations. Each file accommodates 8 registers and 32 digitals.

If additional I/O is implemented (either by adding hardware expansion modules or by via Fieldbus) the file will be automatically expanded as necessary by concatenating it with the next file(s). For example, if outstation 10 is expanded it may also use space within the database allocated for files 11 and 12. This means that outstation addresses 11 and 12 cannot be used. The number of files actually used by a station can be readily derived from the fact that each file holds eight 16-bit registers and 32 digitals and **Mega_Link** itself uses all 8 input and output registers and the first 16 digitals.

The maximum file size for any outstation is 120 input registers, 120 output registers, 480 digital inputs and 480 digital outputs, which uses the space within the database allocated to 15 consecutive files. For a base-station the limit only applies to hardware I/O since data routing and Fieldbus can directly access outstation files. A base-station can use the whole database of 250 files, equivalent to 2000 input registers, 2000 output registers, 8000 digital inputs and 8000 digital outputs.

Station addresses can be calculated to ensure there is no conflict. However, unless there are more than 25 stations on a system, or large amounts of data are used at a given station, it is easiest to simply allocate addresses in increments of 10. This allow each outstation to have a capacity of up to 80 input registers, 320 input digitals, 80 output registers and 320 output digitals.

If it is known from the outset that an outstation will never be expanded then consecutive station addresses can be used.

9.7 Alarm Flags

Each input file includes a number of alarm flags and system parameters related to the relevant station. Data routing can be used to copy these to digital or analogue outputs and/or to external devices via Fieldbus. For more details see section 10.1.

10 System Monitoring

As well as mapping its hardware I/O and Fieldbus data to its database, **Mega_Link** also stores data relating to its functionality:

10.1 Alarm Handling

Mega_Link detects a number of possible fault conditions, and stores them as flags which are mapped to its input file so can be sent over the communications network for monitoring remotely. All alarm flags are at a '1' in the normal state and '0' in alarm. Therefore, if they are copied to digital outputs the relevant relay contact will be closed in the non-alarm state and thus be fail-safe. Note, however, that **Mega_Link** incorporates the provision for any digital outputs to be inverted if required.

10.1.1 Comms Fail Alarms

10.1.1.1 Base-station

When **Mega_Link** is configured to function as a base-station (i.e. when a COM port is selected in the Primary Port box in the XTP Configuration tab of DUCX) it will generate base-station alarm flags:

10.1.1.1.1 Base-station Comms Fail Alarm

Whenever a base-station sends a command to an outstation it expects a response from it. If it fails to receive a response it will retry a finite number of times. When it has exhausted all retries it will assert the Base-station Comms Fail alarm, as well as the Outstation Comms Fail alarm for the relevant outstation. The Base-station Comms Fail alarm therefore signifies that it has failed to get a response from at least one outstation.

When a base-station raises an Outstation Comms Fail alarm it also checks to see if there are any entries in the data routing table that specify a Value on Comms Fail for any inputs at that outstation. If there are it will force the values in its database accordingly, so any outputs to which they are written will adopt the defined values.

Note that this alarm flag doubles as a Rotation Fail alarm if a 7505-1 Electronic Compass is fitted in place of one of the COM port interfaces. The rotation sensor cannot be used in a **Mega_Link** that is configured to function as a base-station.

10.1.1.1.2 Base-station Dual Comms Fail Alarm

If a base-station is configured to operate in Dual Comms mode (i.e. a COM port is also selected in the Secondary Port box in the XTP Configuration tab of DUCX) it will send every command simultaneously on both COM ports. It will expect to receive a response on both COM ports. It will action the response even if it is only received on one port (and hence clear any Base-station Comms Fail Alarm). However, if it fails to receive a response on both COM ports for a finite number of consecutive commands it will flag a Base-station Dual Comms alarm. If it fails to receive a response from a particular outstation on both COM ports for a finite number of consecutive commands it will flag an Outstation Dual Comms alarm.

10.1.1.1.3 Base-station Total Comms Fail Alarm

If a base-station fails to receive responses from any outstation it will raise the Base-station Total Comms Fail alarm.

10.1.1.2 Outstation

Every **Mega_Link** will always function as an outstation, so it will respond to any XTP command received on any port. It will send its response on the same port.

10.1.1.2.1 Outstation Comms Fail Alarm

When an outstation receives two identical message types (e.g. two commands to read digital inputs) it records the time difference between them. If a period greater than this lapses it will assume there is a comms failure and raise an internal alarm flag. It will also check to see if there are any entries in the data routing table that specify a "Value on Comms Fail" for any of its local outputs. If there are it will force the outputs to the values defined.

10.1.1.2.2 Outstation Dual Comms Fail Alarm

If an outstation receives two identical commands on different ports it will assume that the base-station that sent them is configured to use dual comms. From then on, whenever it receives a command on either of the COM ports it will send its response on both ports. If it subsequently fails to receive commands on one of the COM ports for a

finite number of consecutive commands it will raise an Outstation Dual Comms alarm, which will be embedded in the response it sends to the base-station. It will, however, continue to send responses on both COM ports, so the system will continue to function correctly.

10.1.1.2.3 Fieldbus Comms Fail

If **Mega_Link** is configured as a Fieldbus master it will clear the Fieldbus Comms Fail alarm when a slave device responds to commands sent to it. If a slave device fails to respond to commands the alarm will be set.

10.1.2 Power Supply Monitoring

Mega_Link automatically detects the type of power supply fitted and generates alarms accordingly:

10.1.2.1 Battery Low Alarm

All power supply variants either include a battery or are intended to operate from a common site battery supply. This is important, since telemetry systems are usually required to continue to operate through power failures, and in fact are very often required to report power failures. **Mega_Link** detects the type of supply fitted and from this determines the battery type. It monitors the battery voltage and generates a Battery Low Alarm when it believes the battery is nearing the end of its life. The time for which the system will continue operating depends on the type and size of the battery and the total load being drawn, but it should be long enough for the operator to attend site to correct the problem.

10.1.2.2 Charger Fail Alarm

If a mains power supply is fitted **Mega_Link** will continue operating through power failures, using its internal standby battery. However, **Mega_Link** will generate a Mains Fail Alarm so remote stations can know of the failure. When power is restored the power supply will replenish the charge in the battery.

Whenever an **Mega_Link** reads its analogue inputs it also reads the battery volts, and other signals from the power supply module. The battery volts are saved in units of millivolts in the relevant register within its input file.

10.1.2.3 Fieldbus Fail Alarm

If **Mega_Link** is configured as a Fieldbus master it will poll slave devices to pass data to/from them. If a slave fails to respond to a command it will retry a finite number of times before giving up and raising the Fieldbus Fail alarm.

10.2 RSSI

The radio Receive Signal Strength Indicator (RSSI) is dependent on the remote transmitter power, the aerial efficiency and the radio path loss. RSSI is measured in dBm or dBμV, where (x)dBm = (x + 107)dBμV. Each radio receiver has a defined sensitivity, and the viability of the path is determined by the fade margin, which is amount the receive signal can fall from its nominal value before it drops below the receiver sensitivity. For example, a radio receiver would typically have a sensitivity of -120dBm (-13dBμV). If it is close proximity to a transmitter the received signal strength (RSSI) may be -50dBm (+57dBμV), giving a fade margin of 70dB. However, if it is moved away from the transmitter, or obstacles are placed in the path the RSSI could drop to, say, -105dBm (-2dBμV). The fade margin would then be only 13dB. A fade margin less than 10dB would indicate that there is a risk of losing communication in adverse weather.

The RSSI is stored in a register in the station's input file, so it can be read via the Fieldbus port if required, and it can be displayed in diagnostics. The file contents merge the transmit power with the RSSI so when the file contents are received from a remote device the system can calculate the total path loss. Since path loss is symmetrical it can potentially reduce its transmit power to conserve power consumption while still ensuring that the remote system will receive an adequate signal.

The value stored is (100 * dBm + [Transmit Power in dBm]). For example, if a system has an RSSI level of -102dBm and is transmitting at +27dBm (i.e. 500mW) then the register would read 10227. The RSSI can thus be extracted by dividing by 100 (albeit with a small offset due to the transmit power).

When using dual comms the RSSI stored is that of COM port COM1. The RSSI of each COM port can be viewed via diagnostics.

When a base-station is polling more than one outstation the contents of its RSSI register will change each time it polls a different outstation. Therefore it also saves the RSSI of its own receiver in the RSSI register of the output data file allocated to the outstation.

11 SMS Test Messaging

11.1 Introduction

Any **Mega_Link** fitted with an internal GPRS modem can be configured to send SMS text messages, and provide status reports when interrogated.

The user can configure exception messages to be sent when digital inputs change state, or when analogue levels pass user-defined thresholds. A typical exception message could be:

Tue 06/05/14 13:50:49
Tower Hill:
Intruder Alarm activated

The user can configure a directory of up to 15 numbers to which exception reports will be sent. Any land line numbers will receive spoken messages.

Any user whose number is in the directory can interrogate **Mega_Link** at any time by sending the command message 'Status'. The typical response might be:

Tue 06/05/14 13:50:49
Tower Hill:
High Level Alarm OK
Low Level Alarm Tripped
Mains Power OK
Intruder Alarm activated

Any message received from a number that is not in the directory (or any invalid command message received from a number that is in the directory) will be forwarded to the first number listed in the directory.

Tue 06/05/14 13:50:49
Tower Hill:
SMS received from +447976221435
Your account has had an auto top-up of £10.00.
Your new balance is £12.74

This will include any messages from the service provider (e.g. Vodafone). The message received could typically be:

Mega_Link will work with any SIM card that has text messaging enabled. If a Pay-As-You-Go SIM is used we would strongly recommend arranging it to be automatically topped-up to ensure that it never runs out of credit.

The facility can be implemented within **Mega_Link** in a number of ways:

The **Mega_Link** can be used in stand-alone mode whereby its sole function is to deliver messages via SMS text messaging

The **Mega_Link** can simultaneously function as an outstation, whereby it transfers data to/from a base-station as well as reporting alarms via SMS text messaging

The **Mega_Link** can simultaneously function as a base-station, so it will transfer data to/from one or more outstations as well as reporting data received from outstations via SMS text messaging.

Mega_Link is configured using DUCX software. **Mega_Link** and DUCX are fully described in other documents. This section specifies only the SMS text messaging functionality.

11.2 Configuration

11.2.1 System Requirements

SMS Text Messaging is implemented in **Mega_Link** firmware versions 1.0.18 and later. It is configured using DUCX version 1.0.11 or later.

To use SMS Text Messaging a **Mega_Link** must be fitted with a GPRS modem and SIM card.

If the **Mega_Link** is not communicating with other **Mega_Links** via the GPRS network then any SIM card can be used that supports text messaging.

If the **Mega_Link** is communicating with other **Mega_Links** via the GPRS network the SIM card must be enabled for GPRS and must use a fixed IP. These can be supplied with or without SMS text messaging enabled. Fixed IP SIMs are available from many suppliers, such as Wireless Innovations (www.wireless-innovation.co.uk) and Wireless Logic (www.wirelesslogic.com). They can be supplied to work on any required network (e.g. Vodafone).

11.2.2 Station Name

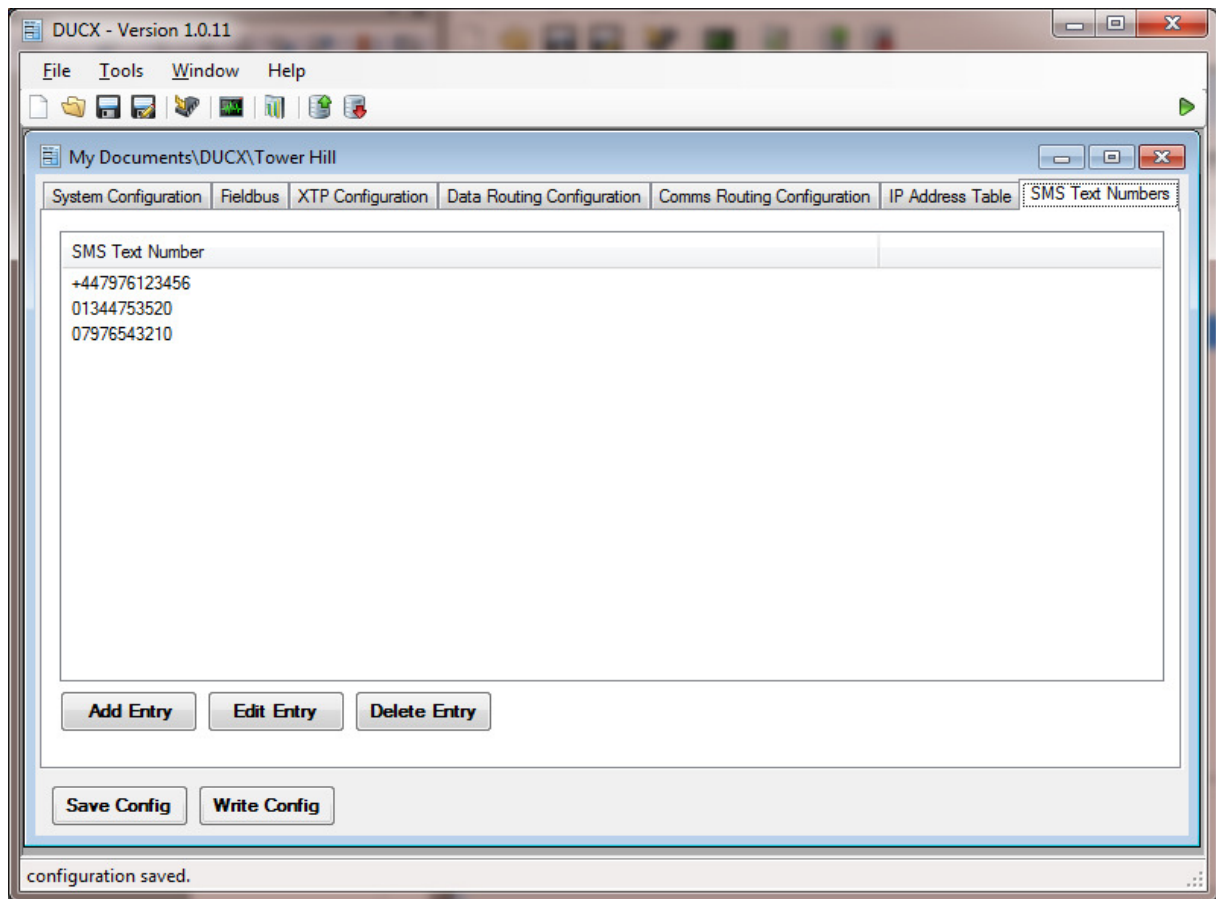
Every message sent from Mega_Link is prefixed with the heading:

Time/Date Station Name

When a new configuration is created via DUCX it will be given a default name 'Configuration'. Before downloading it to **Mega_Link** it should be saved using a sensible file name. This will be the Station Name that will be allocated to **Mega_Link**.

11.2.3 SMS Text Numbers

The first stage of configuring Mega_Link is to define the telephone numbers to which messages are to be sent. This is done through the SMS Text Numbers tab in DUCX:



The numbers in this table define where exception reports will be sent, and also the telephone numbers of the users who are authorised to send command messages.

Note the following:

1. Any message received from a number that is not listed in the table (or any invalid command message received from a number that is in the directory) will be forwarded to the first number in the table
2. Numbers from which commands are required to be sent must precisely match the number reported by the network provider. In many cases the network provider will replace the leading '0' with the country code, as illustrated by the difference between the first and third lines in the table above. If a user sends a command message from number 07976543210 **Mega_Link** might forward the message to the first number (i.e. +447976123456) reporting that it had been received from number +44797654321. This can be fixed by modifying the entry in the table.
3. The table can include land-line numbers, as illustrated in the second line. The network provider will convert the message to speech and deliver it to the relevant number.

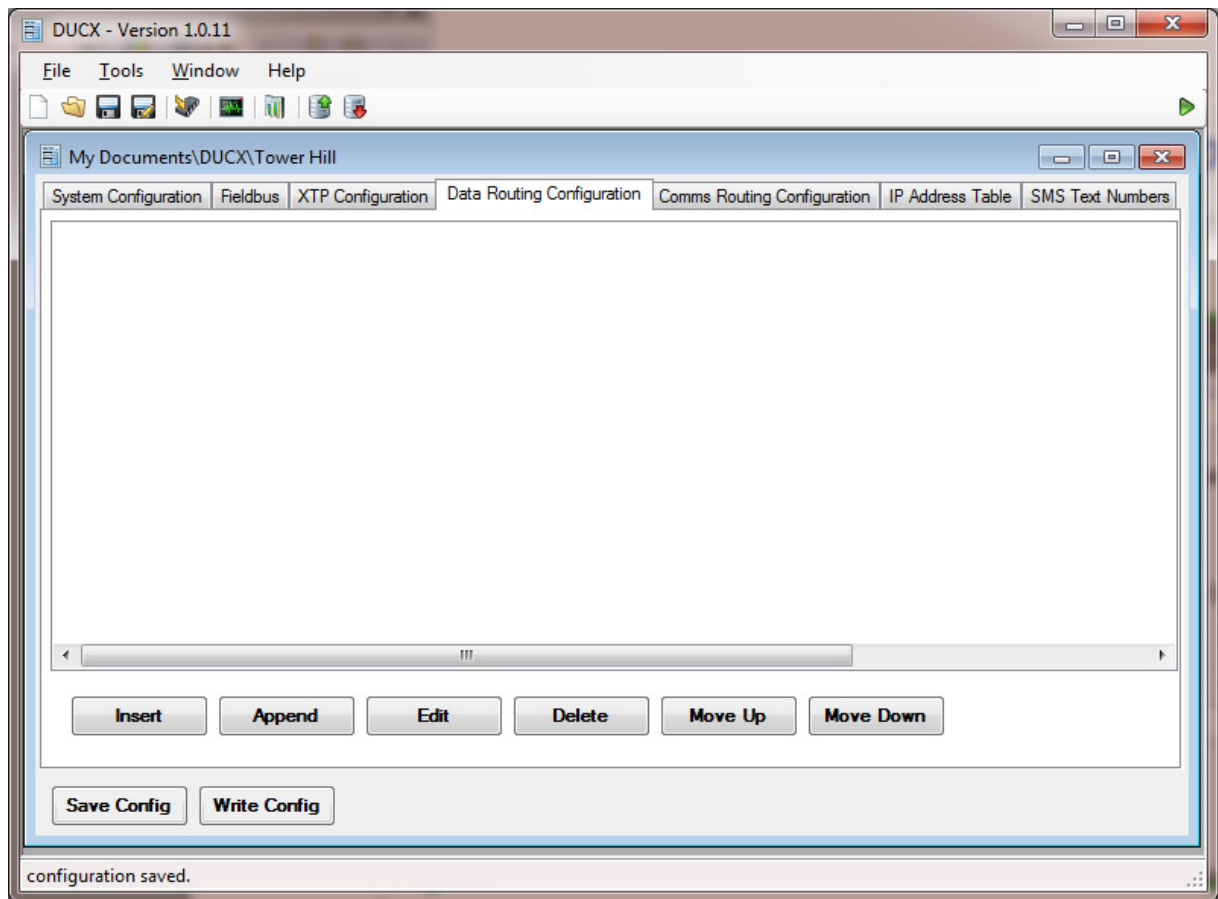
Up to 15 different numbers can be configured.

11.2.4 Configuring Digital Exceptions

Mega_Link can be configured to exception report digital changes between a base-station and an outstation, as described in section 12.2.1.1. All exception reporting of this type is configured at the base-station.

Any exception reporting configured in this way can also be set to report the changes via SMS text messaging. However, **Mega_Link** can also be configured to report digital input changes via SMS text messaging even if the relevant digital inputs are not configured to exception report to a base-station.

All exception reporting is defined in the Data Routing tab. When a new configuration is started the table will be clear:



Clicking Insert or Append opens a data entry form:

Description :

Source ☐ Fieldbus ☐ Local

Station Address

Source Type :

Number

Destination ☒ Local

Destination Type :

Number

Quantity :

To configure digital exception reporting the default values should be changed as follows:

The screenshot shows a 'Data Routing Configuration' window. It has a 'Description' field with the text '\Intruder Alarm {Activated}[OK]'. Below this, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Source Type' is set to 'Digital Exception'. In the 'Destination' section, 'Destination Type' is set to 'Digital Input', 'Number' is '1', and the 'Local' checkbox is checked. At the bottom, 'Quantity' is set to '1'. There are 'OK' and 'Cancel' buttons at the bottom right.

Description:

The text must start with the character '\' to define it as SMS text. Any text enclosed by curly brackets { } will only be included if the relevant input contact closes. Any text enclosed by square brackets [] will only be included if the relevant input contact opens.

Curly = Closed, Square = Open

Note that alarm flags are fail safe, so are treated as being being closed when OK, open on fault. For example, the text associated with a Battery Low alarm could be "Standby Battery [Low]{OK}".

Source Type

Must be set to Digital Exception

Destination

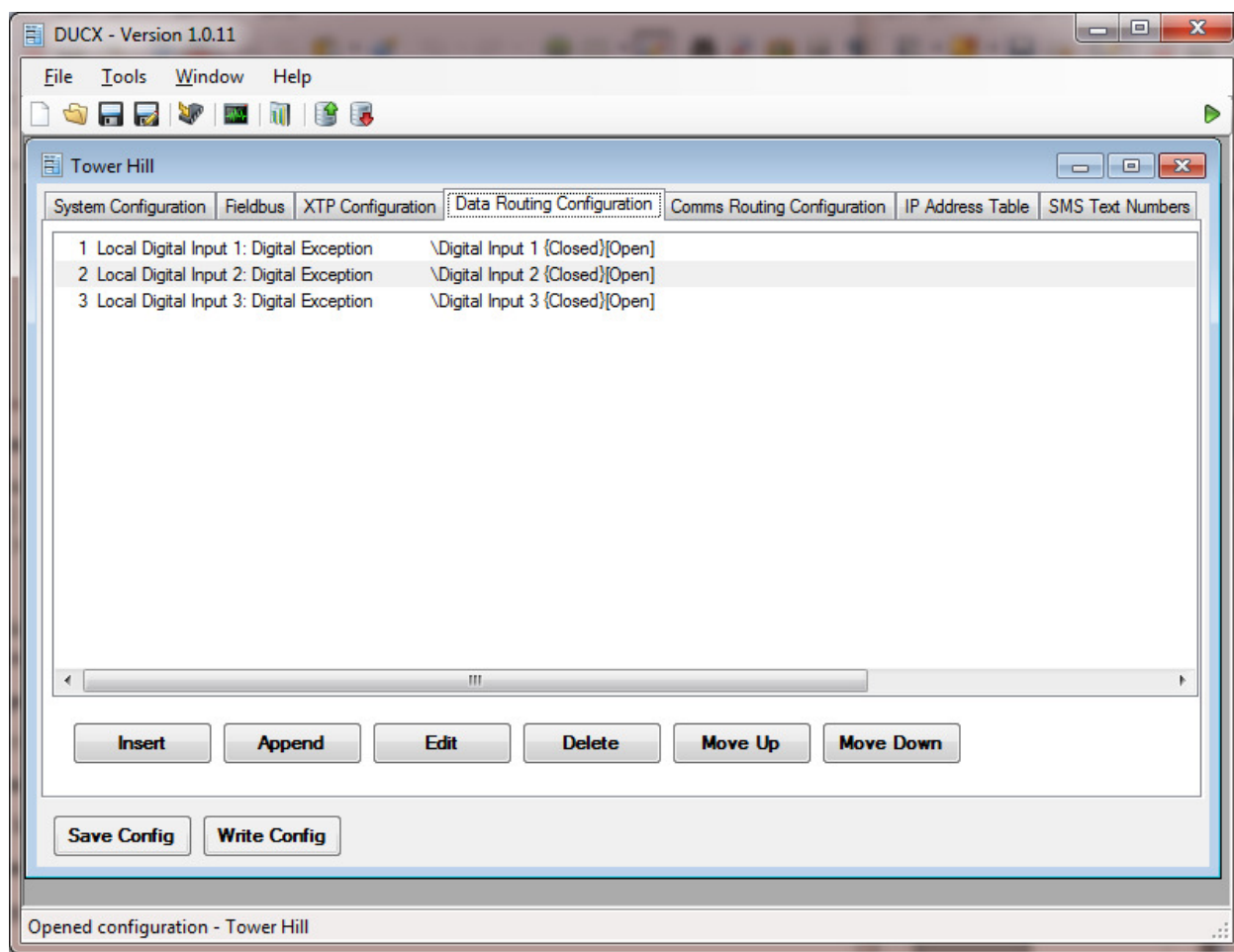
The method of operation is determined by a combination of the Destination boxes:

- If the text in the Description field does not begin with the character '\' then exception reporting via SMS text messaging will not be enabled.
- If **Mega_Link** is not configured as a base-station then the Local box must be ticked.
- If Local is ticked and Destination Type is Digital Input or an alarm flag, then the relevant input will only be sent via SMS text messaging, and the base-station – outstation communications will not be affected.
- If Local is ticked and Destination Type is Digital Output, then a SMS text message will be sent if the remote base-station or outstation reports a change to the relevant output.
- If **Mega_Link** is configured as a base-station, Local is not ticked and Destination Type is Digital Input or an alarm flag, then on start-up the base-station will send a command to the relevant outstation configuring it to send an exception report to the base-station immediately the relevant input changes state, and the base-station will report the change via SMS text messaging.
- If **Mega_Link** is configured as a base-station, Local is not ticked and Destination Type is Digital Output, then on start-up the base-station will configure itself to send an exception report to the relevant outstation immediately a change occurs. At the same time the base-station will report the change via SMS text messaging.

Quantity

When configuring exception reporting via SMS text messaging Quantity should be set to 1, since the relevant text message will normally only apply to one specific point.

The resulting data routing table might look something like this:

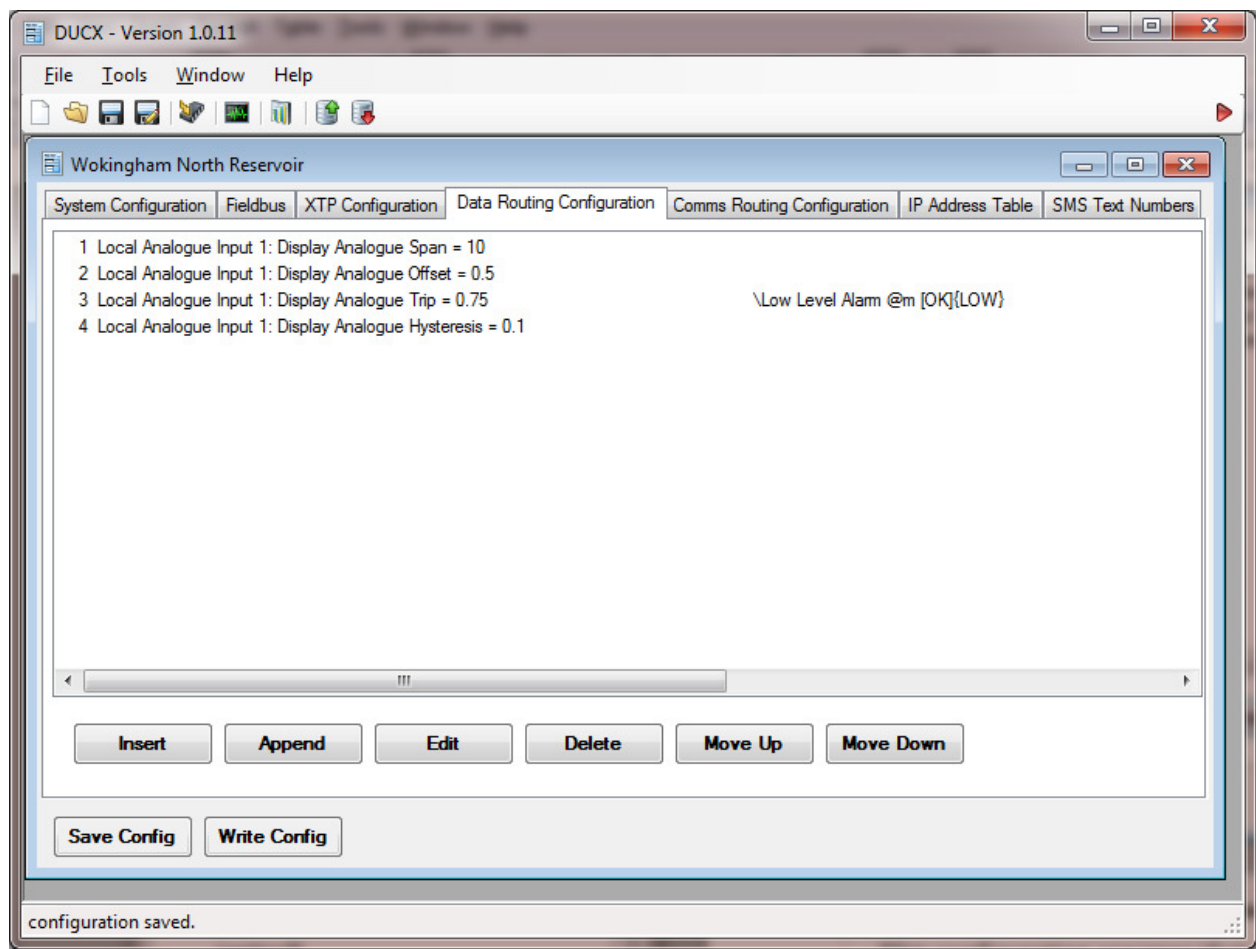


11.2.5 Configuring Analogue Exceptions

When **Mega_Link** is used as a base-station it can be configured to exception report analogue changes to an outstation as they happen by using the Source Type Analogue Exception to define the amount by which an input can change before it is reported to the outstation. The same instruction can also be used to cause it to send a command to an outstation at start-up, configuring it to exception report analogue changes to the base-station. This is explained in detail in section 12.2.1.2 and has no impact on exception reporting via SMS text messaging.

Mega_Link can also be configured to send SMS text messages when they pass through defined trip points, independent of the exception reporting described above.

Analogues will invariably have noise superimposed (for example, water level readings will fluctuate due to surface waves). When the level is close to a trip point the noise could cause multiple exception reports, so trip points should be configured with hysteresis. Furthermore, although the system internally stores analogue level normalised to a defined scale (i.e. 0 – 20mA = 0 – 4000), the user expects them to be scaled to real world levels (e.g. water level = 0 – 10.0m). These parameters can all be configured via the Data Routing tab:



This configuration example assumes that Analogue 1 is connected to a pressure transducer that produces an output of 4 – 20mA and is calibrated for a span of 0 – 10m. Furthermore it assumes that the transducer is installed 0.5m from the bottom of the tank.

Line 1 converts the reading from 4 – 20mA to 0 – 10.0.

Line 2 adds an offset of 0.5m, so the reading will be in the range 0.5 – 10.5m

Line 3 sets a lower trip point of 0.75m. The level will be regarded as low if it drops below this value. It also defines the SMS text to be sent .

Line 4 sets a higher trip point of 0.85m (0.75 + 0.1). The level will be regarded as high if it rises above this value.

If no Analogue Span is set the default is 100.

If no Analogue Offset is set the default is 0.

If no Analogue Hysteresis is set the default is 1% of the Analogue Trip.

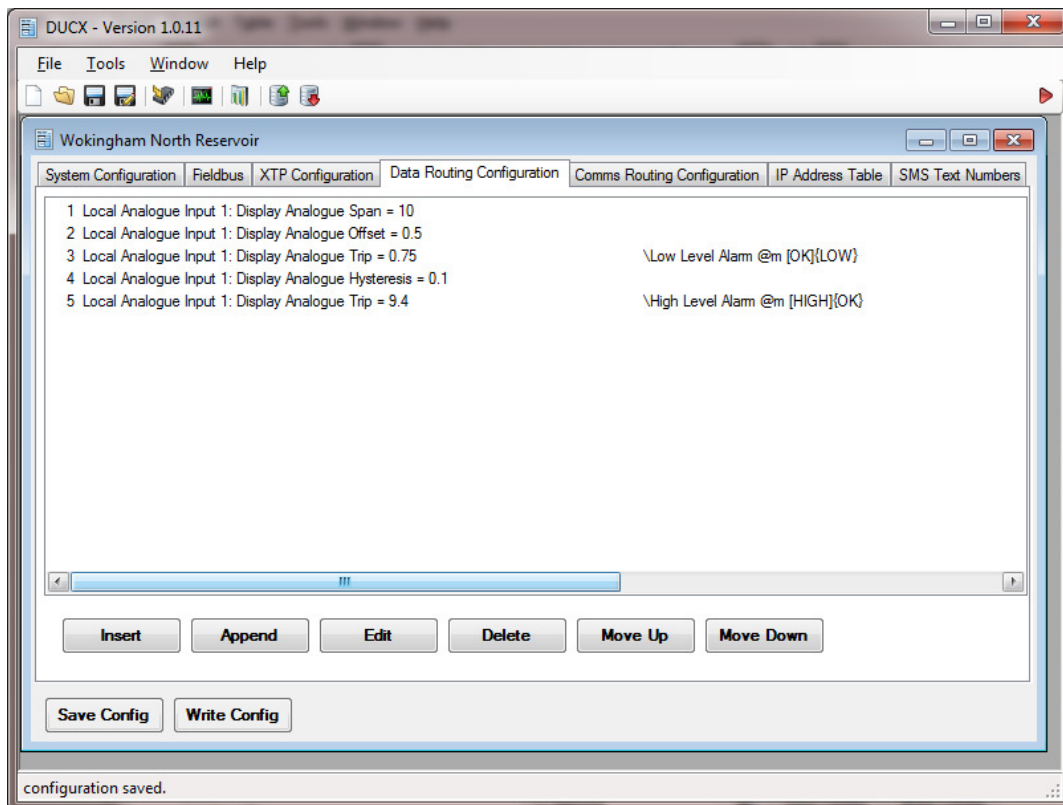
If the Description entered against the Analogue Trip line starts with the character '\\' it is treated as SMS text, otherwise it is treated as simply descriptive text. Any text within the description that is enclosed by square brackets [] will only be included if the level rises above the higher trip point. Any text enclosed by curly brackets { } will only be included if the level drops below the lower trip point.

Square = High, Curly = Low

The '@' character will be replaced by the current analogue value, scaled as defined.

In this example **Mega_Link** will send a text message such as 'Low Level Alarm 0.4m LOW' if the level drops below 0.75m or 'Low Level Alarm 0.93m OK' when it rises above 0.85m.

Multiple alarm points can be defined. For example, the following configuration will set two trip points:

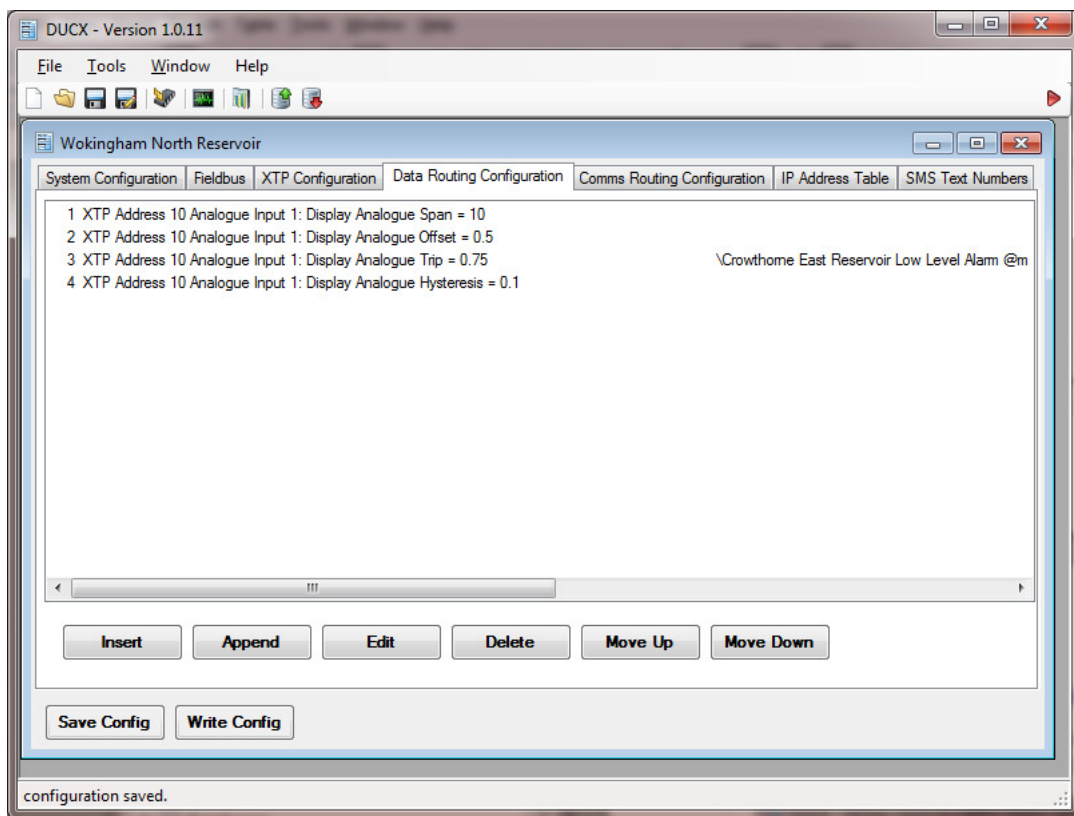


In addition to the Low Level Alarm messages described above the system will now also send a message such as 'High Level Alarm 9.66m HIGH' when the level rises above 9.5m ($9.4 + 0.1$) or 'High Level Alarm 9.33m OK' when it drops below 9.4m.

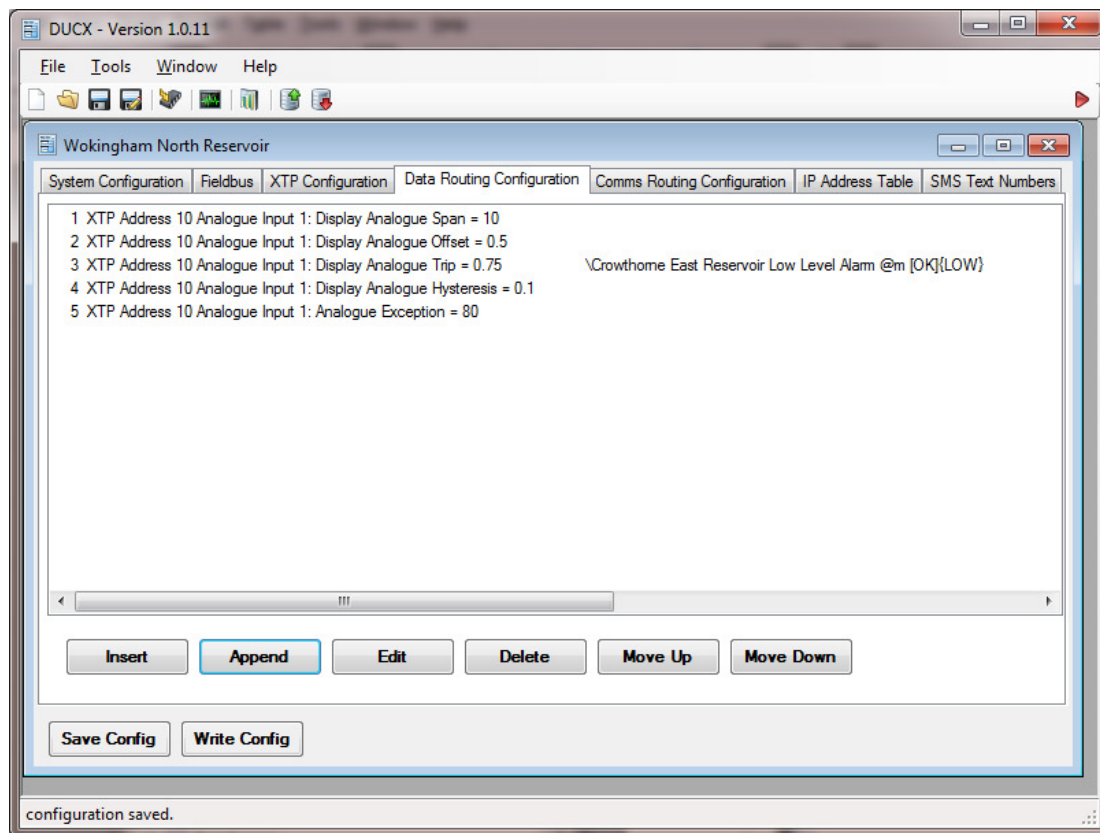
Up to 4 trip points can be set for each analogue.

11.2.5.1 Remote Analogue Exceptions

The above examples are reporting local analogue input changes. The same process can be used at a **Mega_Link** base-station to configure to report analogue exceptions from data read from an outstation:

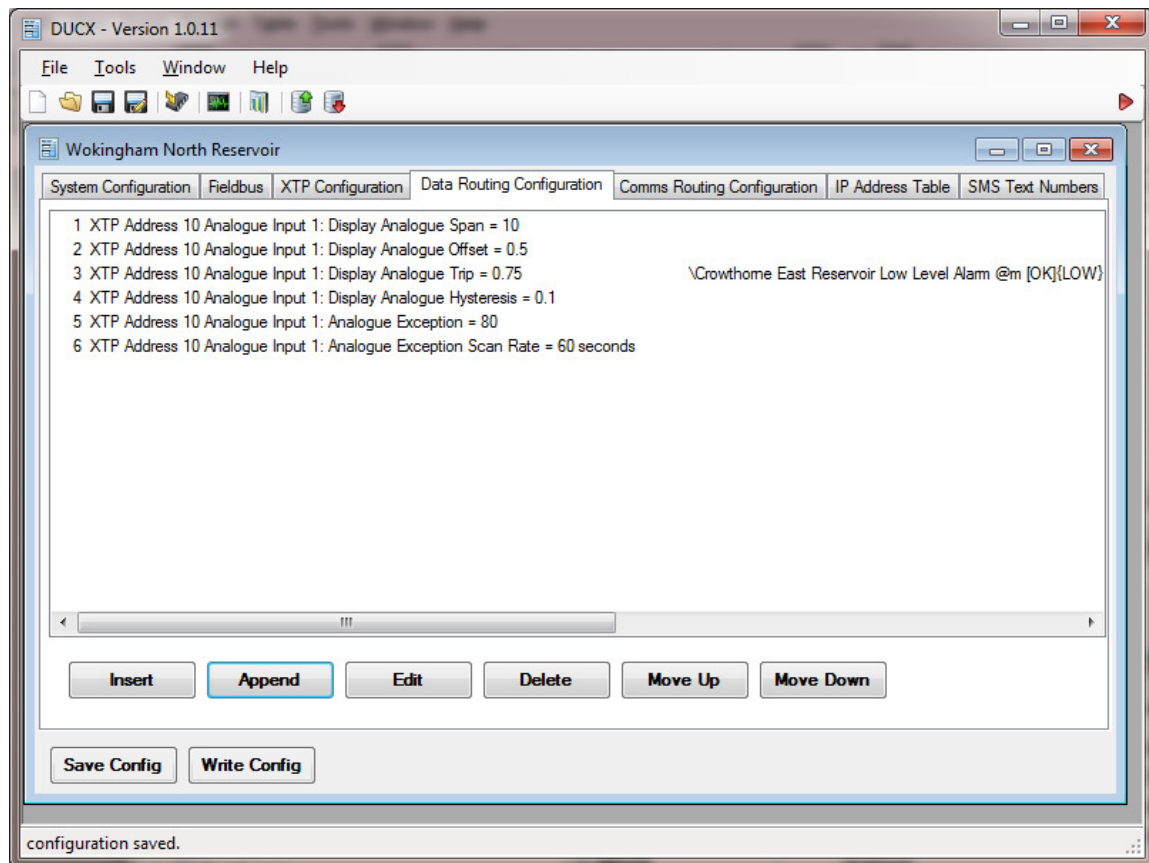


The base-station will poll the outstation as normal, and send SMS text messages when the levels read from it cross the specified trip points. In order to configure the outstation to exception report analogue changes to the base-station the following must be added:



Mega_Link calibrates all analogues such that a current in the range 0 – 20mA is translated to a reading in the range 0 – 4000. The new line illustrated above will cause the base-station to send configuration data to the outstation instructing it to send an exception report if the reading changes by more than 80 (i.e. 2% or 0.4mA) from the last value it has reported to the base-station.

Mega_Link normally samples all analogue inputs every 5 seconds. However, if an outstation is configured in PowerSave mode it will only sample analogues when it next expects to be called, which may be, for example, every 15 minutes. If a faster response is needed from a PowerSave outstation the following line should be added to the base-station data routing table:



The outstation will now be configured to wake every minute, read all analogue inputs and send an exception report to the base-station if analogue 1 has changed by more than 2% from the last value sent to it. When the base-station receives the exception report, if the level has crossed one of the trip points it will send an SMS message. The SMS message will therefore be sent within one minute of the change happening.

11.3 SMS Command Messages

11.3.1 Requesting System Status

A request for a system status report can be sent from any number in the directory by sending a text message "Status" to the **Mega_Link**.

11.3.1.1 Analogues

If multiple trip points are configured for a given analogue only the first in the Data Routing Table will be applied. Therefore a status report from the example given above will include a line such as "Low Level Alarm 0.90m OK".

If the current reading is within the hysteresis band the status will be that which existed before it entered the band, so it could report either “Low Level Alarm 0.79m LOW” if it entered the band from a reading below 0.75m or “Low Level Alarm 0.79m OK” if it entered the band from a higher level.

11.3.1.2 Requesting System Status from a Base-station

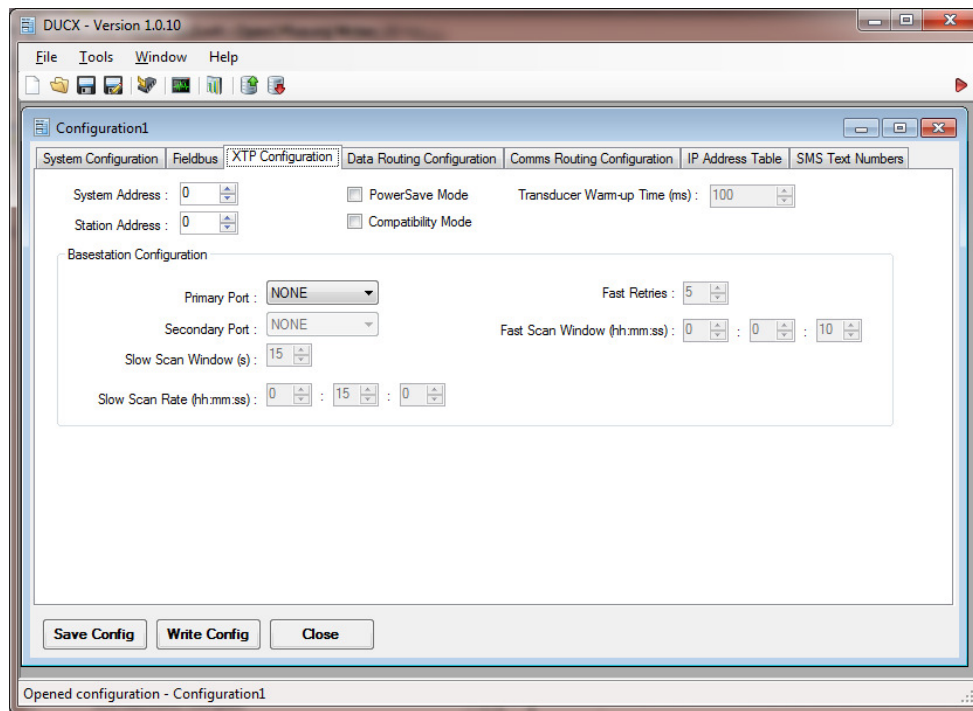
If the message is sent to a base-station that is configured to exception report the status of multiple outstations the response could be a relatively long text message. It can be reduced in size by suffixing the request with the required outstation address. For example the command 'Status 10' will return only the status of outstation address 10.

12 Special Features

As well as passing data around the network, special features can be configured into **Mega_Link** via DUCX (see section 15):

12.1 PowerSave Mode

Mega_Link can be configured to minimise its power consumption if it is supplied from limited power sources such as batteries or solar panels by configuring it in PowerSave Mode:



In PowerSave mode (a) the display will be blanked (b) the communication interfaces will be disabled when not needed (c) the power rails will be switched off when not needed so the relevant monitor LED's will extinguish (d) the Heartbeat LED will flash. Further power saving is achieved by totally switching off the processor when it is idle. This is indicated by reducing duration of each flash of the Heartbeat LED. It is woken from this idle state briefly every second, and any time a digital input changes state.

PowerSave mode will be influenced by the following:

- The joystick is moved. This will enable the display and prevent the processor from entering the idle state. The display will blank again if the joystick is not moved for 20 seconds.
- A PC is plugged into the USB port. This will prevent the processor from entering the idle state.
- Mega_Link** is configured to function as a Fieldbus master device. It will then keep both internal power rails active and prevent the processor from entering its idle state.

The following considerations apply when in PowerSave mode:

- Mega_Link** cannot receive exception reports (because it is likely to be asleep when they are sent).
- Mega_Link** cannot function as a Fieldbus slave device.
- Expansion modules cannot be used.
- Analogue and digital outputs can't normally be used. **Mega_Link** can act on messages that write to outputs and will set them accordingly, but when it goes to sleep it will force them off. They will thus only stay in their set state for a few seconds.

If an outstation is powering external transducers the user can configure the transducer warm-up time. The outstation will then wake up a little earlier and apply power to the transducers so they will be ready when the base-station reads them.

To maximise battery life the scan rate should be set to the longest time possible. If exception reporting is configured then the scan can be regarded as a confidence poll to confirm that the outstation is still functioning. However, it should be noted that the outstation will remain asleep until the times of the next scan. If the user re-configures the base-station it could therefore take a significant time before it can regain synchronisation with the outstation.

PowerSave outstations are intended for use in locations that have no mains power supply, so are assumed to contain minimal electrical plant. They cannot, therefore, communicate with PLCs or SCADA systems using Fieldbus, neither are they intended to provide digital or analogue outputs.

12.1.1 Synchronising PowerSave Systems That Don't Use GPRS

If a PowerSave outstation has lost synchronisation with a base-station it will enter Sniff Mode, whereby it switches on its communication interfaces every 2 seconds for just long enough to detect if there is a carrier present. This is primarily for use with radio interfaces. If no carrier is detected the outstation switches off the interfaces to conserve power.

If a carrier is detected the interface remains powered while the outstation 'listens' for a command from a base-station.

If a base-station gets no response to a command it sends to an outstation it will keep retrying until 2 seconds before the end of the scan window. It will switch on the radio carrier 2 seconds before making its last attempt. If the outstation was in sniff mode it will wake up sometime during this period and respond to the command.

12.1.2 Synchronising PowerSave Systems That Use GPRS

Any outstation that communicates via GPRS will decode the base-station's IP address from each command sent to it and reply to the same address.

If a PowerSave outstation has lost synchronisation with a base-station it will enter Synchronisation Mode, whereby it will wake every ten minutes, register on the GPRS network, then send an exception report to the base-station. If it has never received a command from the base-station since it was last reset then it assumes that the base-station's IP address has been set as Station Address 0 in the IP address table (see section 15.1.6).

If the base-station doesn't acknowledge this the outstation will make one more attempt before going back to sleep.

A PowerSave outstation needs to know the IP address of the base-station in order to send exception reports

If a base-station is using GPRS and gets no response to a command it sends to an outstation it will make one more attempt, then stop until the end of its scan window. Whenever it is not sending a command it is listening for messages from outstations. If it receives an exception report it will acknowledge receipt then re-synchronise with the outstation.

12.1.3 PowerSave Message Formats

Messages from an outstation include a flag to indicate if they are configured in PowerSave mode. When a base-station receives a message from a PowerSave outstation it will send it modified commands. When it requests data from an outstation the command includes the time when it will next call. The outstation will reply to this command, wait for a short time in case any further commands follow, then put itself to sleep. It will wake shortly before it is next due to be called.

The base-station can also send exception report configuration messages to PowerSave outstations, as described in above. However, if it configures analogue exceptions the user must include in the base-station configuration the exception analogue scan rate, which will be included in the command to the outstation. The outstation will then wake at regular intervals, apply power to the transducers then read the current levels. Any level changes will be processed as described in section 8.3.

12.1.4 PowerSave Outstation

The power-up sequence when waking from the sleep state is as follows:

1. The 12V rail will be raised before the next command is due, so any transducers powered from it have time to stabilise before being read. The time required is part of the configuration that can be downloaded to **Mega_Link** (see section 15.1.3.4)
2. Two seconds before the next command is due the 5V rail is activated and the communication interfaces are enabled ready to receive the command.
3. Five seconds after receiving a command the 12V and 5V rails are disabled and **Mega_Link** goes back to sleep. If any further commands are received during this time-out period the timer is re-started.
4. There may be occasions when the base-station requires the outstation to remain active for longer after receiving a command. The command can therefore include instructions telling the outstation to extend its time-out.

To maximise battery life the scan rate should be set to the longest time possible. If exception reporting is configured then the scan can be regarded as a confidence poll to confirm that the outstation is still functioning. However, it should be noted that the outstation will remain asleep until the times of the next scan. If the user re-configures the base-station it could therefore take a significant time before it can regain synchronisation with the outstation.

If the base-station sends commands to the outstation configuring it to use exception reporting, the outstation will wake whenever an exception event occurs (e.g. a digital changes state) and send an unsolicited exception report to the base-station. This enables a system to be configured to report changes with minimal delay without consuming unnecessary power.

12.1.5 PowerSave Base-station

A base-station normally polls outstations at a regular rate. Between polls it is listening for exception reports. However, if the base-station is configured in PowerSave mode it will go to sleep between polls, thus minimising power consumption.

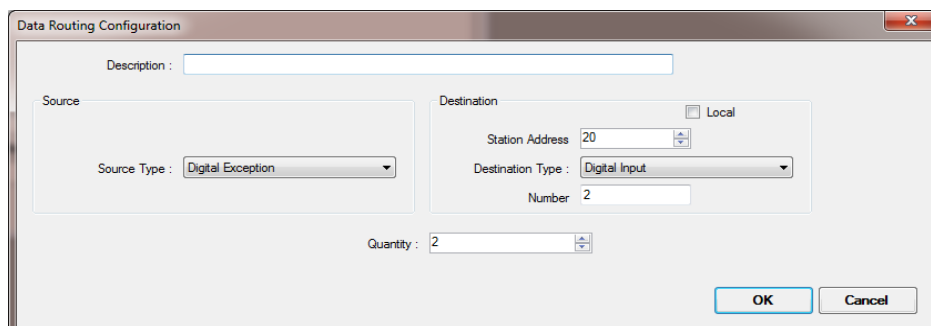
12.2 Exception Reporting

12.2.1 Exception Reporting from an Outstation to a Base-station

The base-station can configure outstations to exception-report changes as they happen. This means that the outstation will send an exception message to the base-station when it detects a change on one of its inputs.

12.2.1.1 Digital Changes

To configure an outstation to exception report digital changes the user must include a line such as the following in the base-station's data routing table:



XTP 20 Digital Input 2 – 3: Digital Exception

12.2.1.2 Analogue Changes

The user can also configure an outstation to exception report analogue changes:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Source Type' is set to 'Analogue Exception' and 'Limit' is set to 40. In the 'Destination' section, 'Station Address' is 20, 'Destination Type' is 'Analogue Input', and 'Number' is 1. There is a 'Quantity' field set to 2. At the bottom right are 'OK' and 'Cancel' buttons.

XTP 20 Analogue Input 1 - 2: Analogue Exception = 40

In this example the outstation will send an exception report if it detects that the value read for analogue input 2 changes by more than 40 from the last value sent to the base-station. Analogues are scaled so that 0...20mA gives a span of 0...4000 this is the equivalent of a change of 1%, or 0.2mA.

12.2.2 Exception Reporting from a PowerSave Outstation to a Base-station

One of the powerful features of **Mega_Link** is the ability to exception report from PowerSave outstations. This means that the outstations can be configured to remain asleep for extended periods to conserve power, and report changes as they happen via exception reporting. The normal polling becomes a confidence poll to confirm that the outstation is still functioning.

12.2.2.1 Digital Changes

A PowerSave outstation continues to monitor its internal digital inputs while it is asleep. Therefore any of the internal 8 inputs can be configured to wake the outstation and send an exception report if they change state.

12.2.2.2 Analogue Changes

If analogue exception-reporting is configured at a PowerSave outstation, the user must also configure an analogue sample time. This is because a PowerSave outstation switches off power to any transducers, and disables its analogue interface, to conserve power. A PowerSave outstation can thus be configured to wake at regular intervals, power its transducers then read them. If the reading has changed it will stay awake, power its communication interface and send an exception message to the base-station. This requires an extra line in the base-station data routing:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Source Type' is set to 'Analogue Exception Scan Rate' and 'Seconds' is set to 600. In the 'Destination' section, 'Station Address' is 20, 'Destination Type' is 'Analogue Input', and 'Number' is 2. There is a 'Quantity' field set to 1. At the bottom right are 'Ok' and 'Cancel' buttons.

XTP 20 Analogue Input 2: Analogue Exception Scan Rate (secs) = 600

12.2.3 Exception Reporting from a Base-station to an Outstation

The base-station can also be configured to exception-report changes to outstation outputs. It will then interrupt its normal poll sequence to send changes to outstations as they happen. This feature can't be used with PowerSave outstations, but may be useful on large systems where to poll rate may be excessively long.

XTP 20 Digital Output 1 – 6: Digital Exception

In this case if any change happens that will result in any of the first six digital outputs at outstation 20 changing state the normal poll sequence will be interrupted while the base-station sends an exception message to the outstation.

Note that the exception is applied to the relevant outstation output rather than the input that caused the change. This makes provision for a digital input that may be copied to more than one digital output, where exception reporting may not be needed to all the outputs.

The same applies to analogues:

XTP 20 Analogue Output 1 - 2: Analogue Exception = 40

12.3 Dual Comms

Mega_Link can be configured to function as a base-station via DUCX by defining the Primary COM port on which is to communicate (see section 15.1.3.5 **Error! Reference source not found.**). However, if a Secondary COM port is also defined then the base-station will work in dual comms mode.

In dual comms mode the base-station will send commands simultaneously on both the Primary and the Secondary port. It will accept responses on either port, but will generate a dual comms alarm if it fails to receive a response on either of them. It will generate a Comms Fail alarm if it fails to receive any response.

In outstation mode **Mega_Link** will normally send a response to any valid command it receives via the port on which it receives the command, and set an internal flag to identify this as its Primary port. However, if it receives an identical command on another COM port it will assume that the base-station is using dual comms and set an internal flag to define this as the Secondary port. It will not respond to the duplicate command, but will send responses to any further commands received on either the Primary or the Secondary port via both ports.

The Dual Comms functionality provides improved system integrity by allowing two independent communication devices to be used. For example, a system could use both licence-free radio and GPRS to provide increased security. Alternatively, two license-free radios could be used, working on different channels, to provide security against a channel being blocked by external interference.

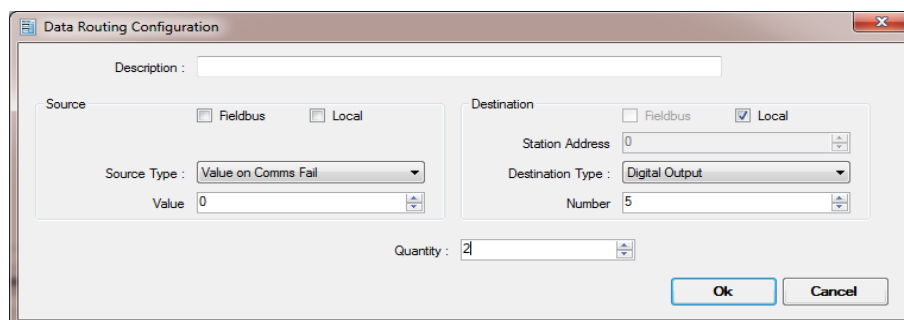
12.4 Value on Comms Fail

If **Mega_Link** loses communication (e.g. if the radio path is blocked, or an outstation fails), by default all outputs remain in their last valid state. However, there are instances where this is undesirable. For example, if the base-station is at a pumping station and the outstation is monitoring the water level in a remote reservoir to control the pumps, a loss of communication means that the monitored level would 'straight line', and the pumps would remain in their last operational state. If they were off there is a risk that the reservoir could empty.

To address this scenario, the base-station can be configured to force outputs to a defined state in the event of a communications failure.

12.4.1 Value on Comms Fail at an Outstation

In the event of a comms fail all outputs will normally remain in their last valid state. However, this can be changed by including entries in the outstation's data routing configuration in DUCX:



This will give the following line in the data routing table:

Local Digital Output 5 – 6: Value on Comms Fail = 0

If the outstation raises a Comms Fail alarm (see section 10.1.1.2) it will force its digital outputs 5 & 6 off.

A similar action can be applied to analogue outputs:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Fieldbus' and 'Local' checkboxes are present, with 'Local' being checked. The 'Source Type' is set to 'Value on Comms Fail' and the 'Value' is set to 800. In the 'Destination' section, 'Fieldbus' and 'Local' checkboxes are present, with 'Local' being checked. The 'Station Address' is set to 0, the 'Destination Type' is set to 'Analogue Output', and the 'Number' is set to 2. A 'Quantity' field is set to 1. At the bottom right, there are 'Ok' and 'Cancel' buttons.

Local Analogue Output 2: Value on Comms Fail = 800

Since analogue outputs are calibrated to give 0...20mA for register values in the range 0...4000, this will force output 2 to a value of 4mA.

If the application needs a digital output to indicate Comms Fail at the outstation the base-station must be configured to send a digital state to it that is normally closed. This is easy to achieve by sending the outstation its own comms fail alarm by including a line like this in the base-station:

XTP 10 Comms Fail Alarm >>> XTP 10 Digital Output 8

then the outstation must be configured to set this output to 0 on comms fail:

Local Digital Output 8: Value on Comms Fail = 0

For more details on configuring via DUCX, see section 15.1.

12.4.2 Value on Comms Fail at a Base-station

Add a line like this into the base-station data routing configuration in DUCX:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Fieldbus' and 'Local' checkboxes are present, with 'Local' being checked. The 'Source Type' is set to 'Value on Comms Fail' and the 'Value' is set to 800. In the 'Destination' section, 'Fieldbus' and 'Local' checkboxes are present, with 'Local' being checked. The 'Station Address' is set to 20, the 'Destination Type' is set to 'Analogue Input', and the 'Number' is set to 2. A 'Quantity' field is set to 1. At the bottom right, there are 'Ok' and 'Cancel' buttons.

This will give the following line in the data routing table:

XTP 20 Analogue Input 2: Value on Comms Fail = 800

For more details on configuring via DUCX, see 15.1.

If the base-station loses communication with outstation 20 it will simulate the readings for analogue inputs 2 and 3 from that outstation as a numeric value of 800.

The Value on Comms Fail can also be applied to digital inputs, for example:

XTP 20 Digital Input 6 – 8: Value on Comms Fail = 1

If the base-station loses communication with outstation 20 it act as if digital inputs 6 – 8 from that outstation are a closed.

will simulate the readings for analogue inputs 2 and 3 from that outstation as a numeric value of 800. Analogues read to 12-bit resolution, so an input of 20mA is represented by a reading of 4000. 800 therefore simulates a reading of 4mA, which may be the reading that would be expected if the reservoir was empty. If the outstation input is copied to an analogue output at the base-station it will therefore read 4mA, which might force the pumps on. Alternatively, if Fieldbus is used to copy the level to a SCADA system or a PLC, it too will think that the reservoir is empty.

12.5 Counts

Each of the first four digital inputs has an associated 16-bit counter. Every time the contact closes the counter is incremented. The contents of the counter can be read via XTP or Fieldbus.

A base-station can be configured to replicated the counts from an outstation by including a data routing configuration entry like this:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Fieldbus' is unchecked and 'Local' is checked. 'Station Address' is set to 20, 'Source Type' is 'Count', and 'Number' is 1. In the 'Destination' section, 'Fieldbus' is unchecked and 'Local' is checked. 'Station Address' is set to 10, 'Destination Type' is 'Digital Output', and 'Number' is 1. At the bottom, 'Quantity' is set to 1. There are 'Ok' and 'Cancel' buttons at the bottom right.

The corresponding entry in the data routing table will be:

XTP 20 Count 1 >>> Local Digital Output 1

The base-station will then output pulses on digital output 1 to match the number of pulses received by outstation 20 on its first digital input. The pulses will be presented in bursts at a rate of 5 pulses/second each time the base-station polls the outstation.

The first 16 digital outputs on a base-station can be used for pulse outputs. Obviously, any digital output used to replicate counts cannot be used for any other purpose.

12.6 Inverting Digitals

12.6.1 Digital Inputs

Each digital input at a base-station or an outstation can be configured to be inverted as it is read by including entries in the DUCX data routing configuration such as:

The image shows a 'Data Routing Configuration' dialog box. It has a 'Description' field at the top. Below it, there are two main sections: 'Source' and 'Destination'. In the 'Source' section, 'Fieldbus' is unchecked and 'Local' is checked. 'Station Address' is set to 10, 'Source Type' is 'Invert Digital', and 'Number' is 5. In the 'Destination' section, 'Fieldbus' is unchecked and 'Local' is checked. 'Station Address' is set to 10, 'Destination Type' is 'Digital Input', and 'Number' is 5. At the bottom, 'Quantity' is set to 8. There are 'Ok' and 'Cancel' buttons at the bottom right.

This will give the following entry in the data routing table:

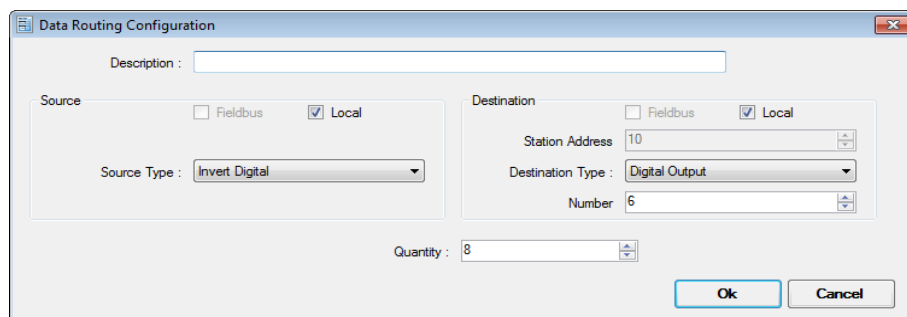
Local Digital Inputs 5 – 12: Invert Digital

This will set digital inputs 5 – 8 on **Mega_Link** to invert (i.e. a closed contact will be read as a logic 0 state), along with digital inputs 9 – 12 (i.e. the first four inputs on the first digital input expansion module).

Note that the monitoring LED's on **Mega_Link** show the state of its inputs after inversion. The monitoring LED's on digital input expansion modules show the state of each input before any inversion.

12.6.2 Digital Outputs

Each digital output at a base-station or an outstation can be configured to be inverted immediately before it is written by including entries in the DUCX data routing configuration such as:



This will give the following entry in the data routing table:

Local Digital Outputs 6 – 13: Invert Digital

This will set digital outputs 6 – 8 on **Mega_Link** to invert (i.e. present a closed contact when a logic 0 is written to it), along with digital outputs 9 – 13 (i.e. the first five outputs on the first digital output expansion module).

Note that the monitoring LED's on **Mega_Link** show the actual state of each output, after any inversion. The LED's on digital output expansion modules, however, show the actual output state.

12.7 Scaling Analogue

Mega_Link sends analogues as 16-bit values, which gives a range of 0..65536. However, it reads analogue inputs with 12-bit resolution and is calibrated so that an input in the range 0...20mA is converted to a register value in the range 0...4000. Similarly analogue outputs are calibrated so register values in the range 0...4000 produces outputs of 0...20mA. Most analogue transducers are scaled 4..20mA, giving register values in the range 800...4000.

It should be noted that the maximum analogue value is actually 4096, so a faulty transducer can be identified.

If a transducer generates a signal of any range others than 0..20mA the value can be normalised to the range 0...4000 by applying a multiplier and/or an offset. Similarly, if an output other than 0...20mA is required a multiplier and/or offset can be applied before it is converted to an analogue.

A secondary use of scaling is to allow analogue values to be displayed within SMS text messages in real units. For example, if a transducer is calibrated to read a level in the range 0...10m the display can be configured to show the value as 0.00...10.00m instead of 0.00...20.00mA.

12.7.1 Scaling Analogue Inputs

If a transducer giving an output range of 0...10mA is connected to a analogue input 1 the reading can be normalised to 800...4000 to simulate 4...20mA. The required scaling is:

Input	Register Value	Output	Register Value
10mA	2000	20mA	4000
0mA	0	4mA	800

The input span is 2000 and the target span is 3200, so a multiplication factor of 1.6 must be applied. An offset of 800 must then be added to the result.

The entries in the data routing table will be:

Local Analogue Input 1: Analogue Multiplier = 1.6
Local Analogue Input 1: Analogue Offset = 800

12.7.2 Scaling Analogue Outputs

The same process can be used to scale analogue outputs. For example, if a signal originates from a 4...20mA transducer, but the output is required to drive a meter scaled 0...10mA from analogue output 1 the target scaling is:

Input	Register Value	Output	Register Value
20mA	4000	10mA	2000
4mA	800	0mA	0

The input span is 3200 and the target span is 2000 so a multiplication factor of 0.625 must be applied. The minimum value would thus be $800 \times 0.625 = 500$ so an offset of -500 must be added.

The entries in the data routing table will be:

Local Analogue Output 1: Analogue Multiplier = 0.625
Local Analogue Output 1: Analogue Offset = -500

12.7.3 Scaling Displayed Analogue Values

If no scaling is applied, any analogues displayed via SMS will be displayed as 0.00...20.00. This can be changed to give more relevant units. Scaling the display assumes that the register value has already been scaled to a range of 800...4000 (i.e. 4...20mA).

Suppose the reading is from a level gauge scaled 1...5m. The required scaling is thus:

Input	Register Value	Displayed Value
20mA	4000	5.000
4mA	800	1.000

The required span is 4.000 with an offset of 1.000. The relevant entries in the data routing table to achieve this would be:

Local Analogue Input 1: Display Analogue Span = 4
Local Analogue Input 1: Display Analogue Offset = 1

12.7.4 Scaling RSSI and Battery Volts for Analogue Output

The RSSI register is scaled so it reads $100 * (\text{RSSI}) + \text{TXpower}$, where RSSI is calibrated to read -dBm and TXpower is calibrated to read +dBm.

For example, if a system has an RSSI level of -102dBm and is transmitting at +27dBm (i.e. 500mW) then the register would read 10227. The RSSI can thus be extracted by dividing by 100 (albeit with a small offset due to the transmit power).

The Battery Volts register is calibrated to read in mV, so a 24.5V source would read 24500.

Analogue outputs are calibrated so register values in the range 0..4000 give currents in the range 0...20.00mA (i.e. $800...4000 = 4...20\text{mA}$).

There is a facility in the data routing table to apply a multiplier and offset to a register value before it is output.

For example, to convert an RSSI range of -80dBm...-120dBm (i.e. register values in the range 8000...12000) to an output of 4...20mA (i.e. 800...4000) on analogue output 1, the span would have to be converted from 4000 to 3200 by applying a multiplier of 0.8, resulting in values in the range 6400...9600. To convert this to 800...4000 an offset of -5600 should be added. The relevant entries in the table would be:

Local Analogue Output 1: Analogue Multiplier = 0.8

Local Analogue Output 1: Analogue Offset = -5600

The same can be applied to battery volts. For example, to convert readings in the range 0...30V (i.e. 0...30000) to give an output of 4...20mA (i.e. 800...4000) on analogue output 2, the multiplier will be 3200/30000, or 0.107, resulting in values in the range 0...3200. An offset of 800 should then be added:

Local Analogue Output 2: Analogue Multiplier = 0.107

Local Analogue Output 2: Analogue Offset = 800

12.8 Pulse Averaging

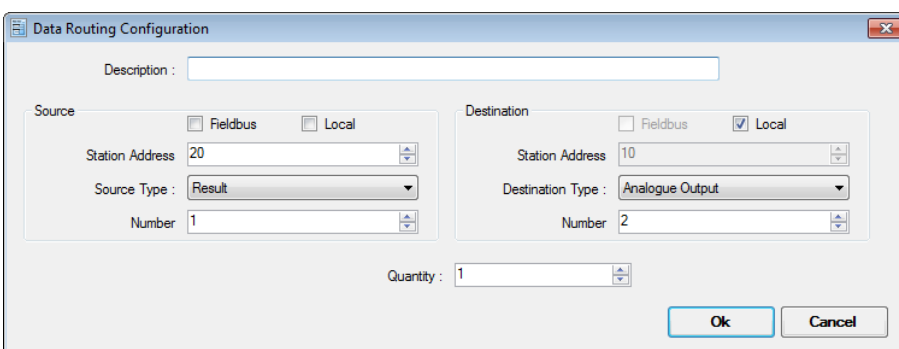
Turbine flow meters do not need a power supply, and pulse a contact each time a defined volume of water passes through them. A PowerSave outstation can count the pulses from these meters and send the totalised count to a base-station. The base-station can then be configured to derive an analogue output proportional to the flow rate. The configuration required is as follows:

1. Define the number of pulses on that will be produced per day at the maximum flow rate:

XTP 20 Count 1: Max Pulse Rate = 14400

This assumes that the maximum pulse rate is 10 ppm, and will cause the base-station to calculate a value in the range 800...4000 and store it in the Result register for the relevant outstation.

2. Copy the result to the relevant analogue output or Fieldbus register:



XTP 20 Result 1

>>> Local Analogue Output 2

This will produce an output of 4...20mA on analogue output 2 at the base-station, proportional to the flow rate. The output will be updated each time the base-station polls the outstation. If a different range is required the analogue output can be scaled as described in.

12.9 Initiation Delay

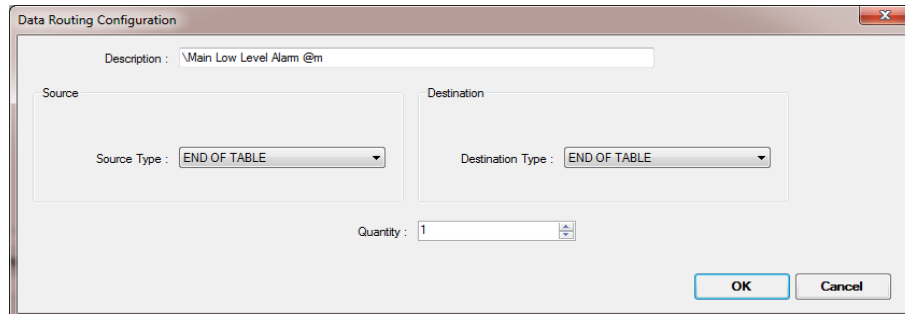
In some applications the user may require short duration digital changes to be ignored. An example is vacuum-driven sewer valves, which periodically open for typically 30 seconds, then automatically shut. However, if the valve remains open for more than 60 seconds a fault should be reported.

The first 8 inputs of each station (i.e. the digital inputs on the **Mega_Link** module) can be individually configured to implement Initiation Delays if required. This means that a change of state must exist for a defined period (measured in seconds) before it is reported. All initiation delays are configured at the base-station by including lines in the data routing table such as:

XTP 20 Digital Input 1 – 4: Initiation Delay = 10

12.10 **END OF TABLE**

When commissioning data transfer to/from an outstation being polled by a base-station that is interrogating multiple outstations it can be time-consuming waiting for it to poll all the outstations. To overcome this a new configuration could be created that only includes the outstation in question, but this can be equally time-consuming. An alternative is to move the relevant data routing lines to the beginning of the data routing table then insert a line with the Source Type END OF TABLE:

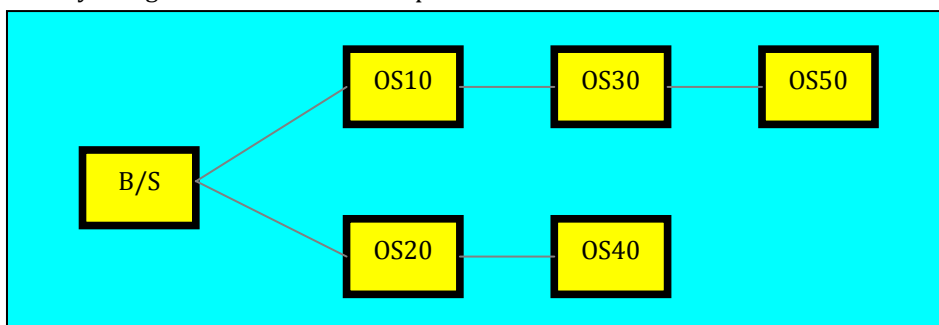


Mega_Link will ignore all entries after this line.

When commissioning is completed the line should be removed.

12.11 **Repeater Station Comms Routing**

By default the base-station assumes it can contact all outstations directly. However, licence-free radio has a finite range so it is possible that the base-station may not be able to reach some outstations directly, but could reach them by using other outstations as repeaters. This can be illustrated as shown:



In this example the base-station can directly access outstations 10 and 20. However, it can only reach outstation 30 by using outstation 10 as a repeater. Similarly it can only reach outstation 50 by passing data via outstations 10 and 30.

This can be configured via the Comms Routing tab in DUCX (see section 15.1.5). It is only necessary to configure the last repeater used to access an outstation, since **Mega_Link** can derive the full routing from this. In the above example the last repeater to access outstation 30 is outstation 10, and the last repeater to access outstation 50 is outstation 30.

The base-station will then modify any commands sent to outstation 50 so they are first directed to outstation 10. Outstation 10 will recognise from the message format that the command is to be forwarded to outstation 30 so will modify the command and re-transmit it. Outstation 30 will do the same. The resulting message received by outstation 50 will be a valid command so it will respond to it, sending its reply to outstation 30 which will then forward it to outstation 10 and hence to the base-station.

Note that command to an outstation are actually addressed to the file corresponding to the outstation address. If an outstation is fitted with expansion modules it may overflow the capacity of a file and hence extend into the next consecutive file number. Thus outstation 30 could use file 31 in addition to file 30. In that case the Comms Routing table must also include an entry to forward messages to outstation 31 via outstation 10.

12.12 *Viewing and Changing Polling Parameters via Fieldbus*

An external Fieldbus master device can access the database by reading/writing digitals in the range 0 - 7999 or registers in the range 0 – 1999. However, for a base-station certain registers outside this range have alternate functions:

12.12.1 *Register 3001 – Normal Scan Window*

If an external device reads this register **Mega_Link** will return the time window used for polling normal (i.e. non-PowerSave) outstations. For example, if the base-station is configured to poll at a rate of one outstation every 10 seconds, **Mega_Link** will return a value of 10.

If an external device writes a value to this register **Mega_Link** will modify its normal scan window accordingly. This may be useful during system commissioning, where the value could be set to 0 to configure the system to poll continuously, thus speeding the data update rate. The change will not be saved in non-volatile memory, so when the device is next reset it will restore the original value.

12.12.2 *Register 3002 – PowerSave Scan Rate*

If an external device reads this register **Mega_Link** will return the PowerSave scan rate in seconds. For example, a PowerSave scan rate of 15 minutes will return a value of 900. Note, however, that since all Fieldbus registers are 16-bit the largest value that can be returned is 65535, which equates to about 18 hours.

If an external device writes a value to this register **Mega_Link** will modify its PowerSave scan rate accordingly. This may be useful during system commissioning. Note that the change will not be saved in non-volatile memory, so when the device is next reset it will restore the original value.

12.12.3 *Register 3003 – PowerSave Scan Window*

If an external device reads this register **Mega_Link** will return the PowerSave scan window in seconds. For example, a slow scan rate of 10 seconds will return a value of 10.

If an external device writes a value to this register **Mega_Link** will modify its PowerSave scan window accordingly, but the change will not be saved in non-volatile memory, so when the device is next reset it will restore the original value.

12.12.4 *Register 3004 – Time to next PowerSave Scan*

If an external device reads this register **Mega_Link** will return the time remaining before the start of the next PowerSave scan sequence, in seconds. For example, if the PowerSave scan rate is 30 minutes and the last scan started 12 minutes ago **Mega_Link** will return a value of 1080 seconds (i.e. 18 minutes). Note, however, that since all Fieldbus registers are 16-bit the largest value that can be returned is 65535, which equates to about 18 hours.

13 Installation

13.1 Mechanical

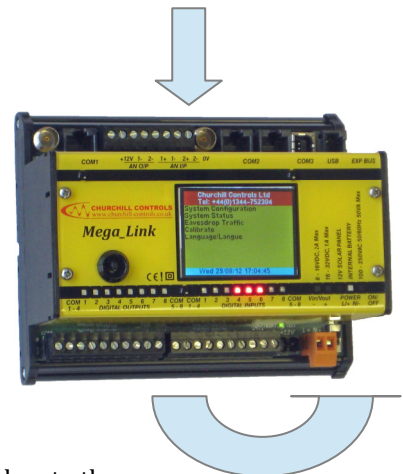
Mega_Link and any associated expansion modules or accessories clip onto symmetrical or non-symmetrical DIN rail. The rail can be mounting in wall-mounting enclosures or in any control panels.

To clip a module onto a rail angle it so that the bottom edge is located first, then pivot it until the top edge clicks in place.

To remove a module from symmetrical DIN rail, press downwards on the top while pulling the bottom towards you.

To remove a module from non-symmetrical DIN rail, press upwards on the bottom while pulling the bottom towards you.

If any expansion modules are used they should be located adjacent to each other, to the right of the main **Mega_Link** module. Each expansion module is supplied with a short jumper lead which should connect it to the module to its left. If there is insufficient room for expansion modules on the DIN rail longer jumper leads are available to enable them to be located up to 5m apart.



13.2 Connectors

All connectors are pluggable, enabling a unit to be replaced without disrupting the wiring. All power and plant I/O connections are through screw terminals on a 5mm pitch, capable of terminating wires up to 2.5mm². All COM port connectors are RJ45, compatible with widely-available Category 5 jumper cables.

13.2.1 Power

The orange connector is the input to the internal power supply module. The system is powered from the output of this module via the adjacent on-off switch. The switched system power can be accessed via the black 2-pin connector. The switch should be set to the OFF position when the unit is not in use to prevent discharge of any internal batteries.

The system will work from any supply in the range 4...16VDC.

The type of power supply fitted is identified by a white tag in the windows adjacent to the power connectors, and can also be read from the display. The internal processor recognises the type of supply fitted and configures the system accordingly.

13.2.1.1 Mains Power Supply

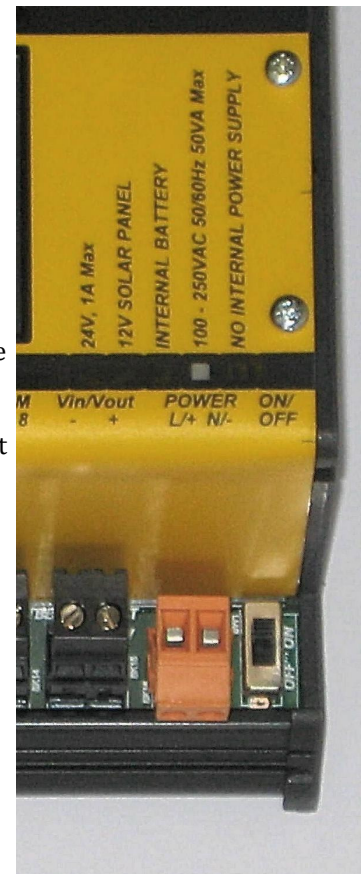
This module works from any supply in the range 100...250VAC and incorporates a charger and a NiMH standby battery. Care must be taken to prevent inadvertent contact with the AC mains on the orange connector.

13.2.1.2 12VDC Power Supply

This option has no internal power module, so expects a supply in the range 10...16VDC to be connected via the black Vin/Vout terminals. It assumes that the supply will be from a supply backed-up by a 12V lead-acid battery, so a Battery Low alarm will be generated if it falls below 10.6V.

13.2.1.3 24VDC Power Supply

This module is intended for operation from a supply backed-up by a 24V lead-acid battery, so expects the input to be in the range 20...32VDC. It divides the input voltage (applied to the orange connector) by 3,



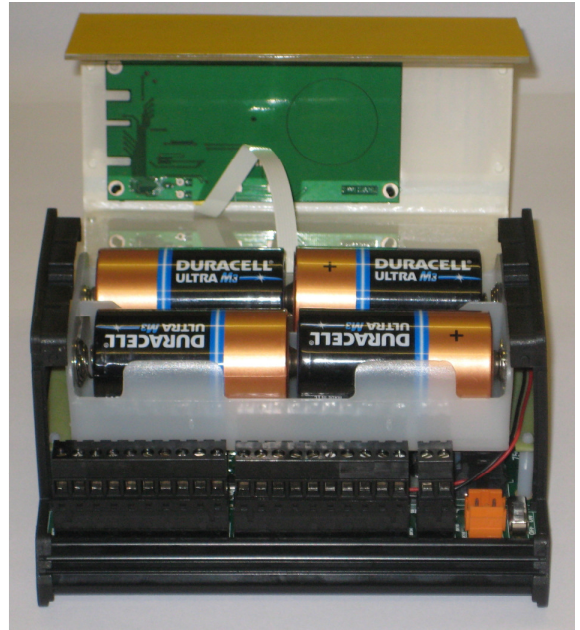
so the system runs from a supply in the range 6.67V...10.67V. A Battery Low alarm will be generated if the supply falls below 21.2V.

13.2.1.4 12V Solar Panel

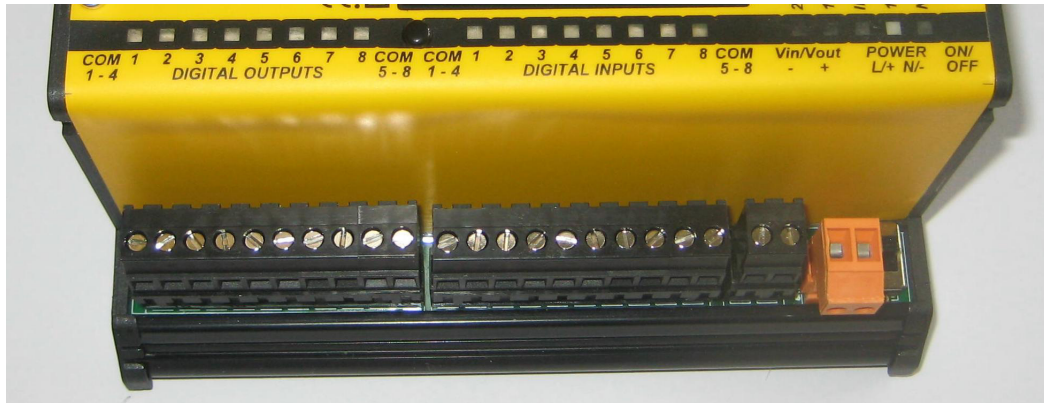
When this module is fitted the solar panel should be connected to the orange plug and a 12V lead acid battery to the 2-pin black connector. The on-off switch should be ON at all times. To remove power from the module, unplug the solar panel and the battery.

13.2.1.5 Alkaline Battery Pack

This variant includes four replaceable D cells. To access them remove the four screws from the cover, then prise the black side panels outwards so the cover can be removed. Take care to not dislodge the flat cable which links the display to the main board. It is important that only alkaline batteries are used (e.g. Duracell or Energiser).

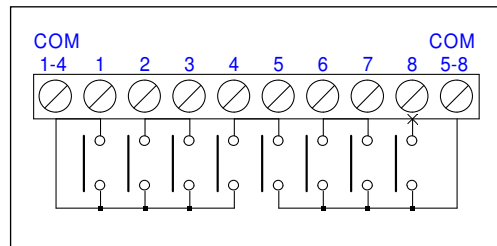


13.2.2 Plant I/O



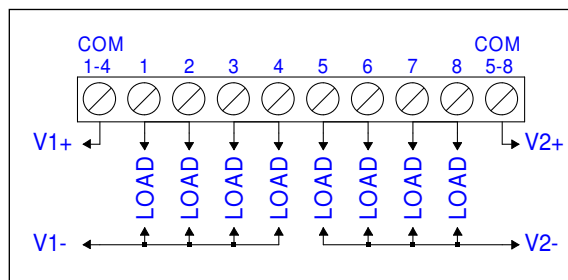
13.2.2.1 Digital Inputs

There are eight digital inputs, in two groups of four. Each group shares a common return terminal which is internally connected to the system 0V rail. The inputs are designed for operation from volt-free contacts:

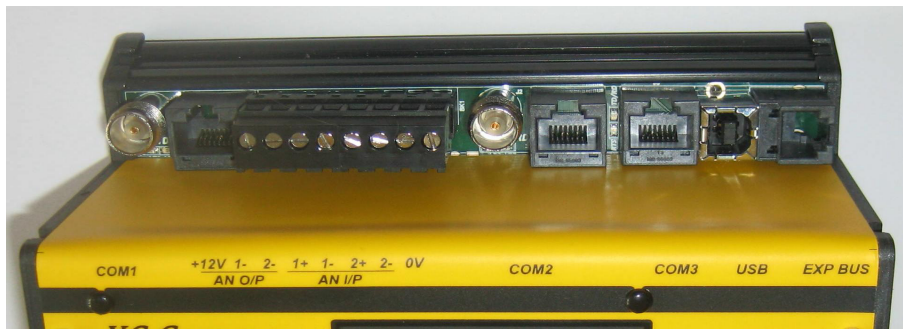


13.2.2.2 Digital Outputs

There are eight digital outputs, in two groups of four. Each group shares a common return terminal which is floating. All outputs are volt-free relay contacts rated 125VAC @ 0.3A, 24VDC @ 1A. All contacts include surge protection devices to prevent arcing when switching inductive loads, but it is recommended that any DC inductive loads (e.g. interposing relays) are fitted with catching diodes. In this illustration V1 and V2 can be either polarity, AC or DC.

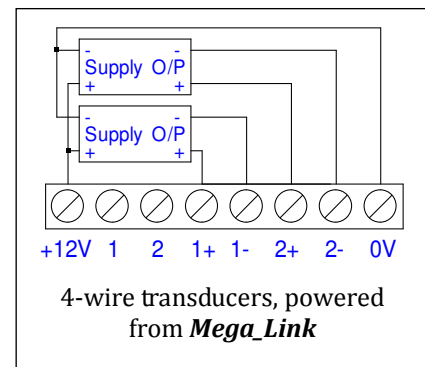
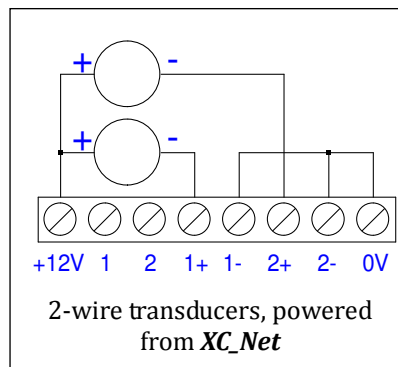
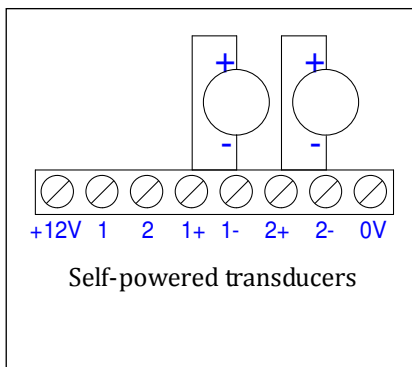


13.2.2.3 Analogue Inputs



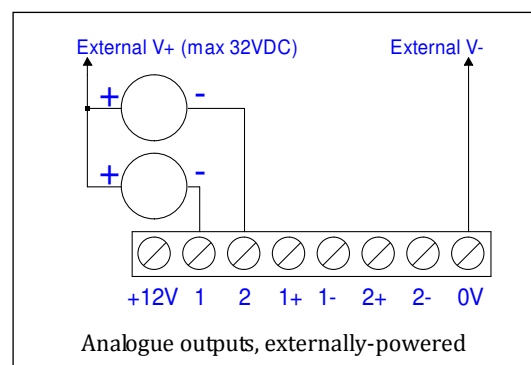
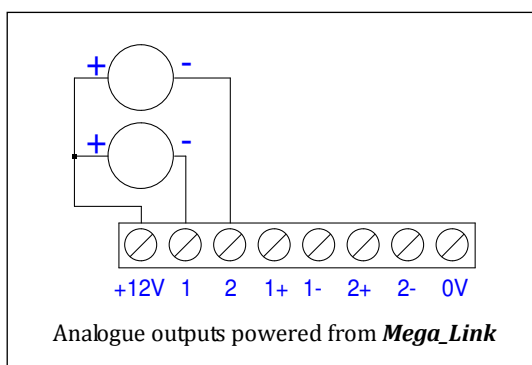
There are two analogue inputs, each with an input resistance of 10Ω , calibrated 0...20mA. Both inputs are fully isolated and can withstand common-mode signals of up to $\pm 240V$. Note that high common mode AC voltages may give reading errors so should be avoided by ensuring that current loops are referenced to 0V.

The 12VDC output can be used for powering external transducers, if required. An LED adjacent to the connector shows when 12V is available:



13.2.2.4 Analogue Outputs

There are two analogue outputs, each calibrated 0...20mA into loads of up to 500Ω . Both outputs sink current to the internal 0V rail, so the external loads must be commoned to a positive supply (normally the system's 12VDC supply, but an external voltage source can be used if required).



13.2.3 Communications

13.2.3.1 COM1, COM2

These ports are similar, and each can be fitted with an internal communications interface. The I/O connections depend on the type of interface fitted (which can be read from the built-in display):

13.2.3.1.1 De-regulated 458 & 869MHz UHF Radio and GSM/GPRS Modules

RF connection is via the TNC co-axial connector. The RJ45 connector is not used.

13.2.3.1.2 V23 Leased Line Modem Module

Wired connection is via the RJ45 connector as in the table below.

This pin-out allows an insulation-displacement flat cable to be used if required between the RJ45 plug and a standard telecommunication network plug (e.g. a 6-way BT plug for connection to UK telephone lines or a 6-way RJ11 plug for connection to telephone lines in other countries).

The line connections on the network plug will be on pins 1/2 and 5/6, so accommodate connections to either leased line or PSTN lines.

Pin	CAT5 Colour	Function
1	White/Orange	No Connection
2	Orange	Line A
3	White/Green	Line A
4	Blue	No Connection
5	White/Blue	No Connection
6	Green	Line B
7	White/Brown	Line B
8	Brown	No Connection

13.2.4 COM3

Connection is via the RJ45 connector. Communication can be via either RS232 or RS485, as selected via the configuration downloaded to **Mega_Link**.

Pin	CAT5 Colour	Function
1	White/Orange	0V
2	Orange	RS485 B
3	White/Green	RS485 A
4	Blue	RX485 T
5	White/Blue	TXD (RS232)
6	Green	RXD (RS232)
7	White/Brown	RTS (RS232)
8	Brown	CTS (RS232)

RS232:

Connection is via the RJ45 connector.

The RS232 level signals can be connected to any compatible device. Typical connections to a 9-way D connector are shown below.

Mega_Link is configured as a DTE device, so TXD and RTS are outputs, RXD and CTS are inputs. If it is connected to another DTE device the cable must incorporate a cross-over to swap TXD and RXD. A simple test to establish the connection required is to measure the voltage between RXD and 0V on the external device before connecting them together. If it is greater than +/- 1V the device is a DTE, otherwise it is a DCE.

RTS is asserted whenever **Mega_Link** needs to send a message. If RTS/CTS flow control is enabled in the system configuration it will wait until CTS is asserted before starting transmission.

If RTS/CTS flow control is not enabled it will wait for the turn-round time defined in the configuration before starting transmission.

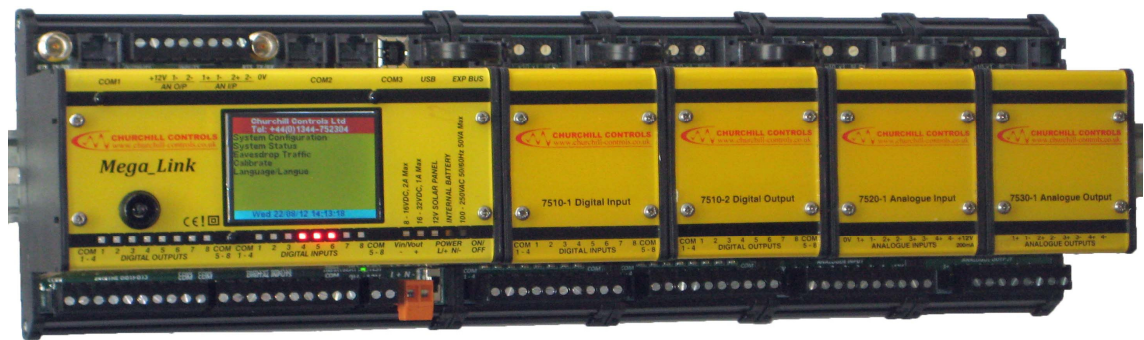
Typical connections to a 9-way D connector			
Function	Pin	DCE (e.g. PC)	DTE (e.g. PLC)
Shield	1	-	-
RXD	2	Green	White/Blue
TXD	3	White/Blue	Green
DTR	4	Link to DSR	Link to DSR
0V	5	White/Orange	White/Orange
DSR	6	Link to DTR	Link to DTR
RTS	7	White/Brown	Link to CTS
CTS	8	Brown	Link to RTS
-	9	-	-

RS485:

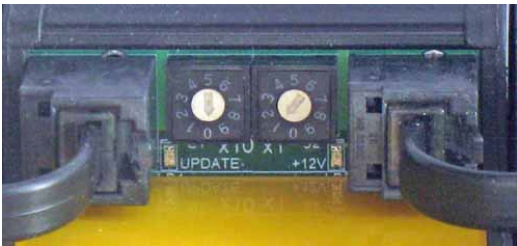
RS485 is a 2-wire interface that can link multiple devices together. The A legs of all devices should be connected together, as should be B legs. For short links the type of wire used is unimportant. However, if the cable is more than 5m long it should be a twisted-pair communications cable with a characteristic impedance of around 120Ω.

If **Mega_Link** is connected at one end of the cable a 120Ω terminating resistor can be connected by linking terminal RS485T to RS485A.

13.3 Expansion Modules



Expansion modules are connected to **Mega_Link** via the EXP BUS connector at the top right. Each expansion module is supplied with a short jumper lead allowing one of its bus connectors to be linked to an adjacent module. Each module extends the bus to an identical socket on its top right corner, so additional modules can be daisy-chained. Every expansion module must be given a unique address. The address is set on two decimal rotary switches on each module, allowing the module address to be set in the range 0...99. Addresses must be contiguous, starting from 0.



The **Mega_Link** main module has 2 analogue inputs (numbered 1 & 2), 2 analogue outputs (numbered 1 & 2), 8 digital inputs (numbered 1 – 8) and 8 digital outputs (numbered 1 – 8). Expansion modules provide additional I/O that contiguously follows the integral I/O. For example, the first Digital Input expansion module will provide an additional 8 inputs, numbered 9 – 16. Similarly, the first Analogue Output module will provide 4 more outputs, numbered 3 – 6.

The physical location of expansion modules is irrelevant. For example, if they modules are numbered sequentially, with module 1 located closest to **Mega_Link**, they could be allocated addresses as in this table:

Location	Address	Module Type	Database location
1	1	Analogue Input	Analogue inputs 3...6
2	2	Digital Output	Digital outputs 9...16
3	0	Digital Input	Digital inputs 9...16
4	4	Analogue Input	Analogue inputs 7...10
5	5	Analogue Output	Analogue outputs 3...6
6	3	Digital Input	Digital Inputs 17...24

This is obviously an extreme example. In practice it would be logical to physically locate expansion modules in the same sequence as their addresses, and collate modules of the same type together, as shown:

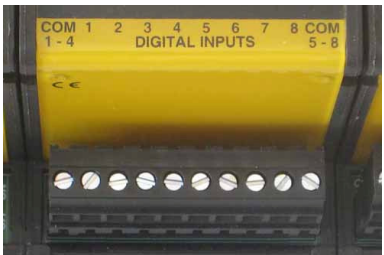
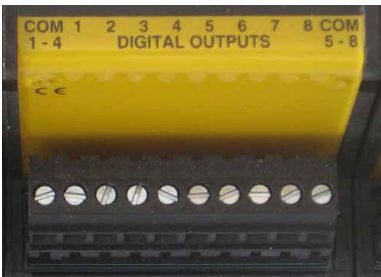
Location	Address	Module Type	Database location
1	0	Digital Input	Digital inputs 9...16
2	1	Digital Input	Digital Inputs 17...24
3	2	Analogue Input	Analogue inputs 3...6
4	3	Analogue Input	Analogue inputs 7...10
5	4	Digital Output	Digital outputs 9...16
6	5	Analogue Output	Analogue outputs 3...6

13.3.1 Digital Input Module

The 8 input connections to this module are identical to those described in 13.2.2.1 above.

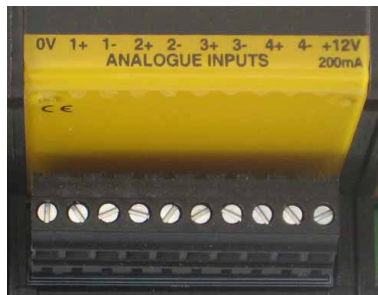
13.3.2 Digital Output Module

The 8 output connections to this module are identical to those described in section 13.2.2.2.



13.3.3 Analogue Input Module

All analogue inputs are fully isolated both from each other and from the power supply. The analogue input module incorporates a power regulator that provides a stable 12VDC supply capable of sourcing 200mA that can be used to power transducers. Any combination of the following diagrams can be used:



13.3.4 Analogue Output Module

All analogue outputs are fully isolated both from each other and from the power supply. Each is capable of sourcing 0...20mA into an external load of up to 500Ω. They can thus each be connected to passive loads.



13.4 Aerials

Most **Mega_Link** systems communicate by radio. The type of aerial and the location of the equipment are usually pre-defined from a site survey. It is important that the equipment, particularly the aerial, is installed in the location specified, since moving it even a small distance can have a significant impact on radio performance.

For short range application the aerials may be mounted close to ground level, and may be inside buildings and even internal within **Mega_Link**. To achieve the best performance the aerials should be mounted externally on elevated poles or masts. Ideally there should be line-of site between stations, and not be obstructed by trees, hills or buildings, but this is not always possible. Obstructions may significantly reduce the range that can be achieved.

The radio survey will also determine the length of cable needed between the aerial and **Mega_Link**. There is some loss along the cable, so lengthening it will degrade the system performance. Care should be taken to ensure that only good quality 50Ω co-axial cable and connectors are used.

Systems using S450 radios can achieve ranges in excess of 20km using elevated aerials. The performance of the S868 matches that of the S450, but the range is reduced because higher frequencies are attenuated more by the atmosphere. For applications that only require a range of up to 2km, lower cost D450/D868 radios can be used. All these radios are licence-exempt, so there is no charge for usage. For longer range GSM cellular modems can be used, but there is a charge for using these.

The radio fitted will be determined from the site survey, and will be chosen to achieve reliable communications and comply with the regulations of the country of use. The type of radio fitted can be checked from the part number of the unit, or from the display.

External elevated aerials are at risk from lighting strikes which could cause significant damage. It is therefore strongly recommended that lightning surge protectors are fitted between them and **Mega_Link**. Surge protectors work by diverting induced current to ground via a gas discharge tube. They therefore rely on being solidly earthed to the same reference point as **Mega_Link** and all associated instrumentation.

13.4.1 Omni-directional Aerials

These are normally designed to fit in the top of a 50mm diameter pole, and radiate equally in all directions in the horizontal plane. There are a number of variants: **End-fed dipoles** radiate in a spherical pattern, and have unity gain in all directions. **Co-linear aerials** are longer, and radiate in a doughnut pattern, so have higher gain in the horizontal plane at the expense of gain upwards and downwards. **Base-station antenna** radiate in a cone pattern, so have higher gain in the horizontal plane and downwards at the expense of reduced gain upwards.

End-fed Dipole



13.4.2 Folded Dipole

These give similar performance to an end-fed dipole, but attach to the side of a pole so can be used on existing poles. They should be mounted with the element vertical.

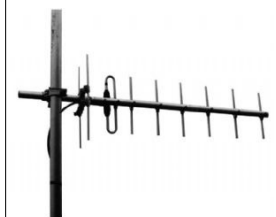
Folded Dipole



13.4.3 Yagi

These are directional and have gain. The directionality and gain are determined by the number of elements. They attach to the side of a pole and must be mounted with the elements vertical. They must also point in the right direction. This may be determined approximately using a compass or GPS, but should be fine-tuned by checking the Received Signal Strength Indicator (RSSI) when the system is operational.

Yagi



13.4.4 Whip Antenna

Whip antennae are suitable for short-range radio communications, and are usually adequate for GSM, unless coverage is particularly poor. As with mobile phone technology, there are likely to be dead spots, particularly within buildings, so it may be necessary to instead use an externally-mounted aerial.



13.4.5 Aerial Fixings

Elevated aerials can be attached to poles up to 6m long. The poles can be attached to walls using stand-off brackets. If the top of the wall is obstructed by soffits or gutters then larger stand-off brackets can be used. Longer poles may need bracing.

13.4.6 Lightning Protection

An important consideration in any system that uses elevated aerials is the possible impact of lightning. The aerial and mast act as an effective lightning conductor, so will attract lightning.

Lightning is caused by an electrostatic charge building up in moist air. It can reach extremely high voltages that eventually discharge to earth via the path of least resistance. If this path has any resistance at all the power induced in it by the strike can cause considerable damage.

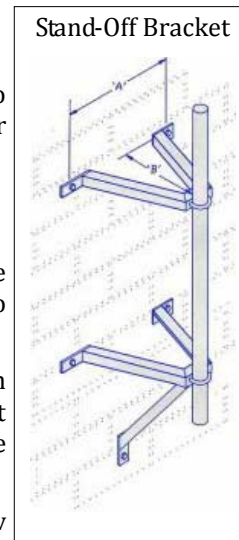
The damage can be minimised by fitting a lightning conductor which provides a low resistance path via an elevated spike. The spike attracts the charged air and can safely dissipate it via a series of small discharges.

A radio mast acts as an effective lightning conductor so attracts lightning. The risk of damage can be greatly reduced by fitting a lightning protection unit (LPU). The LPU includes a gas discharge tube which contains gas that ionises when a strong electrostatic field is applied. The ionised gas has a very low resistance so the charge is conducted through it to the earth terminal. When the charge has been dissipated the gas ceases to be ionised so has a high resistance and hence doesn't affect the normal operation of the radio.

An RF LPU comprises a metal housing with a co-axial socket on each end and an earth stud on the side. The aerial should be connected to one end and the radio to the other. The earth stud should be electrically connected to ground by the lowest possible resistance.

To have maximum effect the LPU should be fitted near the base of the mast (so the surge is dissipated to earth remotely from any electronic equipment) and the housing should be connected to ground via a low impedance path. The electronic equipment should be earthed directly to the LPU earth stud, because any surge current passing from the stud to ground will inevitably pass through some electrical resistance, so the earth stud and the radio signal will therefore rise to some potential above earth. This surge would be passed to the radio if the radio is separately earthed.

The ideal earth connection is heavy gauge cable connected to a buried copper mat covering a large area. A more realistic connection is a long spike driven into the ground. The normal mains earth is not ideal since the wire is relatively light gauge and may be excessively long.



14 Display

The LCD display provides useful information about the system and allows the user to configure and calibrate certain parameters. It is controlled via an adjacent joystick, and is usually fitted to **Mega_Link**, but in cost-sensitive applications it may be omitted. In these cases a hand-held variant of the display can be plugged into the expansion bus as and when required.

Clicking the joystick up or down generally selects menu items, and clicking right activates the current selection. Clicking left reverts to the previous display mode.

If **Mega_Link** detects that it is running from alkaline batteries or from a solar regulator it will blank the display 20 seconds after the joystick was last moved, conserve power. The display will be re-activated by any movement of the joystick.



The home page illustrated above shows the typical page layout and the main uses of the display:

- ➔ The top line (i.e. the red area) is the title bar.
- ➔ The next part (i.e. the yellow area) is a menu. The user can select a menu line to progress to the next level.
- ➔ Any white area below the menu shows 'real' data (in this case the name of the configuration file)
- ➔ The bottom line (i.e. the pale blue area) alternates between the time and date and an alarm banner
- **System Configuration** allows the user to view fixed characteristics of the system, such as the type of interface modules fitted.
- **System Status** allows the user to dynamically view the state of all the system inputs, outputs and alarm flags
- **Eavesdrop Traffic** allows the user to dynamically monitor all communications
- **Calibrate** allows the user to calibrate various inputs and check the calibration
- **Language** allows the user to change the language used by the display

These features are described in detail in the following sub-sections.

Many of these features can also be accessed via the Diagnostics facility provided by DUCX (see section 15.2).

14.1 System Configuration

This allows the user to view the system characteristics, such as the type of power supply fitted and the type of interface fitted in COM 1 and COM 2. It also allows the user to examine certain aspects of the XTP and Fieldbus configurations, such as station addresses.

Finally, the user can read system information such as the firmware version of any expansion modules and the *Mega_Link* processor characteristics.

14.2 System Status

This monitors the actual state of inputs, outputs and alarm flags

14.3 Eavesdrop Traffic

The user can monitor all communication on any of the COM ports. For example, he can view communication between *Mega_Link* and a PLC, or between a *Mega_Link* base-station and a *Mega_Link* outstation.

The data shown is the plain English interpretation of each command and response. If the joystick is toggled up or down the display will sequence through plain English, hexadecimal data and plain English + hexadecimal data. If the joystick is toggled right the display will freeze, which can be useful if monitoring fast communications.

14.4 Calibrate

This allows the user to check and adjust various calibration parameters:

14.4.1 Protection against misuse

To prevent unauthorised users making changes (and authorised users accidentally making changes) a protection system is implemented: When attempting to save new calibration data the user must press the middle of the lower part of the cover (between the 'DIGITAL INPUTS' legend and the digital input terminals) before making the appropriate selection. There is an audible click as an internal push-button is pressed. If this is not done the display will show '**Not Allowed**'.

14.4.2 Calibrate COMx

14.4.2.1 Change COMx Channel

This will only be shown if a radio is fitted in the relevant COM port. The radio channel is normally set as part of the configuration downloaded from DUCX. However, if the operating frequency of a system needs to be changed (for example if a new source of interference blocks the current channel) the user can modify the system without the need to connect a PC. Obviously all units on a system need to be modified to the new channel.

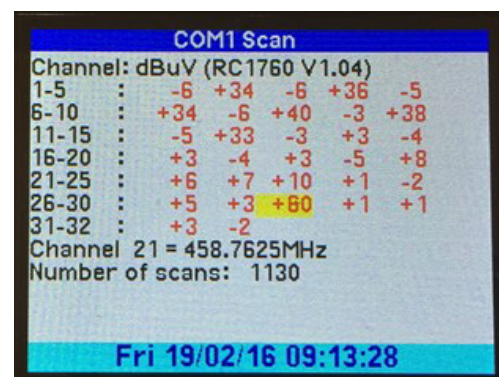
The protection described in section 14.4.1 applies.

14.4.2.2 COMx Scan

This will only be shown if a radio is fitted in the relevant COM port. The normal functions will be disabled and the radio will automatically scan all channels in the band in which it is set. The example shows a system that is set to normally operate on channel 28, since this channel is highlighted in yellow. It is channels 1...32.

The display units can be switched between dBm and dBμV by moving the joystick up or down.

If there is a remote base-station it will show the RSSI of commands received from it, so the scan doubles as a means of testing the path loss.



Since many systems only send messages by radio periodically, **Mega_Link** should be left in scan mode for several minutes to be sure that it has detected all channels that are in use.

The scan can be used before installing a system to attempt to select an unused channel. If none are found the system can be configured to operate on a channel that is already being used, on the assumption that it and the interfering system both use the channel intermittently, so can share it.

14.4.2.3 COMx Path Test BS

Before installing a radio system it is strongly recommended that a path test is carried out to test the path loss and hence confirm that the system will work reliably. In this mode **Mega_Link** will act as a base-station, repeatedly sending commands to a remote outstation that it assumes is set to Station Address 1, and is configured to operate on the same radio channel. This is most easily achieved by temporarily fitting a **Mega_Link** at the remote location set to COMx Path Test OS mode.

When COMx Path Test BS mode is first selected it defaults to the last radio channel that was tested. This can be changed by toggling the joystick up or down, then right to select and save the channel.

The display shows the radio signal strength received by both the base-station and the remote outstation. It also shows the number of messages sent and the number of failed messages. A good path should show an RSSI of 0dBμV or greater, and no failed messages.

14.4.2.4 COMx Path Test OS

This sets **Mega_Link** into a mode suitable for interrogation by another that is operating in COMx Path Test BS mode. To carry out a path test one **Mega_Link** configured in COMx Path Test OS mode should be temporarily installed in the location of the proposed base-station, and attached to an aerial similar to that of the proposed installation. Its radio channel should be set to that of the proposed system. Another **Mega_Link**, configured in COMx Path Test BS mode, should then be taken to each of the proposed outstation locations in turn, and the path readings recorded.

14.4.2.5 COMx TX Constant Carrier

This mode is intended primarily for factory test purposes. The radio will transmit a constant modulated carrier that can be measured on appropriate test equipment to prove its correct operation.

14.4.3 Calibrate Clock

This feature is for use only during factory test.

14.4.4 Calibrate Analogue Inputs

Analogue inputs are calibrated during factory test and should remain accurate for the life of the product. The accuracy can be checked, and the inputs can be re-calibrated, by connecting a current source to the two inputs (connected in series) and setting the display to Calibrate/Calibrate Analogue Inputs. Move the cursor to 'Home' and check that the values at the bottom of the screen track the actual input.

If the inputs need re-calibrating, follow the on-screen instructions. When saving the calibration data the protection described in section 14.4.1 applies.

14.4.5 Calibrate Analogue Outputs

Analogue outputs are calibrated during factory test and should remain accurate for the life of the product. Calibrating analogue outputs can only be carried out after the inputs have been calibrated. Link Analogue Output 1 to Analogue Input 1, and Analogue Output 2 to Analogue Input 2. When the cursor is at Home the outputs will sequence through 0, 4, 8, 12, 16 and 20mA and the values read on the inputs are displayed at the bottom of the screen, so the accuracy can be checked.

If the outputs need re-calibrating, follow the on-screen instructions. When saving the calibration data the protection described in section 14.4.1 applies.

14.4.6 Calibrate Analogue Input Module

If an analogue input expansion module is fitted, and is set to address 0, it can be calibrated in the same way as the **Mega_Link** analogue inputs (see section 14.4.4). The 4 inputs on the module, should be linked in series and connected to the current source.

14.4.7 Calibrate Analogue Output Module

If an analogue output expansion module is fitted, it can be calibrated using a pre-calibrated Analogue Input module. The input module should be set to address 0 and the output module to address 1. The four outputs should be connected to the four inputs, then they can be calibrated in the same way as the **Mega_Link** analogue outputs (see section 14.4.5).

14.4.8 Reset Counters

Mega_Link incorporates a 16-bit counter on each of the first four digital inputs. The count increments each time the input closes, and the total is stored in non-volatile memory. Setting the display to Calibrate/Reset Counters shows the current count on each input. Selecting 'Reset Counters' sets the stored counts to 0. The protection described in section 14.4.1 applies.

14.4.9 Test Digital Outputs

All digital outputs can be tested in this mode. They will be sequenced from all off to all on (including any digital output expansion modules that may be fitted). All Digital Output LED's will also sequence as confirmation that they are all functioning, as will the Digital Input LED's on **Mega_Link**. External monitoring can be used to confirm that the relay contacts are working correctly.

14.4.10 Test Digital Inputs

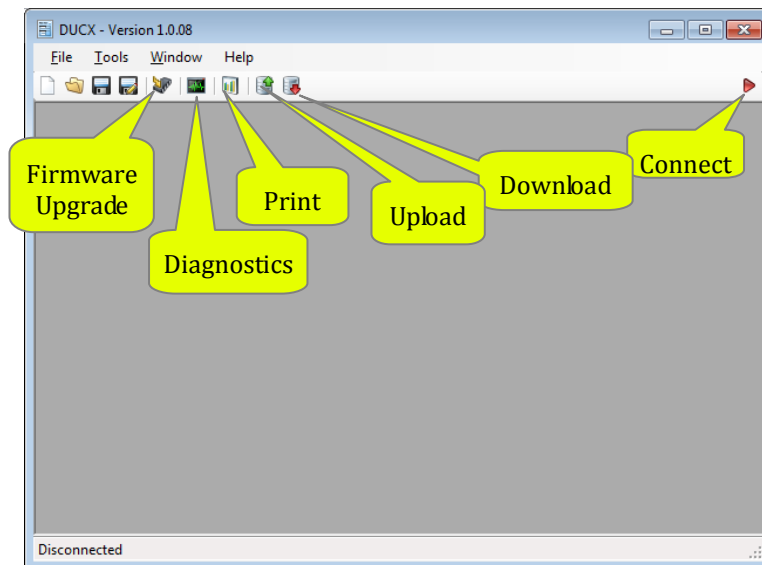
There is no inbuilt function to test digital inputs, since it is not necessary. The digital input monitoring LED's, both on **Mega_Link** and on digital input expansion modules, are independently driven, so the fact that they copy the state of any switch contacts connected to the inputs is confirmation that they are being correctly read.

15 DUCX

DUCX Software and the USB drivers are available free of charge. They are supplied on a CD with every system, or they can be downloaded from our website.

The software is compatible with any PC running Microsoft Windows, including Windows XP, Windows Vista and Windows 7. To install the software follow the instructions given in Appendix 1. The driver emulates two serial ports, which will be allocated COM port numbers (typically COM 3 and COM 4, since COM 1 and COM 2 are pre-defined on most PC's) when DUCX is connected to a **Mega_Link**. Note, however, that if the connection is subsequently made through a different USB port on the PC, the driver will allocate different COM port numbers to it.

There are three parts to DUCX, namely Diagnostics, Configuration and Firmware Upgrade. When it is opened, DUCX is in Configuration mode and displays the following screen:



The Connect arrow in the top right corner shows green if DUCX has established contact with a **Mega_Link**, otherwise it is red. If DUCX fails to connect for any reason, clicking on the arrow will re-establish the connection.

Clicking the Diagnostics icon will open a new window named **Mega_Link Diagnostics**. This can also be achieved by selecting Tools/Diagnostics, or pressing Ctrl+D.

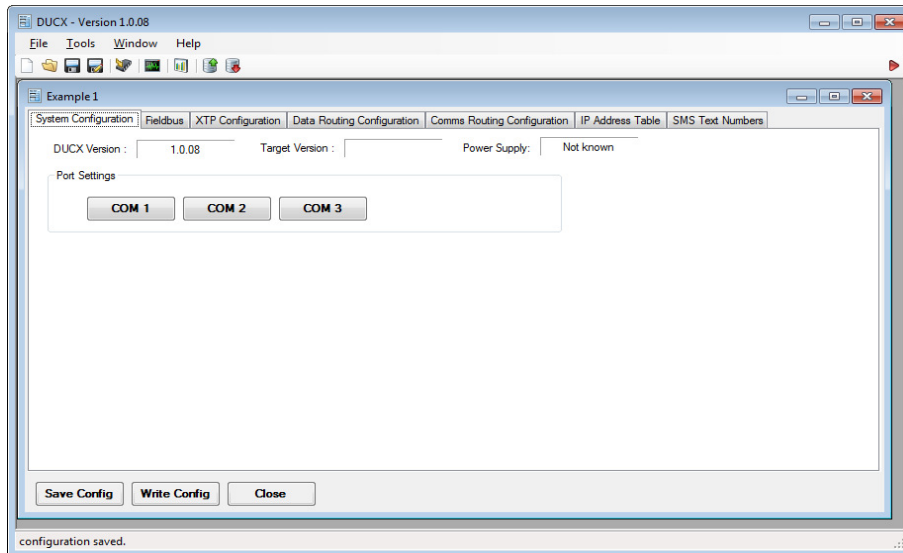
Clicking the Firmware Upgrade icon or selecting Tools/Firmware Upgrade will open a **Firmware Upgrade Form**.

15.1 Configuration

Every **Mega_Link** must be configured to work in the mode required for any given application. All configuration parameters are stored in a file that can be stored on disc, downloaded to **Mega_Link** and/or uploaded from **Mega_Link**.

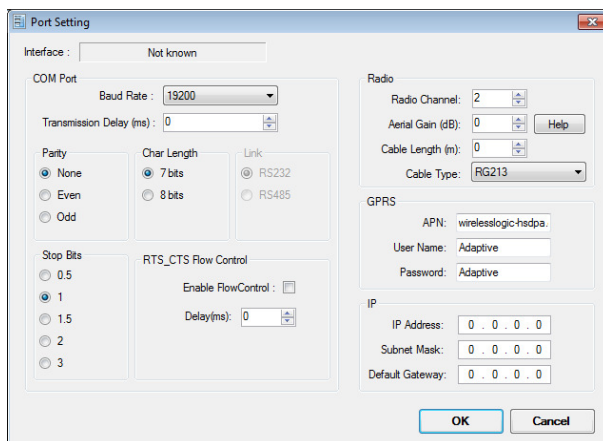
An example configuration is provided on the distribution disc which can be loaded by clicking File/Open. It opens at the System Configuration tab.

15.1.1 System Configuration

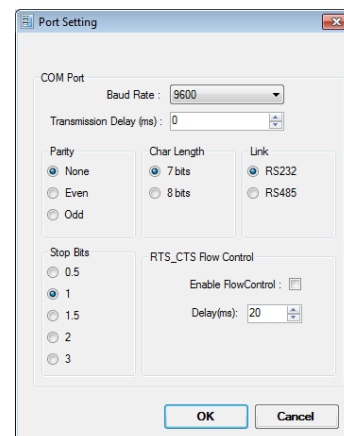


If this configuration had been uploaded from a **Mega_Link**, its firmware version would be displayed in the *Target Version* box, and the type of power supply fitted would be displayed in the *Power Supply* box.

Clicking the COM 1, COM 2 or COM 3 button allows the user to view and/or change the port parameters. COM 3 only displays the COM port frame, but with the Link selection activated so the user can define if it is to use RS232 or RS485.



COM1, COM2



COM3

If the configuration was uploaded from a **Mega_Link** the *Interface* box will show the type of communication interface fitted and any boxes that are not relevant to the interface will be greyed out.

15.1.1.1 COM Port

15.1.1.1.3 Transmission Delay

This is only applicable if the communications media imposes a significant delay (such as satellite communications). Every time a base-station sends a command it calculates the time within which it expects to receive a response from the outstation. This calculation takes into account the type of communication interface fitted and the number of repeaters used. However, the base-station cannot deduce any additional delays, so the user can use this entry to notify it of any additional delay.

15.1.1.1.4 RTS_CTS Flow Control

If this box is ticked **Mega_Link** will raise RTS when it wants to send a message, then wait for the external communication device to raise CTS when it is ready to send.

If this box is not ticked, **Mega_Link** will raise RTS then wait for 20ms plus any time entered in the Delay(ms) box before sending.

15.1.1.2 Radio

15.1.1.2.1 Radio Channel

Each type of radio that can be fitted can be set to one of a selection of channels. For example, a 7501-2 868MHz radio can be set to any of 10 channels, designated 1 ... 10. If DUCX doesn't know which type of radio is fitted and a user selects a channel that is higher than allowed, **Mega_Link** will assume the highest valid channel. If the configuration is subsequently uploaded DUCX will display the channel that is actually used.

A 7501-1 458MHz radio can normally be set to any of 30 channels in the range 458.5125MHz ... 458.9250MHz. However, it can also be configured for use on licensed channels in the Irish Republic. These have designations in the range 33 ... 255. To prevent their unauthorised use, channels in this range will only be accepted if an appropriate PIN number is entered in the COM port Transmission Delay box. The PIN number is only given to the licence owner of the relevant channel and is not stored in **Mega_Link**, so cannot be read back from it.

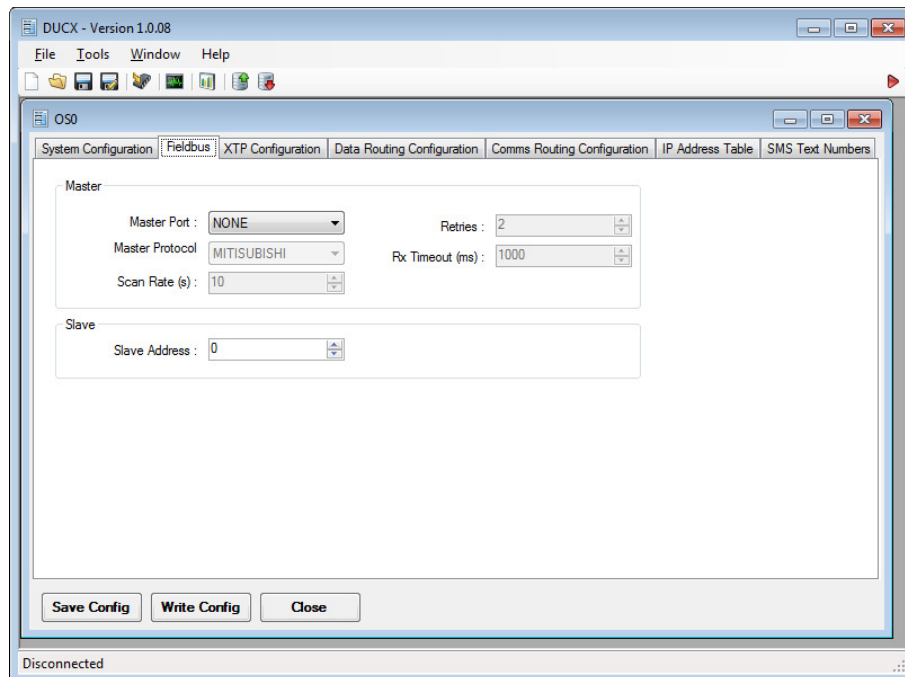
15.1.1.2.2 Aerial Gain, Cable Type, Cable Length

All licence-exempt channels have limits on the maximum Effective Radiated Power (ERP) that can be transmitted. **Mega_Link** calculates the maximum allowable transmitter output power that can be used, based on the aerial gain and the cable loss. The user must therefore identify the aerial type and the cable details. The Help button lists the gain of aerials that would typically be used with **Mega_Link**

15.1.1.3 GPRS

This is only applicable if a 7502-1 GPRS/GSM radio is fitted. The SIM card fitted in the radio defines the network it will use by the APN, User Name, Password and IP Address. These will be provided with the SIM card and should be entered in the relevant boxes.

15.1.2 Fieldbus



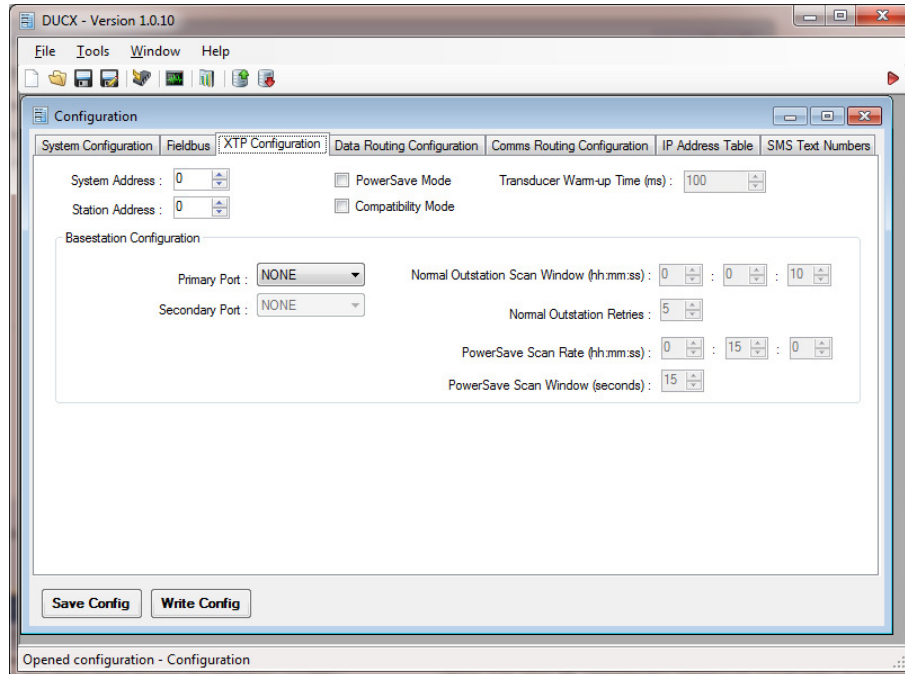
15.1.2.1 Master

If it is to function as a Fieldbus master device the user must define the COM port it is to use, the protocol and the rate at which it is to poll slaves. The box Rx Timeout (ms) defines how long it will wait for a response before giving up. If the scan rate is zero it will make the defines number of retries before flagging a Fieldbus Fail alarm, otherwise it will make as many attempts as possible within the defined Scan Rate time window before raising an alarm.

15.1.2.2 Slave

Mega_Link tests all messages received on COM 1, COM 2 and COM 3 for compatibility with all the protocols it knows. If it finds a valid message it will act on it and respond on the same COM port. It therefore inherently works as a Fieldbus slave with minimal configuration. The only parameter that needs configuring is the slave address.

15.1.3 XTP Configuration



15.1.3.1 System Address

This is only relevant if the Compatibility Mode box is not ticked. Every station on a given system must be allocated the same system address. It will be included in the header of every message, and any message received with a different system address will be ignored. It therefore gives extra security against interference from other systems.

The default system address is 0, but we recommend that this should be changed for maximum security. Any number in the range 0...255 can be used.

15.1.3.2 Station Address

Every station on a given system must be given a unique station address. Any address can be used, in the range 0...250. However, if it is configured as a base-station and it communicates via GPRS the Station Address must be set to 0.

If a station uses Input/Output expansion modules, or if Fieldbus is used to append extra capacity to a station, it may overflow into the database space that would be allocated to the next highest station address. For example, a station equipped with 4 analogue input expansion modules (making a total of 18 analogue inputs) would use three successive file in the database, so would occupy the space allocated for its own station address plus the next two successive addresses.

For this reason we recommend that unless there are more than 25 stations on a system they are allocated addresses in increments of 10 (e.g. 0, 10, 20, 30...). They can then each be subsequently expanded without the need to change any routing configuration.

If there are more than 25 stations on a system they can be allocated addresses that are closer together on the understanding that any expansion will then be restricted. At the ultimate, all 250 addresses can be used, but then no of them can be expanded.

15.1.3.3 **PowerSave Mode**

If this box is ticked and **Mega_Link** is not configured to function as a base-station or as a Fieldbus master, then it will minimise its power consumption. PowerSave mode should be selected if **Mega_Link** operates from an alkaline battery pack, or from a small solar panel.

In PowerSave mode the display will be disabled a short time after the last movement of the joystick. It can be re-enabled at any time by moving the joystick. All communication interfaces are powered down, and analogue and digital outputs are disabled. PowerSave mode shouldn't be selected if expansion modules are fitted, since they are not disabled.

It is assumed that PowerSave mode will be set only to units that are used only as telemetry outstations. In PowerSave mode the outstation will enable the communications interfaces for just long enough for them to identify if there is a radio carrier (or a leased line tone). If none is detected **Mega_Link** will go back to sleep for 2 seconds before repeating the test. This is defined as Sniff Mode.

If a carrier is detected the outstation will remain awake ready to receive a command from the remote base-station. The commands from the base-station will tell the outstation when it will next be called, so it will go to sleep until it is next needed.

15.1.3.4 **Transducer Warm-up Time**

This is only relevant in PowerSave mode. When the base-station recognises that the outstation is configured in PowerSave it will read data from it then tell it when it will next be called. The outstation will then put itself to sleep and wake up just before it is next due to be called. However, if it is powering transducers from its 12V output and the transducers take a significant time to warm up, the outstation will enable the 12V supply before waking up. The warm-up time can be set up to 255 seconds.

15.1.3.5 **Base-station Configuration**

15.1.3.6.1 **Primary Port**

Mega_Link can be configured to act as a base-station on COM1, COM2 or COM3. If none are selected it will function only as an outstation.

15.1.3.6.2 **Secondary Port**

If a Secondary Port is configured **Mega_Link** will use Dual Comms. Every message will be sent via both the primary and the secondary COM port. It will expect the outstation to reply via both ports. It will respond to an outstation response on either port, but if it fails to receive responses on one of the ports it will raise a Dual Comms Fail alarm.

15.1.3.6.3 **Normal Scan Window**

This defines the rate at which the base-station will poll outstations. For example, if there are 3 outstations and the Normal Scan Window is set to 10 seconds, it will poll the first outstation at midnight, the second at 10 seconds past midnight and the third at 20 seconds past midnight. It will then repeat the sequence indefinitely, so each outstation will be polled every 30 seconds.

If it fails to receive a response within the expected time it will retry, and keep retrying until the Normal Scan Window lapses, at which time it will raise a Comms Fail alarm for the outstation.

If the Normal Scan Window is set to 0 the base-station will poll outstations continuously (or as fast as it can while keeping within any duty cycle limits imposed by regulations for the radio band being used).

15.1.3.6.4 **Normal Retries**

If the Normal Scan Window is set to 0, the value entered in this box defines how many attempts it will make to call an outstation before giving up and raising a Comms Fail alarm.

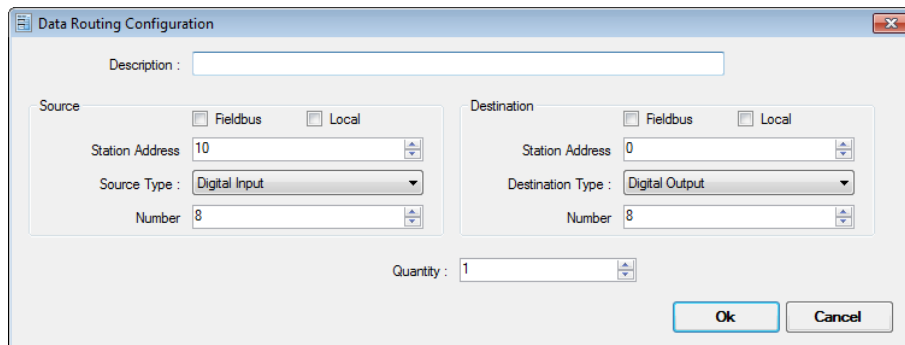
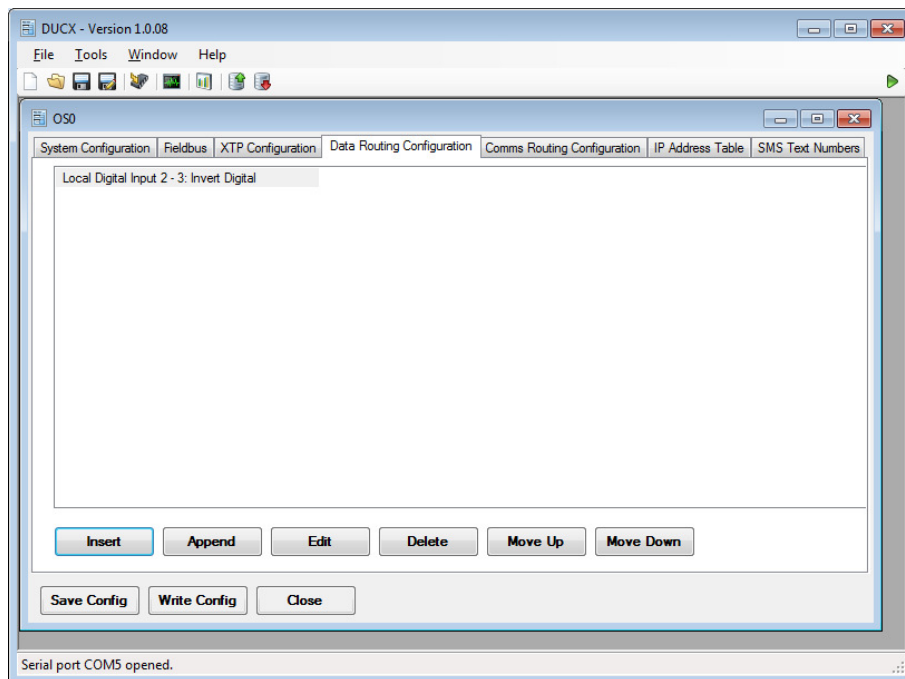
15.1.3.6.5 **PowerSave Scan Rate and PowerSave Window**

This defines the rate at which the base-station will poll any given PowerSave outstation. The base-station synchronises the Scan Rate so it will poll the lowest-numbered PowerSave outstation at midnight. It will follow this by polling each successive PowerSave outstation at the rate defined by the PowerSave Window, then stop wait until the next PowerSave Scan before repeating the exercise.

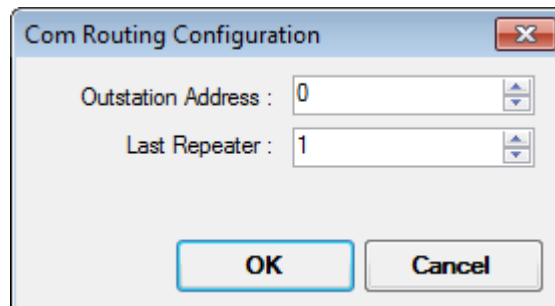
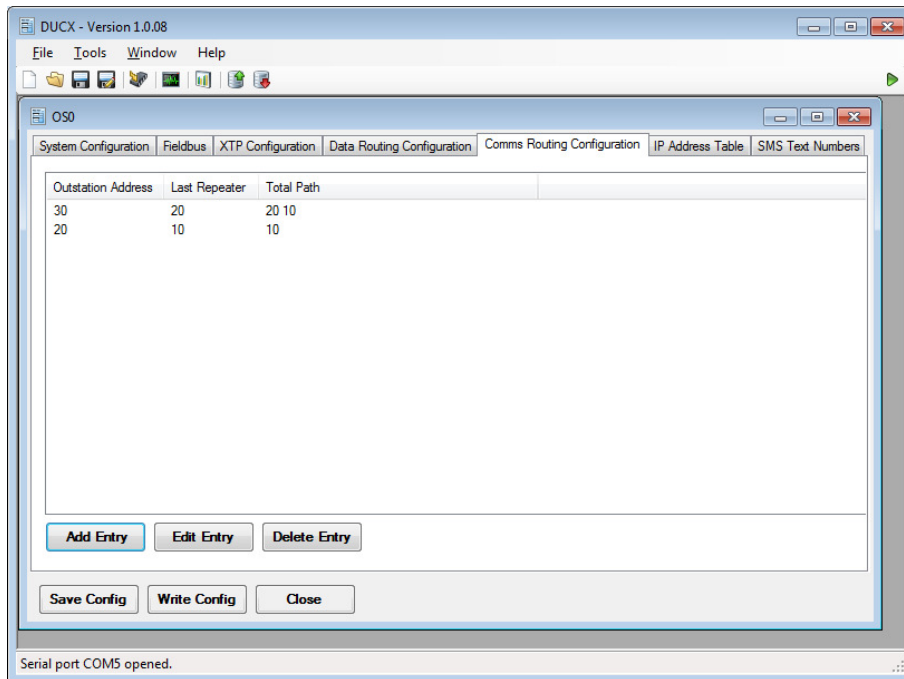
For example, if there are 3 PowerSave outstations, the PowerSave Scan Window is set to 10 seconds and the PowerSave Scan Rate is set to 15 minutes, it will poll the first outstation at midnight, the

second at 10 seconds past midnight and the third at 20 seconds past midnight. It will then wait until 15 minutes past midnight to repeat the sequence. Therefore each outstation is polled every 15 minutes, and the base-station will make as many attempts as it can within the 10 second window to communicate with each outstation.

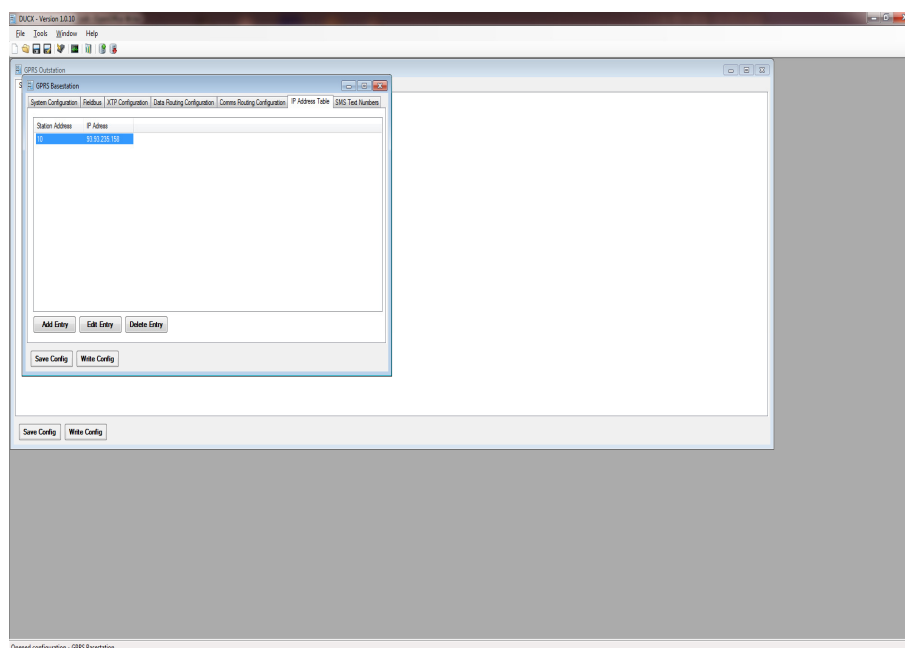
15.1.4 Data Routing Configuration



15.1.5 Comms Routing Configuration



15.1.6 IP Address Table



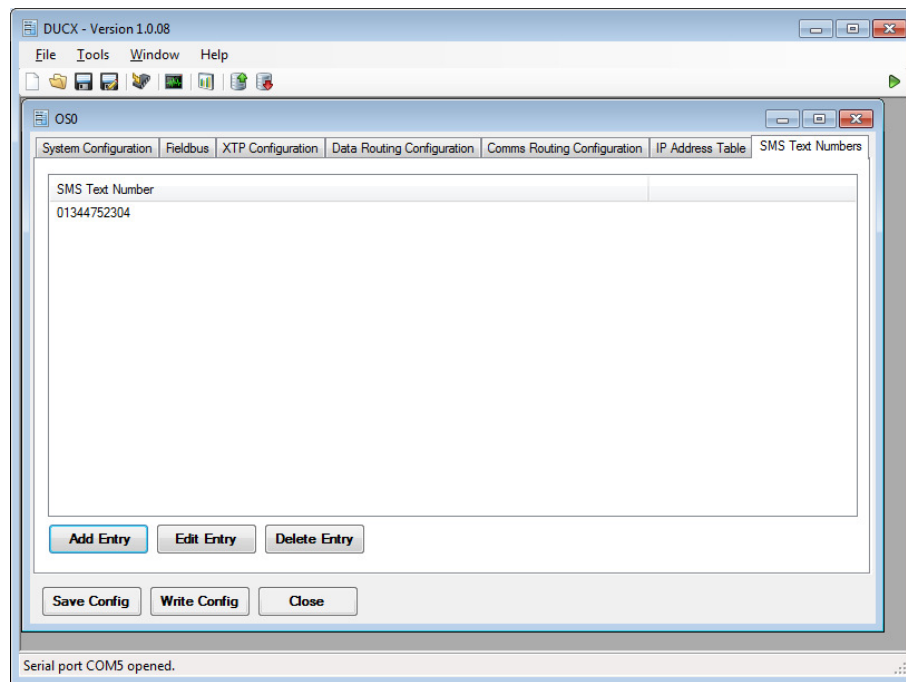
If a GPRS modem is fitted within **Mega_Link** a SIM card must be installed in the modem. The SIM defines the station's IP address. Messages sent over the GPRS modem are directed to the IP address of the required destination. **Mega_Link** therefore needs to know the IP address of the destination. If **Mega_Link** is configured as a base-station the user must configure the IP address of each outstation (see section 7.6). However, when it is used as an outstation it is not normally necessary to set any IP addresses, since it will decode the IP address of the base-station from each command it receives and reply to the same address.

However, if **Mega_Link** is configured as a PowerSave outstation and it is communicating by GPRS it synchronises with the base-station by intermittently sending exception reports until the base-station responds. It therefore needs to know the IP address of the base-station. Any station address can normally be allocated to a base-station, but **Mega_Link** is configured in PowerSave mode and is using GPRS then the base-station address must be set to 0. A PowerSave outstation then assumes that the base-station IP address is stored against Station Address 0.

The IP address of each interface fitted in **Mega_Link** is saved in the configuration as *System Information >>> COMx >>> IP Address*. The user can read it via the display as *System Configuration >>> COM Port Details >>> COMx Port Details* or through diagnostics using the *SD* command.

The table illustrated above could apply to a base-station that is communicating with one outstation which is set to address 10.

15.1.7 SMS Text Numbers



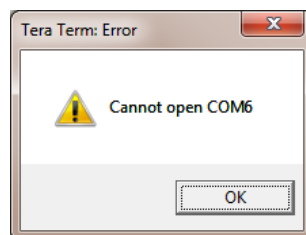
This table is used when configuring SMS Text Messaging, as described in section 11.

15.2 Diagnostics

Clicking on the Diagnostics icon or selecting Tools/Diagnostic Terminal will open a new window named **Mega_Link** Diagnostics. This offer very useful features for monitoring **Mega_Link**.

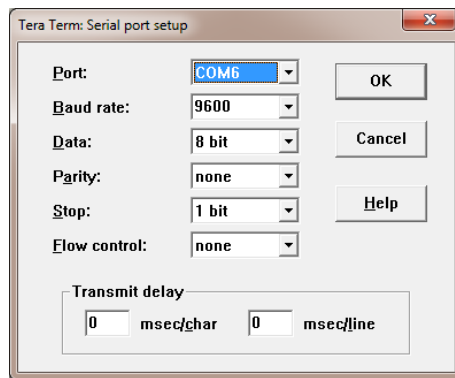
15.2.1 Establishing a USB Connection to Mega_Link

When the **Mega_Link** Diagnostics window opens it attempts to communicate with a **Mega_Link** via a USB port. If it fails to communicate it will show an error message:

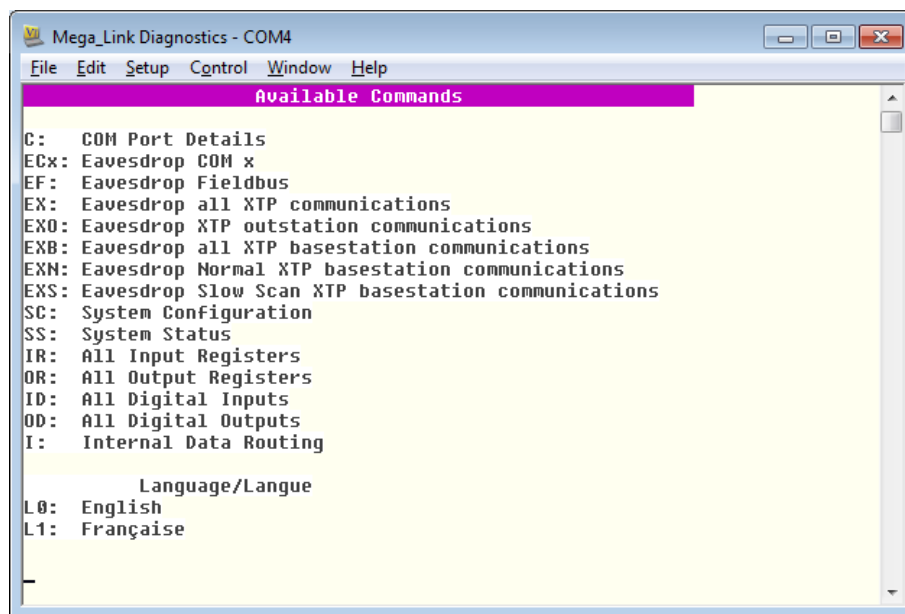


There are two reasons why it might not connect (a) there is no USB connection between the PC and a **Mega_Link** or (b) the USB port has been allocated a different COM port to the one that **Mega_Link** Diagnostics expects:

Every Windows PC can communicate with external equipment using one of many COM ports, designated COM1, COM2, COM3, COM4 etc. COM1 and COM2 are usually reserved for internal RS232 ports (if fitted). When a new device (such as the USB driver used by **Mega_Link** Diagnostics) is detected it is automatically allocated a COM port that is not currently used (e.g. COM4). **Mega_Link** Diagnostics cannot detect which port has been allocated, so assumes a default port. If this is wrong the above message is presented. Click OK then select Setup/Serial Port. The following window will open:



If a **Mega_Link** is connected a COM port will appear in the Port box and clicking the down-arrow next to it will reveal at least one more port. One of these ports will be used by **Mega_Link** Configuration and one is allocated to **Mega_Link** Diagnostics. Select the last COM port then click OK. **Don't change any values in other boxes.** If another error message is displayed repeat the exercise choosing a different COM port.



If no error message is displayed try pressing the return key. The following text should be displayed:

Before proceeding select Setup/Save Setup. A window will open showing the default file name of TERATERM.INI. Click OK to save the modified configuration. This will ensure that next time **Mega_Link** Diagnostics is opened it will default to the correct COM port. However, one of the vagaries of the Windows operating system is that if a different USB port on the PC is used the next time a connection is made, Window may allocate a different COM port, necessitating a repeat of the above procedure. To prevent this it is suggested that the same USB port is used each time.

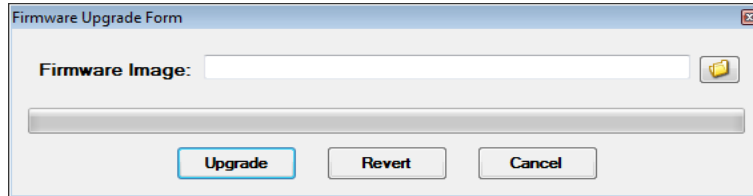
15.2.2 Using Mega_Link Diagnostics

The command menu illustrated above lists all the diagnostic commands that can be used. For example, pressing SC followed by Return will display all aspects of the system configuration. Pressing Return on its own will exit any display mode and instead show the command menu.

15.3 Firmware Upgrade

Firmware upgrades are issued from time to time to fix bugs or to add new features. A new firmware file could be sent via e-mail or downloaded from the Churchill Controls website at www.churchill-controls.co.uk. The file will have a name such as 'Mega_Link V1.0.12.bin'.

To upgrade a **Mega_Link**, save the new firmware file in a known location on the PC then click the Firmware



Upgrade icon or select Tools/Firmware Upgrade. The following window will open:

Click the yellow icon, navigate to the firmware file then click Upgrade. The Fuel Gauge will show progress as the new data is uploaded, at the end of which **Mega_Link** will reset and re-start using the new firmware.

Firmware is stored in two memory banks, designated Bank A and Bank B. When a system is first manufactured it runs from Bank A. When new firmware is uploaded it is stored in Bank B. When the upload is completed **Mega_Link** checks that it is error-free then modifies itself to use Bank B. The previous firmware still resides in Bank A but is dormant. If for any reason the user wants to revert back to the previous firmware he can using the Revert button.

If the firmware is subsequently upgraded again the new version is stored in Bank A.

16 Fieldbus

Mega_Link can communicate with external devices using a variety of protocols and hardware interfaces, via any of the COM ports. All the protocols implemented within **Mega_Link** use a master-slave strategy, whereby all communication is instigated by a master device. It issues commands that include a slave address, so only the relevant slave device will respond. Slave devices only transmit in response to commands received from the master.

Mega_Link is always active in slave mode on all its COM ports. Thus it will respond to any valid command received on any port, in any protocol, as a slave device. It can also be configured to act as a Fieldbus master device on a designated port, using a designated protocol.

16.1 Mapping Fieldbus Data to/from the Mega_Link Database

The database within **Mega_Link** is a linear array of 250 files, each containing 8 registers and 32 digitals (see section 9.6). The main **Mega_Link** module provides 2 analogue inputs, 2 analogue outputs, 8 digital inputs and 8 digital outputs, which are all accommodated within the file number corresponding to the station address. Input and outputs on hardware expansion modules are appended to these.

There are three means of reading and writing data to/from input and output files (see section 9):

- Hardware inputs are automatically copied to the input file corresponding to the XTP station address. This applies both to the inputs integral within **Mega_Link** and any expansion input modules that may be fitted. Similarly data from the output file corresponding to the XTP station address is automatically copied to hardware outputs.
- Data routing (configured via DUCX) can be used to copy data between files at the base-station.
- Fieldbus protocols can be used to copy data between **Mega_Link** files and external devices

Data can be written to input files either by using the data routing mechanism contained within the DUCX configuration software or via Fieldbus. If **Mega_Link** is used as a Fieldbus master then DUCX data routing is also used to configure Fieldbus data transfers.

Data read from an external device via Fieldbus should be appended onto the end of the hardware inputs. Similarly, data can be passed from the output registers and/or digitals that follow the hardware outputs to the external device.

For example, an **Mega_Link** with three digital output expansion modules (each with 8 outputs) will provides 2 analogue inputs, 2 analogue outputs, 8 digital inputs and 32 digital outputs. Fieldbus can thus use analogue inputs and outputs starting from 3, digital inputs starting from 9 and digital outputs starting from 33.

Note, however, that there is a maximum limit on any outstation of 120 registers and 480 digitals.

16.1.1 Fieldbus Master

When **Mega_Link** is used in a Fieldbus master mode it will issue commands to the external device and process the responses it receives. The user must configure it to define the mapping between its database and external device's database. This is done in the Data Routing Table by including lines such as:

Fieldbus Address 1 Input Digital 1000 – 1015 >>> Local Digital Input 9 – 24

This will cause **Mega_Link** to read input digital registers 1000 – 1015 from the external device using whichever protocol has been defined within the configuration file. In this example it is assumed that the external device has slave address 1. The data returned will be appended to the **Mega_Link's** hardware digital inputs so if it is used as an outstation the remote base-station will treat it as having a total of 32 digital inputs.

The user needs to know the database usage within the Fieldbus device, to define which registers to access within it.

16.1.2 Fieldbus Slave

When **Mega_Link** is used in slave mode it will respond to commands issued to it by the external device. The user must configure the external device to map to/from the relevant points in the **Mega_Link** database. The software used to do this will be aware of the database structure of the external device, but it will not be aware of the database structure used by **Mega_Link**. The user therefore needs to know how I/O is mapped to/from the **Mega_Link** database:

The **Mega_Link** database comprises 250 input files and 250 output files. Each file contains eight 16-bit registers and 32 digitals. These files are in a linear array, so the database contains 2000 16-bit input registers, 2000 16-bit output registers, 8000 input digitals and 8000 output digitals. The absolute address of any given register is thus $((8 * \text{Station Address}) + \text{Point Number})$, and the address of any given digital is $((32 * \text{Station Address}) + \text{Point Number})$.

The input and output files corresponding to the XTP station address are defined as root files. If the I/O is expanded the file size is automatically increased by concatenating sequential files to it.

NOTE: If Fieldbus is implemented at a base-station to access data to/from an outstation, there must be at least one internal data routing instruction to access data to/from the root file of the outstation.

Mega_Link's internal inputs and alarm flags are mapped to the root input file is as follows:

INPUT FILE

	Digital	Register	
0	Outstation Comms Fail	Count 1	0
1	Battery Low Alarm		
2	Base-station Comms Fail ¹		
3	Fieldbus Comms Fail		
4	Total b/s Comms Fail	Count 2	1
5	Charger Fail		
6	Primary Comms Fail		
7	Secondary Comms Fail		
8	Digital Input 1	Count 3	2
9	Digital Input 2		
10	Digital Input 3		
11	Digital Input 4		
12	Digital Input 5	Count 4	3
13	Digital Input 6		
14	Digital Input 7		
15	Digital Input 8		
16	Digital Input 9 ²	Battery Volts	4
17	Digital Input 10 ²		
18	Digital Input 11 ²		
19	Digital Input 12 ²		
20	Digital Input 13 ²	RSSI	5
21	Digital Input 14 ²		
22	Digital Input 15 ²		
23	Digital Input 16 ²		
24	Digital Input 17 ³	Analogue Input 1	6
25	Digital Input 18 ³		
26	Digital Input 19 ³		
27	Digital Input 20 ³		
28	Digital Input 21 ³	Analogue Input 2	7
29	Digital Input 22 ³		
30	Digital Input 23 ³		
31	Digital Input 24 ³		

¹ The Base-station Comms Fail is shared with the Rotation Fail alarm.

^{2,3} These inputs are only valid if digital input expansion modules are fitted.

For example, the Battery Low alarm for station 30 is mapped to digital $((32 * 30) + 1)$ = input digital 481. The Battery Volts can be read from register $((8 * 30) + 4)$ = input register 244.

Any digital input expansion modules fitted will be mapped to contiguously follow the core digital inputs (i.e. the first digital input module will be mapped to input digitals 16...23, the next to input digitals 24...31, etc). Data can thus overflow into the next sequential file(s).

Any analogue input expansion modules fitted will be mapped to contiguously follow the core analogue inputs (i.e. the first analogue input module will be mapped to input registers 8...11, the next to input registers 12...15 etc.)

If a Fieldbus device is configured to copy data from its database to that of the **Mega_Link** it should copy to points that follow contiguously from those used by the hardware inputs. **Mega_Link** can thus be expanded by using any combination of expansion modules and/or Fieldbus data.

Mega_Link's internal outputs are mapped to the root output file is as follows:

OUTPUT FILE		
	Digital	Register
0		0
1		
2		
3		
4		1
5		
6		
7		
8	Digital Output 1	2
9	Digital Output 2	
10	Digital Output 3	
11	Digital Output 4	
12	Digital Output 5	3
13	Digital Output 6	
14	Digital Output 7	
15	Digital Output 8	
16	Digital Output 9 ¹	4
17	Digital Output 10 ¹	
18	Digital Output 11 ¹	
19	Digital Output 12 ¹	
20	Digital Output 13 ¹	5
21	Digital Output 14 ¹	
22	Digital Output 15 ¹	
23	Digital Output 16 ¹	
24	Digital Output 17 ²	6
25	Digital Output 18 ²	
26	Digital Output 19 ²	
27	Digital Output 20 ²	
28	Digital Output 21 ²	7
29	Digital Output 22 ²	
30	Digital Output 23 ²	
31	Digital Output 24 ²	

^{1,2} These inputs are only valid if digital output expansion modules are fitted, or data is mapped to Fieldbus devices

Any digital output expansion modules fitted will be mapped to contiguously follow the core digital inputs (i.e. the first digital input module will be mapped to output digitals 16...23, the next to output digitals 24...31, etc)

Any analogue output expansion modules fitted will be mapped to contiguously follow the core analogue outputs (i.e. the first analogue output module will be mapped to output registers 8...11, the next to output registers 12...15, etc)

If a Fieldbus device is configured to copy data from **Mega_Link** to its database it should copy from points that follow contiguously from those used by the hardware outputs. **Mega_Link** can thus be expanded by using any combination of expansion modules and/or Fieldbus data.

16.2 Modbus

Modbus protocol is widely used for communicating with PLC's and SCADA systems. It is a very simple protocol and thus is not subject to vagaries in interpretation. However, it also suffers from limited flexibility.

16.2.1 Modbus Database

Modbus is structured around four database areas which match those used on **Mega_Link**, namely digital inputs, digital outputs, input registers and output registers, although in Modbus naming convention they are called Input Status, Coil Status, Input Registers and Holding Registers respectively. The registers can also be uniquely defined by considering them as one large array, where the offset within the array determines the type:

Modbus Offset	Modbus Type	Mega_Link Type
00001...08000	Coil Status	Output Digitals
10001...18000	Input Status	Input Digitals
30001...32000	Input Registers	Input Registers
40001...42000	Holding Registers	Output Registers

Thus, for example, Output Register 2, Holding Register 2 and register 40002 all refer to the same point.

16.2.2 Modbus Protocol

Modbus protocol uses the Modbus naming convention, so the offset is not used. It provides functionality to read any type of status or register, but can only write to Coil Status's or Holding Registers. Every command comprises a header containing a slave address and a function code, which may be followed by data.

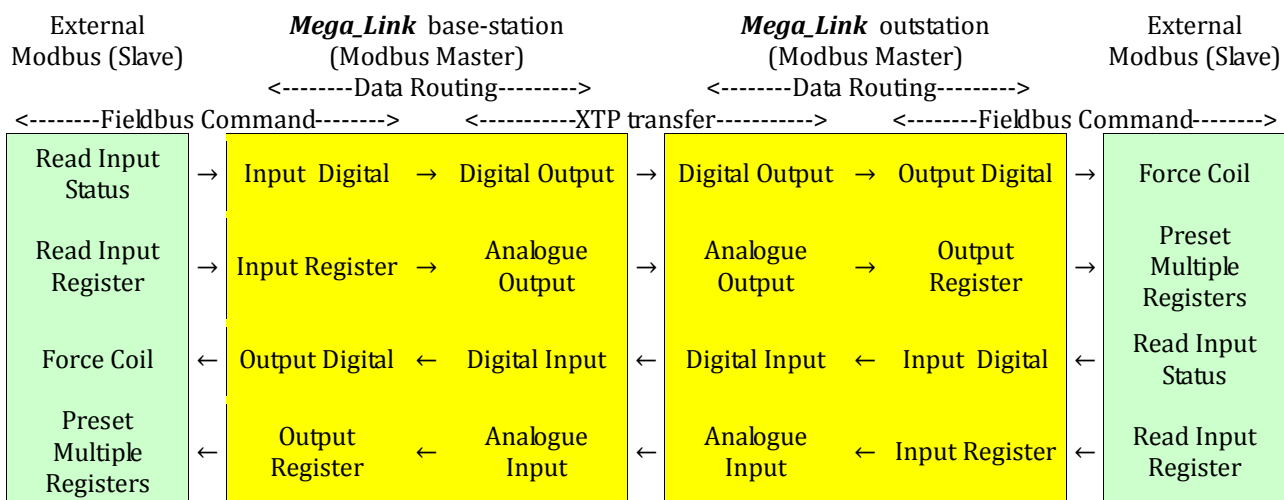
Mega_Link uses only the following Function Codes:

Function Code	Modbus meaning	Mega_Link Terminology
01	Read Coil Status	Read Output Digital
02	Read Input Status	Read Input Digital
03	Read Holding Registers	Read Output Register
04	Read Input Registers	Read Input Register
05	Force Single Coil	Write Output Digital
06	Preset Single Register	Write Output Register
15	Force Multiple Coils	Write Output Digital
16	Preset Multiple Registers	Write Output Register

The slave response comprises a header containing its slave address and a function code, which may be followed by data.

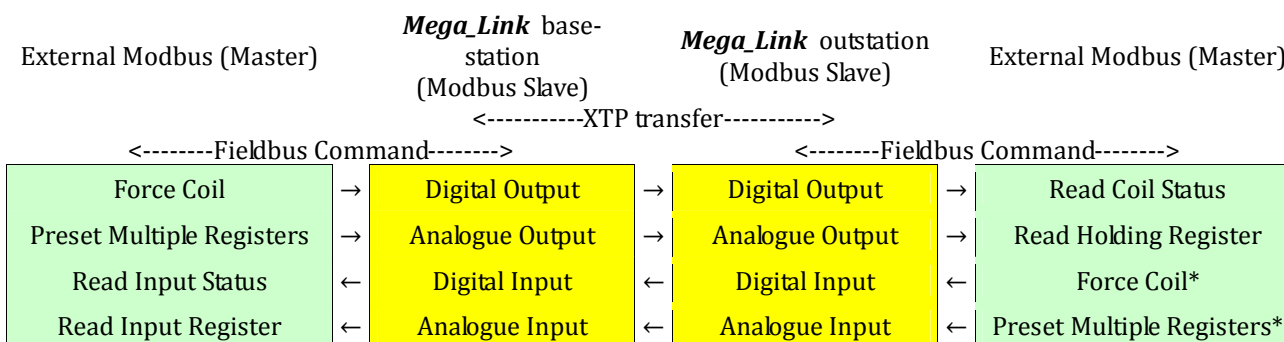
16.2.3 Modbus Master Mode

If an **Mega_Link** is configured as a Modbus master device the data routing table must include instruction to pass data to/from an external slave device. The commands used by **Mega_Link** can be summarised as:



16.2.4 Modbus Slave Mode

If an **Mega_Link** is configured as a Modbus slave device the data routing must be configured in the remote master device. **Mega_Link** responds to Modbus commands as summarised below:



* **Mega_Link** will also accept the commands Force Single Coil and Preset Single Register. These, along with Force Coil and Force Multiple Registers are the only Modbus command that can be used to write data to a slave. Modbus expects Coils and Registers to be outputs, so by default **Mega_Link** interprets these command as writing to Digital and analogue outputs. However, it may be apparent from the above illustration that an **Mega_Link** outstation must respond by copying the data to input registers if they are to be sent remotely. This anomaly can be resolved by adding an offset of 10,000 to the relevant address. If **Mega_Link** receives a command with an address greater than 9,999 it subtracts 10,000 from it and inverts the register type. This is an uncommon scenario, since outstations are rarely required to communicate with Fieldbus master devices.

In the above illustration the Modbus device connected to the **Mega_Link** outstation must apply this rule to the Force Coil and Force Multiple Register commands. This rule can also be used for read commands so, for example, Read Coil 10 and Read Input Status 10,010 will both actually read Digital Output 10 from the **Mega_Link** database.

16.3 DF1

DF1 protocol can be used over high speed interfaces (e.g. Ethernet) or low speed interfaces.

16.3.1 DF1 Database

The database used by DF1 systems is a tree structure: There are up to 255 Files (numbered 0...254). Each File is divided into up to 255 Elements (numbered 0...254). Each Element is divided into up to 255 Sub-Elements (numbered 0...254). Sub-Elements can hold various types of data, including Status, Bit, Timer,

Counter and Integer. However, most systems don't use Sub-Elements so default to a single Sub-Element, numbered 0. Writing to multiple registers will write to Sub-Element 0 of consecutive Elements.

Mega_Link processes only Status and Integer file types, which correspond to digitals and registers.

16.3.2 DF1 Protocol

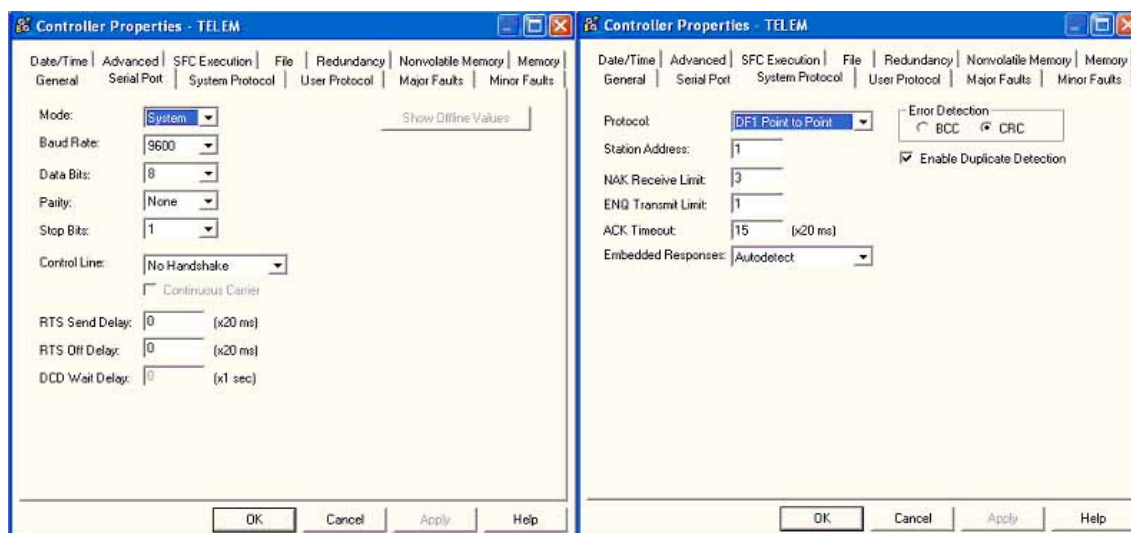
There are two variants of DF1 protocol, Full Duplex and Half Duplex. Full Duplex allows the master to send multiple commands without waiting for responses. The slave can respond at any time. The master matches the slave response to the relevant command by virtue of a message number that is included in each command. The response uses the same message number.

Half Duplex communication uses the same message format, but the master waits for a response to each command before sending the next.

When **Mega_Link** is configured as a DF1 master it uses half duplex. However, as a slave it can accept commands in either half duplex or full duplex mode.

Timing is critical for successful communications. **Mega_Link** should be configured via DUCX such that the RS/CTS delay on any COM port configured as a DF1 master is left at the default value of 20ms, and the Fieldbus RX timeout should be set to 1000ms.

The DF1 device should be configured accordingly to communicate with **Mega_Link**. For example, if using a Control Logix configuration program it should be configured as follows:



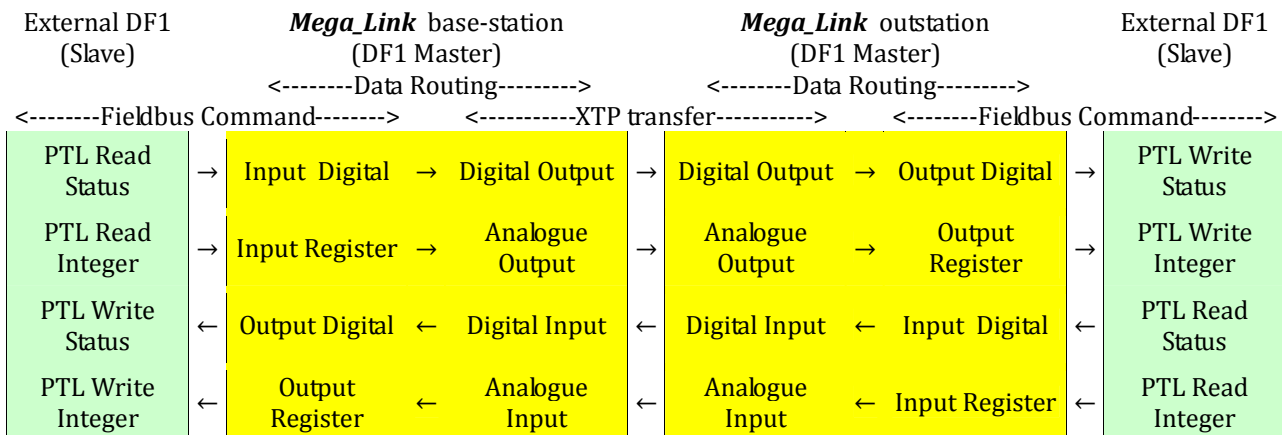
Mega_Link supports only two DF1 commands, namely Protected Typed Logical Read with Three Address Fields and Protected Typed Logical Write with Three Address Fields. Both of these commands include a File Type character. **Mega_Link** supports only two file types, namely Status (digital) and Integer (register). The commands are translated as follows:

Command	File Type	Mega_Link Terminology
Protected Typed Logical Read	Status	Read Input Digital
Protected Typed Logical Read	Integer	Read Input Register
Protected Typed Logical Write	Status	Write Output Digital
Protected Typed Logical Write	Integer	Write Output Register

As noted above, the DF1 database comprised up to 254 Files, each containing up to 254 Elements, which each contain up to 254 Sub-Elements. Most systems don't use Sub-Elements. **Mega_Link** uses addresses in the range 0...3999 for digitals and 0...2000 for registers. It maps these to the DF1 database by translating the File number as Address / 256 and the Element number as (Address - (File number * 256)). The Sub-Element is always 0 and ignored. Thus, for example, File 3, Element 10 translates to Address $(3 * 256 + 10) = 778$. Similarly Address 1000 translates to File $(1000/256) = 3$, Element $(1000 - 3 * 256) = 232$.

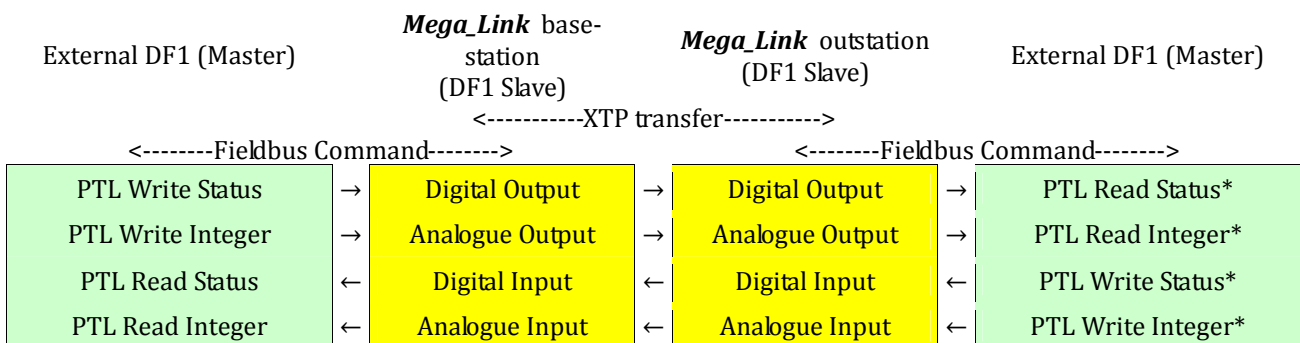
16.3.3 DF1 Master Mode

If an **Mega_Link** is configured as a DF1 master device the data routing table must include instruction to pass data to/from an external slave device. The commands used by **Mega_Link** can be summarised as:



16.3.4 DF1 Slave Mode

If an **Mega_Link** is configured as a DF1 slave device the data routing must be configured in the remote master device. **Mega_Link** responds to DF1 commands as summarised below:



It should be apparent from the above illustration the DF1 commands received by an **Mega_Link** outstation have to operate on different register types to those at the base-station. This anomaly can be resolved by adding an offset of 10,000 to the relevant address. If **Mega_Link** receives a command with an address greater than 9,999 it subtracts 10,000 from it and inverts the register type.

In the above illustration the DF1 device connected to the **Mega_Link** outstation must apply this rule to all the commands it issues.

16.4 Mitsubishi

A number of Mitsubishi PLC's are available, broadly divided into FX types and non-FX. The hardware interface varies, with some using handshaking and some not. To be sure of correct operation the following connections should be made:

Function	PLC (9-pin D plug)	Mega_Link COM port	Category 5 cable colour
TXD	3	4	White/Blue
RXD	2	3	Green
0V	5	8	White/Orange
RTS	4	Link together	
CTS	6		
DSR	7	Link together	
DTR	8		

16.4.1 Mitsubishi Database

Mitsubishi use numerous databases, designated by a single letter, including the following:

Range	Function
X0000...X07FF	Digital Input
Y0000... Y07FF	Digital Output
M0000... M2047	Internal Relay
M9000... M9255	Special Relay
L0000... L2047	Latch Relay
S0000... S2047	Step Relay
B0000... B03FF	Link Relay
D0000... D1023*	Data Register
W0000... W03FF *	Link Register
R0000... R8191*	File Register

* These contain 16-bit registers, all others a single-bit registers

16.4.2 Mitsubishi Protocol

Most FX and non-FX PLC's can be configured to use either dedicated protocol or no protocol. **Mega_Link** uses dedicated protocol. FX PLC's default to no protocol, so should be set to dedicated protocol by writing the value H6881 (decimal 26753) to register D8120 if using RS232 communications, or H6081 (decimal 24705) if using RS485. This configures the serial port to dedicated protocol at 9600 baud, using 8 bits/character, no parity and 1 stop bit. The **Mega_Link** COM port must be configured to match this.

Note that some Mitsubishi serial interface modules do not support dedicated protocol. These will not work with **Mega_Link**.

Mega_Link uses only the commands Batch Read and Batch Write. The payload of each of these is prefixed with the relevant register type and address, and the number of consecutive points.

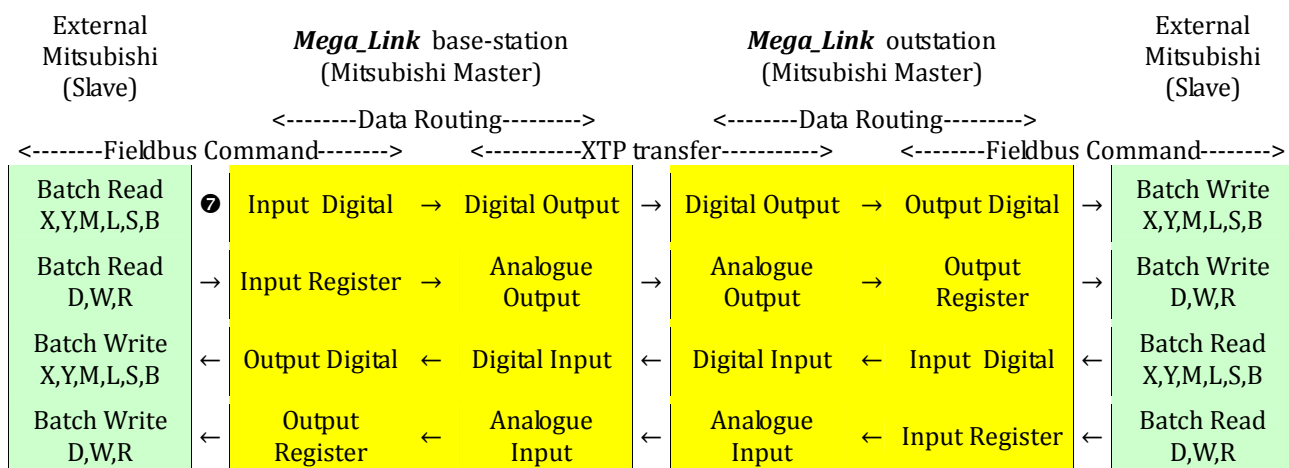
By default, all Mitsubishi PLC's use a Station Address 0 and PLC address of 0xFF. The Station Address FX PLC's by writing a different value to register D8121, but this would only be necessary if connecting more than one PLC to an **Mega_Link** master.

There are subtle differences in the protocol used by FX and non-FX PLC's, so a master device has to establish the type of the slave device with which it is communicating. There are two ways of doing this:

- The master can read register D8001. An FX PLC will return a value in the range 20,000...29,999 or it will return a negative acknowledge (NAK). A non-FX PLC will return a value outside this range. An **Mega_Link** configured as a Mitsubishi master uses this method. An **Mega_Link** configured as a Mitsubishi slave will return a value of 0, indicating a non-FX type..
- The master can issue a 'PC' command to request the PLC type. The PLC will respond with a code identifying its type. An **Mega_Link** configured as a slave will respond as a type A1 CPU, which is non-FX.

16.4.3 Mitsubishi Master Mode

If an **Mega_Link** is configured as a Mitsubishi master device the data routing table must include instruction to pass data to/from an external slave device. The commands used by **Mega_Link** can be summarised as:



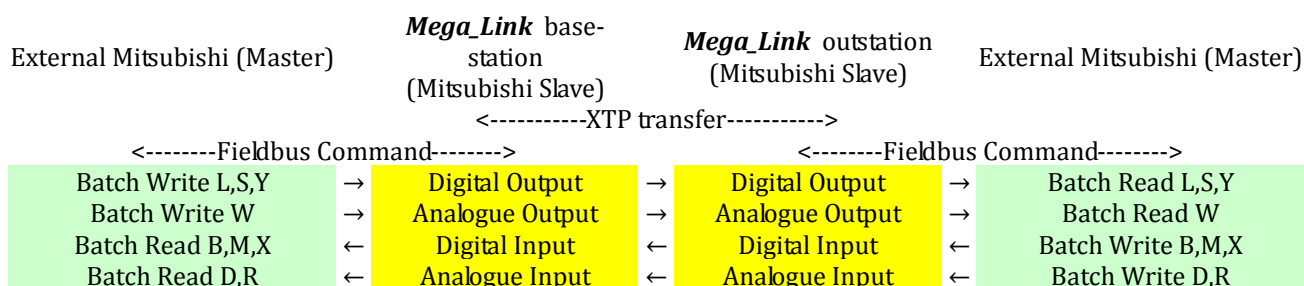
Mega_Link can be configured to access various registers by adding an offset to the register value:

<i>Mega_Link</i> Register Type	<i>Mega_Link</i> Register Address	Mitsubishi Register Type	Mitsubishi Register Address
Digital	0...9,999	X	0...9999
Digital	10,000...19,999	M	0...9999
Digital	20,000...29,999	L	0...9999
Digital	30,000...39,999	S	0...9999
Digital	40,000...49,999	Y	0...9999
Digital	50,000...59,999	B	0...9999
Register	0...9,999	D	0...9999
Register	10,000...19,999	W	0...9999
Register	20,000...29,999	R	0...9999

Thus, for example, to write to Mitsubishi register Y100, *Mega_Link* should be configured to write to Fieldbus Output Digital 40,100. To read from Mitsubishi register W50, *Mega_Link* should be configured to read from Fieldbus Input Register 10,050.

16.4.4 Mitsubishi Slave Mode

If an *Mega_Link* is configured as a Mitsubishi slave device the data routing must be configured in the remote master device. *Mega_Link* responds to Mitsubishi commands as summarised below:



As may be apparent, in slave mode *Mega_Link* uses the file type to decide which type of register to access. For example, to copy digitals from a Mitsubishi master at the base-station to a Mitsubishi master at a slave the base-station end should write to file type L, S or Y, and the outstation end should read from file type L, S or Y;

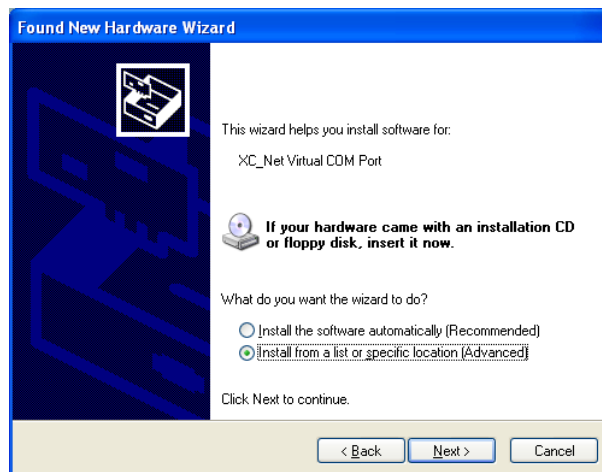
Appendix 1 - DUCX & USB Driver Installation

The following instructions include illustrations from Windows XP, other versions will give slightly different displays:

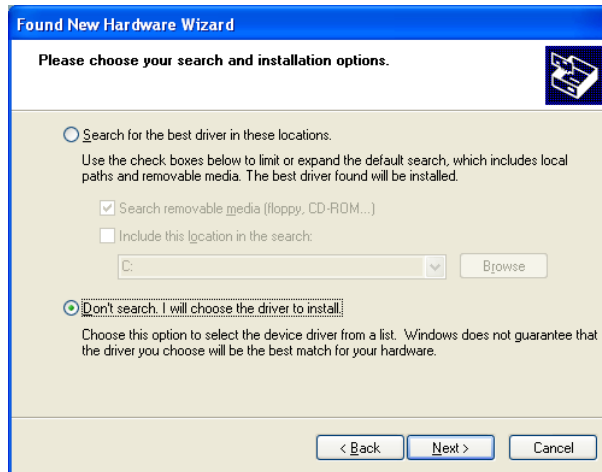
1. Install the CD, or download the software to a known directory and navigate to it.
2. Run setup.exe to install DUCX. During the installation process you will be prompted to select the folder in which you wish to install DUCX. Select the default (Churchill Controls/DUCX) unless there is a reason for installing it elsewhere. When the installation is complete there will be a DUCX short-cut icon on the desktop and an appropriate entry in Start/Programs.
3. Power a **Mega_Link** and connect it to the PC via an USB cable. Windows will recognise it and open the following window:



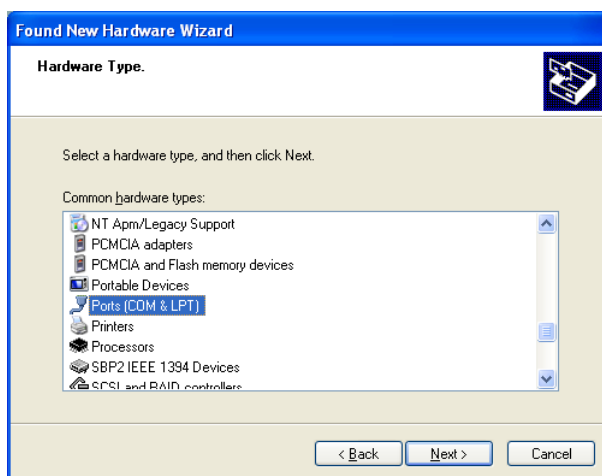
Select “No, not this time”. Click Next.



4. Select “Install from a list or specific location”. Click Next.



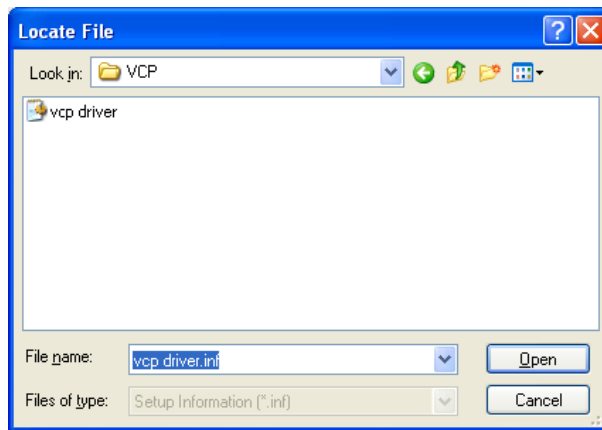
5. Select "Don't search. I will choose the driver to install". Click Next.



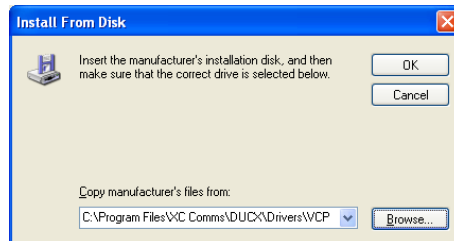
6. Select Ports (COM & LPT). Click next.



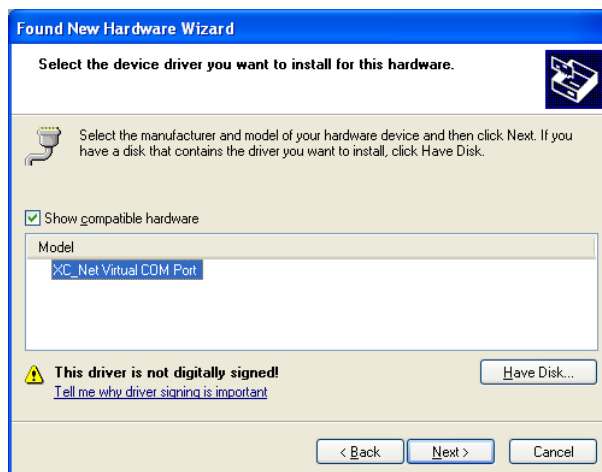
7. Click "Have Disk..." then browse to the Drivers folder within the folder in which DUCX was installed.



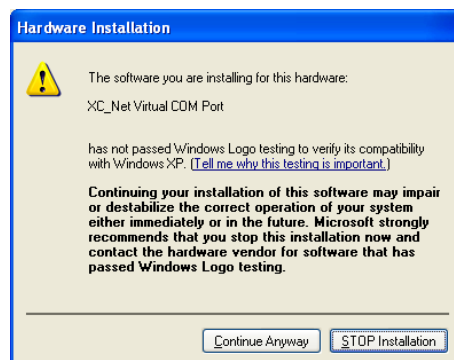
8. Select vcp driver and click Open

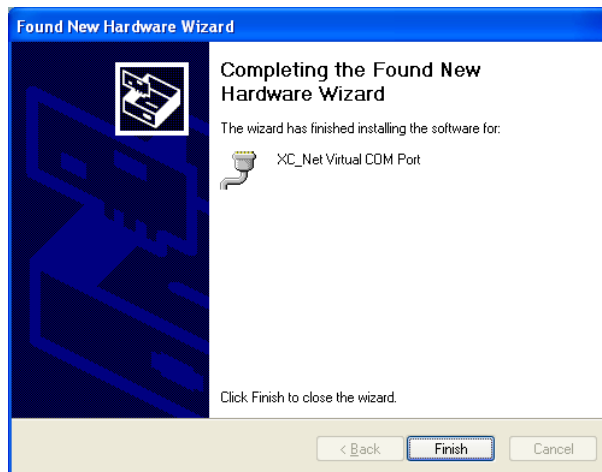


9. Click "OK"

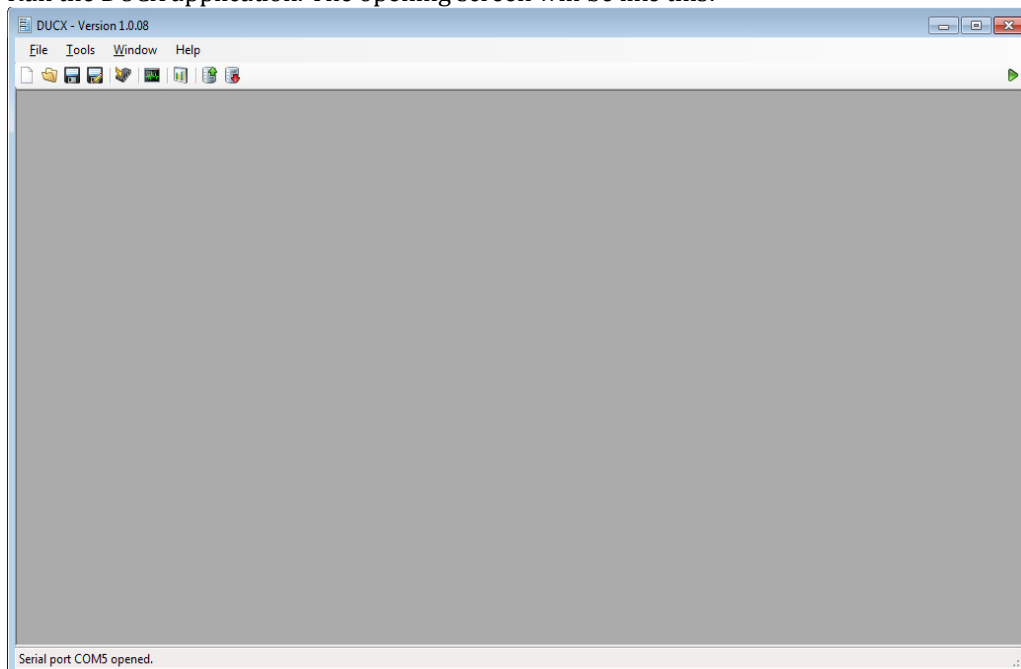


10. Click "Next". A warning will appear stating that the driver is not digitally signed. Click "Continue anyway"



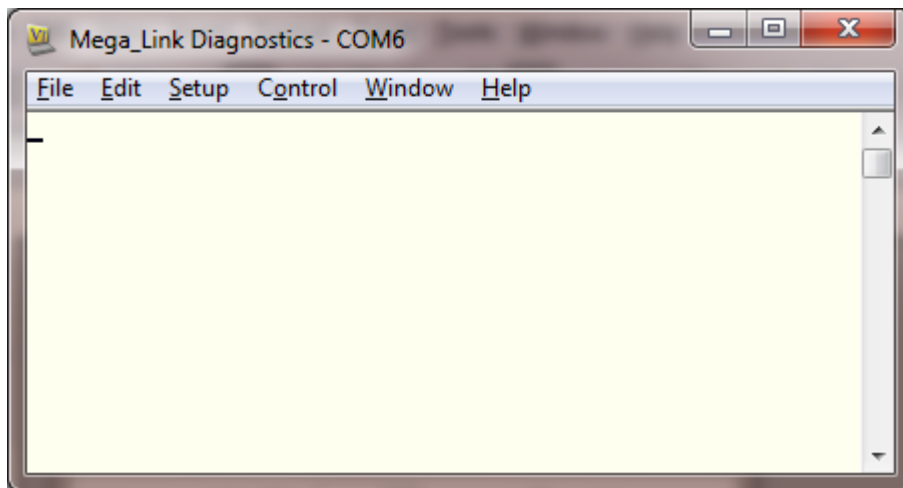


11. Click "Finish"
12. Repeat steps 3 to 11 for the second Virtual COM port driver.
13. Run the DUCX application. The opening screen will be like this:

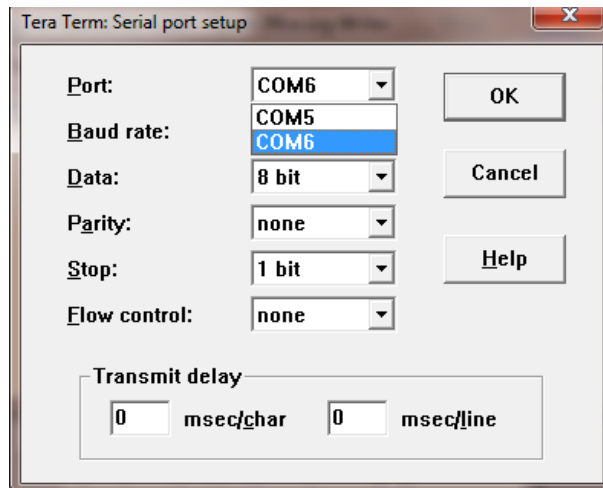


14. Note that the triangle in the top right corner of the screen is green if DUCX has established connection with a **Mega_Link**, otherwise it will be red. If DUCX has difficulty connecting it may be necessary to click on the triangle to re-establish connection.

15. Click on the Diagnostic Terminal icon (as illustrated by the red arrow). The following window will open:

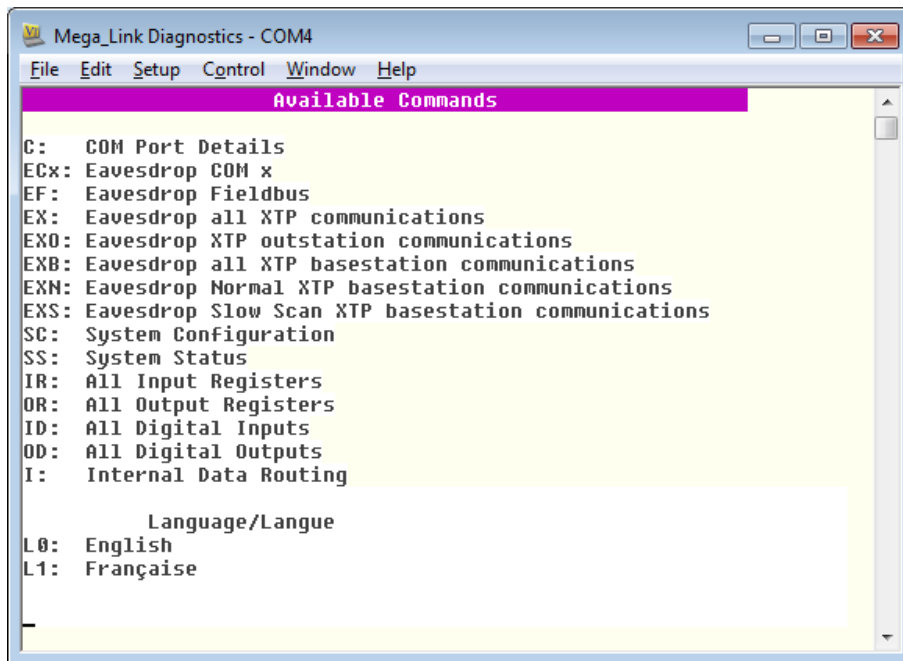


16. Note that the title bar indicates the default COM port that has been chosen. Click Setup/Serial Port, then



click on the Port box and note that two COM ports are offered:

17. Select the second COM port offered, then OK to return to the main window. Press the Return key and note a display similar to this:



18. If this display is not shown, repeat step 19 and select the other COM port. If the display is shown, select Setup>>>Save setup.. and save the configuration to the default location (TERATERM.INI).

The USB drivers and the software are now fully installed and ready for use.

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