CHURCHILL CONTROLS
www.churchill-controls.co.uk

Mega_Link 2

(AES-256 Encrypted Telemetry)

Telemetry & Control Secure Communication System

Technical Manual - Issue DRAFT 0.1i

Issue	Date	Revision
0.1f	05/07/23	Draft
0.1g	20/05/24	Ethernet etc.
0.1h	29/05/24	RS232 & RS485
0.1i	06/10/25	4G +Radio Dual Comms

Churchill Controls Ltd
Unit 30 Wellington Business Park, Dukes Ride, Crowthorne, Berkshire, RG45 6LS
Tel: +44 (0) 1344 750233
e-mail: sales@churchill-controls.co.uk

Table of Contents

1 Introduction & Overview

Mega_Link 2 is a versatile and secure telemetry communication system for passing two-way instrumentation, measurement and control data between industrial plant and equipment distributed over wide geographical areas and remote locations. Using a variety of communications media, including: de-regulated unlicensed UHF low power radio or the national mobile networks it removes the dependency for cables. It builds upon the success of the previous generation of the Mega_Link family with a proven track record and installed base within major utility companies over the past 10 years.

Mega_Link 2 offers secure telemetry transmission with all messages encrypted using the AES-256 data encryption standard in response to the UK implementing the NIS Directive through the Network and Information Systems Regulations (2018). The NIS Regulations apply to operators of essential services and Relevant Digital Service Providers (RDSPs). It offers cost effective, secure, robust and dependable performance, making it the ideal solution for your telemetry and control applications.

COM Ports

- ***COM1 and COM2*** can be fitted with a combination of the following communication interface modules:
  - 458MHz unlicensed UHF low power radio - option of class 1 receiver
  - 869MHz unlicensed UHF low power radio
  - 4G LTE CAT-1modem
  - V23 modem for private wire
  - R232 Serial I/F for external modem (e.g. ADSL, Satellite etc.)
- ***COM3A*** is serial RS232 interface or ***COM3B*** is serial RS485 interface:
  - Fieldbus interface to PLC/SCADA systems using Modbus RTU (master or slave)
  - Communications interface for external modem (e.g. ADSL, Satellite etc.)
- ***COM4*** is 10/100M Ethernet for IP communications;
  - LAN/WAN TCP/IP local or remote MQTT Broker (Amazon Web Services) across the internet
- ***COM5(USB1)*** is USB Host interface for logging to memory card or external modem
- ***COM6(USB2)*** is USB Device interface for configuration and diagnostics using DCD2 software

Security Features

- AES-256 Encryption for messages on all COMs interfaces
- TLS v1.2 for MQTT Amazon Web Services

Telemetry Interfaces

- I/O interfaces are compatible with a wide range of digital & analogue instruments and equipment such as volt-free contacts, depth transducers, flow meters and electrical switchgear:
  - 8 Digital Inputs (volt-free contact)
  - 8 Digital Outputs (relay contact)
  - 2 Analogue Inputs (fully isolated, 0...20mA), with a regulated 12Vdc transducer supply
  - 2 Analogue Outputs (0...20mA)
- I/O interfaces are expandable to add further physical inputs and outputs for larger system applications, using a range of expansion modules
- Power supply options:
  - Internal110/240Vac mains supply (with battery backup)
  - 12Vdc
  - 24Vdc
- DIN rail mounted for fitment in existing equipment racks or Churchill Controls can supply Mega_Link 2 along with expansion modules ready built into a range of standard IP67 enclosures for quick and easy installation

1.1 Advanced Features

- AES-256 cryptographic encryption for messages on all COMs interfaces
- Space for 2nd interface module to give Dual Comms operation for applications requiring extra resilience
- RS232/RS485 port for interface to PLC and SCADA equipment using industry standard fieldbus protocols
- Digital and analogue exception reporting for alerting change of conditions past pre-determined thresholds
- Outstations can also be configured to operate in a repeater mode to relay two-way radio communications over extended distances and overcome otherwise challenging geographical features and locations
- Versatile and user configurable; communications failure, battery condition and RSSI monitoring functions
- Built-in colour LCD display and joystick user interface for easy monitoring of status and operation
- USB programming port for connection to a Windows based PC or tablet running DCD 2 software for setting up system configurations, data routing tables, detailed status monitoring and diagnostics etc.

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 10Ω).

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

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

16-channel Digital Input Expansion Module	7850-1
16-channel Digital Output Expansion Module	7850-2
8-channel Analogue Input Expansion Module	7860-1
4-channel Analogue Output Expansion Module	7870-1

Mega_Link 2 is configured using DCD 2 software, which can be downloaded at no charge and will run on any PC and interfaces via USB.

DCD 2 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 2 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 and diagnosis.

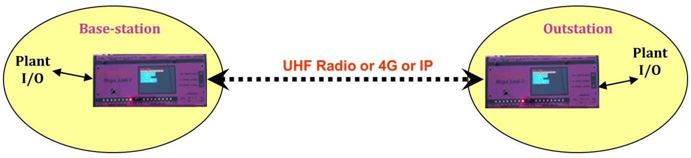
The integral back-lit LCD display allows the user to examine and modify the system configuration, monitor all inputs and outputs, eavesdrop all data being transmitted and received, view the system status and diagnose operation.

Mega_Link 2 operates using AES-256 encryption of data in-transit over a proprietary protocol optimised for radio telemetry and can function as a basestation, an outstation, a Fieldbus master or a Fieldbus slave.

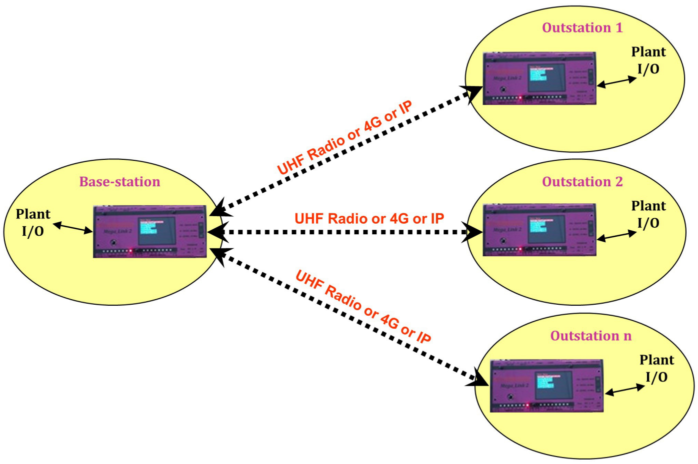
Each Mega_Link 2 maintains a database of analogue and digital values. Local plant I/O is mapped into the database. The user can configure each unit to copy registers within the database, and to copy registers to/from Fieldbus devices.

1.2 Application Examples

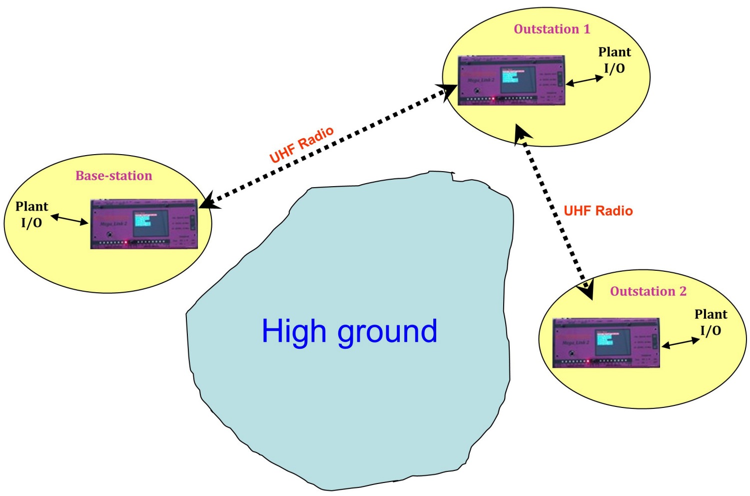
A simple low-cost point to point telemetry system, where inputs from a plant at the outstation are replicated as outputs at the basestation and vice versa:



A simple low cost multipoint to single point telemetry system:



Basestation to Outstation 20 via Outstation 10 (Repeater) system:



1.3 Principle of Operation

In a telemetry system, one unit is designated as the "Basestation" and this is given address #0. The basestation is usually located at the control room or place where data is to be mostly sent.

One or multiple outstations are allocated addresses #10, #20, #30 etc. These are usually located at more remote sites where data, in terms of Analogue & Digital signals, is typically collected from.

The Mega_Link 2, like it's predecessors, the Mega_Link 1, Micro_Link & Nano_Link is primarily designed for communications using licence exempted low power UHF radio. The operating principle for licence exempt radio is to minimise the duration and minimise the duty cycle of radio transmissions.

All Mega_Link 2 units must be set to the same frequency and multiple simultaneous transmissions would result in collisions and self-interference. Hence, Mega_Link 2 works on the basis of command and response where the designated "Basestation" unit will talk first by sending a command message to an outstation address and "Outstations" will only respond when they receive a message that matches their pre-configured address.

The basestation effectively controls the timing and ordering of all transmissions and data exchanges in a system.

The basestation is configured with a scan rate. The most typically used is 10 seconds, although this can be changed for other types of communication media choice.

In a single-point to single point telemetry system, the basestation will scan just outstation #10 every 10 seconds.

In a multipoint to single point telemetry system, e.g. with three outstations, the basestation will scan outstation #10, then 10 seconds later it will scan outstation #20, and 10 seconds after that it will scan outstation #30, Hence, effectively, each of the three outstations will be scanned every 30 seconds.

1.4 Modes of Operation

Single Comms

Mode	Primary	Bus_Link
Radio (RC458)	COM1 (RC458)	COM3A or COM3B
Radio (RM458)	COM1 (RM458)	COM3A or COM3B
Radio (RM869)	COM1 (RM869)	COM3A or COM3B
4G LTE Cat-1 (Sierra)	COM1 (Sierra Wireless RC7620-1)	COM3A or COM3B
4G LTE Cat-4 (Telit)	COM1 (Telit CMBX100A0-WW CAT4)	COM3A or COM3B
RS232	COM3A (RS232)	Not available
RS485	COM3B (RS485)	Not available
Ethernet	COM4 (Ethernet)	COM3A or COM3B

Dual Comms

Mode	Primary	Secondary	Bus_Link
Radio (RC458) + Radio (RC458)	COM1 (RC458)	COM2 (RC458)	COM3A or COM3B
Radio (RM458) + Radio (RM869)	COM1 (RM458)	COM2 (RM869)	COM3A or COM3B
4G (Sierra) + Radio (RC458)	COM1 (Sierra)	COM2 (RC458)	COM3A or COM3B
4G (Telit) + Radio (RC458)	COM1 (Telit)	COM2 (RC458)	COM3A or COM3B
Radio (RC458) + RS232	COM1 (RC458)	COM3A (RS232)	Not available

Radio (RC458) + RS485	COM1 (RC458)	COM3B (RS485)	Not available
Radio (RC458) + Ethernet	COM1 (RC458)	COM4 (Ethernet)	COM3A or COM3B

Key:

RC458 = RadioCrafts 458MHz,

RM458 = RadioMetrix 458MHz,

(RadioMetrix 869MHz in future).

4G = Sierra Wireless RC7620-1, (Telit CMBX100A0-WW CAT4 in future). Local Network (TCP/IP) (or Remote Network (MQTT) in future).

Ethernet = Local Network (TCP/IP) (or Remote Network (MQTT) in future).

1.5 Purpose of this Manual

This manual is intended to give the installer, user and maintenance personnel all the information they are likely to need for implementing telemetry systems using the Mega_Link 2 product range.

The new Mega_Link 2 product is based on a combination of the previous Mega_Link 1 and its predecessors, the Micro_Link & Nano_Link product ranges.

The Mega_Link 2 is subject to continuous evolution, so new features are constantly being added by a combination of software enhancements and new hardware modules.

Some of the features described may not be available, or may function slightly differently, in earlier software versions. However, it is Churchill Control's policy to ensure that wherever possible software is backward compatible. This means that wherever possible the features described will be present in all future software issues.

The current software version installed within the Mega_Link 2 can be seen via the user interface LCD display in the System Configuration >> System Information menu. Or by running DCD 2 Diagnostics on a PC connected to the USB port on the Mega_Link 2 and examining the Station Status by pressing the 'S' key. The software version of the DCD 2 Configuration Tool can be examined by selecting 'About DCD Configuration' from the Help menu.

Before shipping a purchased Mega_Link 2 system, Churchill Controls will configure it to their best understanding of the specific customer application requirements, and test it as a complete system. After installation it should therefore begin operation immediately. If the configuration does not meet the requirements of the application or things require to be changed, then the user can either contact Churchill Controls for support or self modify the configuration.

The configuration is defined and downloaded to Mega_Link 2 using the DCD 2 configuration & diagnostics tool software programme on a laptop.

1.6 Software Versions and DCD 2 Compatibility

Software version V0.1.34 and before require DCD 2 version 0.6.

Software version V0.1.35 to V0.1.39 requires DCD 2 version 0.7.

Software version V0.1.40 onwards requires DCD 2 version 0.8.

Software version V0.1.44 onwards requires DCD 2 version 0.9.

Unfortunately, DCD 2 files cannot be transferred between different versions hence they must be re-written from scratch.

FW	DCD 2
V0.1.27 – V0.1.34	0.6

V0.1.35 - V0.1.39	0.7
V0.1.40 – V0.1.43	0.8
V0.1.44 -	0.9

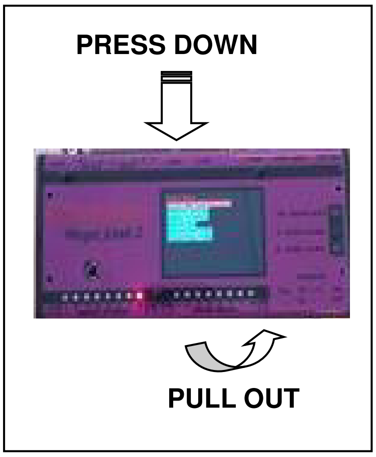
2 Specifications

Mechanical:	Size 150w x 125h x 110d, DIN rail mounting
Power Supply:	Mains: 100…250VAC, 50VA max (including 15WH battery back-up) 12VDC: 10…16VDC, 24W max 24VDC: 20…32VDC, 30W max
Electrical Connections:	Pluggable 2.5mm² screw terminals
Current Consumption:	From 12V supply: Awake: < 500mA
Power Output:	12V +/-0.5V @ 100mA to power external transducers
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. Regulated 12Vdc output for transducer excitement.
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, up to 15km, depending on topography and aerial system UHF 869MHz, 500mW, up to 8km, depending on topography and aerial system 4G LTE Cat 1 cellular radio modem (Quad band) Leased line V23 modem RS232 serial
COM3:	Configurable RS232 or RS485 for fieldbus or external modem communications
COM4:	10/100M Ethernet for IP communications
COM5 (USB1):	USB-A Host interface for logging to memory card or external modem
COM6 (USB2):	Mini-USB Device interface for configuration & diagnostics using DCD 2 software
Display:	320 x 240 colour TFT with adjacent joystick
I/O Expansion Modules:	Module size: 57w x 125h x 110d, DIN rail mounting Max number: 32 Digital Input: 16 inputs, designed to interface from volt-free contacts. Digital Output: 16 outputs, volt-free relay contacts rated at 125Vac/1A, 60Vdc/1A. Analogue Input: 8 fully isolated inputs calibrated 0…20mA into 10Ω, 0.025% resolution, 0.1% accuracy Analogue Output: 4, fully isolated outputs calibrated 0…20mA into 500Ω max, 0.025% resolution, 0.1% accuracy
System Capabilities:	No of outstations: 249 max per basestation No of repeaters: 8 max on any path
Fieldbus/Bus_Link Protocols:	Modbus RTU Master or Slave
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

2.1 Mechanical

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

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



2.2 Polycarbonate Enclosures

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

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

Larger systems can be supplied in steel enclosures if required.

2.3 Security

2.3.1 Mega_Link2 Operation

Mega_Link2 is intended for use as a local telemetry and control system either operating stand-alone or on the periphery of a utility companies' wider network of telemetry and control infrastructure.

A normal Mega_Link2 application comprises a basestation and one or more associated outstations. The basestation communicates with each outstation in turn to exchange low level digital and analogue measurement and control signals.

Fundamentally, Mega_Link2 is used to exchange 4-20mA analogue and discrete digital signals between different locations over a common transmission link in a peer to peer arrangement; physical signals go in one end and are relayed to come out at the other end of the link.

These low-level signals are normally interfaced to customer specific equipment at the analogue and digital hard-wired physical level and can also be interfaced to PLC/SCADA systems using serial Modbus RTU or similar.

Mega_Link2 incorporates industry standard AES-256 encryption for secure communications of the messages which represent the analogue and digital signal data whilst in-transit between the basestation and outstation(s) over which ever communications media option(s) is being used, see later section.

2.3.2 Mega_Link2 AES-256 Encryption

Mega_Link2 incorporates AES-256 encryption for secure communications between basestation and outstation(s).

AES-256 is a highly secure symmetric encryption algorithm, developed by the National Institute of Standards and Technology (NIST), that uses a 256-bit key to encrypt data, making it virtually unbreakable for current computing capabilities.

Mega_Link2 is based around a Renesas S5D9 Synergy family MCU which incorporates a Secure Cryptographic Engine (SCE7) module to provide security functions. This “hardware encryption engine” module consists of an access management circuit, encryption engine and random number generator. In combination with the Renesas Synergy Software Package (SSP) Crypto library, the SCE7 can prevent eavesdropping (confidentiality), falsification of information (integrity), and impersonation (authenticity).

Encryption engine Advanced Encryption Standard (AES): Compliant with NIST FIPS PUB 197 algorithm.

- Key size: 256 bits
- Block size: 128 bits
- Chaining modes

  - ECB, CBC, CTR: Compliant with NIST SP 800-38A

  - GCM: Compliant with NIST SP 800-38D

  - XTS: Compliant with NIST SP 800-38E

  - GCTR.

2.3.3 NIS Cyber Security Compliance Strategy

In the context of the Network and Information Security Directive 2 (NIS2) and UK cybersecurity, AES-256 encryption is a widely recognized and robust method for protecting data, ensuring compliance with the directive's stringent security requirements, especially for essential and important entities.

By implementing and adopting Mega_Link2 with AES-256 encryption, organizations can demonstrate their commitment to data security and meet the requirements of NIS and Cyber Assessment Framework (CAF).

2.3.4 AES-256 Key Management

The Mega_Link2 equipment is shipped to a customer with a default or “factory” encryption key. If requested it can also be supplied with a customer specific encryption key. Obviously, this will be known to Churchill Controls.

The USB interface can be used with a laptop running a small utility programme to download a new “Custom” encryption key file. After commissioning, for utmost security, it is recommended that customers should install their own “known only by them” encryption key file and then periodically update or rotate keys according to their company’s NIS key policy.

3 Part Numbering System

Mega_Link 2 can be configured with a variety of power supplies and communication interfaces.

The part number defines the build variant.

The basis part number is 7800 and this is followed by a suffix of 4 characters to define the options.

The complete part number is thus **7800-abcd**:

a	Power Supply	A	AC mains
		1	12V
		2	24V
b **c**	COM1 Interface COM2 Interface	4	Radiocrafts 458MHz Digital UHF Radio
		5	Radiometrix 458MHz Digital UHF Radio
		8	Radiometrix 869MHz Digital UHF Radio
		G	4G LTE Cat-1
		L	Leased line modem
		R	RS232 Level Interface
		M	RS232 CMOS Level Interface
		0	No interface
d	Display	D	LCD display fitted

Expansion Modules and Accessories:

16-channel Digital Input Expansion Module	7850-1
16-channel Digital Output Expansion Module	7850-2
8-channel Analogue Input Expansion Module	7860-1
4-channel Analogue Output Expansion Module	7870-1
Aerials	Various, depending on application
Aerial downlead cable	Per metre
Aerial mounting poles, brackets and hardware	Various, depending on application
Surge and lightning protection units	Mains power, aerial and leased line

4 System Concept

4.1 Hardware

Mega_Link 2 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 “plug-in” COM ports (COM1 & COM2) that can be fitted with any of a range of interface modules.
- A serial port COM3 that can be configured as an RS232 or an RS485 interface.
- A power supply chosen from the following: AC mains with battery back-up, 12VDC or 24VDC.
- A USB2 (Device) 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.
- An expansion port for connecting expansion modules to increase the I/O count. The following add-on expansion modules are available:
  - 16-channel digital input
  - 16-channel digital output
  - 8-channel analogue input
  - 4-channel analogue output

4.2 Software

Mega_Link 2 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_Link 2 units can be used to create a telemetry system. The units will communicate with each other via any of their communication interfaces. One unit must be configured as a basestation and the others will act as outstations and/or repeaters.

The user can configure the system via the DCD 2 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 basestation.

Each Mega_Link 2 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 2 is its ability to communicate via dual paths. For example, it could be configured to communicate via radio and leased line. A basestation 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 basestation 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 Mega_Link 2 Protocols

When Mega_Link 2 is configured as a basestation it will communicate with outstations in the system using a message protocol which is proprietary to Churchill Controls and is then overall encrypted using the industry standard AES-256. All Mega_Link 2 units within the system obviously must share a common encryption key.

1. The user must define the COM port(s) on which units will send and receive messages.
2. Repeaters: A basestation 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.
3. System Address: In addition to a station address, each unit is configured with a system address. Mega_Link 2 will only act on successfully decrypted 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.
4. Time Synchronisation: Commands sent from a basestation include the time, according to the real-time clock within the basestation. Each outstation synchronises its clock to that of the basestation.

When Mega_Link is configured as a Fieldbus master or slave the user must define the protocol and the COM port on which it is to communicate.

4.4 Configuration and Diagnostics

Mega_Link 2 is configured using DCD 2, which is an application that will run on any computer running Microsoft Windows. DCD 2 is provided free-of-charge, and in addition to allowing the user to configure Mega_Link 2 it also allows the user to upgrade the firmware and to carry out diagnostics.

Diagnostics is a very powerful and useful feature of Mega_Link 2 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 offered by DCD 2, the Mega_Link 2 also incorporates various LEDs and a colour LCD display and joystick. The LEDs give an immediate indication of the status of the system.

The LCD display emulates many of the features provided by DCD 2 without the need to connect a PC.

It also facilitates additional features, such as system calibration.

4.6 Compatibility

4.6.1 Hardware Compatibility

The Mega_Link 2 physical dimensions and mounting arrangement is directly compatible with Mega_Link.

4.6.2 Power Connector Compatibility

The Mega_Link 2 power connector and power characteristics are directly backward compatible with Mega_Link.

4.6.3 I/O Connector and I/O Compatibility

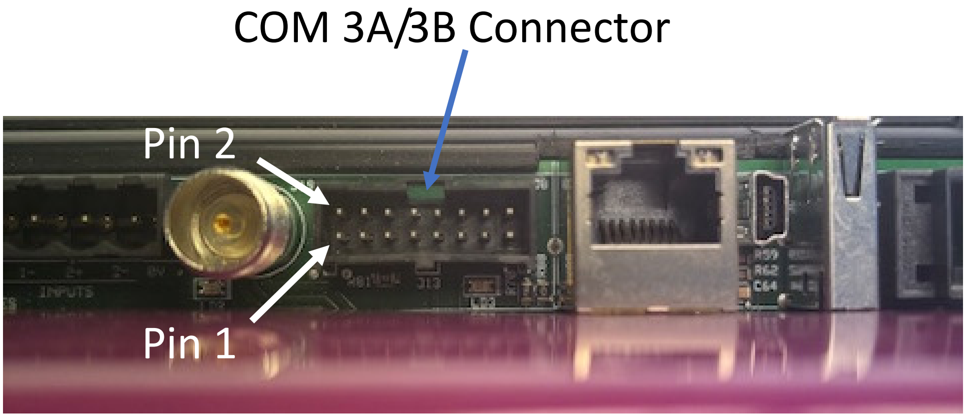
The Mega_Link 2 I/O connectors and I/O characteristics are directly backward compatible with Mega_Link.

4.6.4 RF Compatibility

Although the RF channel frequencies and power levels are the same, the Mega_Link 2 is not backward compatible with Mega_Link at the RF and data messaging level by virtue of the addition of AES-256 encryption on messages.

4.6.5 COM3 Fieldbus Compatibility

The Mega_Link 2 is compatible with Mega_Link on the COM3 for Fieldbus/Bus_Link communications on RS232/RS485. Because of space constraints the main connector arrangement is different. However, an adapter is available to make it directly compatible with the RJ45 style connector as used on Mega_Link1 and Micro_Link. This is highly recommended.



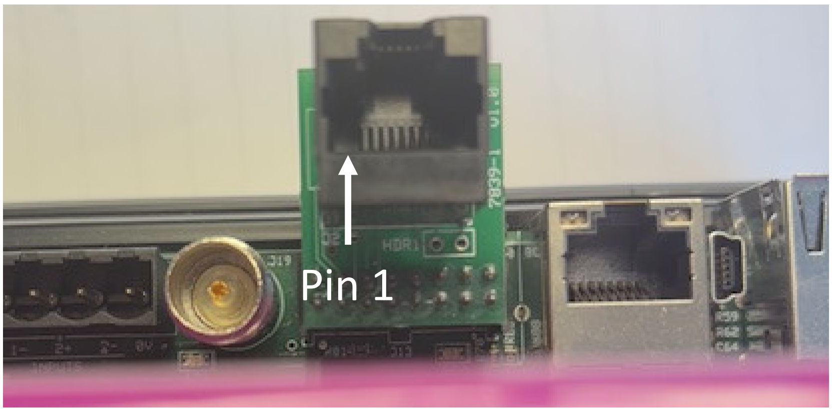
Wire Connector type: 16-pin Female Connector, MOLEX 90142-0016 and crimp terminal 90119-2120

Pin	Function	Notes
1	0V	Ground
2	RS485 B (D+)	Differential In/Out
3	RS485 T	Termination Resistor (connect to RS485 B if used)
4	RS485 A (D-)	Differential In/Out
5	RS232 TXD	Output from Mega_Link 2
6	RS232 RXD	Input to Mega_Link 2
7		
8		
9		
10		
11		
12		
13		
14		
15		
16	0V	Ground

Mega_Link 2 COM 3 Adaptor Board, part number 7839-1.

This provides an RJ45 socket which is compatible with the interface of Mega_Link 1and Micro-link units.

COM 3A/3B Adaptor



Pin	Function	CAT5 Colour	Notes
1	0V	White/Orange	Ground
2	RS485 B (D+)	Orange	Differential In/Out
3	RS485 T	White/Green	Termination Resistor (connect to RS485 B if used)
4	RS485 A (D-)	Blue	Differential In/Out
5	RS232 TXD	White/Blue	Output from Mega_Link 2
6	RS232 RXD	Green	Input to Mega_Link 2
7			
8			

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 2 is located at one end of the cable an internal 120Ω terminating resistor can be connected by linking terminal RS485T to RS485B.

5 Overview

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 2. 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 2 incorporates an internal power supply module. The type of power supply is indicated by a marker on the cover. Note that there is an ON/OFF switch on the low voltage side, between the output of the power supply and the internal circuitry.

The mains powered version includes battery back-up so the system can continue operation through power failures. When mains power is available the internal batteries remain on charge even when the ON/OFF low voltage switch is in the OFF position.

The low voltage output of the internal power supply is fed internally to the Mega_Link 2 motherboard, via the ON/OFF switch. The motherboard will operate from any supply in the range 4...16VDC, and derives from this its internal power rails and also generates a switched 12V supply which powers the analogues and the digital output relays. This supply is also capable of powering external transducers.

When required it also generates an internal +5V for the Ethernet and USB interfaces and powering of additional I/O expansion modules at +5V.

5.2.1.2 Display

Mega_Link 2 incorporates various LED's and an LCD display.

5.2.1.3 Communication Interfaces

One or two communication interfaces can be fitted inside Mega_Link 2.

Unlike Mega_Link 1 the type of interface module fitted must be enabled or selected by the configuration settings on <u>both</u> the basestation and the outstation using DCD 2. After this is done, the type of communication interface(s) which are fitted and enabled can subsequently be viewed via the LCD display.

5.2.1.4 Expansion Modules

Mega_Link 2 can be expanded by adding I/O expansion modules. These connect to it through short jumper leads. Each expansion module has DIP 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 the first one set to 00. This is irrespective of module type.

5.2.2 Software Configuration Summary

Mega_Link 2 is configured from a PC running DCD 2 software. This can be provided on a USB stick upon request or can be downloaded from our website at www.churchill_controls.co.uk.

DCD 2 allows numerous features to be configured including:

5.2.2.1 Basestation Mode

In Basestation Mode Mega_Link 2 will instigate communications with outstations via a defined COM port (or dual COM ports) and respond to replies from them.

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

In Outstation Mode (i.e. non Basestation selected) Mega_Link 2 will function as an outstation, so will respond to any commands received from a basestation on its pre-configured COM port(s).

5.2.2.2 Fieldbus/Bus_Link Mode

In Fieldbus/Bus_Link Slave Mode Mega_Link 2 will function as a slave and will respond to any commands received from a master on the enabled COM3 port and selected protocol.

In Fieldbus/Bus_Link Master Mode Mega_Link 2 will instigate communications with slave devices via the COM3 port and respond to replies from them. Part of the configuration is to define the protocol to be used.

In Master Mode the user must define which slave devices are in use, and the data commands to be passed between them, as data mapping in the DCD2 configuration file.

5.2.2.3 Miscellaneous Parameters

Other parameters may need to be configured, such as radio channel, baud rate and TCP/IP addresses etc.

5.3 Diagnostics

5.3.1 Indicator LEDs

Mega_Link 2 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 green when the port is sending data and red when the port is receiving data, hence during normal communications a Basestation will briefly flash Green then Red and an Outstation will flash Red then Green.

5.3.1.2 +12V Power Monitor LED

This yellow LED is situated in the top right-hand side of the Ethernet socket of COM4.

5.3.1.3 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 DCD 2 Diagnostics

When a PC is plugged into the USB1 port and DCD 2 is opened, selecting Diagnostic Terminal on it will open a new window that allows the user to select various diagnostic modes. Pressing ? shows a list of the available commands.

5.4 Power and 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

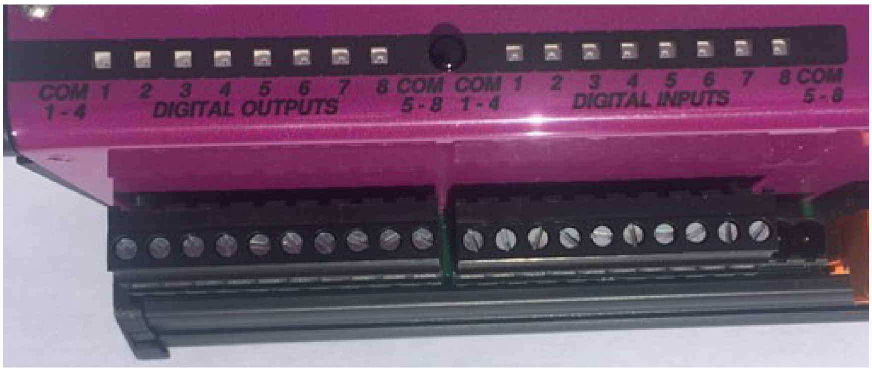
The supply used must match the marker in the top cover. Power is connected via the orange connector. The output of the internal power supply is fed through the ON/OFF switch to the internal circuitry and to the Vin/Vout connector. The voltage on this connector could be anywhere in the range 4.0V...16.0V.

If 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.

Wire Connector type: 2-pin Female Connector, WEIDMULLER 1281760000

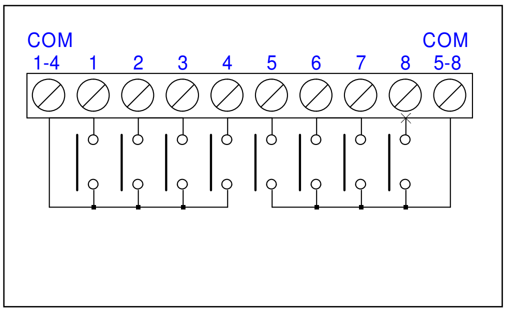
Pin	110/240 AC Mains Operation	12V DC Operation	24V DC Operation
1	Live	+12V	+24V
2	Neutral	GND	GND

5.4.2 Digital I/O



5.4.2.1 Digital Inputs

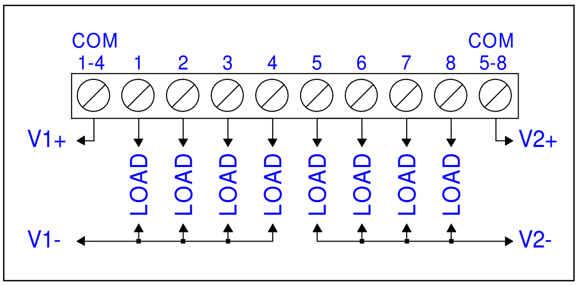
There are eight digital inputs, in two groups of four. Each group shares a common return terminal which is connected to the system 0V rail. The inputs are designed for operation from volt-free contacts.



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.

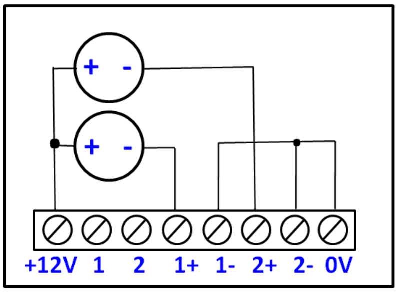
All outputs are volt-free relay contacts rated 125VAC @ 0.3A, 24VDC @ 1A. All contacts include surge protection devices which clamp the maximum voltage across open contacts to 170V to prevent arcing when switching inductive loads. However, it is recommended that any DC inductive loads (e.g. interposing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



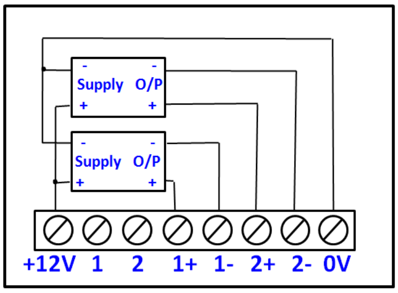
Analogue I/O

5.4.2.3 Analogue Inputs

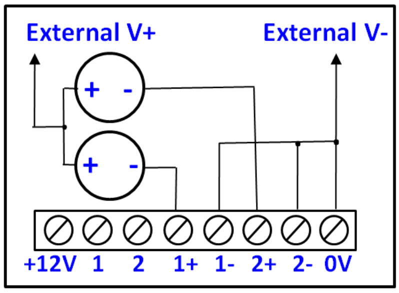
There are two analogue inputs, each with an input resistance of 10Ω, calibrated 0…20mA. Both inputs are fully isolated and can withstand common-mode signals of up to +/-240V. Note that high common mode AC voltages may give reading errors so should be avoided by ensuring that current loops are referenced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



Analogue inputs.
Powered from ***Mega_Link***



4-wire transducer inputs.
Powered from ***Mega_Link***

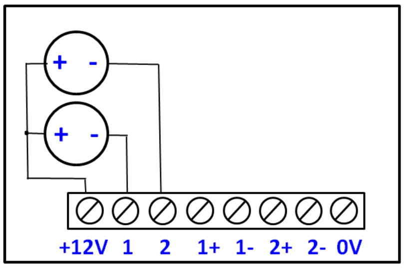


Analogue inputs.
Powered externally.

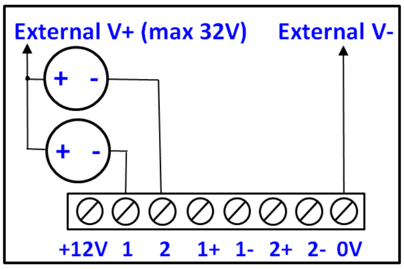
The 12VDC output can be used for powering external transducers, if required. An LED adjacent to the connector shows when 12V is available.

5.4.2.4 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 together to a positive supply (normally the system's 12VDC supply, but an external voltage source can be used if required).



Analogue outputs.
Powered from ***Mega_Link***



Analogue outputs.
Powered externally.

5.4.3 Aerial

If Mega_Link 2 is fitted with one or more radio interfaces 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 2 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 basestation and at least one outstation. Each is physically identical, but its mode of operation is defined by a DCD 2 Configuration file downloaded to it from a PC running DCD2 software.

5.5.1 DCD 2 Configuration

DCD 2 can be used to create configuration files, save them to disc, download them to a Mega_Link 2 or upload them from Mega_Link 2. It can also be used for diagnostics, as outlined above.

For convenience it is often practical to use DCD 2 to create configurations in the office, then save them to disc before going to site to download them into Mega_Link 2.

5.5.2 DCD 2 Diagnostics

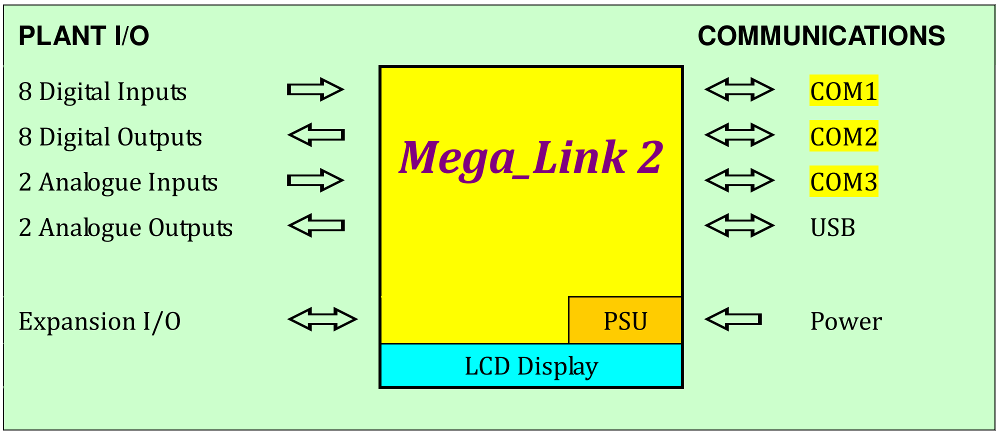
DCD 2 Diagnostics are relatively easy to use, and can be used to confirm the correct operation of a system and to pinpoint faults. Enter diagnostics mode by clicking on the Diagnostic Terminal icon.

Pressing ? RETURN will display a list of available commands. Useful commands include:

- D is for monitoring all data communications between a basestation and outstation. It will display any message originating from the Mega_Link 2 or received by it. It will also indicate the port on which the message is sent/received.
- B is a similar command to monitor all Fieldbus/Bus_Link messages.
- S shows a continually-updated list of the status.

6 Communication Interfaces

The modular construction of Mega_Link 2 provides multiple 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.

COM6 is a USB port providing a serial connection to a PC for use by the DCD 2 configuration software

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.

6.1 Radio Communications

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 2 allowing the following radio networks to be used:

6.1.1 458 MHz Digital UHF Radio

The IR2030/2/6 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 2 can be configured to use this band by fitting a 7501-RCA UHF radio in one or both of its COM ports.

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

It can be configured to operate at any of 32 channels in the band 458.5125…458.9250MHz, as designated in the UK standard IR2030/2/6, so can be used licence-exempt anywhere in the UK.

Channel	Frequency
1	458.5125MHz*
2	458.5250MHz*
3	458.5375MHz*
4	458.5500MHz*
5	458.5625MHz*
6	458.5750MHz
7	458.5875MHz
8	458.6000MHz
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	458.7500MHz
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	458.9000MHz
31	458.9125MHz
32	458.9250MHz

* Shaded frequencies are recommended to be avoided due recent announcement from Ofcom that these are also to be shared use with UK sites licences.

6.1.2 869 MHz Digital UHF Radio

CEPT Recommendation 70-03 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 2 can be configured to use this band by fitting a 7506-2 UHF radio in one or both of its COM ports.

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 300mW (+25dBm) 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 6km.

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

6.1.3 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 4G Mobile Network

Mega_Link 2 can be configured to use this interface by fitting a 7512-1 4G Radio Modem in its COM1 port position.

This radio modem operates on the cellular phone network, so provides unlimited range in most countries of the world. Mega_Link 2 uses the modem in 4G mode which allows data to be sent over the network using TCP/IP internet protocol.

4G modems use SIM cards similar to those used in a cellular phone to allow access to a defined mobile network (e.g. Vodafone or EE). However, standard GPRS SIMs allocate an IP address that may change each time the device is powered up. Mega_Link 2 needs to use fixed IP SIMs so each device has a known IP address that can be used to route data to it, SIMs also need to be set for peer to peer communications and it is recommended that only SIM cards set up and supplied by Churchill controls are used.

In addition to the station address and system address used to identify outstations, Mega_Link 2 also needs to know the IP address so messages can first be routed via the mobile network. When an outstation receives a command from a basestation it can derive the basestation's IP address from the message content, so it can route responses back to it. Therefore, only the basestation needs to be programmed with the IP addresses.

6.1.5 7504-1 V23 Leased Line Modem

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

6.2 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 basestations 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.

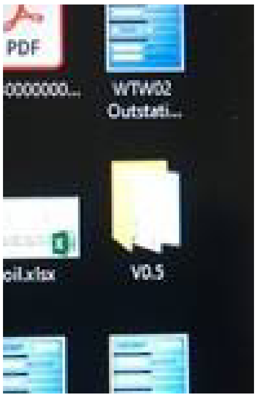
7 Configuration

Each Mega_Link 2 needs to be configured via a PC running DCD 2 software, connected to the USB port.

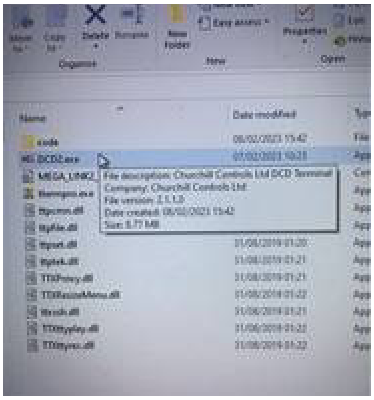
Outstations need minimal configuration, since all data routing is configured through the basestation.

The DCD2 software tool is used to configure and diagnose problems on Mega_Link 2. It comprises a software package running on a PC for DCD2 Configuration and DCD2 Diagnostics. It is supplied on a USB stick and is compatible with Windows 11.

There is no need to install the software, simply copy the folder containing the latest version over to your PC, e.g. to the desktop:



Navigate to the chosen location, e.g. on the desktop and double click on the copied folder to open and view into the folder, then highlight and double click on the “DCD2.exe” file.



Using a USB-Mini to USB-A cable, connect a spare USB port from the PC to the COM (USB1) port on Mega_Link 2.

Note that a DCD2 Configuration can be run without connection to Mega_Link 2, allowing configurations to be created and saved to disc before going to site.

The parameters that require configuration can be summarised as follows:

7.1 System configuration

The user needs to define the characteristics of the interface type, depending on the type of interface at both the basestation and the outstation:

- 458MHz or 868MHz UHF Radio: Channel, aerial type, cable type, cable length
- 4G LTE Cat-1: APN, User Name, Password (for use in COM1 only)

COM3 also needs some configuration:

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

COM4 also needs some configuration:

- Ethernet: IP address etc.

7.2 Polling

A basestation interrogates all its outstations at a defined rate. Each interrogation comprises a command to the outstation followed by a response from it. If the basestation 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 that outstation.

The poll rate is configurable, so the user can define the rate at which outstations are scanned but normally this can be left at 10 seconds (which is the fastest setting).

Each command message which is transmitted includes the current time, which is used to synchronise all clocks. The outstation response includes flags that notify the basestation of its configuration and status.

7.3 Example Configuration Set-Up (458MHz RadioCraft Radio)

7.3.1 Basestation and Outstation Mode (458MHz RadioCraft Radio)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basetation only.

d) A primary COM port selection at the basestation and each outstation.

e) A radio module type selection at the basestation and each outstation.

f) A Network Protocol selection at the basestation and each outstation.

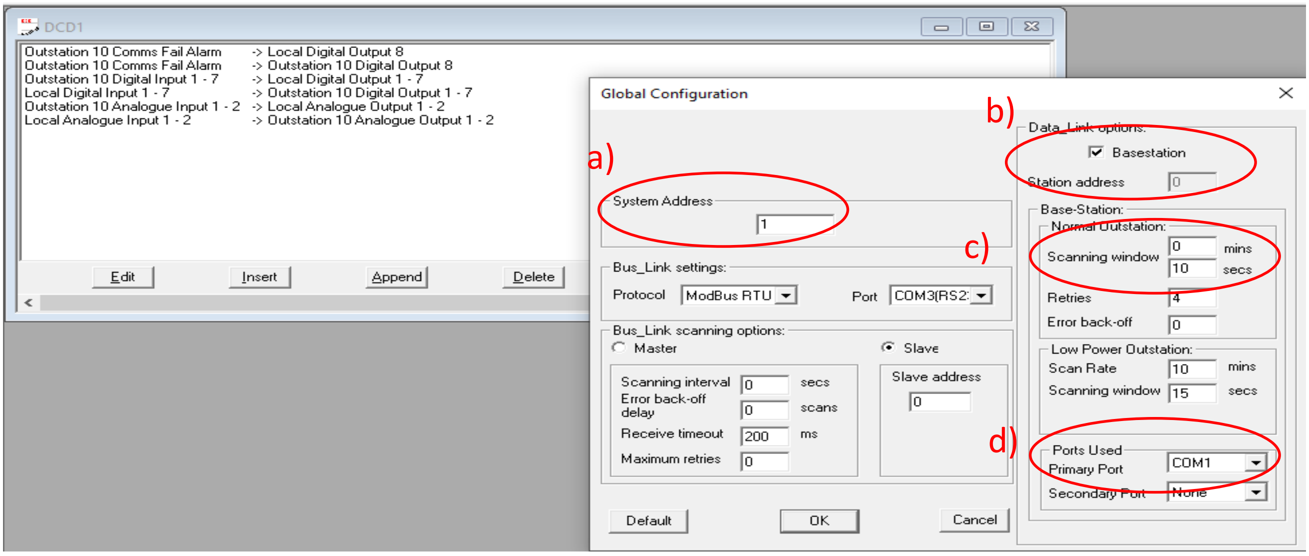
g) A common Radio Channel selection at the basestation and each outstation.

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion. First the basic 458 MHz UHF radio configuration settings a) to g) will be described and then the standard one to one signal routing configuration will be explained.

7.3.2 Basestation Set-Up Example (458MHz RadioCraft Radio)

Entries a) to d) are set in the "Global" configuration screen as follows:



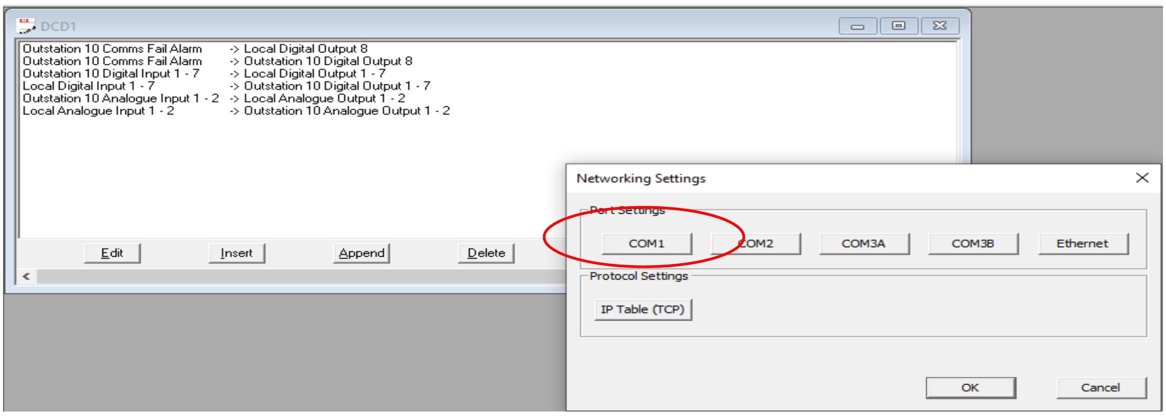
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

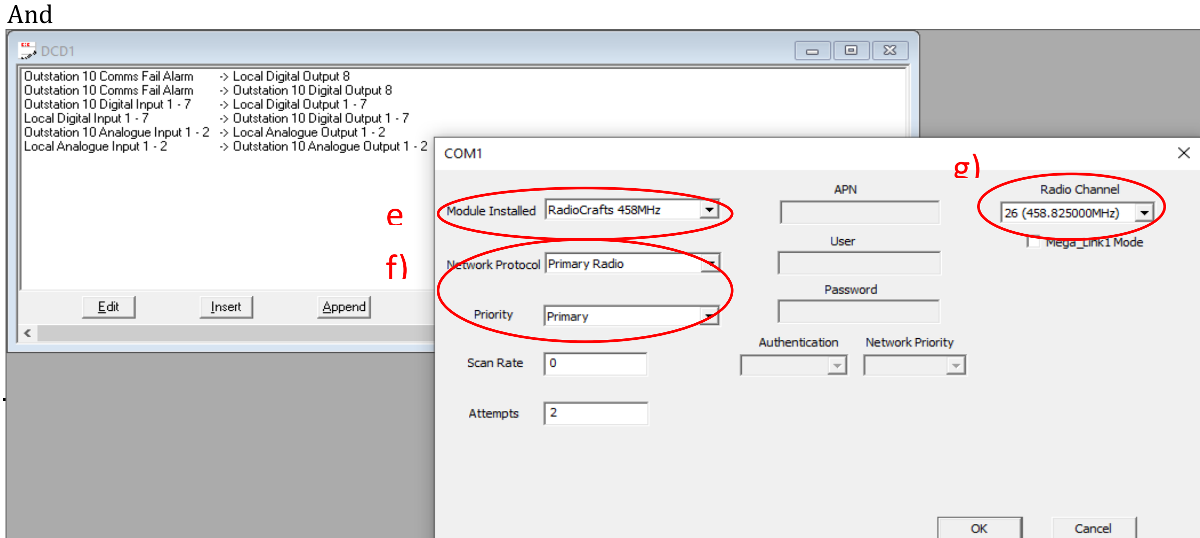
c) Scanning Window = 10 secs

d) Primary Port selection = COM1

Entries e), f) and g) are set in the "COM1" configuration screen which is found by clicking on the "COM1" button in the "Network Settings menu as follows:



And



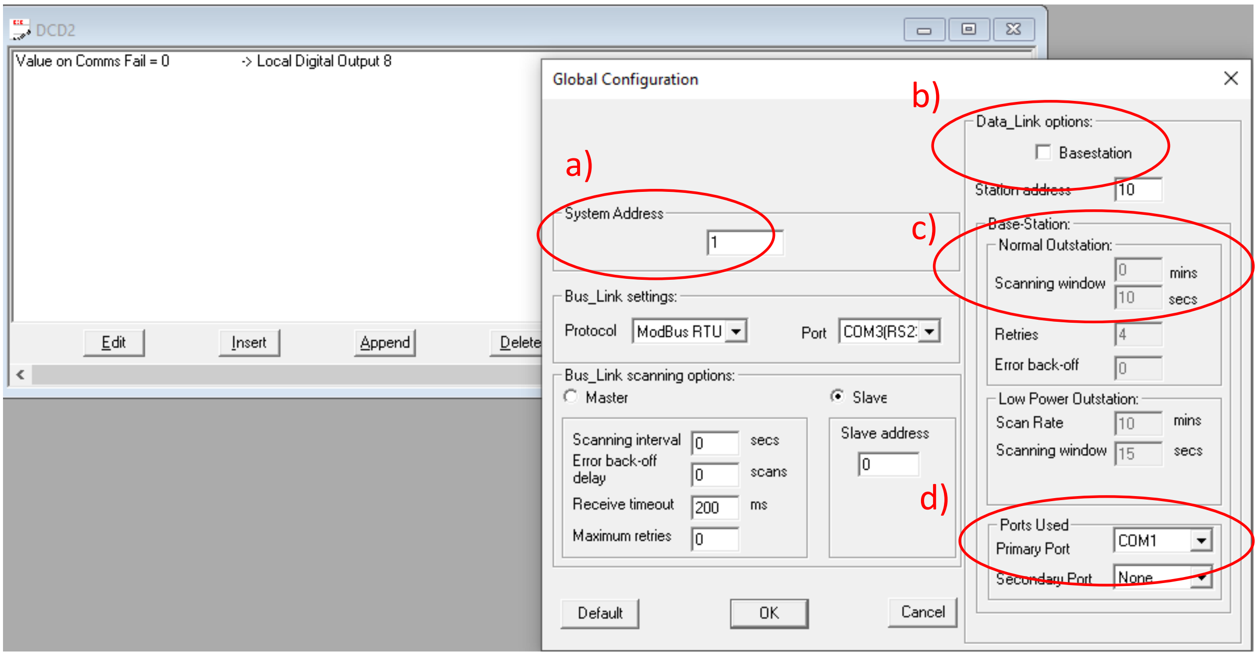
e) Module Installed = RadioCrafts 458MHz

f) Network Protocol = Primary Radio and Priority = Primary

g) Radio Channel = 26

7.3.3 Outstation Set-Up Example (458MHz RadioCraft Radio)

Entries a) to d) are set in the "Global" configuration screen as follows:



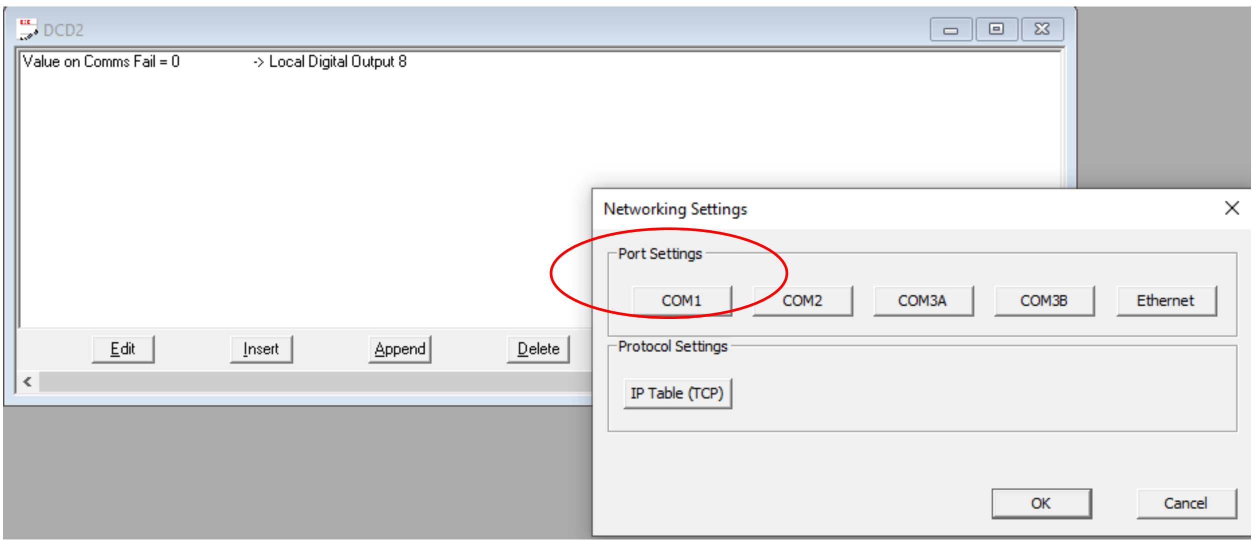
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

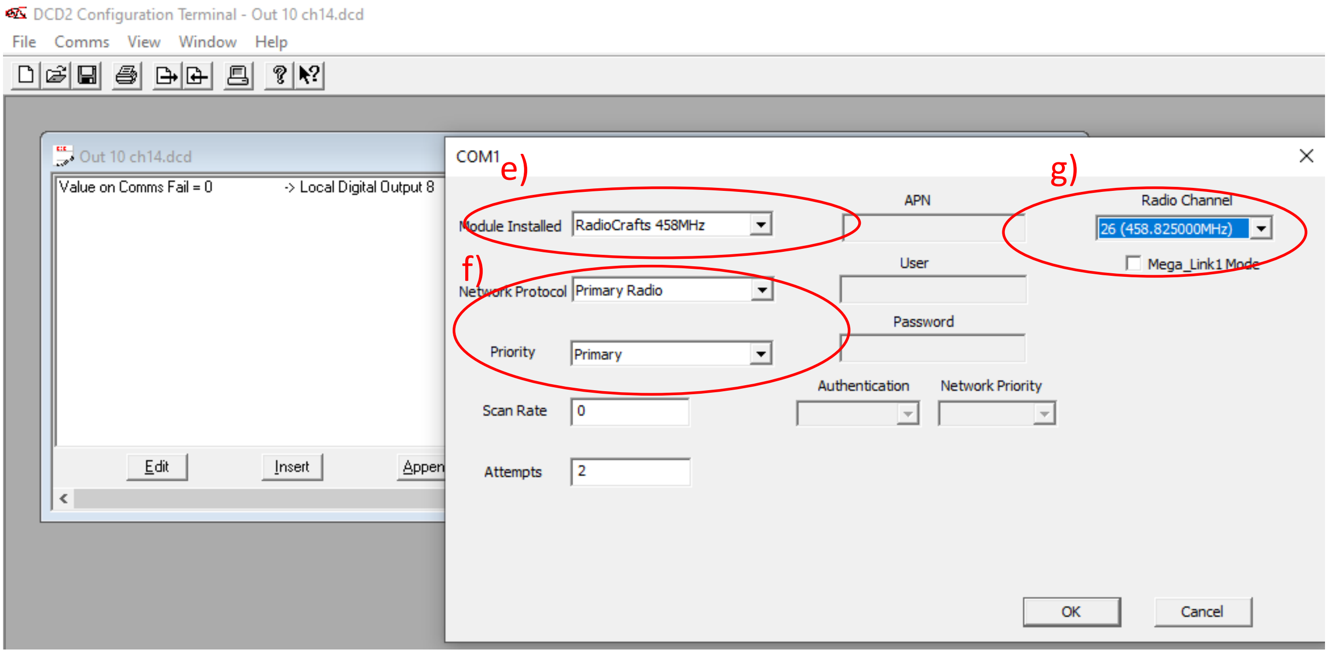
c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = COM1

Entries e), f) and g) are set in the "COM1" configuration screen which is found by clicking on the "COM1" button in the "Network Settings menu as follows:



And



e) Module Installed = RadioCrafts 458MHz

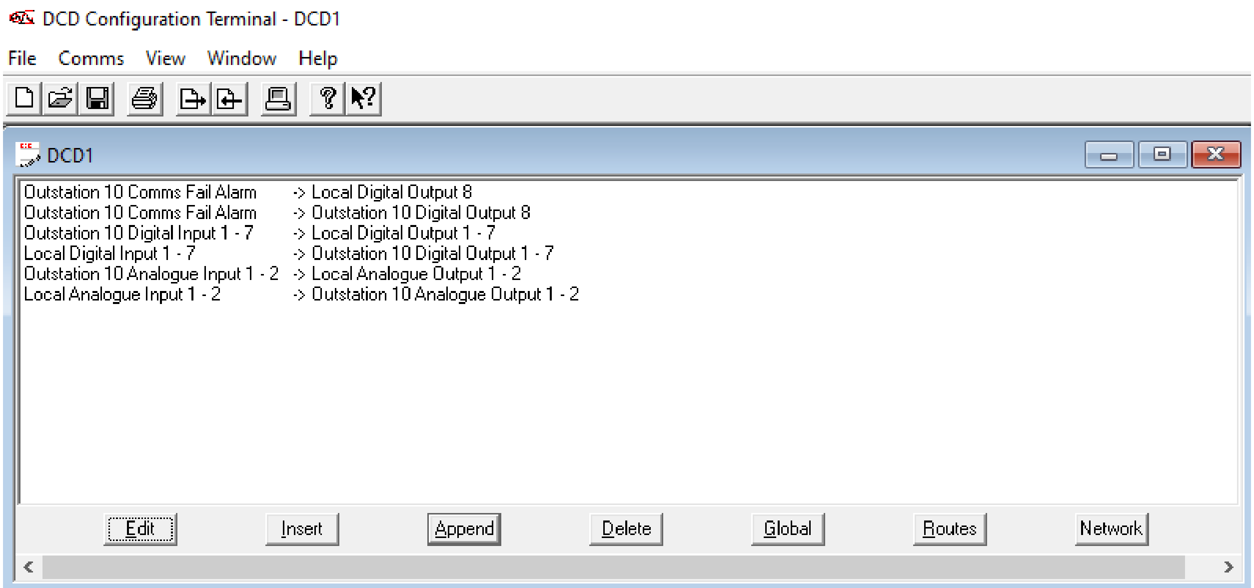
f) Network Protocol = Primary Radio and Priority = Primary

g) Radio Channel = 26

7.3.4 Basestation Signal Routing Configuration Example (General)

The following example is a standard one to one mapping of signals with a Comms Fail indication on output 8.

Signal routing or mapping is defined going from the source on the left to the destination on the right.



Line 1: Outstation 10 Comms Fail Alarm >>> Local Digital Output 8

The Comms Fail Alarm flag received in messages from outstation 10 is mapped to output 8 on basestation.

This means that each time the basestation receives a message then this output will be activated. In the event of a break down in communications and no valid message received as a result of the basestation polling then this output will de-activated.

Line 2: Outstation 10 Comms Fail Alarm >>> Outstation 10 Digital Output 8

The Comms Fail Alarm flag received in messages from outstation 10 is also mapped to output 8 on outstation 10.

This means that each time the outstation receives a valid message sent from the basestation then this output will be activated at the outstation. See later section about Outstation signal mapping to show how this is deactivated.

Line 3: Outstation 10 Digital Input 1 -7 >>> Local Digital Output 1 - 7

The digital inputs 1 – 7 from outstation 10 are mapped to digital outputs 1-7 here on basestation.

Line 4: Local Digital Input 1 -7 >>> Outstation 10 Digital Output 1 - 7

The digital inputs 1 – 7 from here at basestation are mapped to digital outputs 1-7 on outstation 10.

Line 5: Outstation 10 Analogue Input 1 -2 >>> Local Analogue Output 1 - 2

The analogue inputs 1 – 2 from outstation 10 are mapped to analogue outputs 1-2 here on basestation.

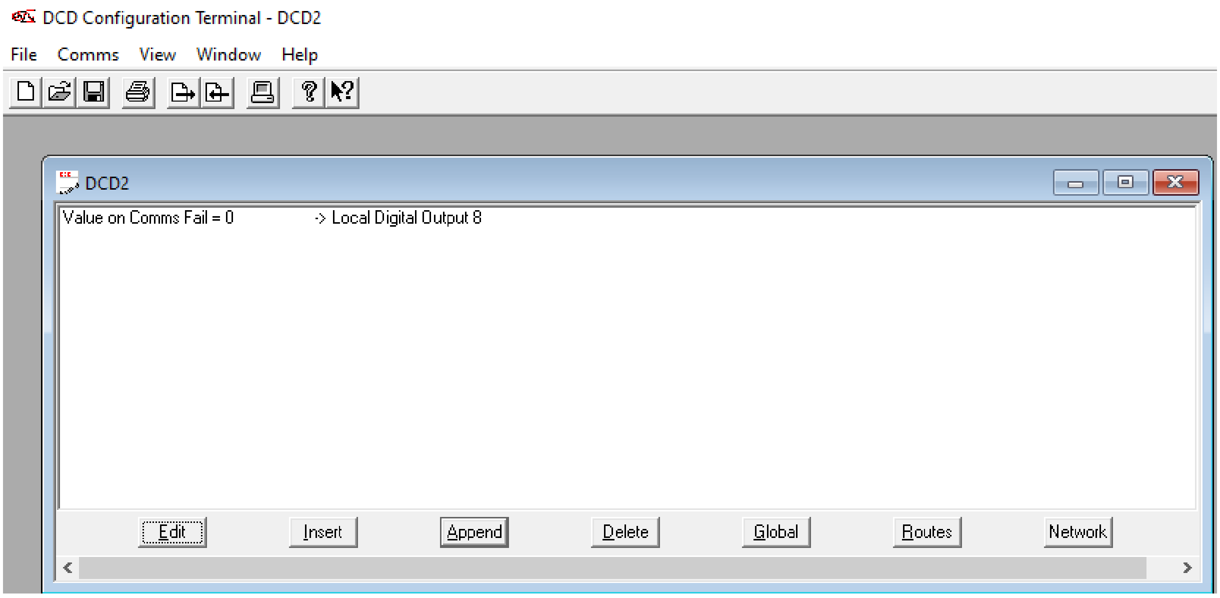
Line 6: Local Analogue Input 1 -2 >>> Outstation 10 Analogue Output 1 - 2

The analogue inputs 1 – 2 from here at basestation are mapped to analogue outputs 1-2 on outstation 10.

7.3.5 Outstation Signal Routing Configuration Example (General)

The majority of signal routing or mapping configuration is performed only at the Basestation.

The following example is a standard configuration for a typical Outstation.



Line 1: Value on Comms = 0 >>> Local Digital Output 8

In the standard configuration of a basestation a Comms Fail Alarm flag is sent to Output 8 here at outstation 10. This means that each time the outstation 10 receives a valid message this output 8 is activated (=1). In the event of a break-down of communications where no valid message is no longer received after a few minutes time-out period this line will cause a de-activation (ie setting to =0) of this output 8 here at outstation 10.

7.4 Repeater Comms Routing Configuration (Radio only)

If a Mega_Link 2 is configured as a basestation 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 basestation 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 basestation will assume it can be contacted directly.

7.5 Example Configuration Set-Up (4G Mobile Networks)

Systems using 4G cellular communications need some special attention. The destination of every message sent over the cellular network is defined by the IP address that is embedded within it. A Mega_Link 2 that is using 4G 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 2 must instead use Fixed IP SIM's, which route each message through a Radius server for Peer to Peer mode. The Radius server will allocate the SIM a fixed IP address which will be given to the user by the SIM provider.

Mega_Link 2 needs to know how to access the Radius server, so must be configured with the relevant APN, User Name and Password. These details will also be given to the user by the SIM provider

If a basestation is to communicate with outstations via the cellular network it needs to know the IP address of the SIM fitted in each outstation. The user must therefore include in the basestation configuration a list of the IP addresses for each outstation. When an outstation receives a command from a basestation it derives the basestation IP address from the message content, so doesn't necessarily need to be configured.

7.5.1 Basestation and Outstation Mode (4G Mobile Networks)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basestation only.

d) A primary COM port selection at the basestation and each outstation.

e) A radio module type selection at the basestation and each outstation.

f) A Network Protocol selection at the basestation and each outstation.

g) An APN (Access Point Name), Username & password at the basestation and each outstation.

h) Network Priority

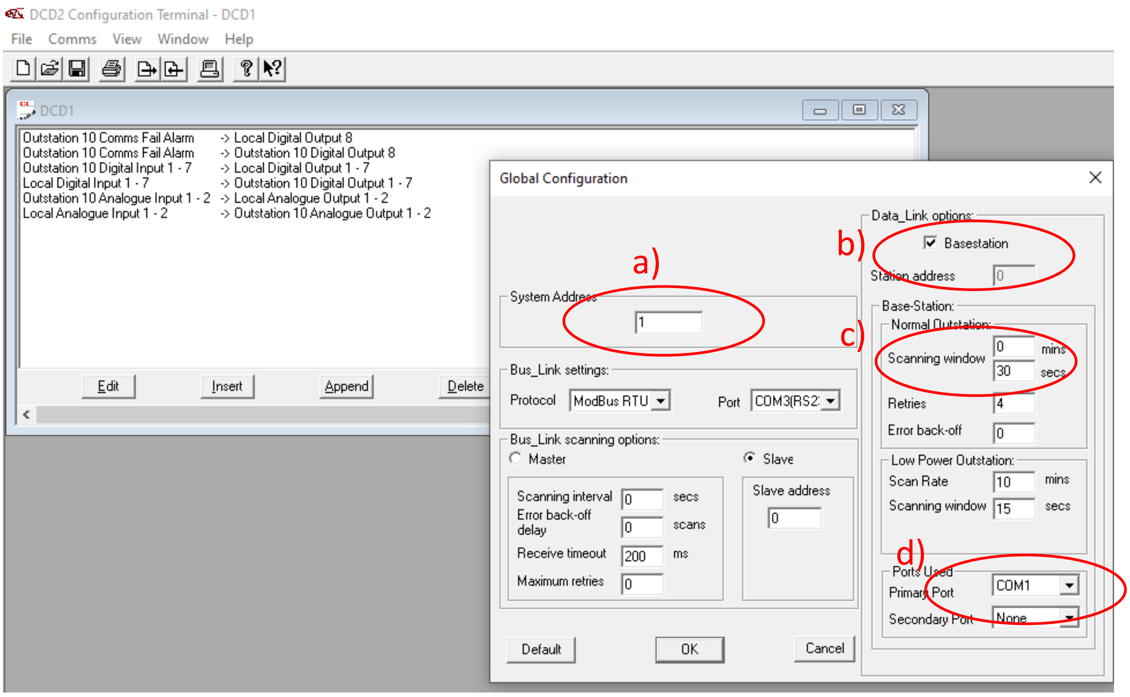
i) At Basestation only, a fixed IP address for each of the associated outstations.

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion.

7.5.2 Basestation Set-Up Example (4G Mobile Networks)

Entries a) to d) are set in the "Global" configuration screen as follows:



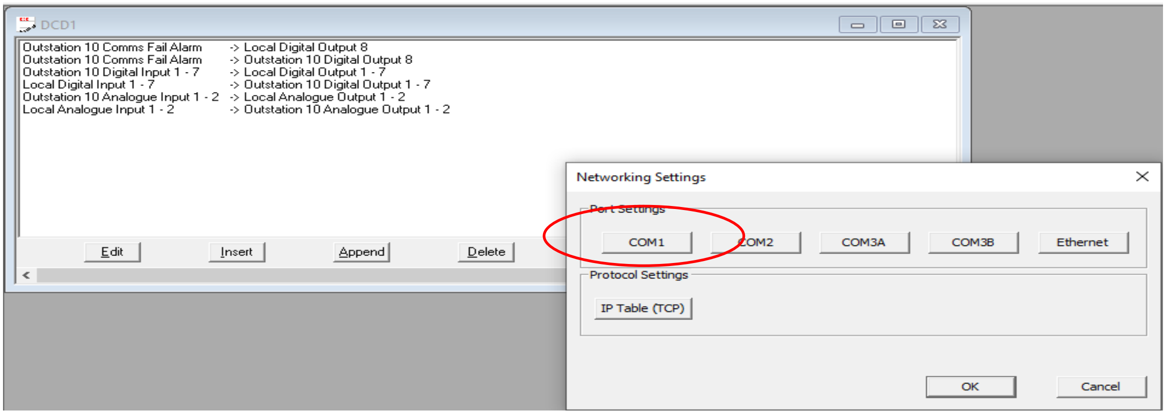
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

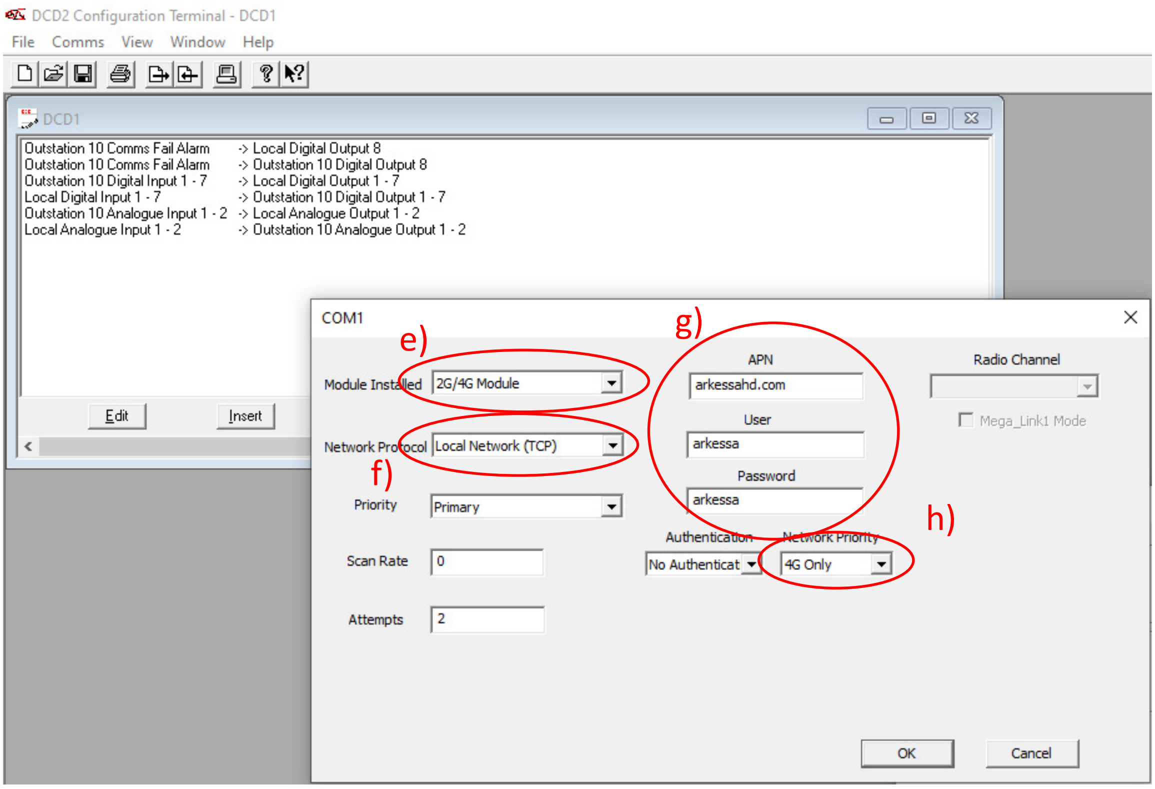
c) Scanning Window = 30 secs

d) Primary Port selection = COM1

Entries e), f), g) and h) are set in the “COM1” configuration screen which is found by clicking on the “COM1” button in the “Network Settings menu as follows:



And



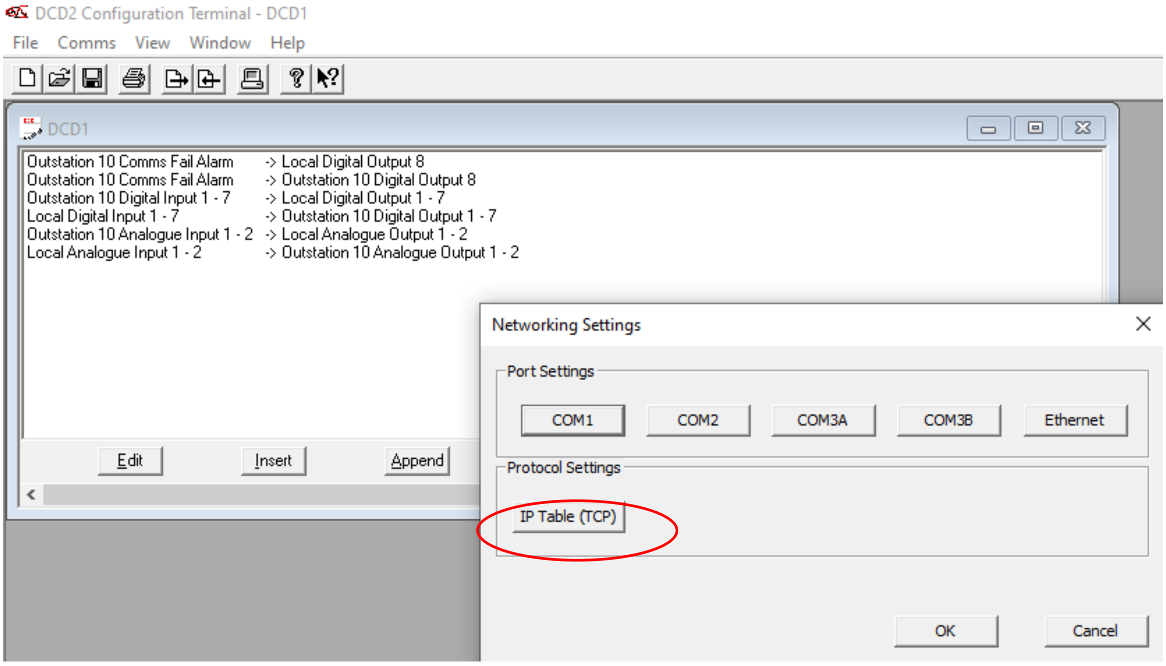
e) Module Installed = 2G/4G Module

f) Network Protocol = Local Network (TCP)

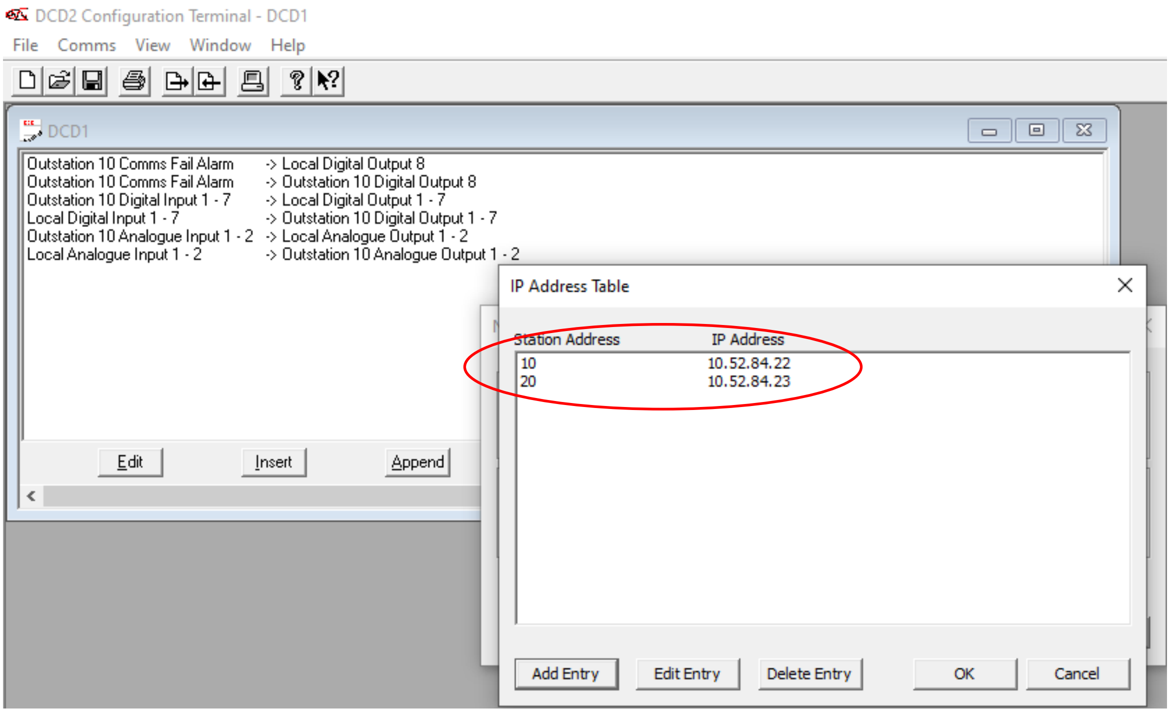
g) An APN (Access Point Name) = arkessahd.com, Username = arkessa & password = arkessa at the basestation and each outstation.

h) Network Priority = 4G Only

Entry i) is set in the “IP Address Table” configuration screen which is found by clicking on the “IP Table (TCP)” button in the “Network Settings” menu as follows:



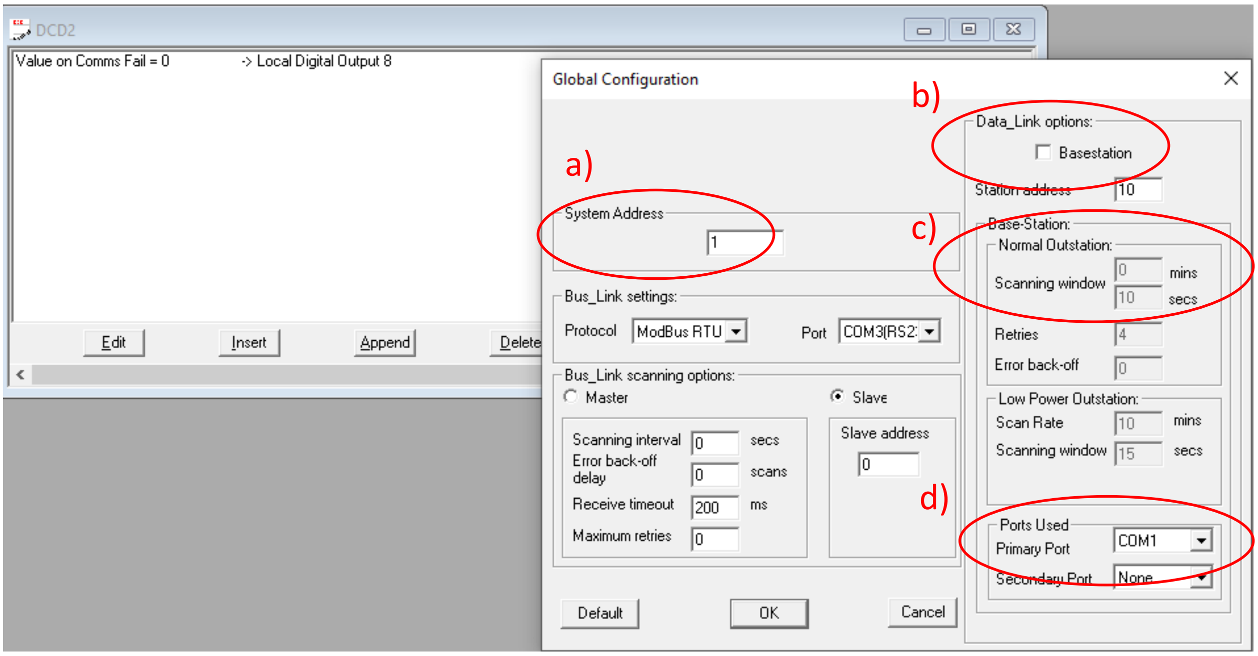
And:



i) At basestation only, a fixed IP address at the basestation for each of the associated outstations.

7.5.3 Outstation Set-Up Example (4G Mobile Networks)

Entries a) , b), c) & d) are set in the "Global" configuration screen as follows:



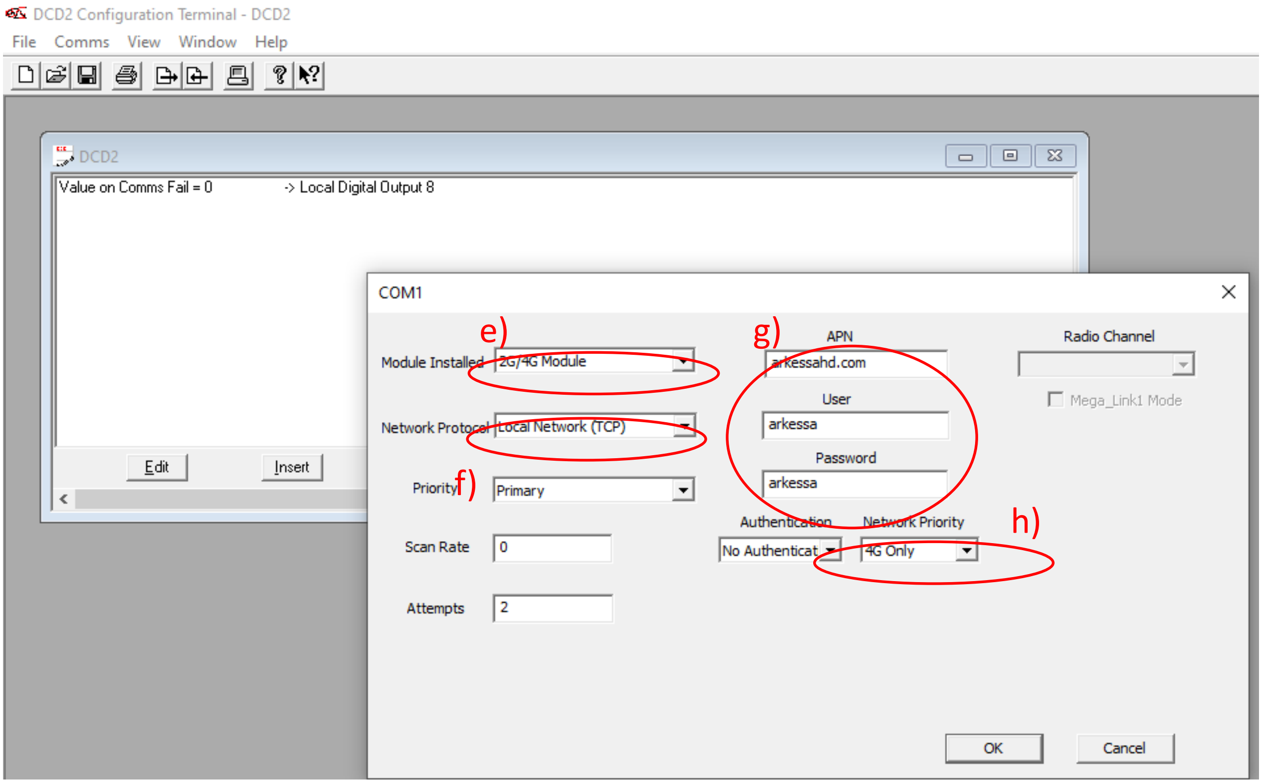
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = COM1

Entries e), f), g) & h) are set in the "COM1" configuration screen which is found by clicking on the "COM1" button in the "Network Settings menu as follows:



e) Module Installed = 2G/4G Module

f) Network Protocol = Local Network (TCP)

g) An APN (Access Point Name) = arkessahd.com, Username = arkessa & password = arkessa at the basestation and each outstation.

h) Network Priority = 4G Only

At the Outstation the entry i) does not need to be set in the “IP Address Table” configuration screen.

7.6 Example Configuration Set-Up (Ethernet TCP/IP)

7.6.1 Basestation and Outstation Mode (Ethernet TCP/IP)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basestation only.

d) A primary COM port selection at the basestation and each outstation.

e) A Network Protocol type selection at the basestation and each outstation.

f) A Static IP address unique to each basestation and outstation unit

g) Default Gateway = 192.168.1.1

h) Subnet Mask = 255.255.255.0

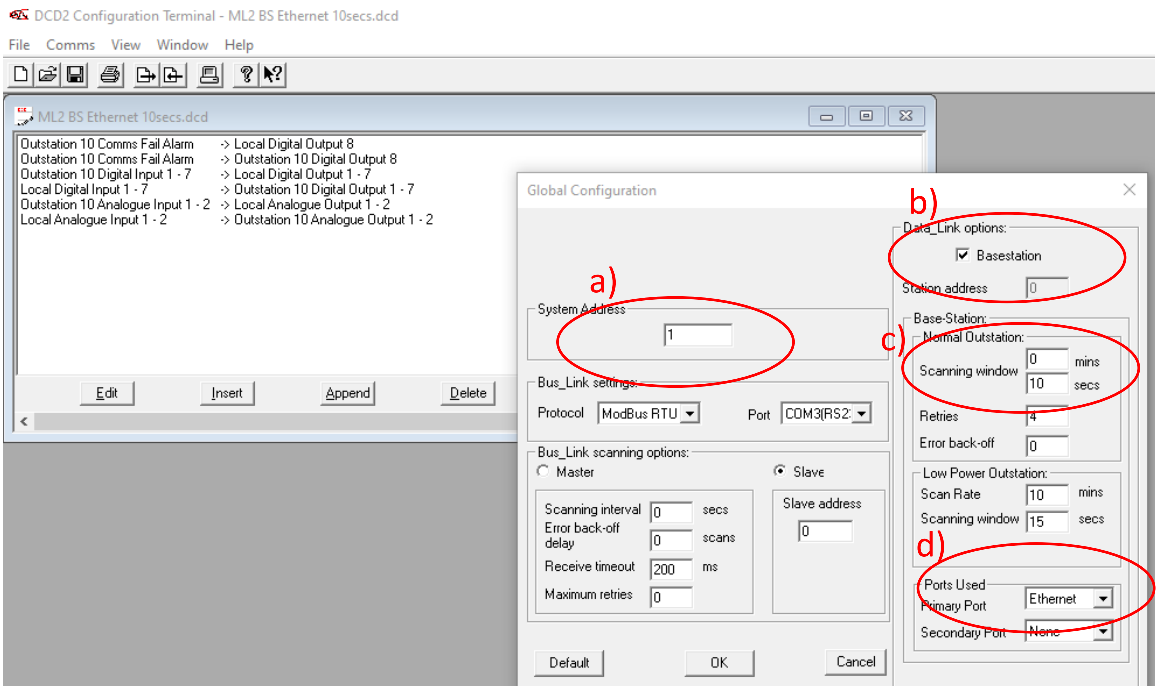
i) Receive timeout = This value is included to allow for round latency time of communications network

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion.

7.6.2 Basestation Set-Up Example (Ethernet TCP/IP)

Entries a) to d) are set in the "Global" configuration screen as follows:



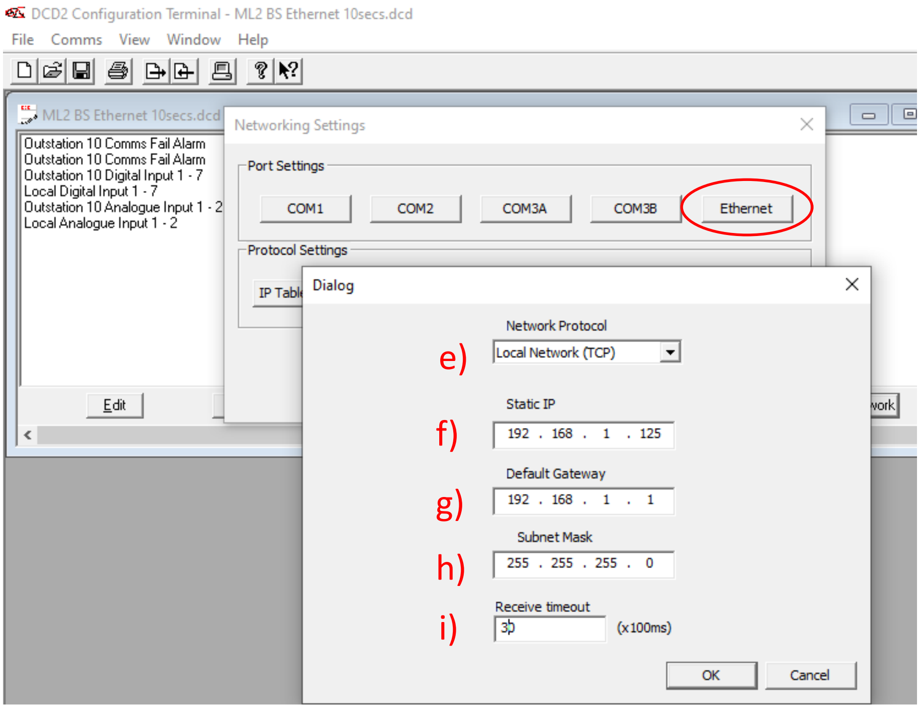
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

c) Scanning Window = 10 secs

d) Primary Port selection = Ethernet

Entries e), f), g) and h) are set in the "Ethernet" configuration screen which is found by clicking on the "Ethernet" button in the "Network Settings" menu as follows:



e) Network Protocol = Local Network (TCP)

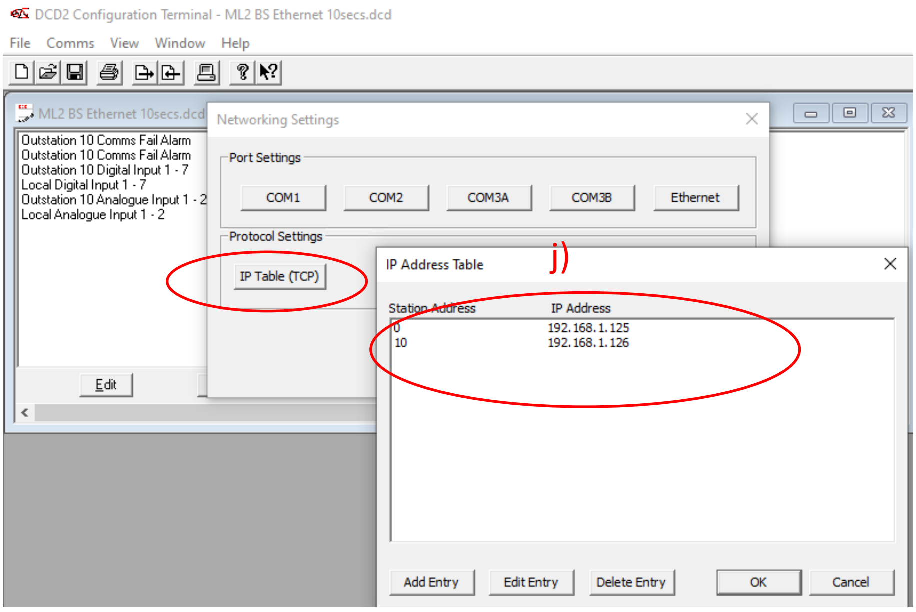
f) Static IP = A unique IP address given to basestation e.g. 192.168.1.125

g) Default Gateway = 192.168.1.1

h) Subnet Mask = 255.255.255.0

i) Receive timeout = This value is included to allow for round latency time of communications network, e.g. 30 = 3 seconds

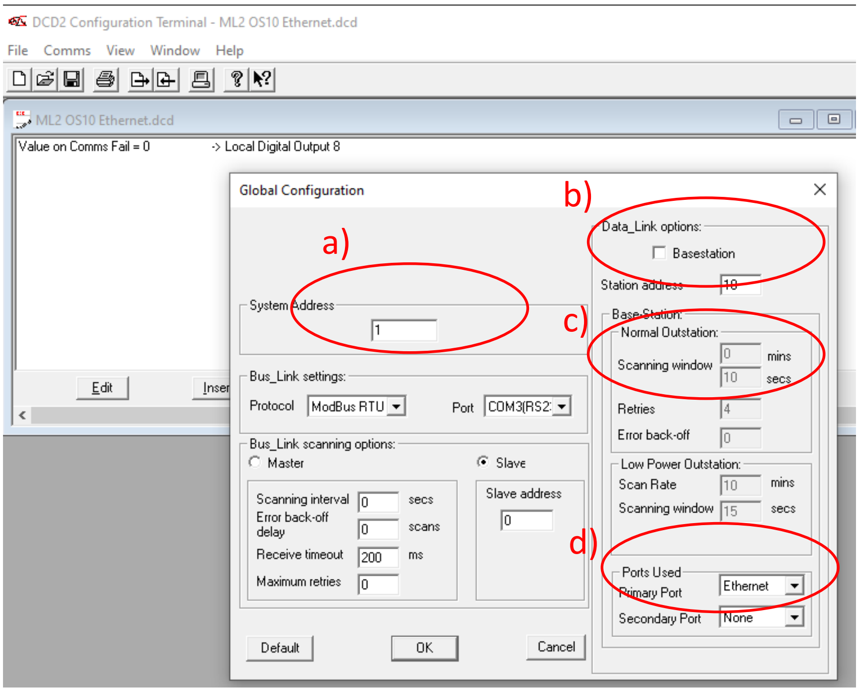
Entry j) is set in the "IP Address Table" configuration screen which is found by clicking on the "IP Table (TCP)" button in the "Network Settings" menu as follows:



j) The fixed IP address of the basestation entered at step f) will automatically be seen. The fixed IP addresses of each of the associated outstations shall be added by using the “Add Entry”.

7.6.3 Outstation Set-Up Example (Ethernet TCP/IP)

Entries a) , b), c) & d) are set in the “Global” configuration screen as follows:



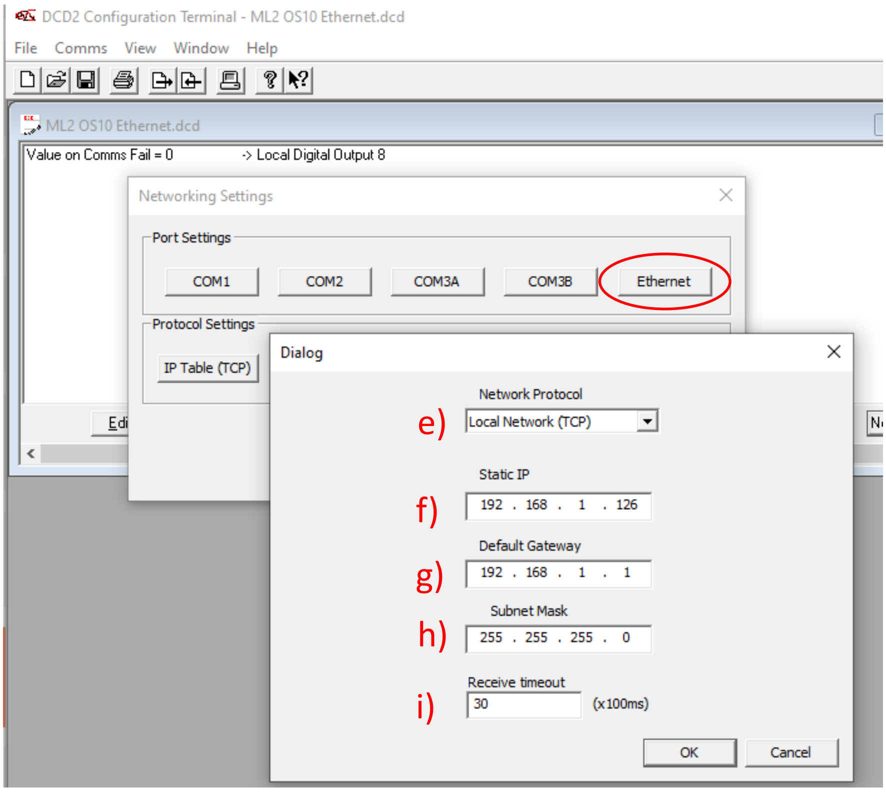
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = Ethernet

Entries e), f), g) & h) are set in the "Ethernet" configuration screen which is found by clicking on the "Ethernet" button in the "Network Settings menu as follows:



e) Network Protocol = Local Network (TCP)

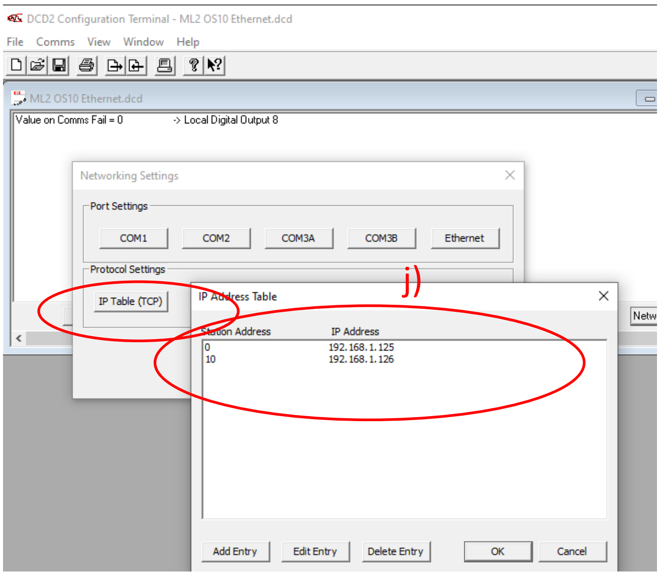
f) Static IP = A unique IP address given to basestation e.g. 192.168.1.126

g) Default Gateway = 192.168.1.1

h) Subnet Mask = 255.255.255.0

i) Receive timeout = This value is included to allow for round latency time of communications network, e.g. 30 = 3 seconds

Entry j) is set in the "IP Address Table" configuration screen which is found by clicking on the "IP Table (TCP)" button in the "Network Settings" menu as follows:



j) The fixed IP address of the outstation being configure which was already entered at step f) will automatically be seen. The fixed IP address of the basestation (0) can be added by using the "Add Entry" for completeness although this is not necessarily required because the outstation will know the IP address of the basestation by means of replying to the incoming TCP/IP poll.

7.7 Example Configuration Set-Up (RS232 via COM3A)

7.7.1 Basestation and Outstation Mode (RS232 via COM3A)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basestation only.

d) A primary COM port selection at the basestation and each outstation.

e) Network Protocol - Baud Rate setting at the basestation and each outstation.

f) Network Protocol – Data Bits setting at the basestation and each outstation.

g) Network Protocol – Stop Bits setting at the basestation and each outstation.

h) Network Protocol – Parity setting at the basestation and each outstation.

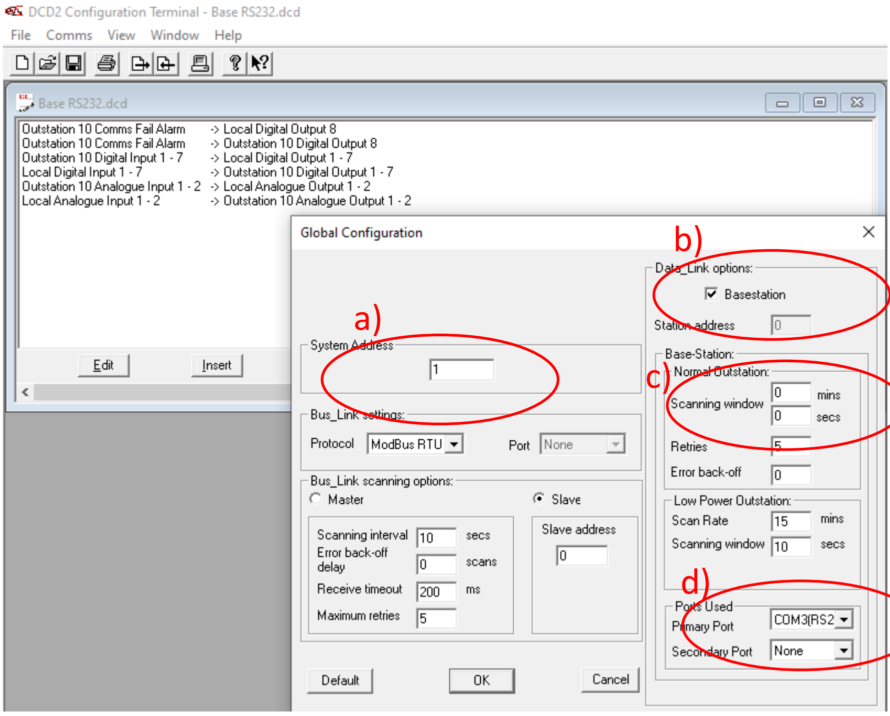
i) Network Protocol - Receive timeout = This value is included to allow for round latency time of communications network

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion.

7.7.2 Basestation Set-Up Example (RS232 via COM3A)

Entries a) to d) are set in the "Global" configuration screen as follows:



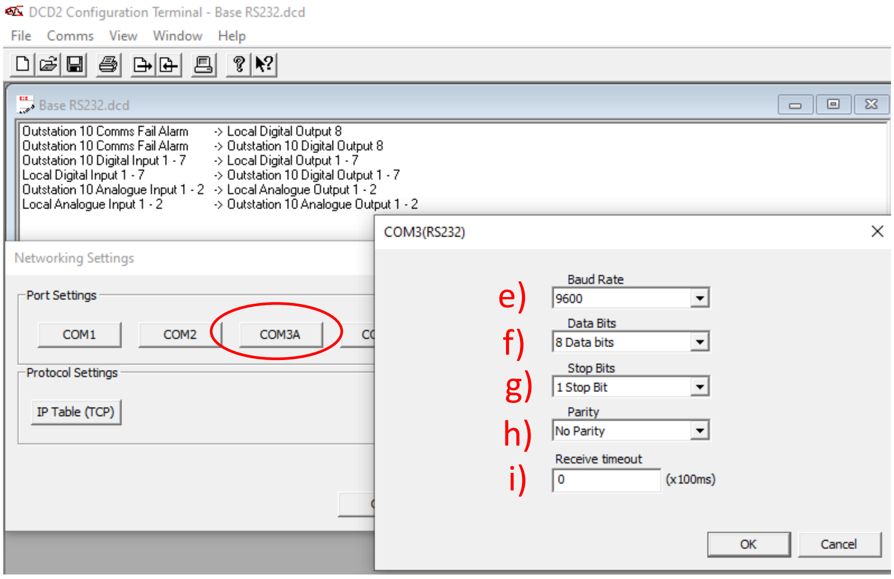
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

c) Scanning Window = 0 secs

d) Primary Port selection = COM3(RS232)

Entries e), f), g), h) and i) are set in the “COM3A” configuration screen which is found by clicking on the “COM3A” button in the “Network Settings” menu as follows:



e) Baud Rate = 9600 baud (default)

f) Data Bits = 8 Data Bits (default)

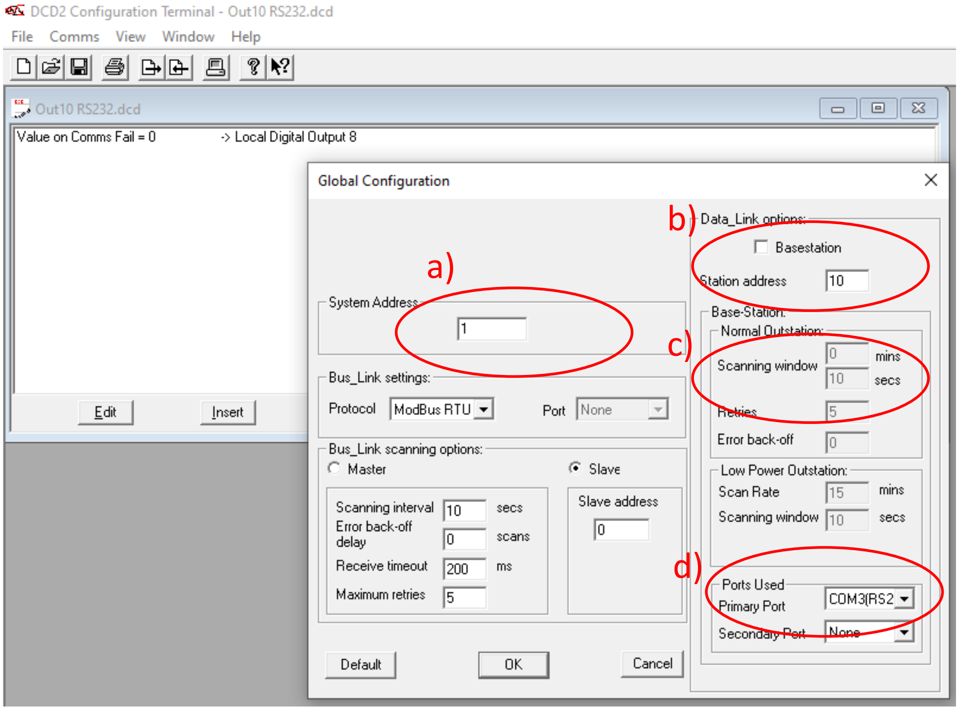
g) Stop Bits = 1 Stop Bit (default)

h) Parity = No Parity (default)

i) Receive timeout = This value is included to allow for extra round latency time of communications network. For RS232, the minimum base value is 3 seconds, an entry is added to this. E.g. 10 would make 3 +10*0.1 = total of 4 seconds

7.7.3 Outstation Set-Up Example (RS232 via COM3A)

Entries a) , b), c) & d) are set in the "Global" configuration screen as follows:



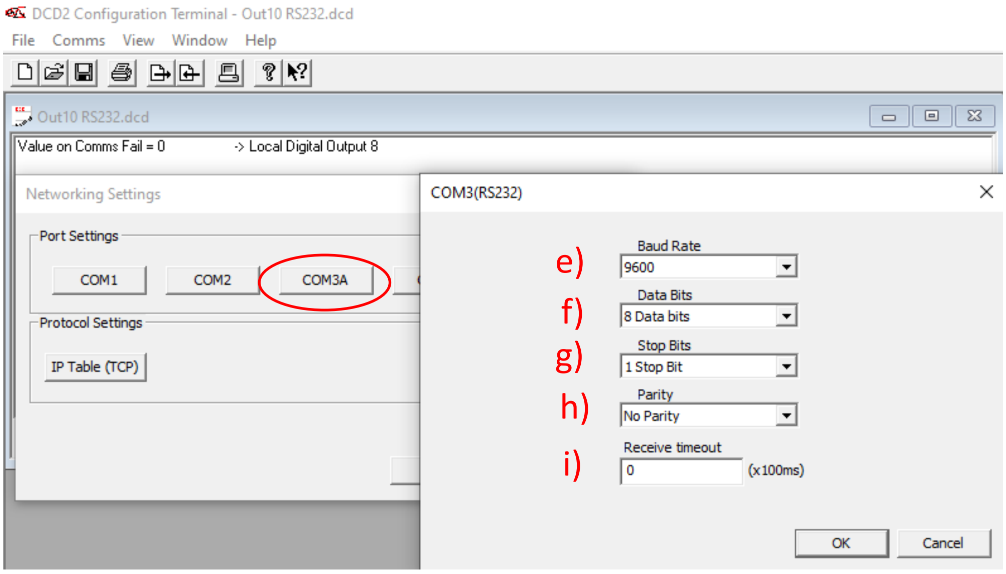
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = COM3(RS232)

Entries e), f), g), h) and i) are set in the "COM3A" configuration screen which is found by clicking on the "COM3A" button in the "Network Settings" menu as follows:



e) Baud Rate = 9600 baud (default)

f) Data Bits = 8 Data Bits (default)

g) Stop Bits = 1 Stop Bit (default)

h) Parity = No Parity (default)

i) Receive timeout = This value is included to allow for extra round latency time of communications network. For RS232, the minimum base value is 3 seconds, an entry is added to this. E.g. 10 would make 3 +10*0.1 = total of 4 seconds

7.8 Example Configuration Set-Up (RS485 via COM3B)

7.8.1 Basestation and Outstation Mode (RS485 via COM3B)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basestation only.

d) A primary COM port selection at the basestation and each outstation.

e) Network Protocol - Baud Rate setting at the basestation and each outstation.

f) Network Protocol – Data Bits setting at the basestation and each outstation.

g) Network Protocol – Stop Bits setting at the basestation and each outstation.

h) Network Protocol – Parity setting at the basestation and each outstation.

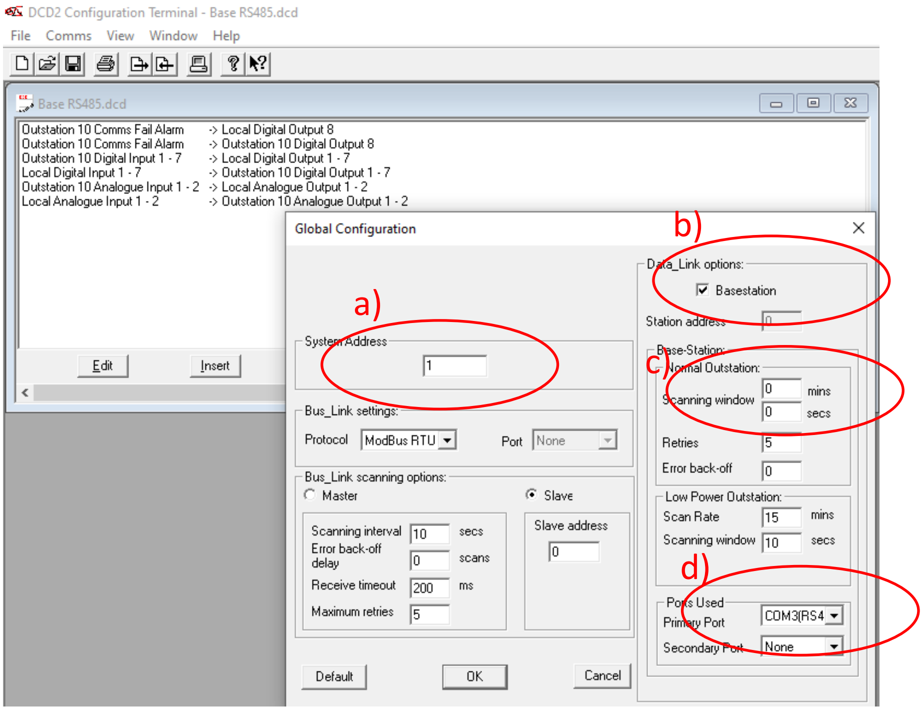
i) Network Protocol - Receive timeout = This value is included to allow for round latency time of communications network

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion.

7.8.2 Basestation Set-Up Example (RS485 via COM3B)

Entries a) to d) are set in the “Global” configuration screen as follows:



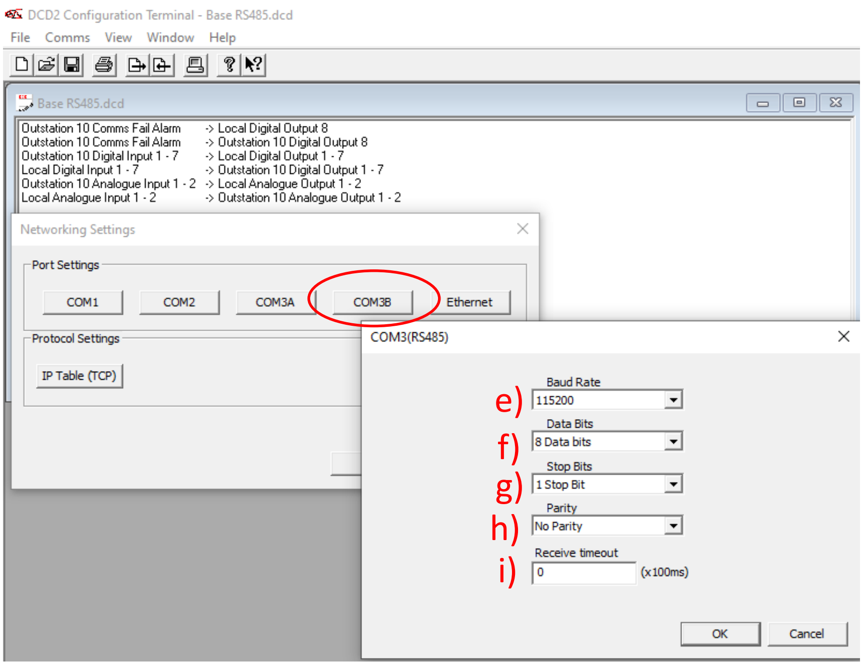
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

c) Scanning Window = 0 secs

d) Primary Port selection = COM3(RS485)

Entries e), f), g), h) and i) are set in the “COM3B” configuration screen which is found by clicking on the “COM3B” button in the “Network Settings” menu as follows:



e) Baud Rate = 115200 baud (default)

f) Data Bits = 8 Data Bits (default)

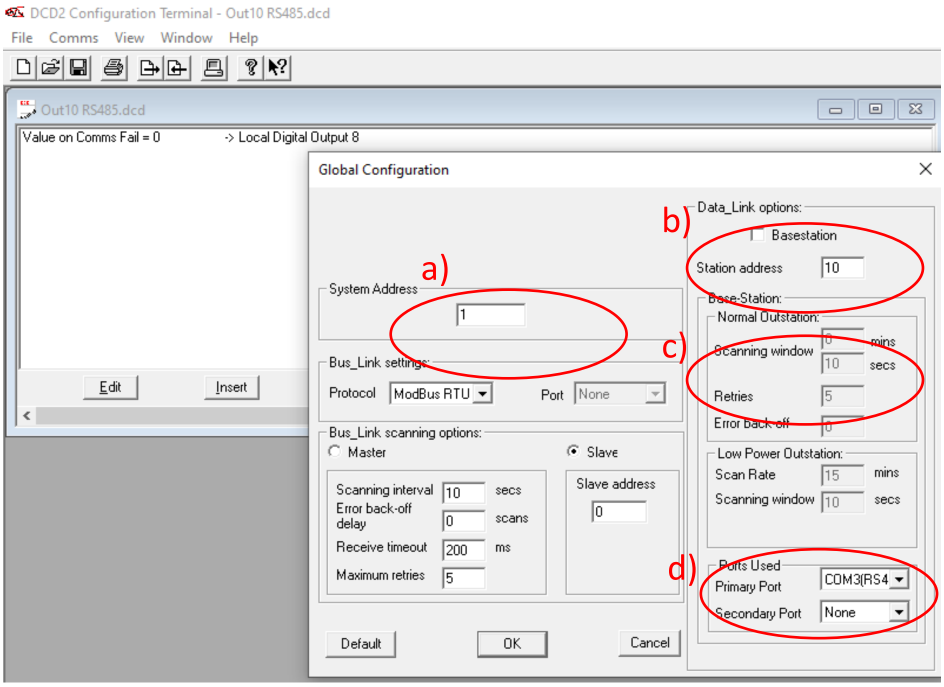
g) Stop Bits = 1 Stop Bit (default)

h) Parity = No Parity (default)

i) Receive timeout = This value is included to allow for extra round latency time of communications network. For RS485, the minimum base value is 3 seconds, an entry is added to this. E.g. 10 would make 3 +10*0.1 = total of 4 seconds

7.8.3 Outstation Set-Up Example (RS485 via COM3B)

Entries a) , b), c) & d) are set in the "Global" configuration screen as follows:



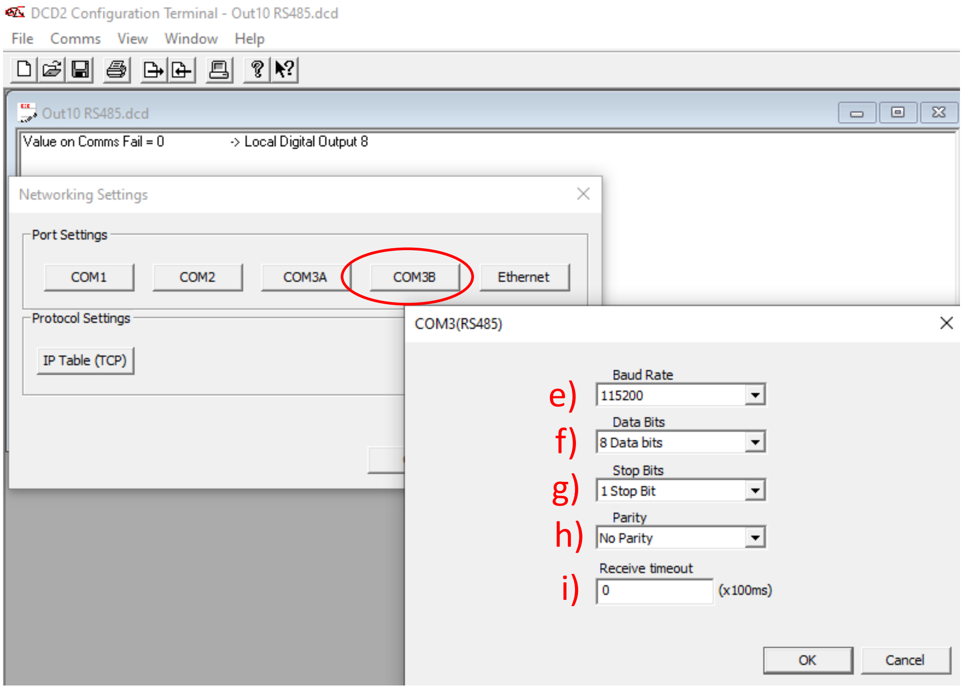
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = COM3(RS485)

Entries e), f), g), h) and i) are set in the "COM3B" configuration screen which is found by clicking on the "COM3B" button in the "Network Settings" menu as follows:



e) Baud Rate = 9600 baud (default)

f) Data Bits = 8 Data Bits (default)

g) Stop Bits = 1 Stop Bit (default)

h) Parity = No Parity (default)

i) Receive timeout = This value is included to allow for extra round latency time of communications network. For RS485, the minimum base value is 3 seconds, an entry is added to this. E.g. 10 would make 3 +10*0.1 = total of 4 seconds

7.9 Example Configuration Set-Up (Dual Comms, 4G + Radio)

7.9.1 Basestation and Outstation Mode (Dual Comms, 4G + Radio)

The user needs to configure the following aspects:

a) A System Address entry common to the basestation and all of the outstations in that system.

b) Basestation selection with Station address, 0 for the basestation or non-basestation and Station address selection by convention, 10, 20, 30 etc. for each outstation.

c) A polling rate (known as Scanning Window) and number of retries at the basestation only.

d) A primary COM port and secondary COM port selection at the basestation and each outstation.

e) A 4G module type selection at the basestation and each outstation.

f) A Network Protocol selection at the basestation and each outstation.

g) An APN (Access Point Name), Username & password at the basestation and each outstation.

h) Network Priority

i) At Basestation only, a fixed IP address for each of the associated outstations.

j) A radio module type selection at the basestation and each outstation.

k) A Network Protocol selection at the basestation and each outstation.

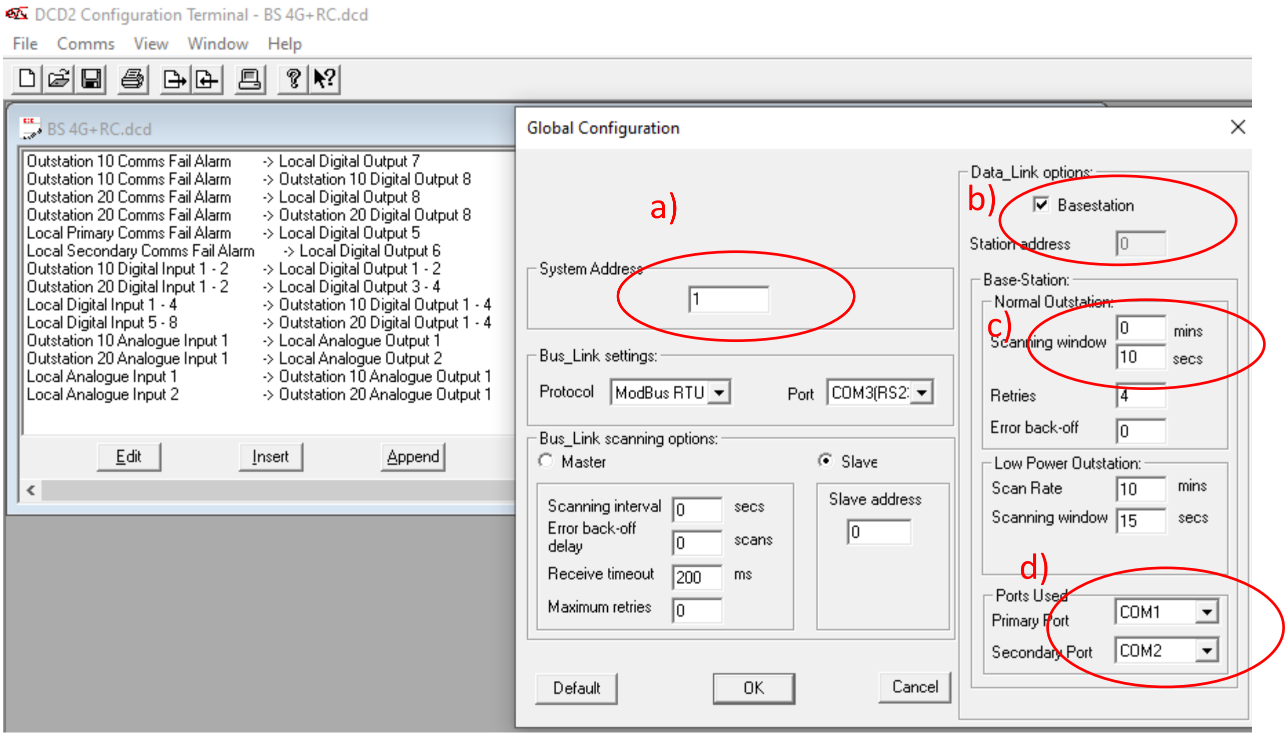
l) A common Radio Channel selection at the basestation and each outstation.

Data routing configuration takes place mostly at the basestation but a few entries for example action in the event of comms fail at the outstation.

The following sections describe and example of a standard Basestation and single Outstation pair without expansion.

7.9.2 Basestation Set-Up Example (Dual Comms, 4G + Radio)

Entries a) to d) are set in the “Global” configuration screen as follows:



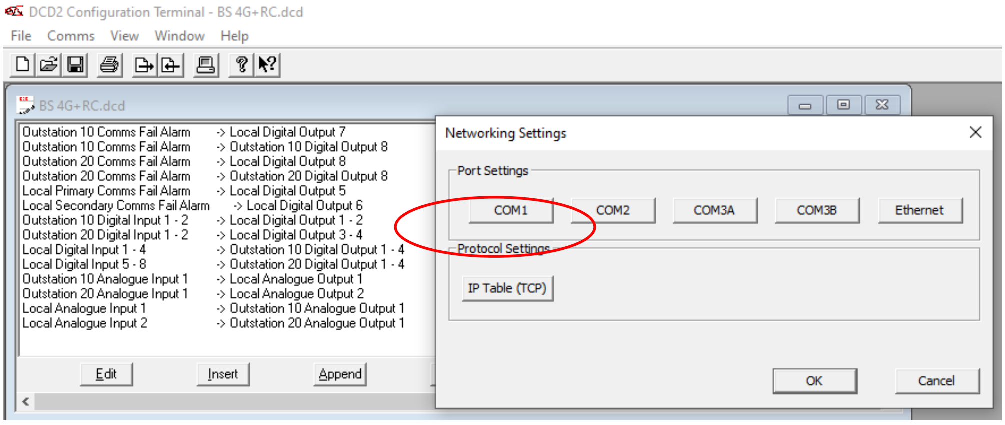
a) System Address = 1

b) Basestation mode selected (always with Station address = 0)

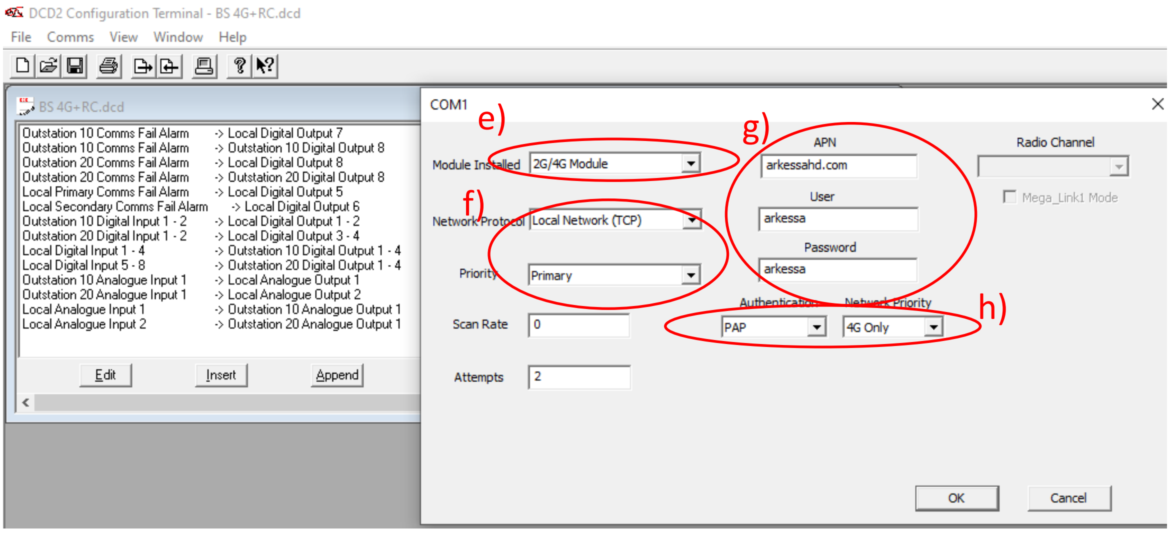
c) Scanning Window = 10 secs

d) Primary Port selection = COM1, Secondary Port selection = COM2.

Entries e), f), g) and h) are set in the “COM1” configuration screen which is found by clicking on the “COM1” button in the “Network Settings menu as follows:



And



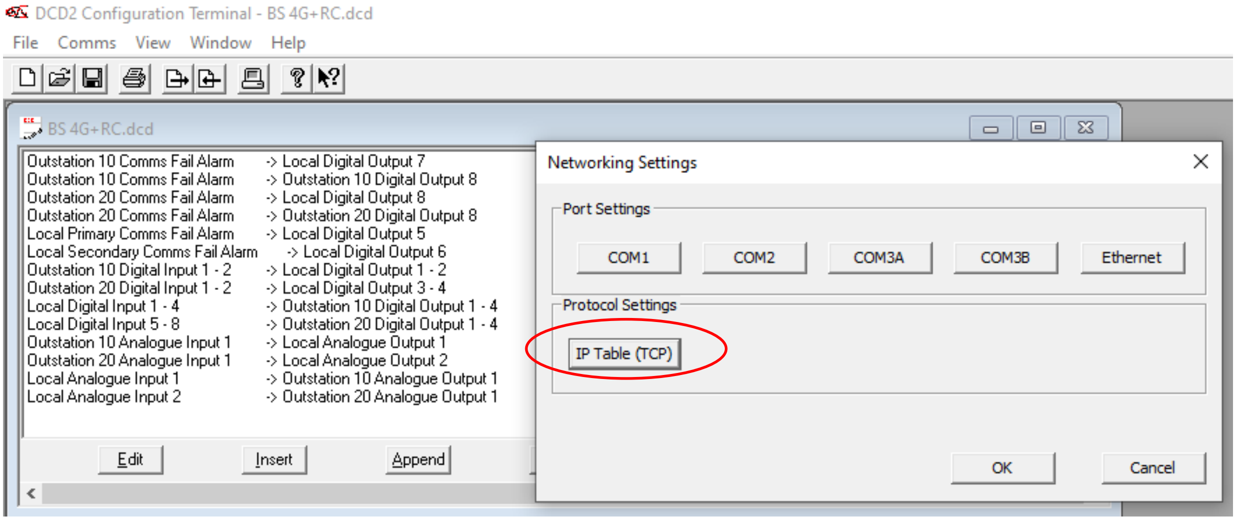
e) Module Installed = 2G/4G Module.

f) Network Protocol = Local Network (TCP) and Primary.

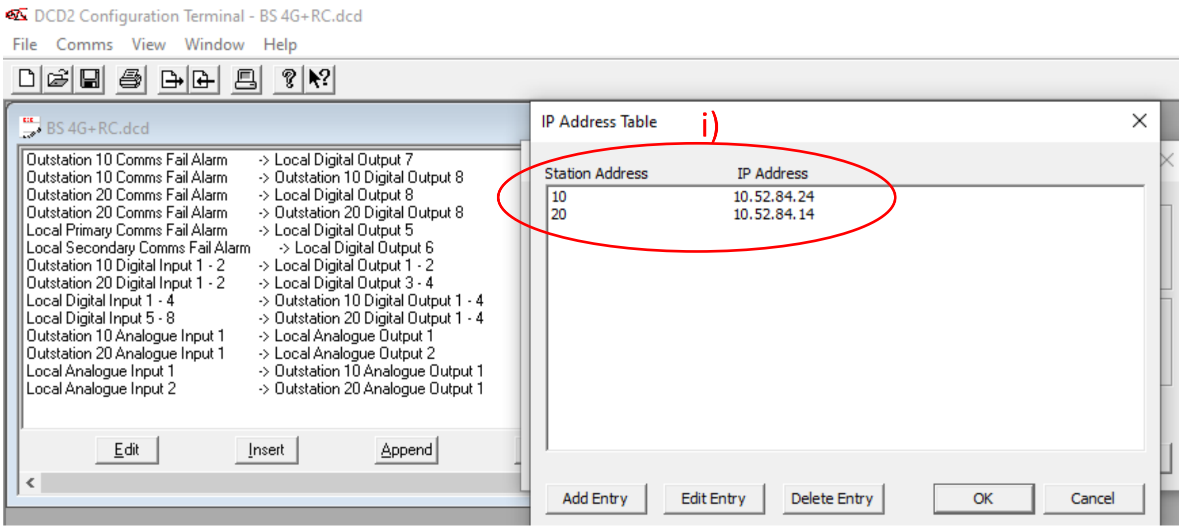
g) An APN (Access Point Name) = arkessahd.com, Username = arkessa & password = arkessa at the basestation and each outstation.

h) Authentication = PAP, Network Priority = 4G Only.

Entry i) is set in the “IP Address Table” configuration screen which is found by clicking on the “IP Table (TCP)” button in the “Network Settings” menu as follows:

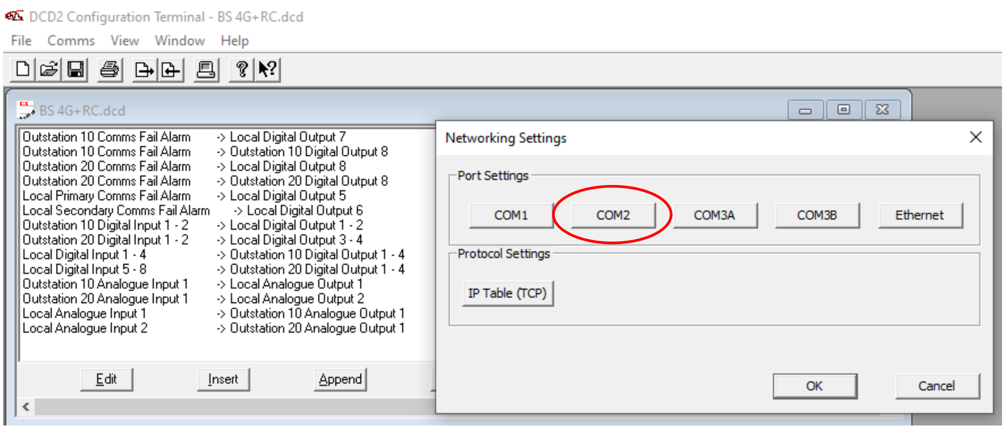


And:

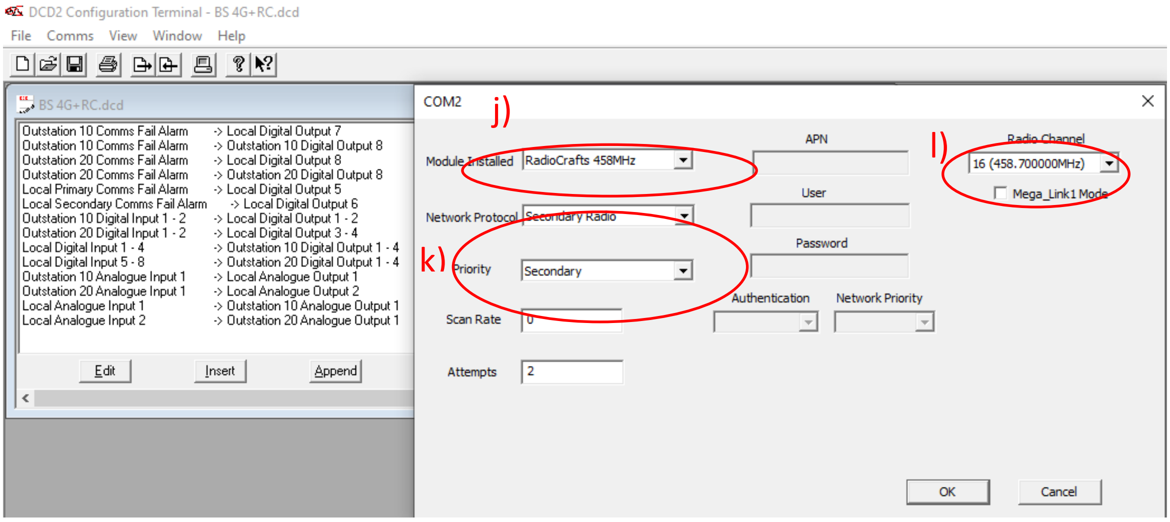


i) At basestation only, a fixed IP address at the basestation for each of the associated outstations.

Entries j), k) and l) are set in the "COM2" configuration screen which is found by clicking on the "COM1" button in the "Network Settings menu as follows:



And



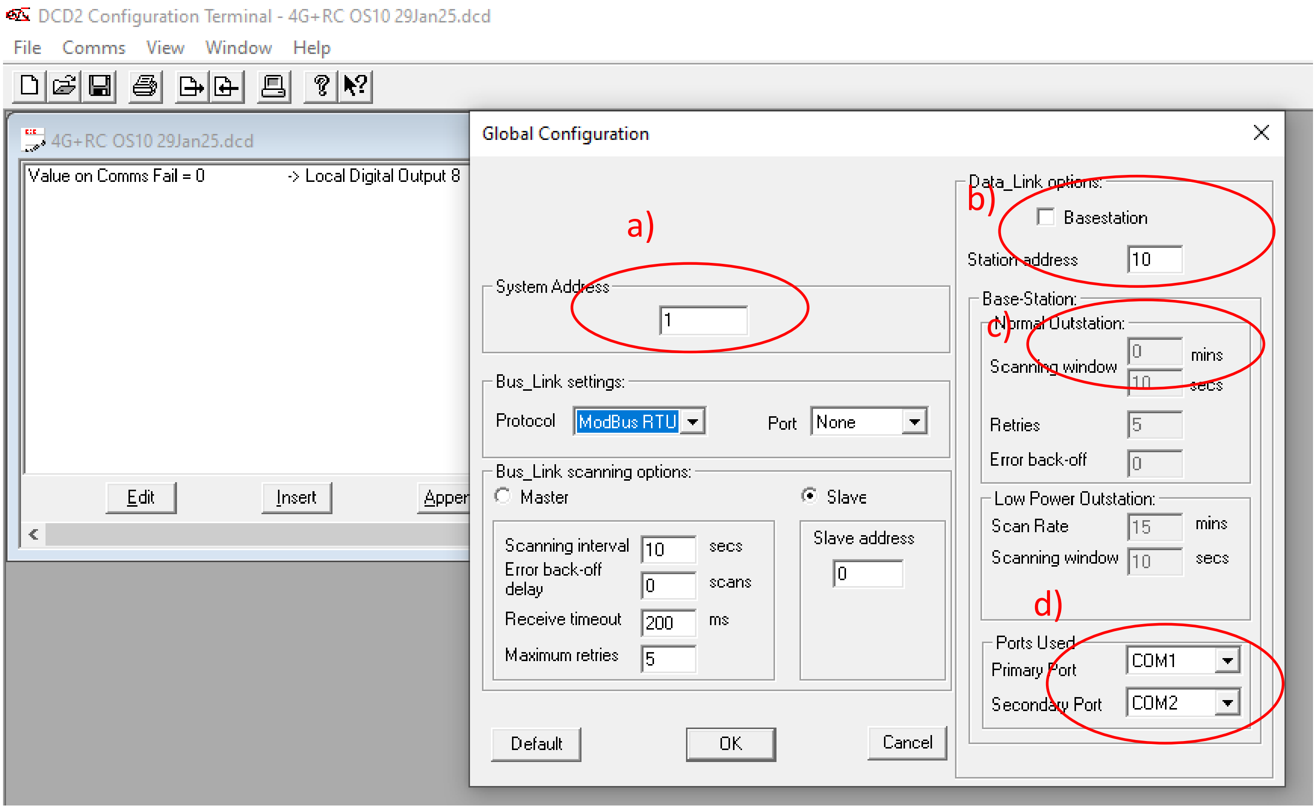
j) Module Installed = RadioCrafts 458MHz

k) Network Protocol = Secondary Radio and Priority = Secondary

l) Radio Channel = 16

7.9.3 Outstation Set-Up Example (Dual Comms, 4G + Radio)

Entries a) to d) are set in the "Global" configuration screen as follows:



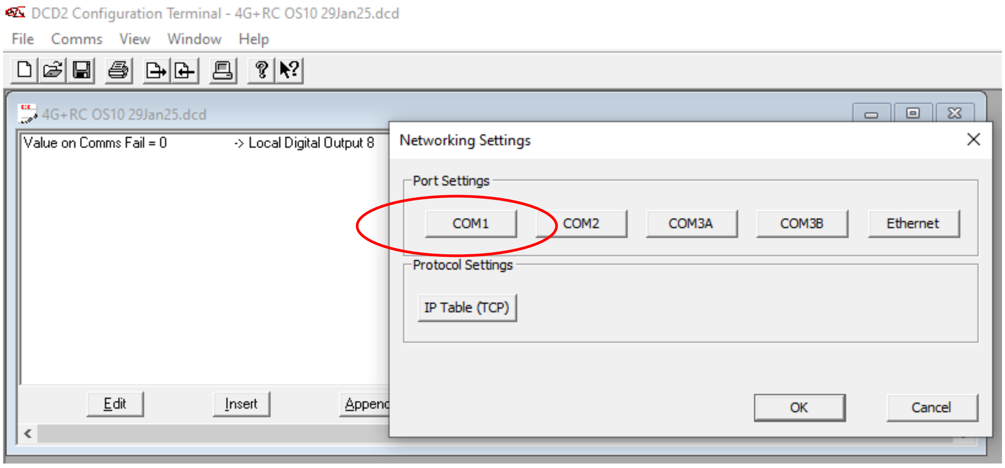
a) System Address = 1

b) Basestation mode tick box unselected and Station Address = 10

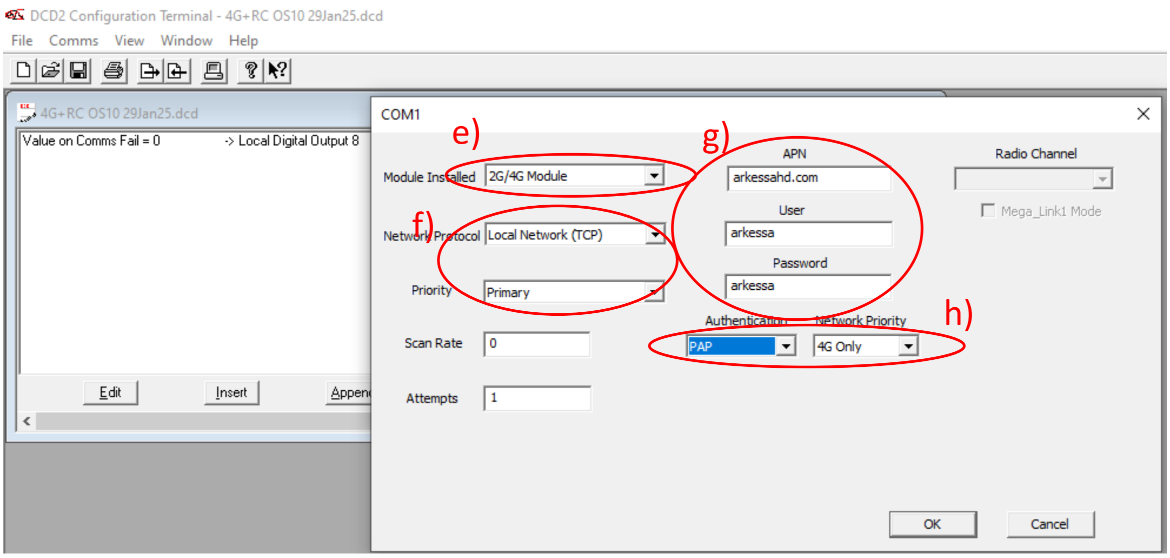
c) Scanning Window = NOT RELEVANT for an Outstation and hence greyed out

d) Primary Port selection = COM1, Secondary Port selection = COM2.

Entries e), f), g) and h) are set in the “COM1” configuration screen which is found by clicking on the “COM1” button in the “Network Settings menu as follows:



And



e) Module Installed = 2G/4G Module.

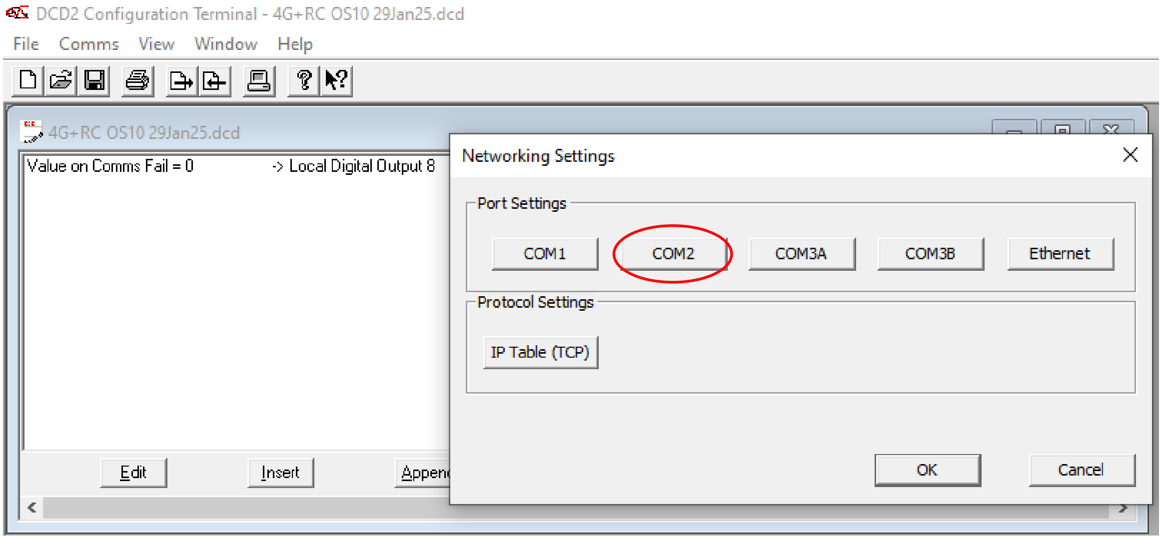
f) Network Protocol = Local Network (TCP) and Primary.

g) An APN (Access Point Name) = arkessahd.com, Username = arkessa & password = arkessa at the basestation and each outstation.

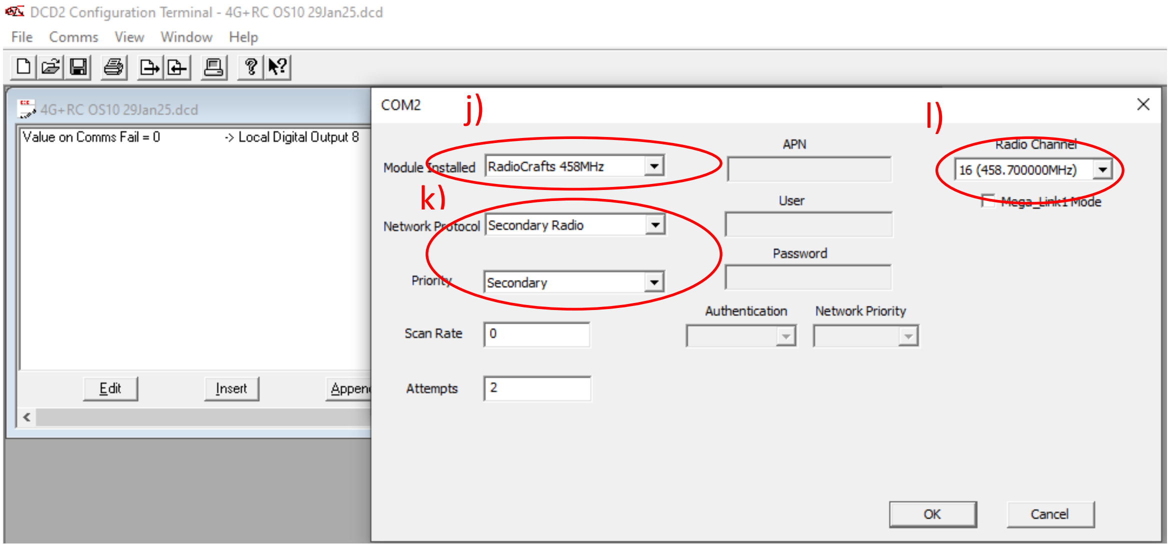
h) Authentication = PAP, Network Priority = 4G Only.

At the Outstation the entry i) does not need to be set in the “IP Address Table” configuration screen.

Entries j), k) and l) are set in the “COM2” configuration screen which is found by clicking on the “COM1” button in the “Network Settings menu as follows:



And



j) Module Installed = RadioCrafts 458MHz

k) Network Protocol = Secondary Radio and Priority = Secondary

l) Radio Channel = 16

8 System Configuration

8.1 Introduction

Every Mega_Link 2 system comprises a base-station and one or more outstations, communicating via radio, 4G or Ethernet. The base-station and each outstation can be fitted with any mix of expansion modules, to a maximum of 32 modules.

The system configuration is user-programmable via the ***Data_Link Configuration and Diagnostic*** (DCD 2) terminal. This is a software package that runs on any IBM-compatible PC. It allows the user to create a configuration file, save it to disc, download it to Mega_Link 2**,** and to upload it from Mega_Link 2. Before a user can begin to configure a system, it is necessary to understand the system configuration, as described in the remainder of this chapter.

8.2 Physical

All data transfer is instigated by the base-station, and all data is routed through it. The location of the base-station is at the discretion of the system integrator, but it will usually be at the site at which most data is accessed. A communications path must be available between the base-station and every outstation, but in a radio system, some outstations can be designated as repeaters to relay data to/from more distant outstations to overcome limitations on radio range.

8.3 Database

To understand the addressing requirements of a Mega_Link 2 system, a basic understanding of the database is necessary. The base-station maintains a complete database, whilst outstations and repeaters only maintain the part of the database which is relevant to them.

It is divided into an input database and an output database, both of which are further divided into 251 data blocks, numbered 0…250:

INPUT DATABASE
Input data block 0
Input data block 1
…
Input data block *n*
…
Input data block 250

OUTPUT DATABASE
Output data block 0
Output data block 1
…
Output data block *n*
…
Output data block 250

Each data block comprises 32 digital states (numbered 0…31) and eight registers (numbered 0…7). Each digital state holds a value 0 or 1 (which could represent states on/off, open/closed etc). Each register holds a 16-bit value, which can represent a numeric value in the range 0…65,535 or -32,768…+32,768 (e.g. water level, pressure or totalised flow).

Every station on a Mega_Link 2 network is allocated at least one input data block and one output block. Each station must be given a unique station address, and this defines the Root Data Block used by the station.

Block address 0 is always the basestation and all other addresses are outstations or repeaters. As convention, outstations are numbers #10, #20, #30 etc.

A Mega_Link 2 outstation or base-station equipped with up to one digital input expansion module and/or one digital output expansion module occupies only the root data block:

Mega_Link 2 Root Data Block Usage

Bit	INPUT DATA BLOCK – Digital	INPUT DATA BLOCK – Register	Register No.	OUTPUT DATA BLOCK – Digital	OUTPUT DATA BLOCK – Register
0	Comms Fail alarm	Count for digital input 1	0	-	
1	Battery Low alarm			-	
2	Hardware Fail alarm			-	
3	Bus_Link fail alarm			-	
4	Complete Comms Fail	Count for digital input 2	1	-	
5	Mains Fail			-	
6	Primary Comms Fail Alarm			-	
7	Secondary Comms Fail Alarm			-	
8	Digital Input 1	Count for digital input 3	2	Digital Output 1	
9	Digital Input 2			Digital Output 2	
10	Digital Input 3			Digital Output 3	
11	Digital Input 4			Digital Output 4	
12	Digital Input 5	Count for digital input 4	3	Digital Output 5	
13	Digital Input 6			Digital Output 6	
14	Digital Input 7			Digital Output 7	
15	Digital Input 8			Digital Output 8	
16	Digital Input 9[1]	Battery Volts	4	Digital Output 9[2]	-
17	Digital Input 10[1]			Digital Output 10[2]	
18	Digital Input 11[1]			Digital Output 11[2]	
19	Digital Input 12[1]			Digital Output 12[2]	
20	Digital Input 13[1]	Radio Receiver Signal Strength (RSSI)	5	Digital Output 13[2]	-
21	Digital Input 14[1]			Digital Output 14[2]	

22	Digital Input 15[1]			Digital Output 15[2]	
23	Digital Input 16[1]			Digital Output 16[2]	
24	Digital Input 17[1]	Analogue Input 1	6	Digital Output 17[2]	Analogue Output 1
25	Digital Input 18[1]			Digital Output 18[2]	
26	Digital Input 19[1]			Digital Output 19[2]	
27	Digital Input 20[1]			Digital Output 20[2]	
28	Digital Input 21[1]	Analogue Input 2	7	Digital Output 21[2]	Analogue Output 2
29	Digital Input 22[1]			Digital Output 22[2]	
30	Digital Input 23[1]			Digital Output 23[2]	
31	Digital Input 24[1]			Digital Output 24[2]	

All alarm bits are ‘1’ in the normal state and ‘0’ when in alarm

NOTES

1 Only available if a digital input expansion module is fitted, otherwise read ‘0’

2 Only available if a digital output expansion module is fitted, otherwise ignored

If more than one digital input expansion module is fitted it will ‘spill over’ into the next input data block, as will any analogue input expansion modules. Similarly, if more than one digital output expansion module is fitted it will ‘spill over’ into the next output data block, as will any analogue output expansion modules. A Mega_Link 2 base-station or outstation could therefore occupy up to 33 consecutive data blocks in the worst case (i.e. if it is fitted with a full complement of 32 8-channel analogue input modules).

8.4 I/O Expansion

Mega_Link 2 can be fitted with up to 32 expansion I/O modules by 'daisy-chaining' them using the expansion bus. Each module must be set to a unique address in the range 0…31, using the DIP switches on each module. The addresses must be contiguous, starting from 0. Mega_Link 2 automatically detects the expansion modules when power is first applied, then sorts them by type, and concatenates them to its built-in I/O, allocating them I/O addresses as appropriate. If the I/O exceeds the capacity of the Root data block, it will 'spill over' into the next data block(s).

The physical location and sequence of each module along the expansion bus is unimportant.

The following example shows how Mega_Link 2 will allocate I/O when expansion modules are fitted to a base-station (i.e. root data block = 0):

Module Type	Address	I/O address allocated	I/O register
16-channel Digital Input	0	Digital input 9…24	Input Data Block 0, Digital 16…31
8-channel Analogue Input	1	Analogue input 3…10	Input Data Block 1, Register 0…7
8-channel Analogue Input	2	Analogue input 11…18	Input Data Block 2, Register 0…7
16-channel Digital Output	3	Digital output 9…24	Output Data Block 0, Digital 16…31
4-channel Analogue Output	4	Analogue output 3…6	Output Data Block 1, Register 0…3
4-channel Analogue Output	5	Analogue output 7…10	Output Data Block 1, Register 4…7

In this example the modules have been allocated logical addresses, starting with digital inputs and progressing through analogue inputs, digital outputs and analogue outputs. Mega_Link 2 automatically appends onto the end of its own I/O contiguous addresses for I/O on expansion modules, in ascending order of the addresses set on their DIP switches.

The physical location of I/O modules on the expansion bus is not important, neither is the sequence of I/O modules. For example, suppose this system is expanded at a later date by adding expansion modules. To overcome the need for re-routing cabling to expansion modules, the modules can be appended in any order:

Module Type	Address	I/O address allocated	I/O register
16-channel Digital Input	0	Digital input 9…24	Input Data Block 0, Digital 16…31
8-channel Analogue Input	1	Analogue input 3…10	Input Data Block 1, Register 0…7
8-channel Analogue Input	2	Analogue input 11…18	Input Data Block 2, Register 0…7
16-channel Digital Output	3	Digital output 9…24	Output Data Block 0, Digital 16…31
4-channel Analogue Output	4	Analogue output 3…6	Output Data Block 1, Register 0…3
4-channel Analogue Output	5	Analogue output 7…10	Output Data Block 1, Register 4…7
16-channel Digital Input	7	Digital input 25…40	Input Data Block 1, Digital 0…15
4-channel Analogue Output	8	Analogue output 12…15	Output Data Block 2, Register 1…4
8-channel Analogue Input	9	Analogue input 19…26	Input Data Block 3, Register 0…7

Mega_Link 2 automatically appends the new digital inputs to the end of the previous ones, even though the module addresses are not contiguous.

8.5 Station Addresses

Every Mega_Link 2 system comprises one base-station and one or more outstations. The base-station is by default always set to station address 0. Convention is to set each outstation main module to #10, #20, #30 etc.

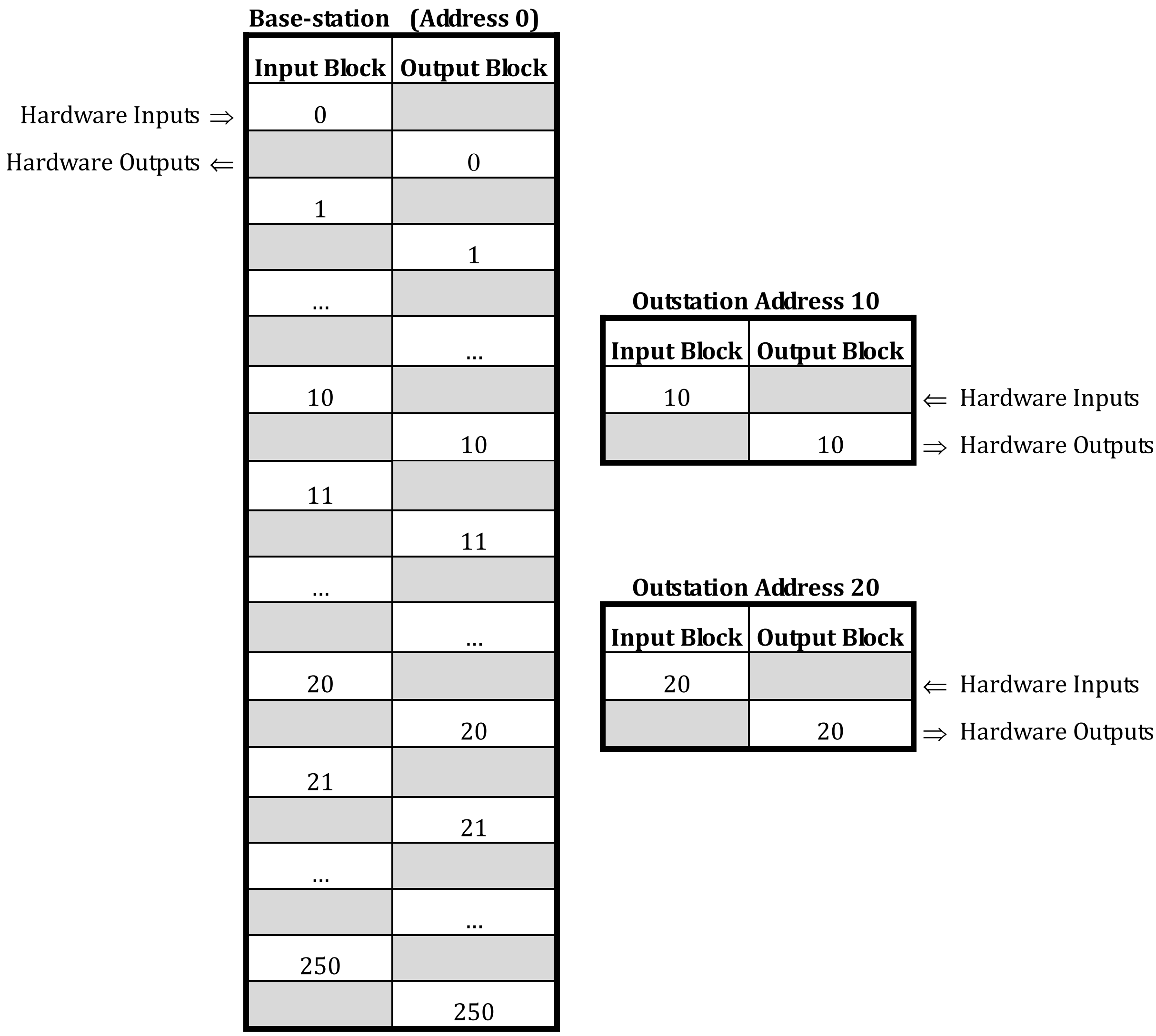
As stated above, the station address defines the root data block. A Mega_Link 2 station fitted with expansion modules may occupy more than one data block, as illustrated in the previous example. To ensure that there is no conflict between data blocks used by outstations and those used by base-station expansion modules, it is advisable to set the first outstation to address #10, to allow for any future expansion of the base-station. A good plan is to uses addresses #10, #20, #30… allowing up to 24 large outstations to be used.

8.6 Data Routing

Once it has identified the internal and expansion I/O with which it is equipped, a Mega_Link 2 station can pass data to/from its own I/O using the addresses it has allocated for them. However, the base-station also need to know what data to pass to/from outstations. Until this is configured it does not know how many outstations exist, what their addresses are, or how big they are.

8.6.1 Basic system

Suppose three stations are used on a system, and set to addresses 0, 10 and 20. Station address 0 is by definition the base-station, and maintains a full database. The others are outstations. All stations automatically map their hardware I/O to their Root Data Blocks:



It should be apparent that at this stage no meaningful data is being sent around the network, since hardware inputs are not mapped to hardware outputs. The base-station doesn't know how many outstations are installed, so it doesn't communicate with any.

This is solved by configuring the base-station to carry out internal data transfers:

8.6.2 Internal Data Transfers

Internal data transfers can be easily configured in a Mega_Link 2 base-station by using the DCD 2 Configuration Software. They allow the user to copy digitals and registers from any given location to any other location(s). Obviously, care must be taken in configuring internal data transfers to ensure that no digital or register is written data from more than one source, or unpredictable results may occur.

For example, the following entries could be made in the data routing table of the base-station:

Outstation Address 10 Analogue Input 1 - 2 → Local Analogue Output 1 - 2

Outstation Address 20 Analogue Input 1 - 2 → Local Analogue Output 3 - 4

Outstation Address 10 Comms Fail Alarm → Local Digital Output 1

Outstation Address 20 Comms Fail Alarm → Local Digital Output 2

Outstation Address 10 Battery Low Alarm → Local Digital Output 3

Outstation Address 20 Battery Low Alarm → Local Digital Output 4

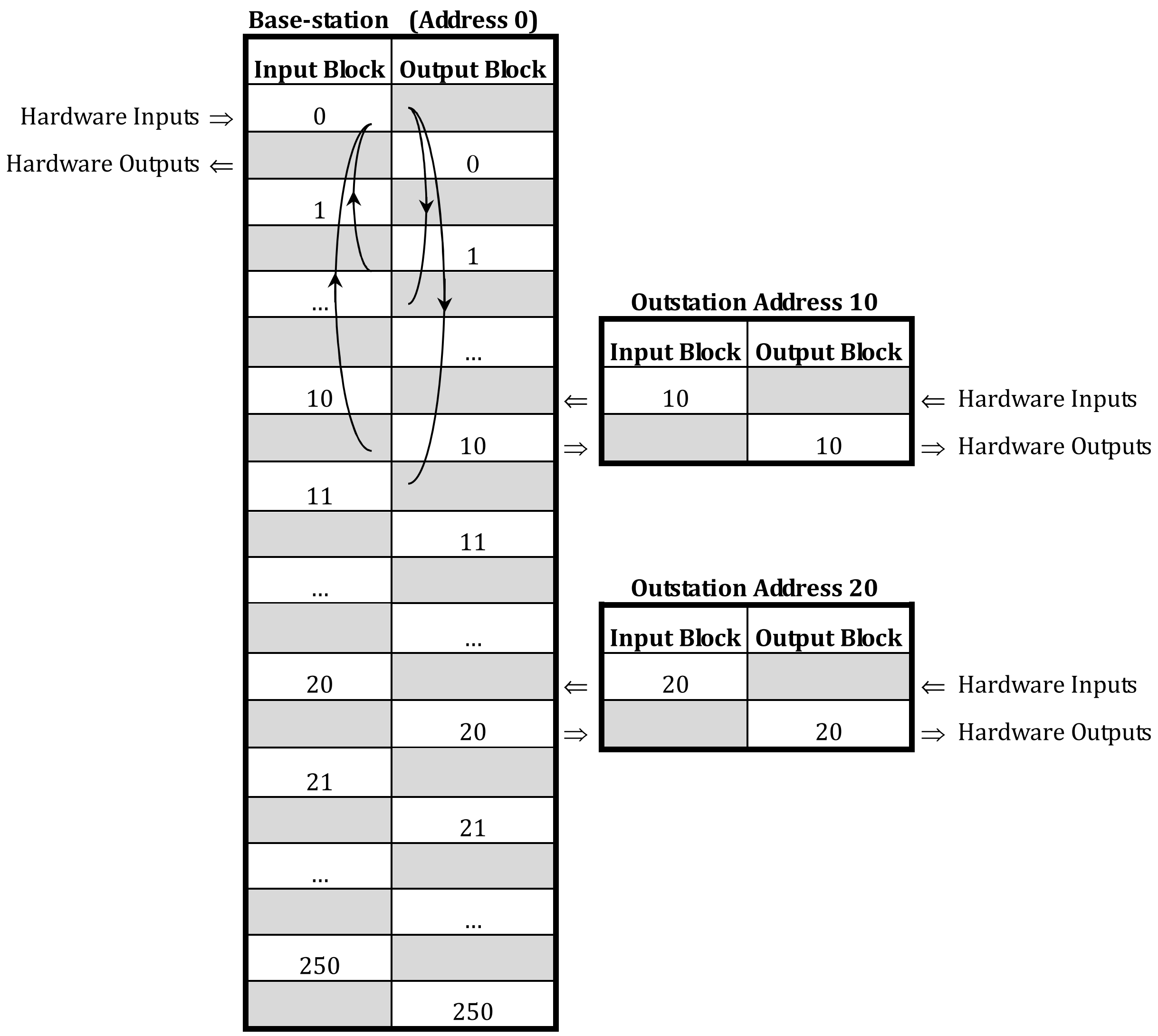
When the base-station recognises an entry in the data routing table which refers to a data block which is not allocated to its internal I/O or to expansion I/O, it assumes it must get the data from an outstation. It thus adds the outstation to its poll sequence.

If the following lines were added:

Local Digital Input 1 - 4 → Outstation Address 10 Digital Output 1 - 4

Local Digital Input 5 - 8 → Outstation Address 20 Digital Output 1 - 4

Then the base-station will also send a data block to each outstation. This can be visualised as follows:



The poll sequence for the above system would be:

Request Input Data Block 10

Send Output Data Block 10

Request Input Data Block 20

Send Output Data Block 20

8.6.3 Bus_Link Data Transfers

Data can also be passed to and from the database using serial communications through the ***Bus_Link*** port. If an external device accesses any register which is not allocated to local I/O, Mega_Link 2 will assume it is to be passed to/from an outstation, and incorporate that outstation in its poll sequence.

8.7 Polling

The smallest system configuration comprises two Mega_Link 2s configured as a point-to-point link. One is defined as a base-station (station address 0) and the other as an outstation (station address 10).

A Mega_Link 2 base-station knows which data blocks are being used because they are either being accessed by internal data transfers stored in the DCD2 Configuration file, or they are being accessed via Bus_Link.

After a power interruption (and after downloading a configuration), a Mega_Link 2 base-station first scans the configuration table to read any exception data included within it. It then polls all outstations, writing data to them and reading data from them, so that all I/O is initialised without undue delay. In the process of doing this, it sends to each outstation any relevant exception configuration data.

When it has finished this initial scan, the base-station starts polling the outstations at the rate defined in the global configuration downloaded into it.

All outstations are scanned at the rate defined in DCD2 Configuration by Normal Outstation Scanning Window. The base-station will attempt to write and/or read data to/from an outstation at the beginning of a window. It will then wait until the end of the window before communicating with the next outstation. When it has scanned all of the outstations it will repeat the cycle. The overall scan time is thus (n * Normal Outstation Scanning Window), where n is the number of data blocks used.

If exception reporting is configured the base-station checks its inputs for exceptions during the pauses between outstation polls. If any configured input change occurs at the base-station it will immediately send an exception report to the relevant outstation. Similarly, each outstation monitors its inputs for exception changes and, if detected, sends an exception report to the base-station. The recipient of an exception report will send back an acknowledgement. If an acknowledgement is not received an outstation will repeatedly send the exception report at random time intervals (in the range 2…10 seconds). This ensures success even if multiple outstations initiate exception reports simultaneously.

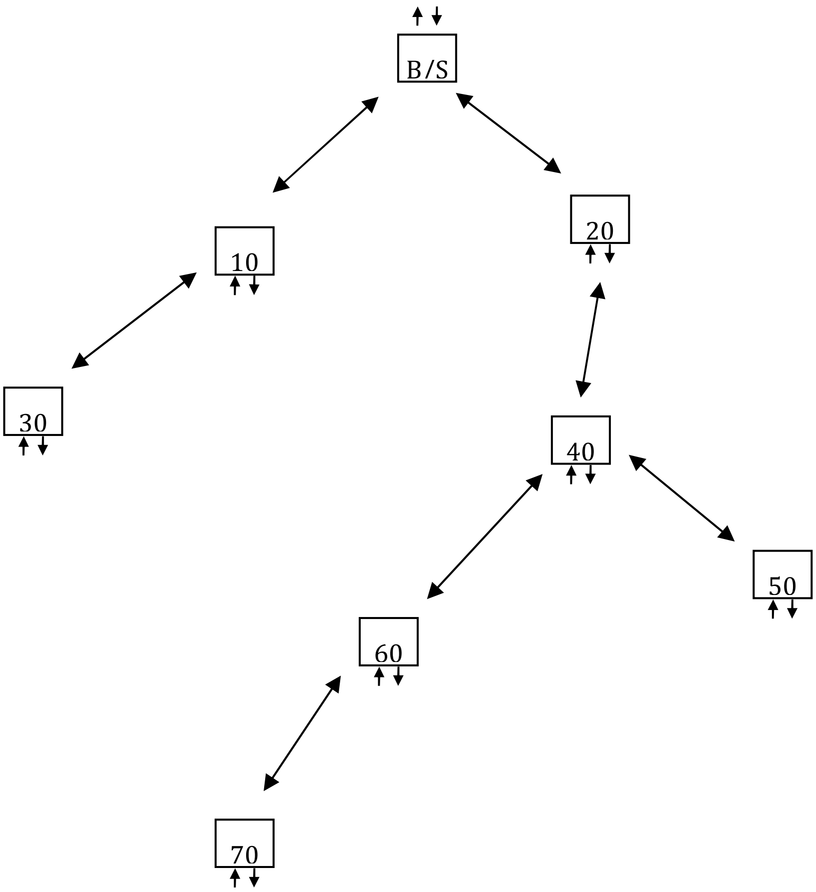
8.8 Radio Network Routing

A Mega_Link 2 system could range from a simple small point-to-point link up to a large polling system with multiple outstations, repeaters and interfaces to PLC’s, SCADA systems and/or regional telemetry schemes.

A fundamental consideration of any system using de-regulated radio is the limitation on radio transmit power, which is an inherent requirement to restrict interference with other users. MPT1329 is the UK standard for telemetry applications, which allocates 32 channels in the 458.5MHz band, with the transmit power limited to 500mW. (Other countries may use a different band, but most still allow up to 32 channels within the band). With modern technology the corresponding receivers are sensitive enough to achieve a range of up to 25km (15 miles) with good elevated aerials and no obstructions. The range will be reduced if smaller aerials are used near ground level, if there are obstacles such as large buildings, or if there are geographical features such as hills. In a typical urban environment with a good base-station aerial and outstations in roadside cabinets the range could typically be reduced to 5km (3 miles). Communication with outstations below ground, within manholes, is possible, but the range is reduced to typically 500m. Extending the radio range beyond this requires the use of repeaters.

e.g. Basestation = Address 0, Repeater = Address 10, Outstation = Address 20.

A hypothetical system might be as follows:



The illustration shows 4 levels of repeaters to reach outstation 70. In fact, up to 8 levels of repeaters can be used to reach distant outstations.

The DCD2 Configuration software only expects the user to identify the last repeater used to access each outstation. If no entry is made for a specific outstation the base-station assumes it has direct communications. If the last repeater is configured to be accessed via another repeater, the software will automatically derive the chain of repeaters needed. For example, for the above system the user may first identify that to access outstation 40 the last repeater is 20.

The routing table for this network will thus be:

Address	Route
40	20

If another entry is made to access outstation 60 via 40, the table will become:

Address	Route
40	20
60	40 20

The final table for the above system will be:

Data Block	Last Repeater
30	10
40	20
50	40 20
60	40 20
70	60 40 20

If an outstation occupies more than one data block, an entry is required for each data block used. For example, if outstation 40 includes expansion modules that occupy two additional data blocks, then the network routing table will need to be modified thus:

Data Block	Last Repeater
30	10
40	20
41	20
42	20
50	40 20
60	40 20
70	60 40 20

8.9 Fieldbus or Bus_Link

One of the key features of Mega_Link 2 is its ability to communicate through a serial data interface with external devices, using one of a variety of standard protocols. Churchill Controls proprietary name for this interface is Bus_Link a term used by Micro_Link or Fieldbus for Mega_Link 1.

Mega_Link 2 can be configured as a Fieldbus/Bus_Link slave or master via COM 3, with the protocol and timing requirements. If it is used as a slave the user must define its slave address.

Industrial automation has developed around Programmable Logic Controllers (PLC's) which are available from a wide range of manufacturers. Originally these were stand-alone devices, but the need soon arose for passing data between them. Supervisory, Control and Data Acquisition (SCADA) systems were also developed to provide a man-machine interface with features such as alarm annunciation, data archiving and closed loop control.

Unfortunately, each PLC manufacturer has evolved his own communications protocol. Some have a hierarchy of protocols optimised for different applications, some of which use multiple master protocols operating on high-speed LAN networks. However, all have low-speed variants operating in master-slave mode at either RS232 or RS485 signal levels.

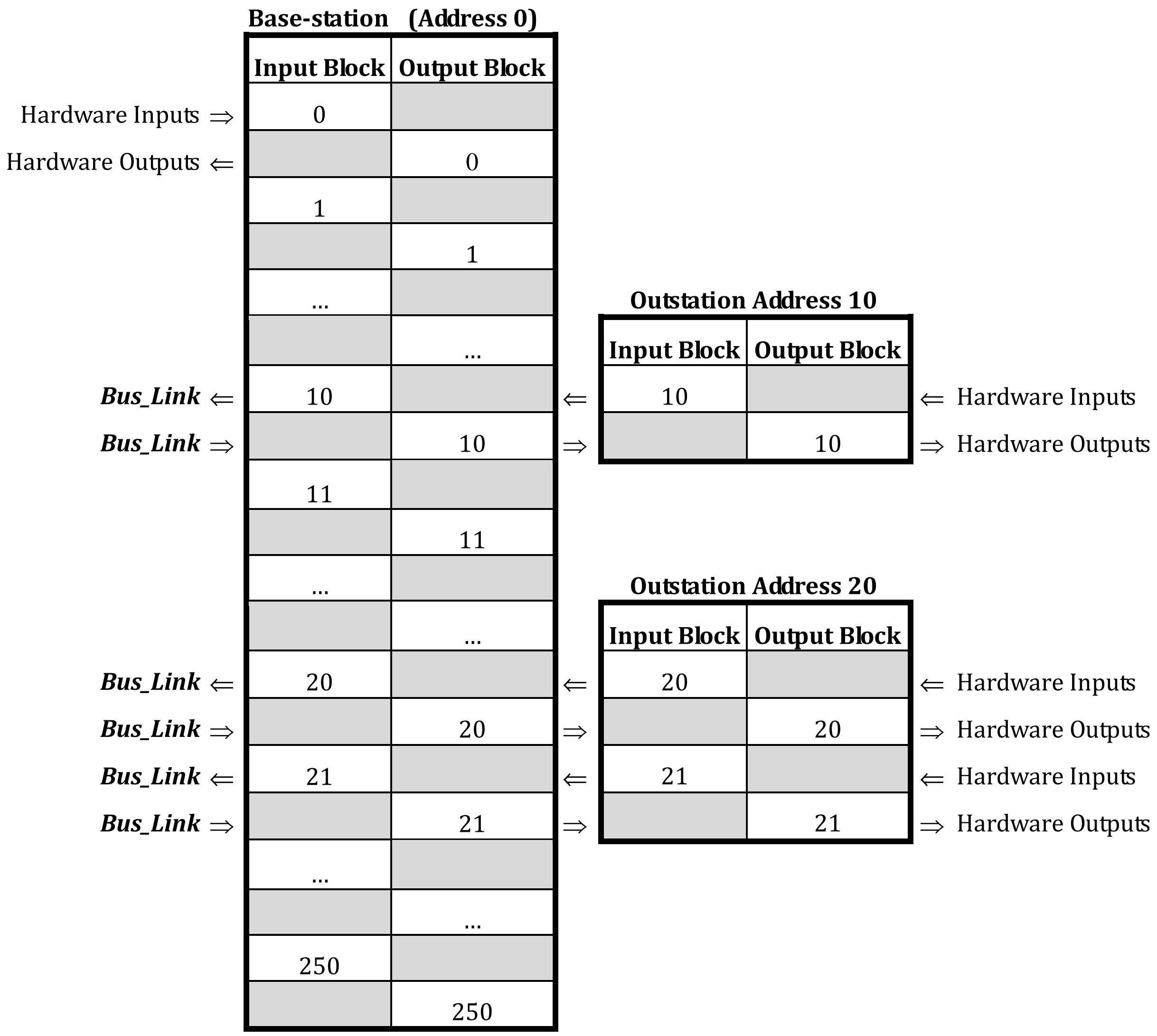
Because of the plethora of protocols, all general-purpose devices that need to communicate with PLC's (such as SCADA systems) have to be designed with a variety of software drivers, which can be selected to match the required standard. Bus_Link has been designed in the same way.

Bus_Link can be configured to use either a standard RS232 interface or a multi-drop RS485 interface. It can be configured to emulate either a slave device or a master device, and to communicate using a variety of different protocols. All configuration is carried out using the DCD2 Terminal.

All PLC protocols are based around registers. In all master-slave protocols the communication is instigated by the master device, which can copy data between its own registers and registers in the slave device(s). Some registers contain 16-bit values, while others represent the state of individual digitals. Mega_Link 2 maintains a database that closely resembles that of any PLC.

8.10 Configuring Bus_Link at the Basestation

Bus_Link could typically be used in a Mega_Link 2 basestation to allow data to be passed to/from a SCADA/PLC system. Since most SCADA systems emulate a PLC master, the Mega_Link 2 Bus_Link would be configured in slave mode:



Since the SCADA system is a PLC master it will be configured to identify which data it requires to access, using absolute addressing.

Basestation Examples

To gather and read analogue inputs from Outstations by PLC1 at the Basestation use the following commands. PLC1 is a master and the basestation is set to Slave ID=1.

To read Outstation #10 analogue inputs 1 & 2, which start at register address 10 x 8 +6 =86:

At the PLC1 (Basestation);   04 Read Input Registers, Slave ID 1, Address 86, Qty 2.

This will automatically cause the basestation to repeatedly poll and exchange data with Outstation #10, if not already doing so.

To read Outstation #20 with analogue input expansion module, analogue inputs 1 - 10, which start at register address 20 x 8 +6 =166:

At the PLC1 (Basestation);   04 Read Input Registers (3x), Slave ID 1, Address 166, Qty 10.

This will automatically cause the basestation to repeatedly poll and exchange data with Outstation #20 and its analogue input expansion module (Outstation #21), if not already doing so.

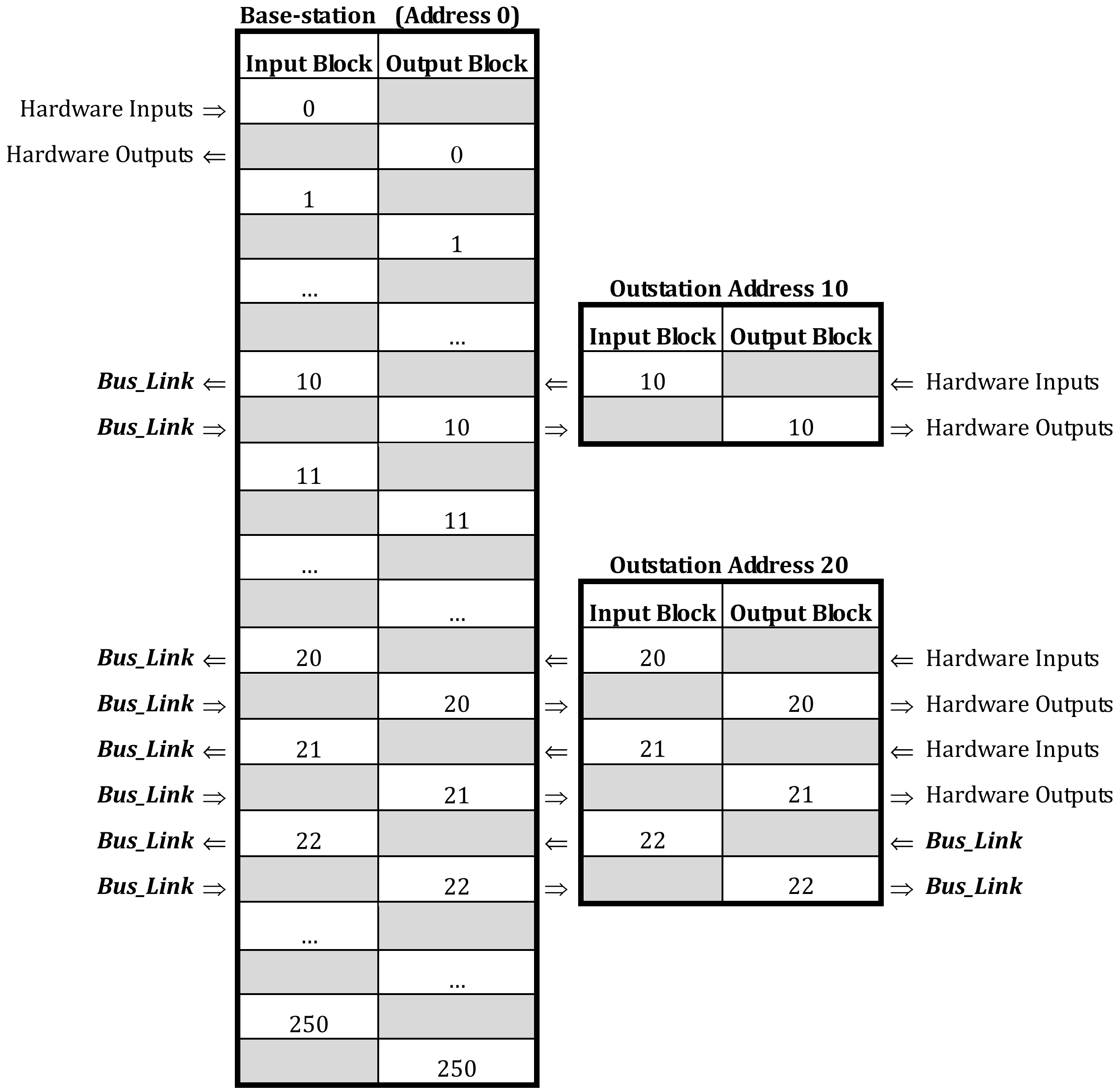
To read Outstation #20 battery volts the PLC1 should read Input Register 164 (20 x 8 + 4 = 164).

At the PLC1 (Basestation);   04 Read Input Registers (3x), Slave ID 1, Address 164, Qty 1.

Any register or digital can be copied to any destination(s) via Bus_Link and/or internal transfers. However, any given output register or digital must only be fed data from one source.

8.11 Configuring Bus_Link at the Outstation

Bus_Link is also available on Mega_Link 2 outstations. Its most likely application here is to exchange data with PLC's or intelligent instruments. The user must decide which registers and digitals to use in the outstation. Small amounts of data can use spare capacity in the outstation's Root Data Block or expansion data blocks. Larger amounts of data can be directed to/from any other data block (except those used by other outstations!). It is most logical to append Bus_Link data to the end of the hardware I/O, although thought should be given to the possibility of expanding the hardware I/O at some time in the future:



In the above example data to/from Bus_Link on outstation 20 has arbitrarily been routed to/from data block 22. The base-station treats the data exactly as it would data from expansion modules at the outstation. By this means, data is transferred seamlessly between hardware I/O and PLC's, SCADA systems and third-party equipment

The Bus_Link interface at the outstation has to read data from the Mega_Link 2 output registers and write to the Mega_Link 2 input registers. If the outstation is configured to emulate a slave device the external master system needs to follow this convention. Some PLC protocols don't support commands to comply with this requirement. Therefore Mega_Link 2 translates any command received by an outstation in Bus_Link slave mode as accessing the correct register type, regardless of the command detail.

Example #1

To transfer 8 registers of data from PLC1 at Basestation to PLC2 at Outstation #20 use the following commands. Both PLCs are masters. Both basestation and outstation #20 are set to Slave ID=1.

At the PLC1 (Basestation); 16 Write Multiple Registers, Slave ID 1, Address 168, Qty 8.

At the PLC2 (Outstation #20); 04 Read Input Registers (3x), Slave ID 1, Address 168, Qty 8.

This will automatically cause the basestation to repeatedly poll and exchange data with a virtual Outstation #22, if not already doing so.

Example #2

To transfer 8 registers of data in opposite direction, from PLC2 at Outstation #20 to PLC1 at Basestation use the following commands. Both PLCs are masters. Both basestation and outstation #20 are set to Slave ID=1.

At the PLC2 (Outstation #20); 16 Write Multiple Registers, Slave ID 1, Address 168, Qty 8.

At the PLC1 (Basestation); 04 Read Input Registers (3x), Slave ID 1, Address 168, Qty 8.

This will automatically cause the basestation to repeatedly poll and exchange data with a virtual Outstation #22, if not already doing so.

8.12 Modbus Protocol

The Modbus protocol was originally defined by AEG Modicon (now part of Schneider Electric) for communicating with their PLC's. However, it has now become the de facto standard and has been adopted by many other PLC manufacturers. In Modicon terminology digital outputs are Coils, digital inputs are Status's, output registers are Holding Registers and input registers are Input Registers. To further distinguish one from another, they are given unique addresses:

00001…08000	Coils
10001…18000	Status's
30001…32000	Input Registers
40001…42000	Holding Registers

However, Modbus protocol defines within each command the type of data required, so the x000 prefix is not required. Furthermore, although the database registers start counting from 1, Modbus protocol starts from 0.

Bus_Link interface makes allowance for the x000, prefix, so for example the first status input is designated 1, not 10001. However, some PLC implementations of Modbus also allow for the 0/1 discrepancy, so they may refer to the first digital as digital 0 rather than digital 1. Since there is no universal conformity the user has may have to adjust all addresses by 1 to allow for the translation within the PLC's Modbus driver.

8.12.1 Modbus Slave Mode

If Bus_Link is configured to operate in Modbus slave mode, it will respond to the following commands from master device:

Function Code	Modbus meaning	***Bus_Link* action**
01	Read Coil Status	Read digital outputs
02	Read Input Status	Read digital inputs
03	Read Holding Registers	Read output registers
04	Read Input Registers	Read input registers
05	Force Single Coil	Write to digital output
06	Pre-set Single Register	Write to output register
15	Force Multiple Coils	Write to digital outputs
16	Pre-set Multiple Registers	Write to output registers

An outstation configured as a Bus_Link slave will interpret any command that is reading any digital/register other than those used by hardware I/O as addressing an output digital/register. Similarly, any command writing to a digital/register will address the relevant input.

8.12.2 Modbus Master Mode

If Bus_Link is configured to operate in Modbus master mode, it will send the following commands to a slave device:

***Bus_Link* action**	**Function Code**	**Modbus meaning**
Read slave digital outputs	01	Read Coil Status
Read slave digital inputs	02	Read Input Status
Read slave output registers	03	Read Holding Registers
Read slave input registers	04	Read Input Registers
Write to slave digital inputs	15	Force Multiple Coils
Write to slave output registers	16	Pre-set Multiple Registers

For example, the following line within the data routing table of a base-station will copy the first two analogues from outstation 10 to holding registers 10…11 (i.e. registers 40010…40011) of a PLC set to address 0, using Function Code 16:

Outstation 10 Analogue Input 1-2 -> Bus_Link Add 0 *Analogue o/p register 10-11

This line will copy digital inputs 20…27 from the PLC to the first 8 digital outputs at outstation 20, using Function Code 02:

Bus_Link Add 0 *Digital i/p register 20-27 -> Outstation 20 Digital Output 1-8

9 Data Routing

Every Mega_Link 2 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

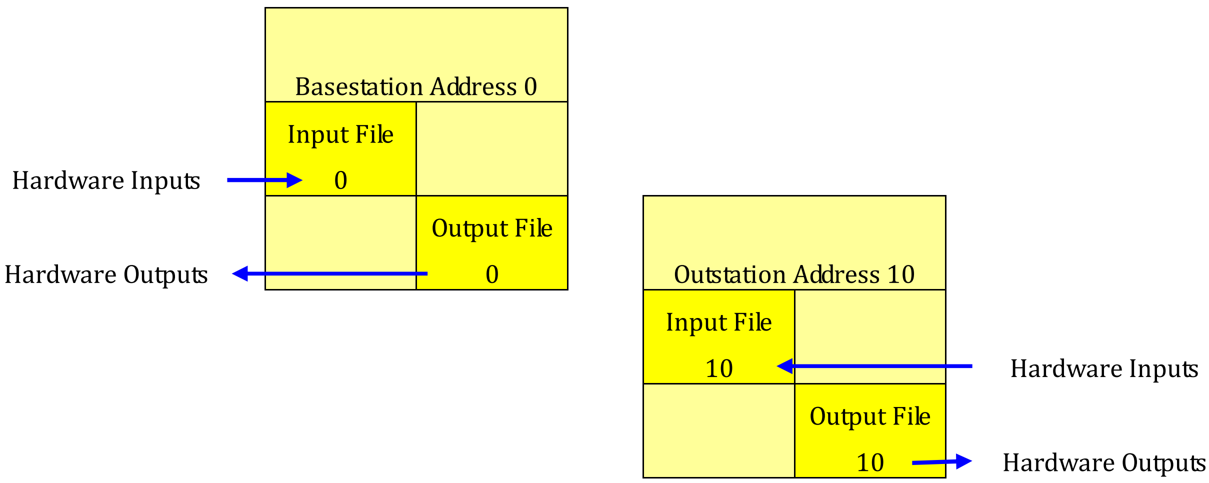
Output File	
Register 0	Digital 0
Register 1	Digital 1
.	.
.	.
Register 7	Digital 31

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

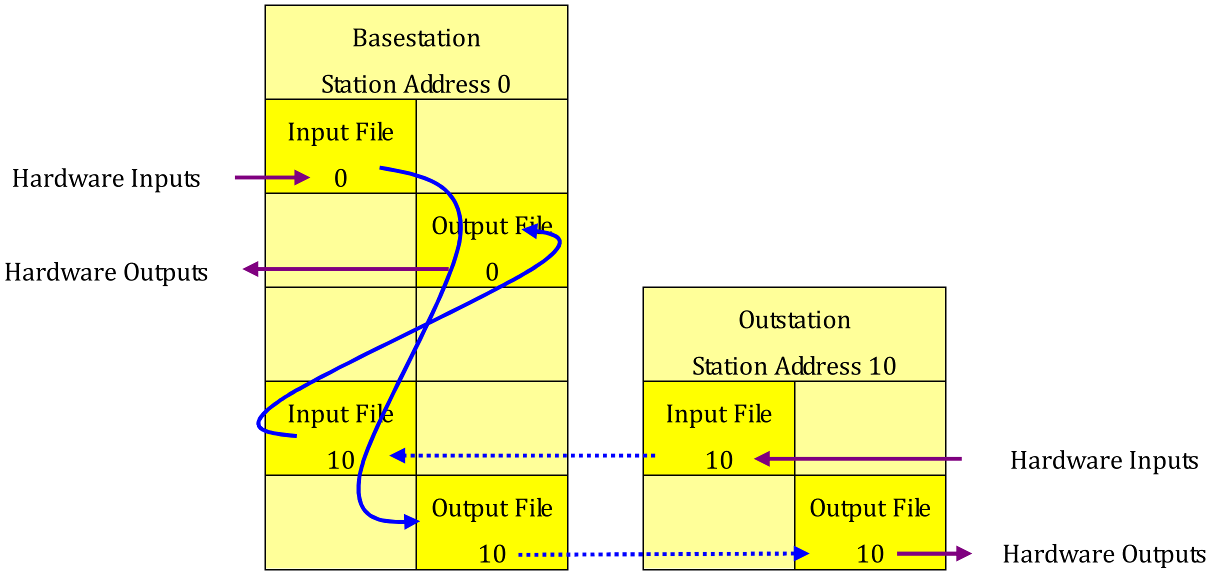
Every Mega_Link 2 is configured with a station address. It maps its hardware inputs and alarm flags to the input file corresponding to its station address, and copies the corresponding output file to its hardware outputs. The databases of a system of two stations could be visualised as follows:



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 the basestation (address 0). The system could be configured as follows:



The additions from the last example are shown in blue:

- The basestation 0 has been configured to function on one of its COM ports. Station 10 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 radio modems on COM1.
- Data routing has been configured in the basestation to copy data from outstation 10 to its local outputs. The basestation will automatically poll outstation 10 to populate Input File 10 with data from the outstation inputs.
- Data routing has also been configured in the basestation to copy some of its local inputs to outputs at outstation 10. Mega_Link 2 protocol will automatically poll outstation 10 to copy the data to it.

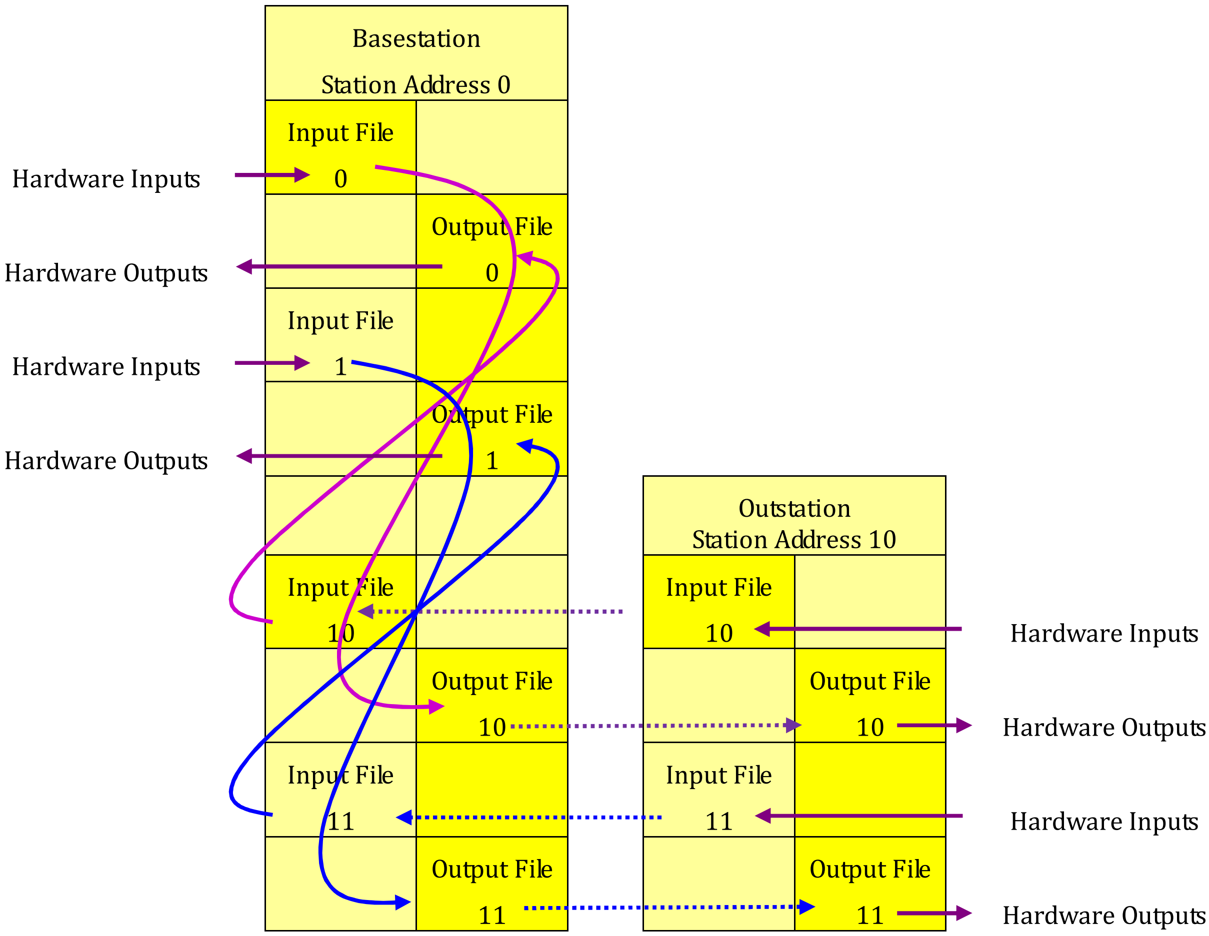
It should be apparent that by configuring the basestation and configuring data routing within it the system now functions as a simple telemetry system.

The entries in the basestation data routing table could typically include:

Outstation 10 Comms Fail Alarm	>>>	Local Digital Output 8
Outstation 10 Comms Fail Alarm	>>>	Outstation 10 Digital Output 8
Outstation 10 Digital Input 1 – 7	>>>	Local Digital Output 1 – 7
Local Digital Input 1 – 7	>>>	Outstation 10 Digital Output 1 – 7
Outstation 10 Analogue Input 1 – 2	>>>	Local Analogue Output 1 – 2
Local Analogue Input 1 - 2	>>>	Outstation 10 Analogue Output 1 - 2

9.2 Example 2 – Adding Hardware Expansion

The I/O capacity of every Mega_Link 2 can be increased by adding Analogue and expansion modules:

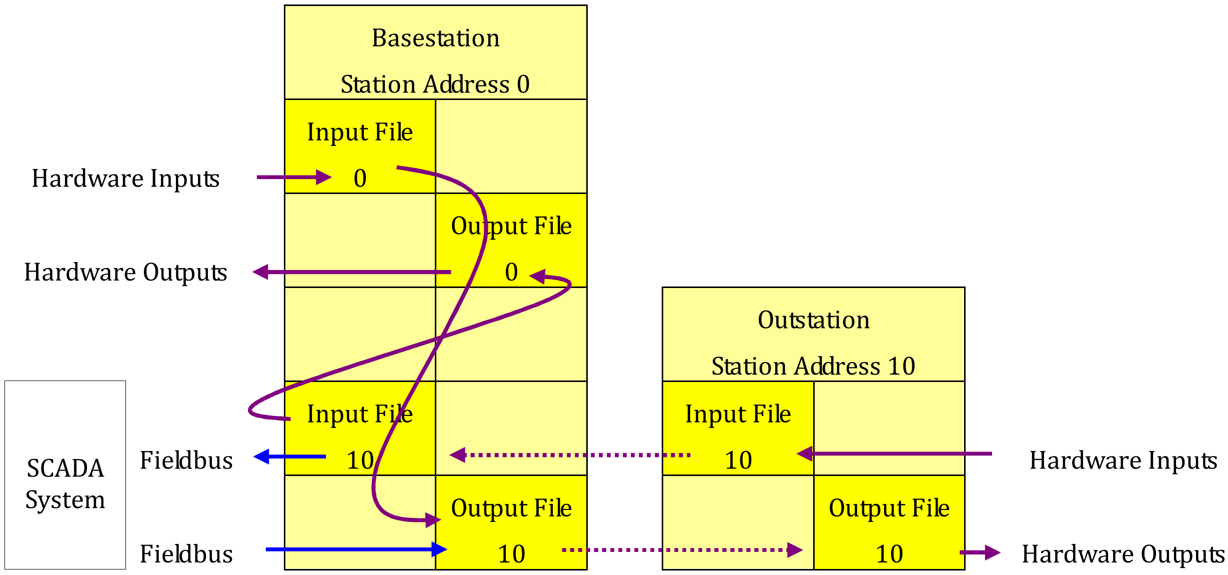


The additions from the previous example are shown in blue:

- Input expansion modules have been added to the basestation. Mega_Link 2 automatically maps these to be appended to the internal inputs, so they may spill over into input file 1.
- Output expansion modules have been added to the basestation, which could similarly spill over into output file 1.
- Outstation 10 has been similarly expanded and these will spill over into Outstation 11

9.3 Example 3 – Adding Fieldbus at the Basestation

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

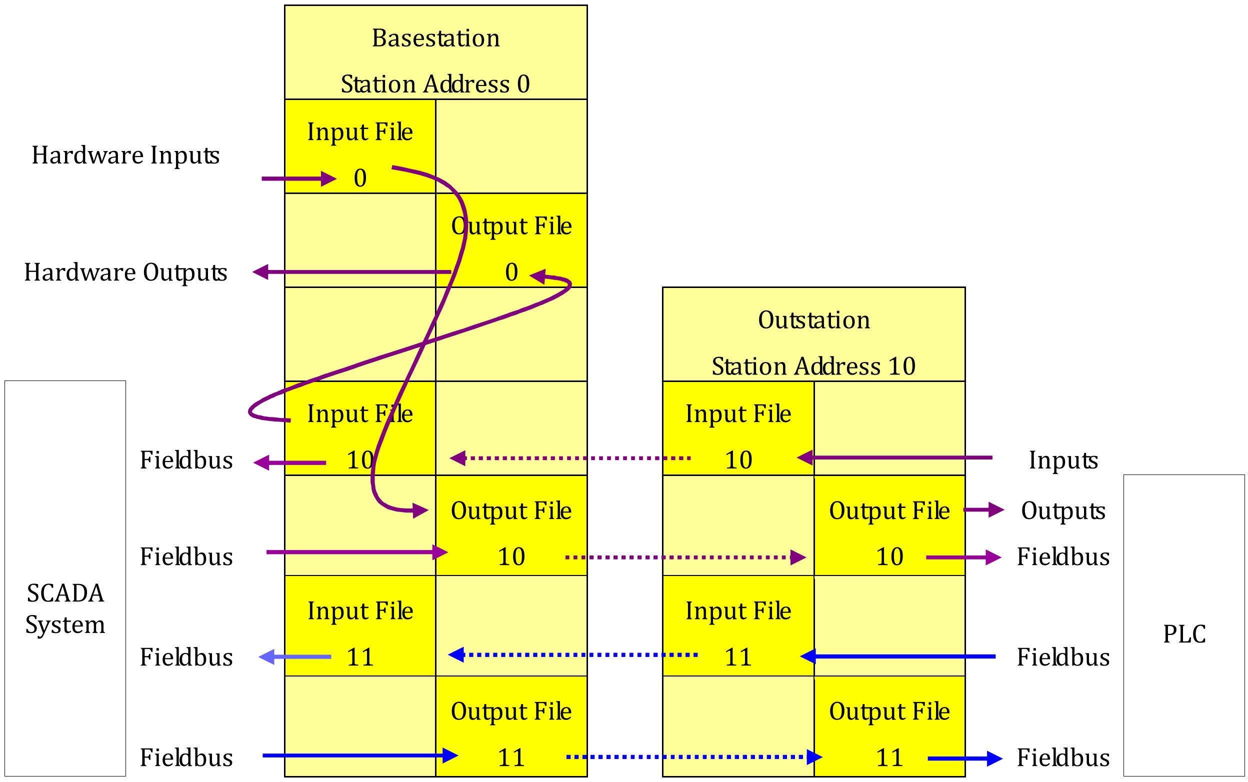


The additions from the previous example are shown in blue:

- A connection has been established between the basestation 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 basestation will respond to commands from the SCADA system.
- The SCADA system has been configured to read from to registers in Input Files 10. The Mega_Link 2 functions as a Fieldbus slave device, so the basestation 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 10. It is assumed that it is writing to different registers within file 10 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 10 has been linked to a PLC via via COM3 at RS485 levels. It has been configured to act as a Mitsubishi master, copying data from registers within output files 10 and 11 to the PLC, and copying data from the PLC into registers in input file 11.
- The SCADA system configuration has been expanded to also read from registers in Input File 11 and write to registers in Output File 11. This will automatically cause the basestation to poll for these files. Outstation 20 will recognise that it is using these files so it will respond.

Since outstation 10 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 2 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 File Mapping

The database within Mega_Link 2 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 2 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 station address. This applies both to the main inputs within Mega_Link 2 and any expansion input modules that may be fitted. Similarly, data from the output file corresponding to the station address is automatically copied to hardware outputs.
2. Data routing (configured via DCD 2) can be used to copy data between files at a basestation.
3. Fieldbus can be used to copy data between Mega_Link 2 files and external devices.

Whichever method is used, the following rules apply:

1. Data written to an output file at a basestation other than those used for local outputs will automatically be sent via Mega_Link 2 protocol to the corresponding outstation. (If no outstation acknowledges receipt of the data a Comms Fail alarm will be generated).
2. If data is read from an input file at a basestation 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 basestation.
4. If data is read from an output file at an outstation it is assumed that the basestation will write to this file to update the data.

Mega_Link 2 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 DCD 2 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 2 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 basestation the limit only applies to hardware I/O since data routing and Fieldbus can directly access outstation files. A basestation 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.

9.6 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.

10 System Monitoring

As well as mapping its hardware I/O and Fieldbus data to its database, Mega_Link 2 also stores data relating to its functionality:

10.1 Alarm Handling

Mega_Link 2 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 2 incorporates the provision for any digital outputs to be inverted if required.

10.1.1 Power Supply Monitoring

Mega_Link 2 automatically detects the type of power supply fitted and generates alarms accordingly:

10.1.1.1 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 2 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.

10.1.1.2 Charger Fail Alarm

If a mains power supply is fitted Mega_Link 2 it will continue operating through power failures, using its internal standby battery. However, Mega_Link 2 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 a Mega_Link 2 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.

10.2 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.

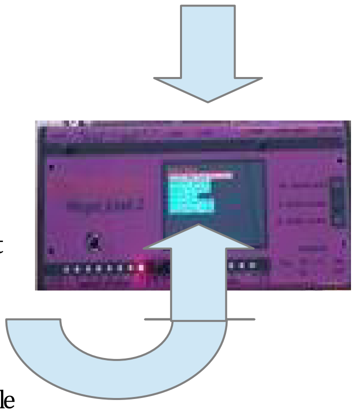
The value stored is (100 * dBm + [Transmit Power in dBm]). For example, if a system has an RSSI level of -102dBm and is transmitting at +27dBm (i.e. 500mW) then the register would read 10227. The RSSI can thus be extracted by dividing by 100 (albeit with a small offset due to the transmit power).

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

11 Installation

11.2 Mechanical



Mega_Link 2 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 2 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.

11.3 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 2.5mm^2. All COM port connectors are RJ45, compatible with widely-available Category 5 jumper cables.

11.3.1 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.

11.3.1.1 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.

11.3.1.2 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.

11.3.1.3 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.

11.4 Aerials

Most Mega_Link 2 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 2. 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 2. 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.

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 2. 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 2 and all associated instrumentation.

11.4.1 Omni-directional Aerials


End-fed Dipole

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. **Basestation antenna** radiate in a cone pattern, so have higher gain in the horizontal plane and downwards at the expense of reduced gain upwards.

11.4.2 Yagi


Yagi

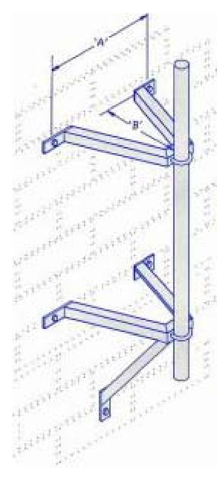
These are directional and have gain. The directionality and gain are determined by the number of elements. They attach to the side of a pole and must be mounted with the elements vertical. They must also point in the right direction. This may be determined approximately using a compass or GPS, but should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

11.4.3 Whip Antenna


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.

11.4.4 Aerial Fixings


Stand-Off Bracket

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.

11.4.5 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 cause by an electrostatic charge building up in moist air. It can reach extremely high voltages that eventually discharge to earth vie 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 comprised 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.

12 Display User Interface

The LCD display provides useful information about the system. It is controlled via an adjacent joystick. 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.

TBA

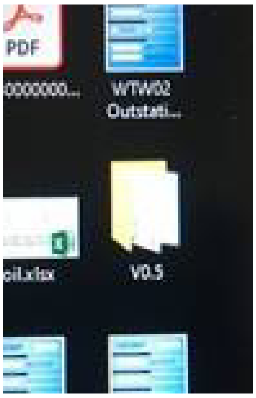
13 DCD 2 Terminal

Using a USB-Mini to USB-A cable, connect a spare USB port from the PC to the COM (USB1) port on Mega_Link 2.

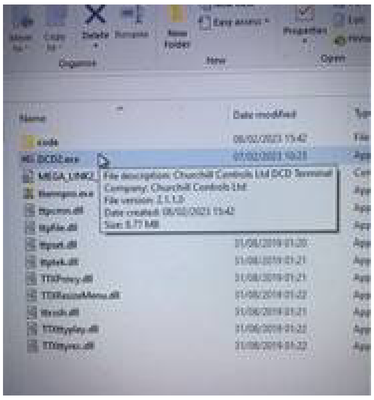
With the Mega_Link 2 unit powered up then the PC should make a bing noise as the USB port is enumerated.

DCD 2 Terminal is used to configure and diagnose problems on Mega_Link 2. It comprises two software packages running on a PC, DCD2 Configuration and DCD2 Diagnostics. It is supplied on a USB stick and is compatible with Windows 10.

There is no need to install the software, simply copy the folder containing the latest version over to your PC, e.g. to the desktop:



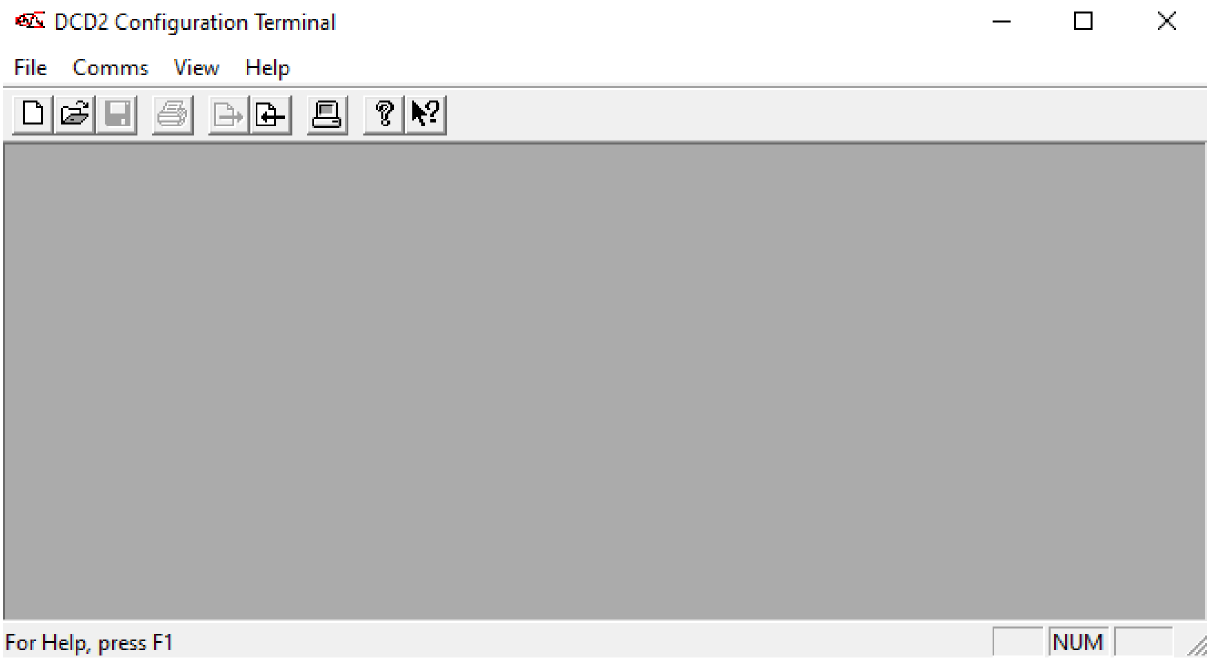
Navigate to the chosen location, e.g. on the desktop and double click on the copied folder to open and view into the folder, then highlight and double click on the “DCD2.exe” file.



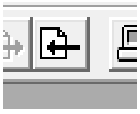
Note that a DCD 2 Configuration can be run without connection to Mega_Link 2, allowing configurations to be created and saved to disc before going to site.

13.1 DCD 2 Configuration

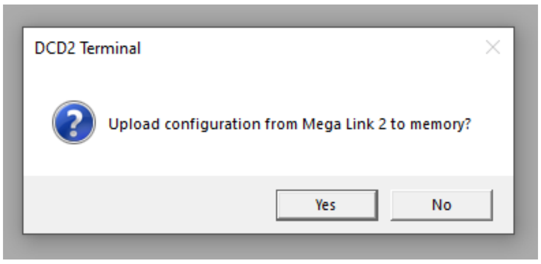
Double-click on the DCD2.exe file (or a short-cut icon) and the following window should open:



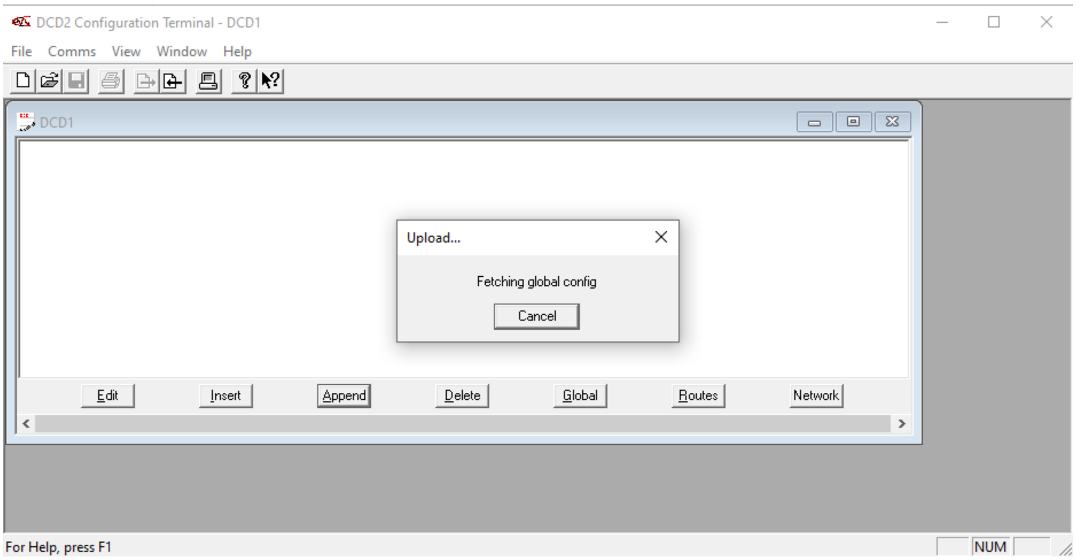
If the Maga_Link 2 already has a config loaded then clicking on the “left arrow” icon will allow the user to upload an existing config.



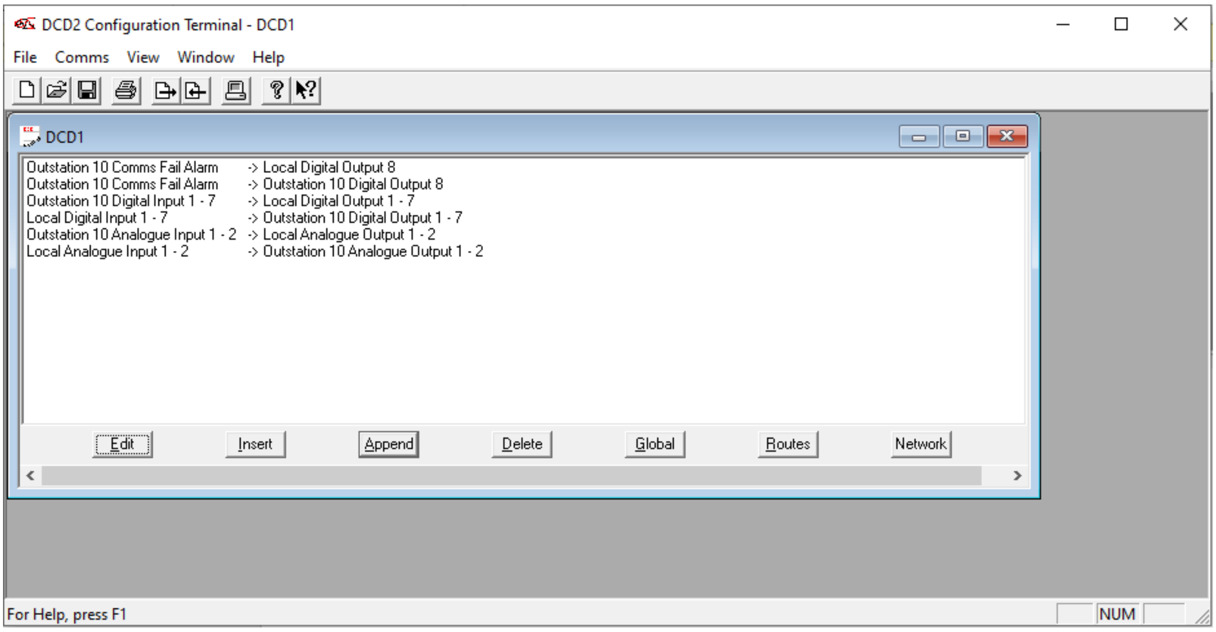
Click “Yes” to continue:



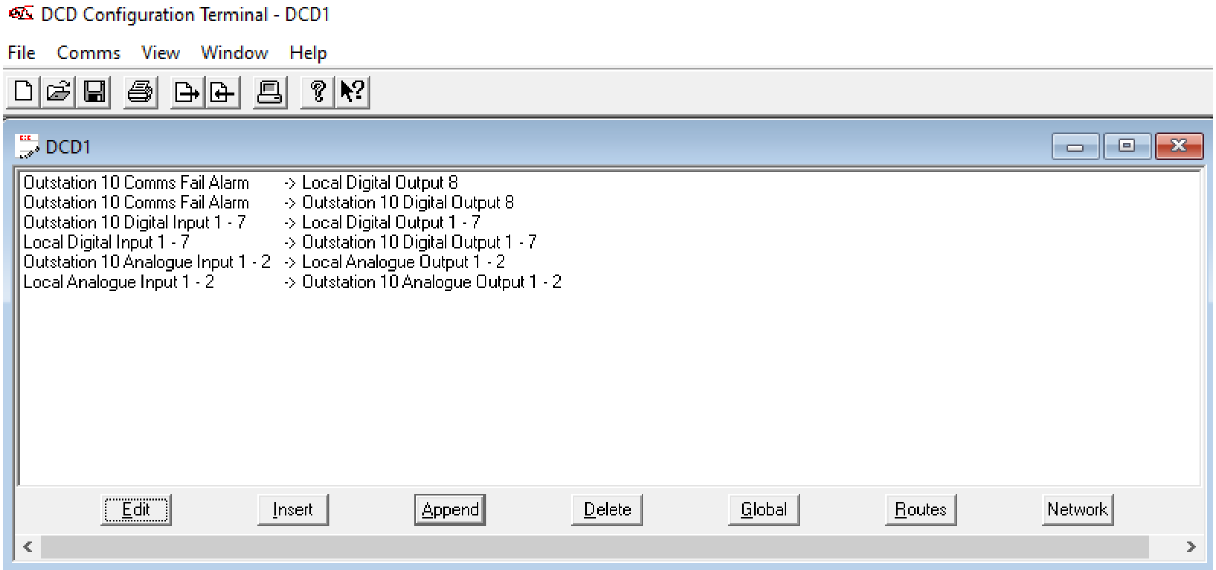
The screen will go through a few steps and an example is follows:



After a few seconds the current config will be available on the screen for example:

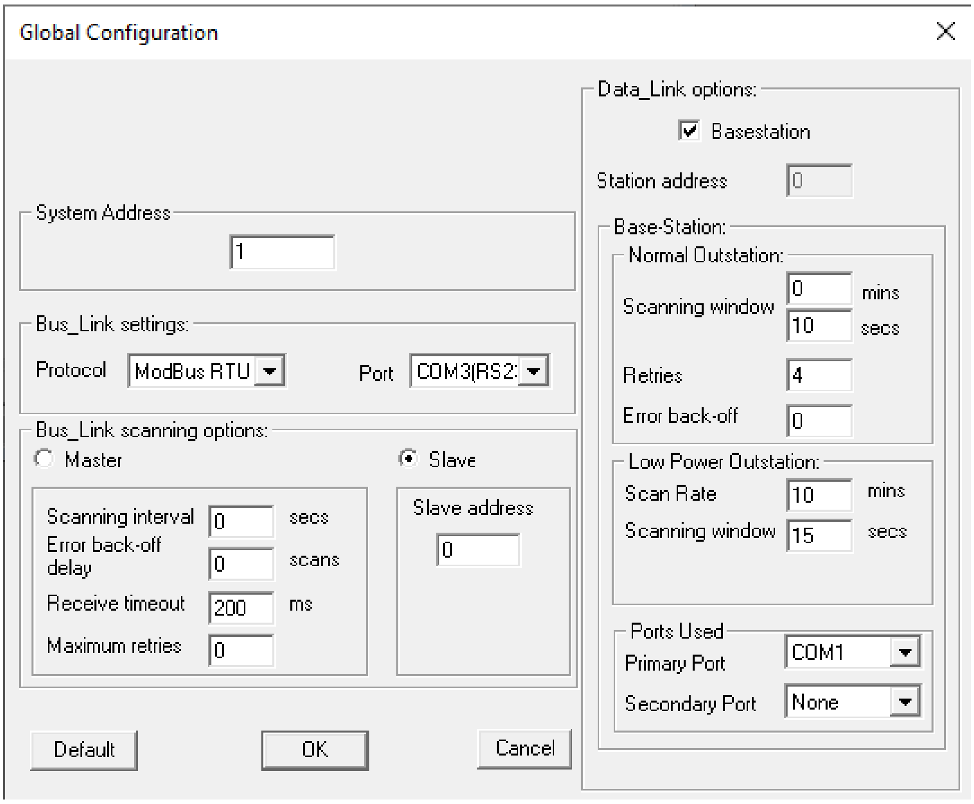


Select File/Open, and then select file Example1 from the installation USB. The screen will now show:



The opening window shows the Data Routing Table. However, before describing this, the Global Data and Network Data must be defined. Click on the Global button:

13.1.1 Global Configuration:



This window is divided into a number of parts:

13.1.1.1 System Address

This can be used to enter a system address (default = 0) for all stations within a common system.

Should another Mega_Link 2 system be operating nearby on the same common frequency, then if the system number is different these messages will be rejected.

13.1.1.2 Bus_Link Settings

This part is only relevant if the *Bus_Link* interface is used:

Protocol must obviously match that of the device(s) to which the *Bus_Link* port is connected, as must the serial data parameters.

Port is used to select the COM port to be used, normally COM3.

13.1.1.3 Bus_Link Options

This part is also only relevant if the *Bus_Link* interface is used:

Master/Slave radio buttons define the fundamental operation of the Bus_Link interface. In slave mode Bus_Link responds to commands from an external master, provided the address matches that in the Slave Address dialogue box.

Scanning interval sets the rate at which Bus_Link scans through the data routing table. If it is set to 0 the scan is continuous. Otherwise a timer is started at the beginning of each scan. At the end of each scan Bus_Link waits until the timer has lapsed before starting the next scan.

Receive time-out defines the maximum time Bus_Link will wait for a response to a command it has issued. If no reply has been received within this time it will log the fact and continue. It should typically be set to 200ms.

Maximum retries defines how many consecutive unsuccessful attempts are allowed for a given command before an error is flagged.

Error back-off delay defines how many scans of a faulty slave device will be skipped before repeating the retry sequence. If more than one slave is being polled, this prevents communication with the remaining slaves from being unnecessarily delayed. If only one slave is being polled, set this to 0.

Slave address only applies if the Slave radio button has been selected. It defines the address to which Bus_Link will respond to an external master.

13.1.1.4 Comms_Link Options

This area configures the ***Mega_Link 2*** communications network:

Basestation tick box sets the unit into basestation mode. There should be only one basestation in a system. When not ticked then the unit will be an outstation.

Station address determines the root data block allocated to hardware I/O. If the I/O capacity exceeds that of a data block it will 'spill over' into the next higher station address as well. Address 0 has the specific meaning of defining **Mega_Link 2** unit as a basestation.

The parameters in the **Base-station** box apply only if the Station Address is set to 0.

Normal Outstation: Scanning Window:

If configuring a base-station, this defines the frequency at which it will interrogate outstations.

If configuring an outstation the comms fail alarm will be raise 2 * (Normal Outstation: Scanning Window) seconds after the outstation expects to be polled. It therefore determines the window allowed for retries before raising an alarm. The value should typically be set to match the Normal Outstation: Scanning Window configured for the base-station, but it can be adjusted if required.

Normal Outstation: Retries defines the number of attempts the basestation will make to establish communications with each outstation. If all attempts are unsuccessful the basestation will flag an outstation communications alarm and wait for the expiry of the Scanning Window before proceeding to the next outstation.

Normal Outstation: Error back-off defines the number of scans that will be skipped following a communications failure if more than one outstation is being polled. This prevents communication with the remaining outstations from being unnecessarily delayed.

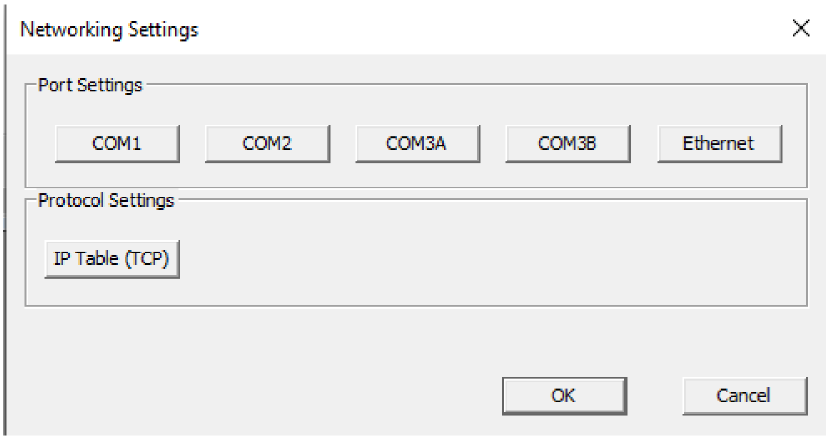
Low Power Outstation: is not implemented yet.

13.1.1.5 Ports Used

Primary Port is used to select the primary COM port to be used for single comms and dual comms mode.

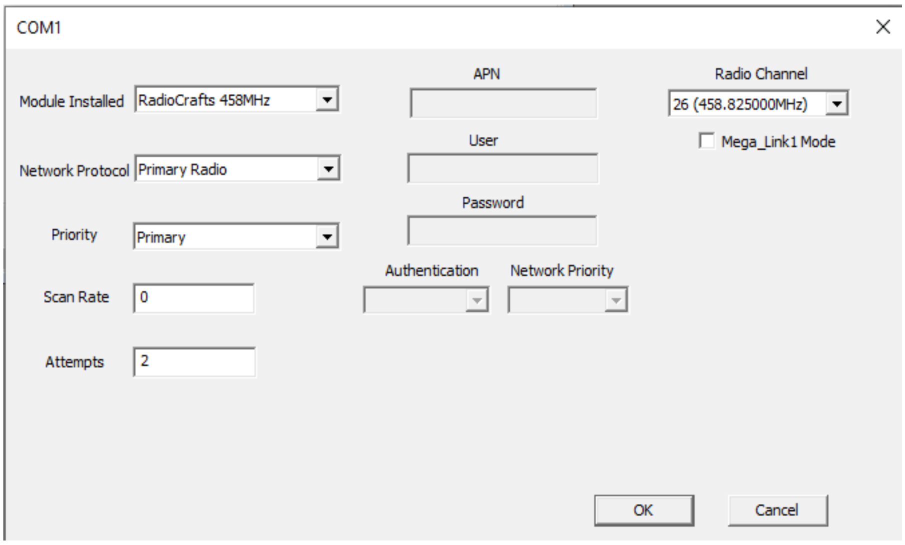
Secondary Port is used to select the secondary COM port to be used for dual comms mode.

13.1.2 Networking Settings Configuration:



This window is used to configure the individual COM Port Settings as follows:

13.1.3 COM1



Module Installed is used to select the hardware modules installed in COM1 (and also COM2 window).

Network Protocol is used to select the network type where relevant

Priority is not yet implemented.

Scan Rate is not yet implemented.

Attempts is not yet implemented.

Radio Channel is applicable when **Mega_Link 2** is fitted with a de-regulated radio, and defines the frequency at which the radio will operate. When using a standard MPT1329 UHF radio the operating frequency is as defined in the following table:

Channel Selected	Frequency (MHz)
1	458.5125
2	458.5250
3	458.5375
4	458.5500
5	458.5625
6	458.5750
7	458.5875
8	458.6000
9	458.6125
10	458.6250
11	458.6375
12	458.6500
13	458.6625
14	458.6750
15	458.6875
16	458.7000
17	458.7125
18	458.7250
19	458.7375
20	458.7500
21	458.7625
22	458.7750
23	458.7875
24	458.8000
25	458.8125
26	458.8250
27	458.8375
28	458.8500
29	458.8625
30	458.8750
31	458.8875
32	458.9000

Note that the channels are at 12.5 kHz spacing, but omit frequencies of 458.8250MHz, 458.8375MHz and 458.9000MHz, in accordance with MPT1329.

Note that this table lists the channels used in the UK, which start at 458.5000MHz. Any of these channels can be used, but all stations on a given network must be set to the same channel.

APN is used for Access Point Name for the 2G/4G module operation.

User is used for User Name for the 2G/4G module operation.

Password is used for Password for the 2G/4G module operation.

Authentication is used for Authentication method for the 2G/4G module operation.

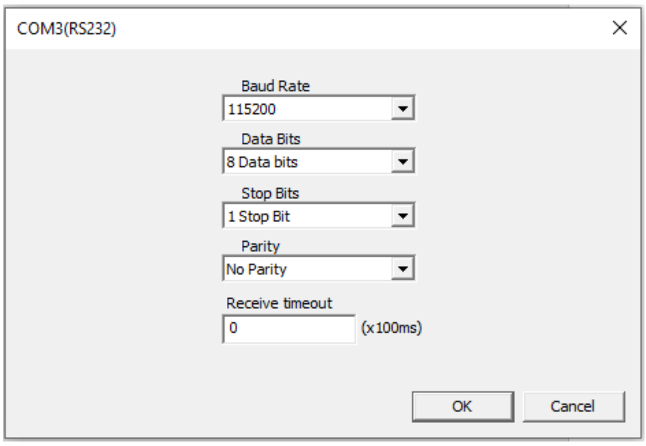
Network Priority is used for the 2G/4G module operation.

13.1.4 COM2

See section TBA.

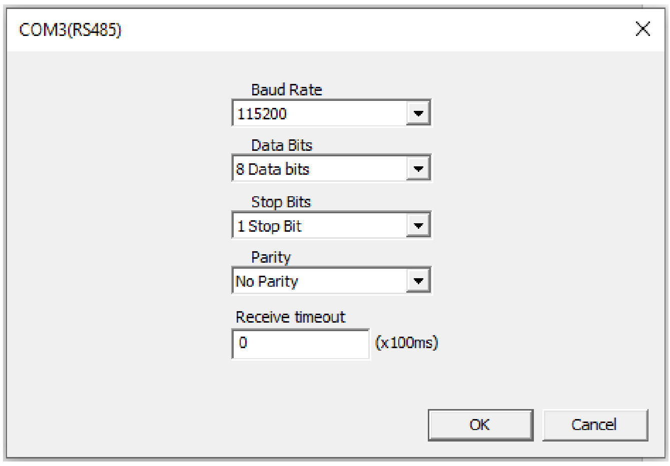
13.1.5 COM3A

This button is used for the menu to set COM3 (RS232) parameters as follows.



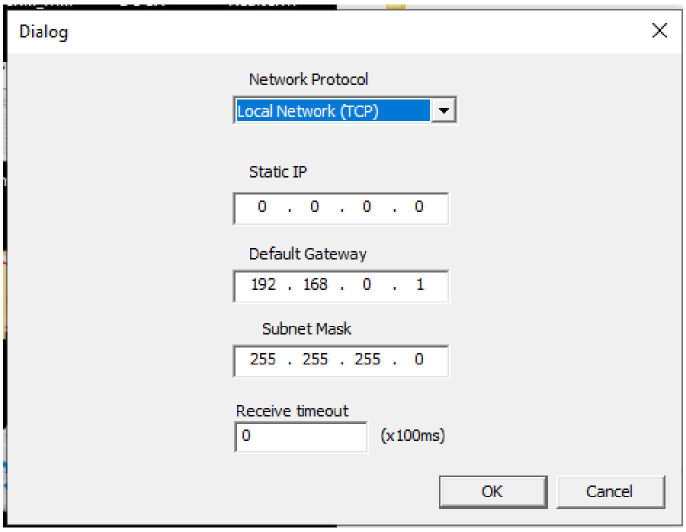
13.1.6 COM3B

This button is used for the menu to set COM3 (RS485) parameters as follows.



13.1.7 COM4 Ethernet

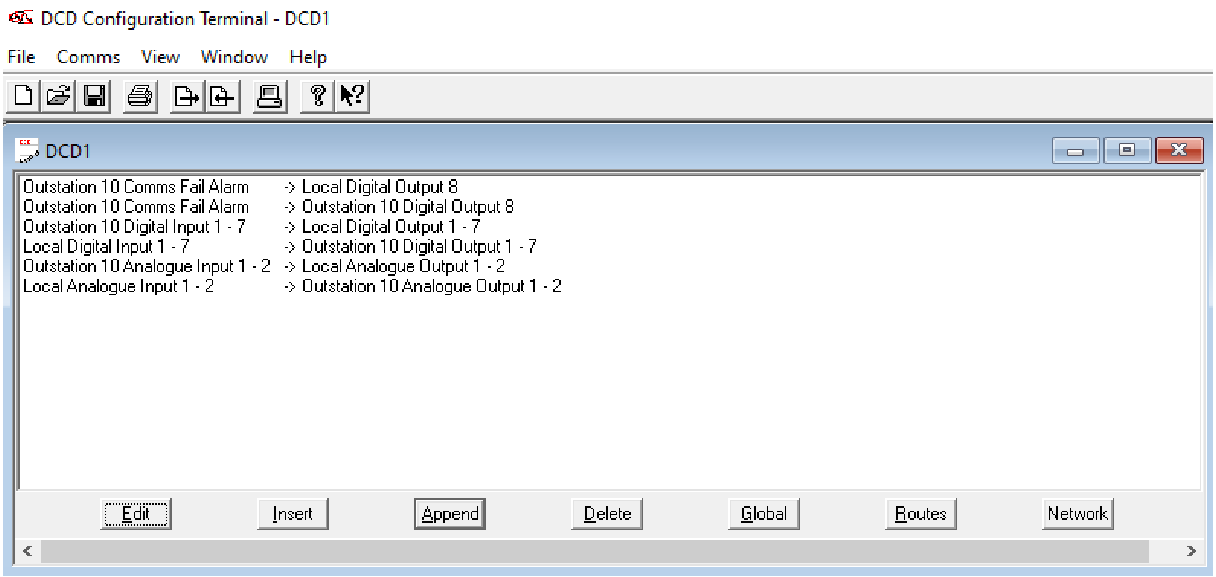
This button is used for the menu to set COM4 (Ethernet) parameters as follows.



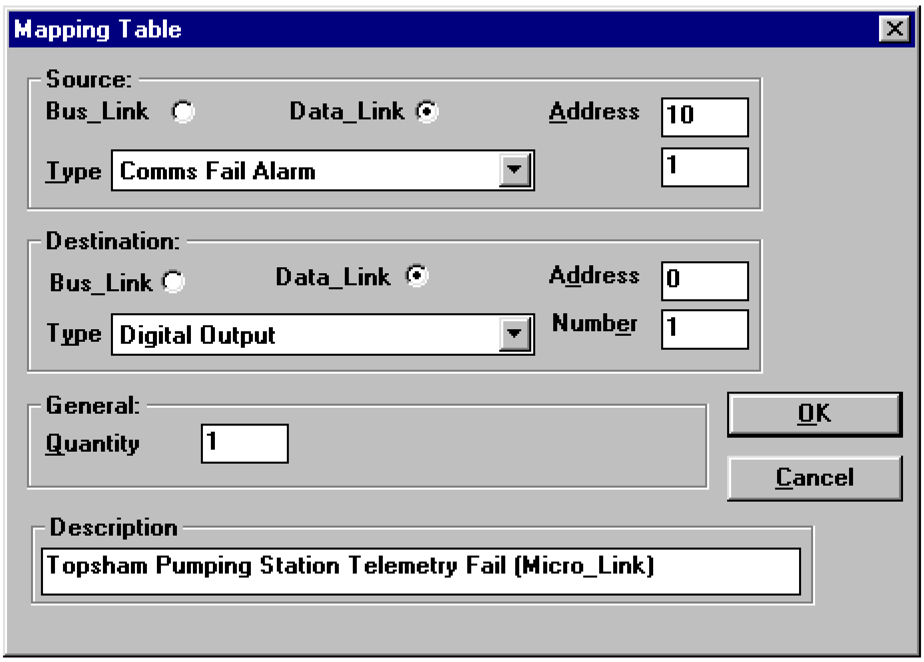
Press **OK** to return to the Data Routing Table:

13.2 Data Routing Table

The file Example1 has the following Data Routing Table:



Select the first line of the table and click on Edit (or double-click). The following dialogue box will open:



If the Source is selected as ***Data_Link***, then the Address identifies the address of the outstation from which the data originates (Address 0 = base-station). If Address matches the Station Address set in the Global dialogue box then it will be interpreted as Local.

If the Source is selected as ***Bus_Link*** then it is assumed that Master mode has been selected from the global ***Bus_Link*** scanning options. Address then defines the address of the PLC or other device from which Mega_Link 2 is to request the data.

The Source Type allows the user to select from a drop-down list. The items at the beginning of the list are prefixed with '*', and define absolute I/O addresses (e.g. *Digital Input Register), as required by devices accessed over the ***Bus_Link*** port. All other items either map into the I/O of Mega_Link 2 or are configuration parameters.

If the Source Type is multiple I/O the adjacent box is labelled **Number** and allows the user to define the first point (e.g. Digital Input 1 is the first digital input on Mega_Link 2).

If the Source Type is a configuration parameter that requires a value, the adjacent box is labelled **Value**.

If the Source Type is a single I/O point (e.g. Comms Fail Alarm), or a configuration parameter that does not require a value (e.g. Invert Digital) the label on the adjacent box is blank, and any value entered in it is ignored.

The Destination box functions are identical to the Source box.

The **Quantity** allows successive points to be configured. For example, if the Source is Digital Input Number 1 the Destination is Digital Output Number 10 and the Quantity is 10, then Digital Inputs 1…10 will be copied to Digital Outputs 10…19.

The **Description** box allows free-format text to be added to each line entry. This text is included in any printed copies, and saved to disc as part of the configuration file. However, it is not downloaded to Mega_Link 2, so cannot be restored if the configuration is subsequently uploaded from Mega_Link 2.

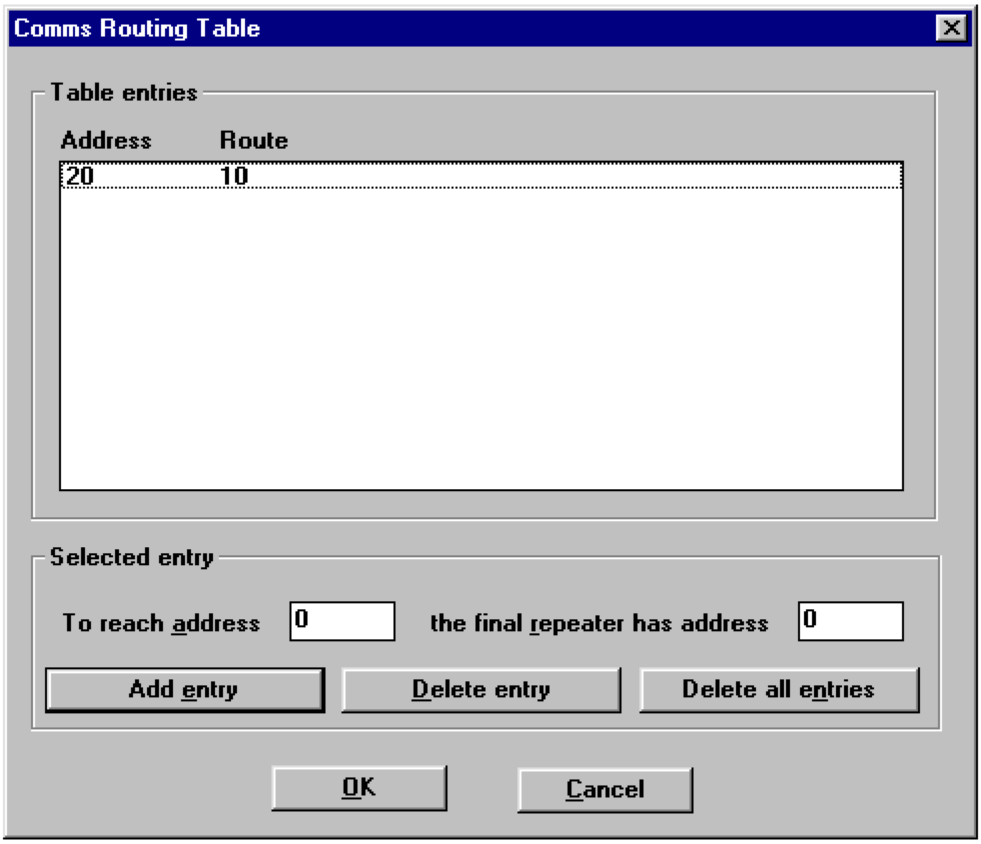
Hardware I/O numbering starts from the Mega_Link 2 module, and continues contiguously onto expansion modules. For example, analogue outputs 1 and 2 are on Mega_Link 2, with outputs 3, 4, 5 & 6 on the first analogue output expansion module, 7, 8, 9 & 10 on the next, and so on.

Mapping data between the Mega_Link 2 database and ***Bus_Link*** is only needed if ***Bus_Link*** is configured in master mode within the Global dialogue box. If it is configured as a slave then the host device will be programmed to define the required registers within Mega_Link 2. If it is configured as a master, the user must define both the slave address of the device to which data is being transferred (in the Address field) and the address of the register within the slave (in the Number field). Absolute addresses should be used to access registers via ***Bus_Link*** (using one of the data Types with a * prefix).

The system configuration defined in this example should be obvious. Note that the table has been constructed so that destinations (i.e. the right-hand column) are in logical sequence. This is preferred, since it is immediately apparent if an attempt is made to write data from different sources to the same destination.

For systems with repeaters, click on the Routes button to edit the Network Routing Table:

1.1.1 Radio Network Routing Table



This shows the communications route to reach each outstation. The example shows that outstation 10 can be reached directly by the base-station (by default, because there is no entry for it). Outstation 20 is reached by using outstation 10 as a repeater.

1.1.2 Saving Configuration Files to Disc

The configuration file can be saved to disc at any time by selecting File/Save or File/Save As. It is good practice to use meaningful file names that relate to the relevant station.

1.1.3 Downloading and Uploading Station Configurations

Before attempting to communicate with ***Bus_Link***, check that the serial port configuration is correct by selecting Comms/Setup.... Check that the correct PC serial port is selected, and it is configured for 9600 bps, no parity, 1 stop bit. Any changes that are made will be automatically saved to disc for future use.

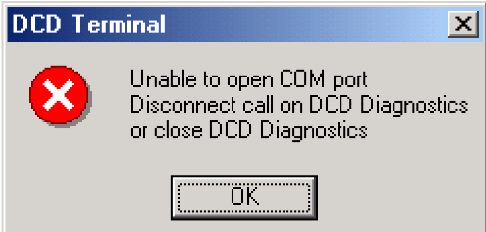
To download a new or modified configuration to Mega_Link 2, select Comms/Download Configuration **(**or use the shortcut key combination of ctrl+D or click on the → button). While downloading, Mega_Link 2 ceases its normal operation, stores the new configuration in non-volatile memory then restarts using the new configuration.

To upload the configuration from Bus_Link, select Comms/Upload configuration (or press ctrl+U or click the ← button). A new window will be opened with a default name of 'DCD1', containing the configuration currently running on Mega_Link 2. This can be edited and/or saved to disc if required.

13.3 DCD 2 Diagnostics

1.1.4 General

DCD 2 Diagnostics incorporates a terminal emulator which must be invoked to run diagnostics, by clicking on the terminal button (below Help on the menu). This should open a new window titled **DCD 2 Diagnostics** followed by the comm port number.



DCD 2 Diagnostics operates independently from ***DCD 2 Configuration***, with the proviso that due to limitations inherent within the terminal emulator, If an attempt is made to upload or download a configuration via ***DCD 2 Configuration*** while ***DCD 2 Diagnostics*** is running a dialog box like this will open.

DCD 2 Diagnostics distinguishes diagnostic commands from configuration commands entered via ***DCD 2 Configuration*** by the fact that they are all one or two characters followed by enter (↵), and all keys are pressed within two seconds of each other. If these criteria are not met ***DCD 2 Diagnostics*** will display TIME-OUT.

Displays which are constantly updating (e.g. 'S - Display station status') can be terminated by pressing enter. This also applies to commands that take a long time to display all their data (e.g. 'OD - Display output digitals').

1.1.5 Listing available commands

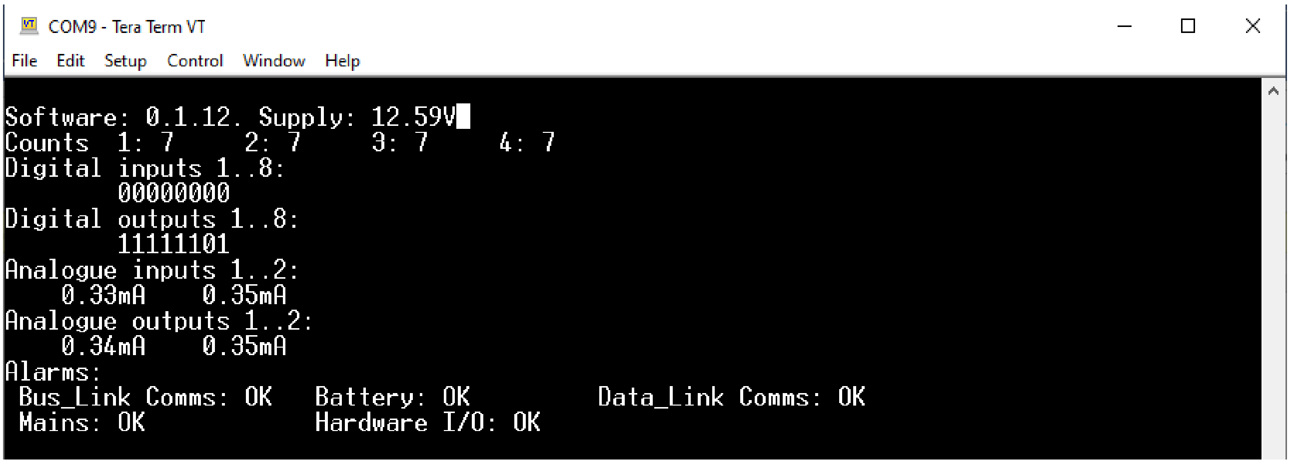
Enter **'?'** followed by **enter** (↵) for a list of available commands:

Note that all commands must be terminated by the enter (↵) key, and that any one or two key command other than those listed exits the current mode. The screen will display the text EXIT as shown above.

Data that has scrolled off the top or bottom of the screen can be viewed by dragging the scroll bar.

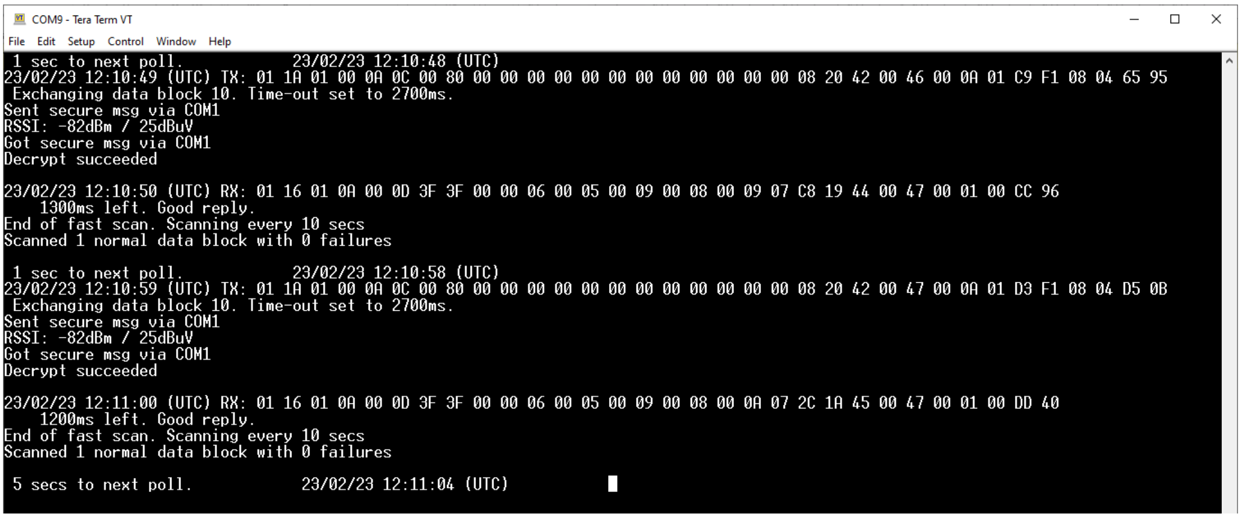
The following sections describe some of the command functions, approximately in order of relevance:

1.1.6 S - Display Station Status



This reads and displays the station address and comms configuration followed by the states of all plant I/O. The I/O capacity displayed includes any expansion modules that Mega_Link 2 has detected in addition to its own I/O.

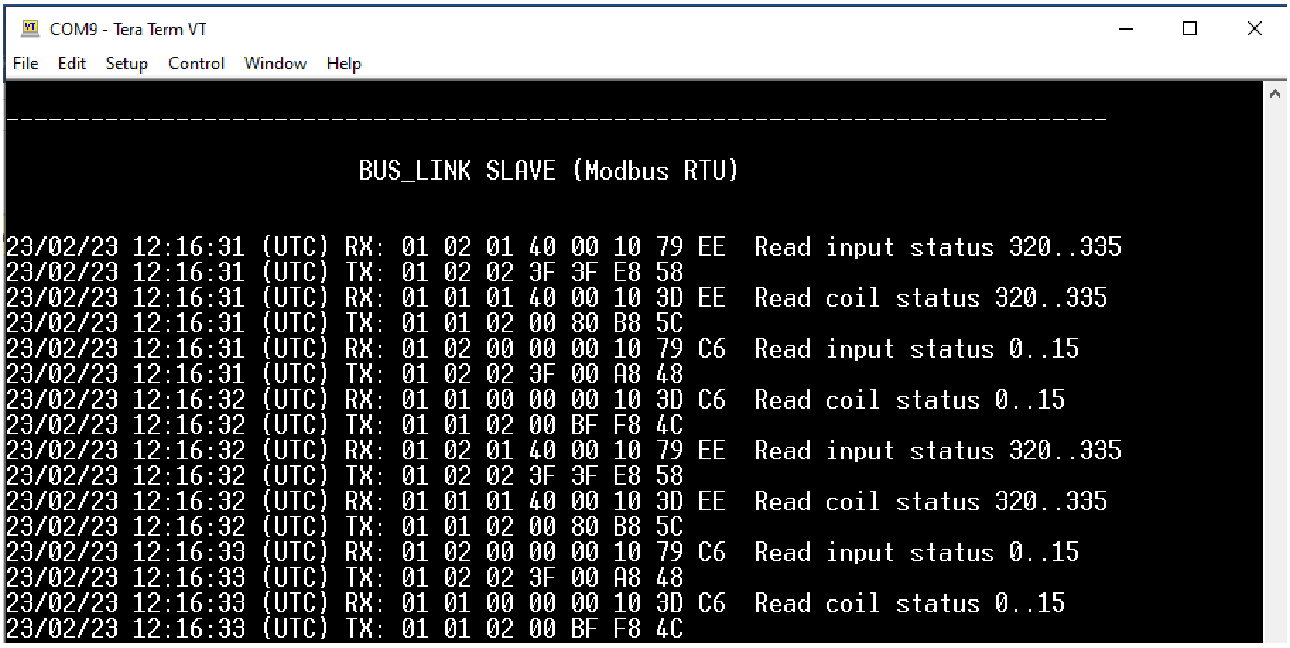
1.1.7 D – Display Normal comms



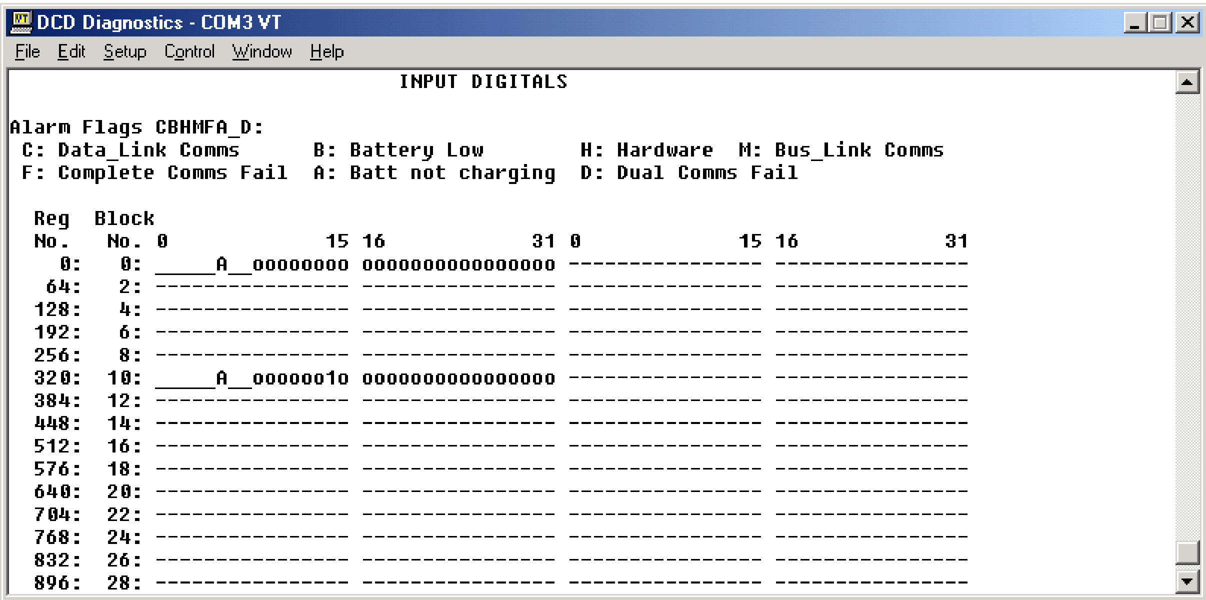
This display shows the communication between the base-station and the outstation(s). It normally shows all communications. However, if it is run on a base-station that is communicating with a combination of continuously powered outstations and battery-powered outstations, then it will only show communications with the continuously powered outstations.

Note that each line is prefixed by a time stamp. The absolute time is not relevant, but the time stamp can be useful for indicating the relative time between commands.

1.1.8 B – Display Bus_Link Comms



1.1.9 ID - Display Input Digitals



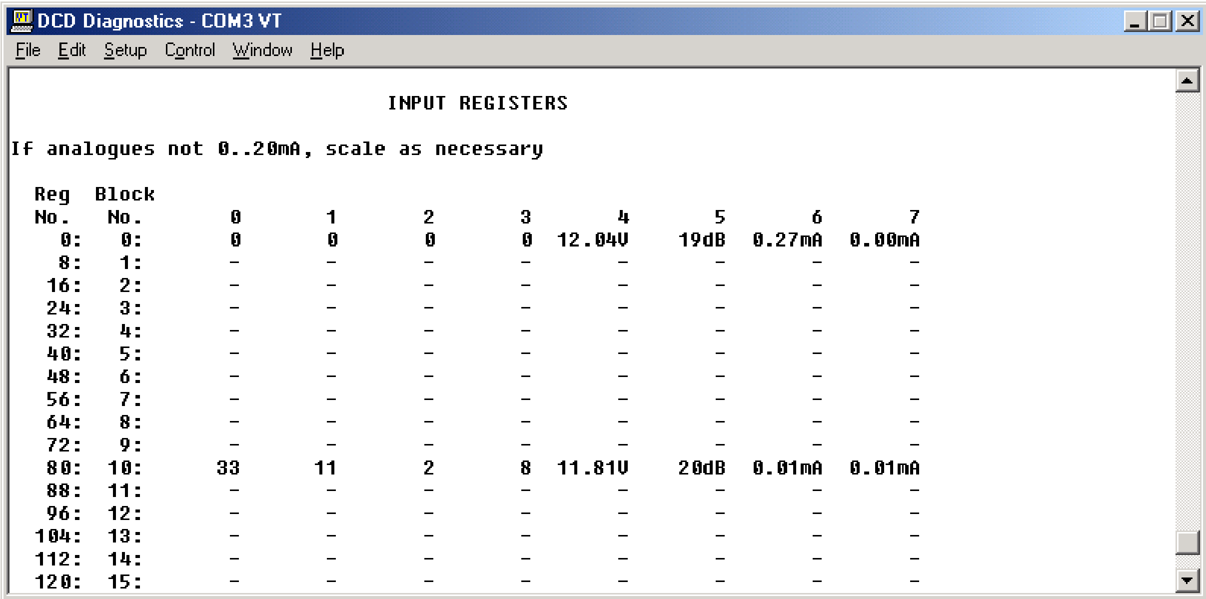
This displays the current state of all digital input data blocks. The display will scroll until either all 250 blocks have been shown or until the user exits (by pressing any key followed by enter).

Note that the base-station only displays data from the data blocks that are actually used. Furthermore, it learns which are root data blocks and displays the alarm flags contained within them as illustrated above. Each data block has 32 digitals, so the root data blocks can also incorporate one 16-channel digital input expansion module. If more are fitted the inputs will 'spill over' into the next data block.

Input data blocks that are not used by the local I/O at the base-station copy the respective inputs from an outstation. In the above illustration the base-station is obviously interrogating an outstation at address 10, so the first 8 inputs in this block are the alarm flags from that outstation, followed by its digital inputs.

Digital output data blocks can be similarly displayed using the OD command.

1.1.10 IR - Display Input Registers


DCD Diagnostics - COM3 VT

File Edit Setup Control Window Help

INPUT REGISTERS

If analogues not 0..20mA, scale as necessary

Reg No.	Block No.	0	1	2	3	4	5	6	7
0:	0:	0	0	0	0	12.04V	19dB	0.27mA	0.00mA
8:	1:	-	-	-	-	-	-	-	-
16:	2:	-	-	-	-	-	-	-	-
24:	3:	-	-	-	-	-	-	-	-
32:	4:	-	-	-	-	-	-	-	-
40:	5:	-	-	-	-	-	-	-	-
48:	6:	-	-	-	-	-	-	-	-
56:	7:	-	-	-	-	-	-	-	-
64:	8:	-	-	-	-	-	-	-	-
72:	9:	-	-	-	-	-	-	-	-
80:	10:	33	11	2	8	11.81V	20dB	0.01mA	0.01mA
88:	11:	-	-	-	-	-	-	-	-
96:	12:	-	-	-	-	-	-	-	-
104:	13:	-	-	-	-	-	-	-	-
112:	14:	-	-	-	-	-	-	-	-
120:	15:	-	-	-	-	-	-	-	-

The software learns which are root data blocks and displays the data in the appropriate units. Thus, in the above illustration it is readily apparent that it is a base-station interrogating an outstation set to address 10. The base-station power sully is 12.04V and the outstation is 11.81V. The signal strength of the last command received by the outstation was +20dBuV and the last response received by the base-station was +19dBuV. If either station was equipped with analogue input expansion modules the value of each analogue input would be displayed in mA, as are the two within each root blocks.

If any register inputs are read via ***Bus_Link***, they will be displayed as 16-bit values in the range 0…65535.

1.1.11 P - Display PLC Communications

The format of this display will depend on the protocol used on the ***Bus_Link*** port for communications with a PLC, SCADA system or some other device. Each line will begin with cmd: or rep: to define if the following data is a command or a reply to a command. If ***Bus_Link*** is configured as a slave device commands will originate from the host that is connected to it, whereas a master ***Bus_Link*** port will originate commands.

As well as showing the encoded message, the display also shows a plain English interpretation.

1.1.12 FR - Force Register

This command and the associated FD, FH and FC commands allow the user to force values into the database. The user is prompted for a block number, a register number within the block and a new value to enter. These commands can typically be used to force digital and analogue outputs to defined states to check the integrity of installation wiring and instruments. Note that the outputs will revert to their correct state when the system next updates. If these commands are used it is preferable to disconnect the aerial or leased line to prevent true data over-writing the test values. Alternatively, the configuration can be temporarily modified (e.g. by changing to a different radio channel) for the duration of the tests.