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# NETWORK DESIGN

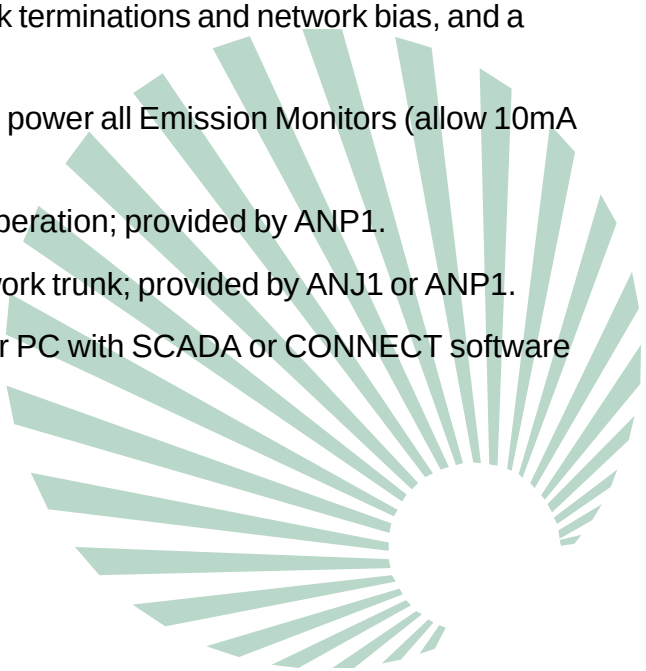
## Introduction

This document contains information relevant to the layout, installation, commissioning and trouble-shooting of a CONNECT network. The associated CONNECT software and this manual are subject to continuous development, and it is acknowledged that the manual may contain errors and/or omissions. For the most up-to-date information, including applications information, the user should always refer to the supplier, or to the latest issue of CONNECT, whose HELP system will also include this Manual.

## CONNECT System Components

To create a fully functional CONNECT system for emission monitoring will generally require these components:

- Emission Monitors as needed (eg EMS6) or other network nodes (eg AXD1).
- Cabling as needed (4 wire screened data cable for networks up to 1km total, low loss screened cable for longer networks (either dual twisted pair or twisted quad).
- Networks can be daisy chained from each Emission Monitor to the next, but junction boxes allow convenient isolation of any Emission Monitor without disturbing the remainder of the network, for easier commissioning, maintenance and fault-finding, and are therefore recommended. Each ANJ1 Junction Box provides terminations and isolation switching for up to two Emission Monitors, plus switchable End-of-line trunk termination.
- An RS485 network tap, which may be a proprietary RS485 PLC port, a commercial automatic RS232-RS485 converter, or an ANP1 (which also includes automatic RS232-RS485 conversion, switchable End-of-line network terminations and network bias, and a secure 12VDC regulated power supply).
- A secure regulated 12V power supply sufficient to power all Emission Monitors (allow 10mA each; provided by ANP1).
- A secure DC bias supply for noise-free network operation; provided by ANP1.
- End-of-line resistor terminations for the main network trunk; provided by ANJ1 or ANP1.
- A Modbus network master, which can be a PLC or PC with SCADA or CONNECT software (under Windows 95 or NT 4.0 or later).



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# CONNECT Network Design

## General

Each CONNECT network of up to 30 nodes, consisting of 1 master (eg, a PC and ANP1) and 29 slaves (eg EMS6 or AXD1), is interconnected by 2 pair screened cable, carrying both 12VDC power and RS485 communications. The network design is constrained by voltage drop in the power supply pair, and by signal propagation issues in the communications pair.

## Voltage Drop

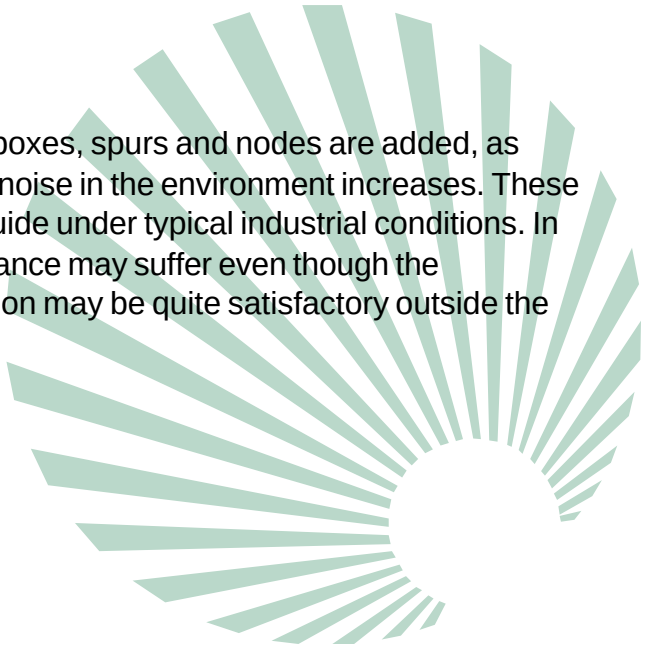
Each EMS6 or AXD1 requires at least 5VDC (8-15VDC nominal) and the nominal network power supply is 12VDC, so the voltage drop may not exceed 7V total. The minimum recommended data cable uses 7/0.20 stranding, for a resistance of 88 Ohms/km at 20C. With an ANP1 power supply in the middle of such a network, up to 29 slave nodes may be evenly distributed up to 1km total length (allowing 10mA per node). If the ANP1 is at one end of the network, the situation worsens considerably, but may be improved by adding another ANP1 or using heavier cable.

## Spurs

Ideally, for correct signal propagation, an RS485 network like CONNECT would consist of up to 30 nodes all connected directly to a single trunk cable. This is impractical as the Emission Monitors are seldom conveniently located. Instead, ANJ1 junction boxes are connected at points along the main network trunk, and cable spurs (branches) are run out from each ANJ1 to one or two Emission Monitors. The spurs are a necessary compromise, and should be kept as short as possible, with staggered lengths, and never more than 100m for up to 12 nodes, reducing by 5m for each additional node. Furthermore, junction boxes must be separated electrically by at least 10m.

## Network Specs

Network performance will degrade as more junction boxes, spurs and nodes are added, as trunk and spur lengths increase, and as the electrical noise in the environment increases. These specifications are therefore intended as a practical guide under typical industrial conditions. In some circumstances, communications errorsperformance may suffer even though the specifications are followed, yet in other cases operation may be quite satisfactory outside the specifications.



| Specification | Condition | Value |
|---|---|---|
| Max total cable length (trunk + spurs) | Trunk #24 (Belden 9534, 3084A) | 1000m (3300ft) |
| | Trunk #18 (Belden 3082A) | 3000m (10000ft) |
| Max individual spur length | up to 12 nodes total | 100m (330ft) |
| | up to 16 nodes total | 80m (260ft) |
| | up to 20 nodes total | 60m (200ft) |
| | up to 24 nodes total | 40m (130 ft) |
| | up to 28 nodes total | 20m (66ft) |
| Min spur length difference | Per junction box | 20% of longest spur |
| Min Separation of j-boxes | All 4 spurs wired | 10m (33ft) |
| | 3 out of 4 spurs wired | 5m (16ft) |

Various options are available to extend the total network further. For example AUD1 can be configured (alongside it's normal function) as a simple network extender, or as an active hub, creating a sub-net. In either case the effective network reach is doubled. The simple extender approach has the advantage that all nodes are still controlled by one network master (usually Connect software). The subnet approach has the advantage that traffic on the main network is reduced, allowing many more nodes to be added to that network (including more AUD1s).

## Master Configurations

On every network is needed a single network master, which cyclically polls all the slave devices (nodes) on the network using the Modbus RTU protocol and collecting their data. The master may be a PC running Connect software, a SCADA system, a PLC, an AUD1 or any other Modbus RTU master. This master would normally assemble all the collected data into a table and optionally perform some processing (filtering, alarming, logging, display, etc). The master in turn may act as a slave to another higher-level master, returning the tabled data on demand. For example, A Scada system may collect data from Connect (by DDE), which collects data from AUD1, which collects data from EMS6.

As CONNECT software is generally the simplest and most cost-effective solution, it is most commonly used, either with or without DDE connection to other software. CONNECT provides, amongst others,

- Current-value displays,
- Flexible realtime alarms,
- Multi-function charts (Each independent of the others, so it can have different scaling and averaging times, etc),
- Logging to disk,

- DDE connection for all data,
- Broken bag discrimination,
- Mass density conversion,
- Averaging,
- Automatic network search with convenient tools to set up CONNECT and the connected devices,
- Full online help system,
- Etc.

## Setup Procedure

### Switch Setting Summary

- ANJ1 NETWORK: If there is a connection to the Network Out port, switch to Through (else to Terminate).
- ANJ1 PROBE 1, 2: Switch off to isolate device as needed.
- ANP1 BIAS: Leave jumper OFF ONLY if another ANP1 on the network is jumpered ON.
- ANP1 TERMINATE: Place jumper ON if ANP1 is at the end on the network (normal).
- EMS6 Gain: Set to cover the expected range of emissions (High for 0-20 / Med for 0-150 / Low for 0-1000mg/m3 approx, though all depend on material, velocity and geometry).
- EMS6 Network ID: Set both the tens toggle switch (0, 1 or 2) and the units rotary switch (0-9) to make up the required Network ID; set each network node to a different Network ID in the range 01 to 29.

The EMS6 Gain and Network ID switches may be set by either physical switches in the instrument or by network commands via the CONNECT software, through the network, with some restrictions (check with the supplier). If the physical switches are to be used, they should be set before or during installation. Please record the settings for future reference (in the space provided, if this document is printed):

| | |
|---|---|
| Name | – |
| Date | – |
| Serial Number | – |
| Gain | – |
| Net ID | – |

## Network Connections

Wire all network cable connections as shown:

| Terminal | Function | Suggested Colour |
|---|---|---|
| 1 | RS485 + | White |
| 2 | RS485 - | Green |
| 3 | Drain | None |
| 4 | Power - | Black |
| 5 | Power + | Red |

After wiring an Emission Monitor, replace the lid, tighten the lid screws and connect an Earth wire from the external Earth Screw on the Emission Monitor's lid to the duct earth, eg, under a mounting screw.

## Conventional Network

The network consists of a trunk linking a series of ANJ1 Junction Boxes, and spurs from the Junction Boxes out to the connected instruments. The entire network and all the connected instruments are powered by a ANP1 Network Power Supply connected to the trunk at one end.

Mount the ANP1 Network Power Supply by the four mounting holes provided, near the PLC or PC to which it will connect. Mount the ANJ1 Network Junction Boxes by the four mounting holes provided, in accessible positions along the network path.

Lay out network cable for the trunk from the ANP1 to the Network In port of the first ANJ1 Junction Box, then from the Network Out port of that Junction Box to the Network In port of the next Junction Box, and so on. Also run network cable as spurs from each junction box to up to two network devices. Ensure that the ANP1 BIAS and TERMINATE jumpers are on, and switch the very last ANJ1 Junction Box on the trunk to TERMINATE. For more detail see Network Design.

## Networks With Only One Node

For networks which feed only one device it is permissible to wire direct from the device to the ANP1 Power Supply without an ANJ1 Junction Box. Ensure that the ANP1 BIAS and TERMINATE jumpers are on. Add a 120 Ohm / 0.5Watt resistor from RS485 + to - (terminal 1 to terminal 2) at the Node, for network termination.

## Networks Fed From The Middle

An ANP1 Power Supply is normally positioned at one end on the network, and it's BIAS and TERMINATE jumpers are on. However it is also possible to position the ANP1 at any position along the trunk, so that the ANP1 effectively feeds two trunk sections. In this case, ensure that:

- the wires from the two trunks are twisted together before insertion into ANP1's terminals, to ensure good contact
- each trunk section is wired normally (from the ANP1 to Network Out port), with the last Junction Box switched to TERMINATE.
- ANP1's TERMINATE jumper is OFF, and the BIAS jumper is ON.

## Using a Different RS232-RS485 Converter

If a third party RS232-RS485 converter is used instead of the ANP1 Power Supply, either configure it to provide network bias, or connect the RS485- wire through a 2K2 resistor to the supply common negative, and the RS485+ wire through either a 2K2 resistor to +5VDC, or a 10K resistor to +12VDC.

## Using a PLC

If the PLC is equipped with an RS232 port, the connection should be made via an ANP1 Power Supply in the same way as for a PC. If the PLC is equipped with an RS485 port it can be connected to the network either directly or via a Junction Box. In either case network power can be derived either from an ANP1 (with the RS232 port unconnected) or from any reliable, external isolated regulated 12VDC source. Since an over-voltage fault in this power supply could destroy all connected network devices, it is recommended that any network power supply be equipped with over-voltage crowbar protection (like ANP1). As with an Emission Monitor, if the network trunk terminates at a PLC rather than at an ANJ1 or ANP1, the network should be terminated by a 120 ohm resistor directly across the RS485 terminals, under the network wires (twist the resistor leads with the network wires before insertion to ensure good connections.

## Commissioning With CONNECT

Even if it is intended to use third party SCADA software or a PLC to poll the CONNECT network, it will generally be most efficient to use CONNECT software for initial commissioning, because this method is proven, easy and reliable. Once any connection problems have been resolved, the network can be connected to the final master, and the master set up in the knowledge that all the hardware is functional. It is recommended that the PC, CONNECT software and ANP1 power supply be wired initially to one node at a time, so that:

- Each node can be checked for proper operation,
- Each node's Network ID can be checked and changed if needed, and
- This initial commissioning is not confused by wiring or other faults in the network.

## Commissioning Procedure

Install and execute the CONNECT software and select Configure (this selection may be automatic the first time the software is run). Configure the common settings (the correct COM port and a sample interval of, say, 1000ms), and search for devices in turn. There are two ways to perform this initial commissioning:

- Plug each node directly to the ANP1 in turn before installation (recommended), or
- Install all devices but leave all nodes switched OFF at the ANJ1 Junction Boxes and all NETWORK switches set to TERMINATE. Then have a colleague move around the plant starting at the closest Junction Box: Switch one device (probe) ON, search and change it as needed (from CONNECT), switch it off, repeat for the other device if present, then switch to THROUGH and move to the next Junction Box.

## Network Search Process

CONNECT's Network Search process can find and identify any node on the network, and automatically perform some useful setup operations. Search's configurability includes scope (which Network IDs will be tested), and action (what happens when a node is found). It will be most convenient to poll all possible Network IDs, and to automatically change Network ID to the next available value, and to add the new node to the Node List (MOST IMPORTANT, so that subsequent nodes are not all assigned a Network ID of 01). When all devices have been connected, found, changed and disconnected, they may be installed.

When switching devices on selectively at the Junction Boxes, the same procedure applies, however a wiring or other fault may prevent communications. In this case the stage at which the fault becomes evident will indicate the general location of the fault.

## Adding a Node

To add a node to a running network it is first necessary to set the new node's Nework ID to a value not already in use by the existing nodes. To find out what nodes already exist, open CONNECT's Configurator at the Network page. If the new node has Network ID switches, set them to an unused Network ID. Otherwise, run momentarily disconnect the network from the ANP1, connect the new node instead, search for the new node as above, then restore the network connection to ANP1 and install the new node.

## Final Commissioning

When the initial commissioning is complete, each device on the network will be listed in the Node List, and the primary signal from each node will be listed in the Signal List. When the configurator is closed, CONNECT will begin to poll the listed nodes.

To be useful to an operator, however, it is also necessary to set up the range, units and alarms for each signal, to group signals appropriately into graphs, to assign averaging to each graph, disk log, DDE source, etc, and to set up any additional functions. To this end, CONNECT includes a comprehensive internal HELP system which can be accessed from within CONNECT by pressing the F1 function key.

Alternatively, the network may be moved to any other SCADA system, or to a PLC, in the confidence that the network and all connected devices are functioning correctly.

## Trouble-Shooting

Difficulties during commissioning are almost always caused by either wiring errors or incorrectly set Network Ids. If the network is a new installation, or if it has been changed substantially, then the above Commissioning Procedure should be followed.

### Cable Faults

Spur cables are often subject to harsher environments than trunk cables. In the unlikely event of a network failure, individual spurs and sections of the trunk may be switched OFF from the Junction Boxes to determine where the fault is. The faulty section may then be left isolated while the remainder of the network is brought back into operation, and the fault repaired.

### Other Faults

If it is not found possible to communicate with any network device, have a qualified electrical technician carefully remove the cover from ANB1 (there are dangerus voltages inside).

Set a device to a known Network ID such as 01 (easiest with EMS6), Manually set up a node to that Network ID in CONNECT, connect the device to the ANP1 and exit Configurator, leaving CONNECT running. CONNECT should recognise the device and the TX and RX LEDs should flash periodically. Otherwise, if no ANB1 LEDs are flashing, then:

- The ANP1 is not powered, or
- There is a problem in the serial cable between ANP1 and the PC, or
- CONNECT is set to the wrong COM port (usually COM1 or COM2), or
- The node is not selected to ON-LINE in CONNECT, or
- There is a hardware fault in the PC.

If the TX LED alone flashes, then:

- CONNECT is not set to the same Network ID as the device, or
- There is a problem in the serial cable between ANP1 and the PC, or

- There is a problem in the network cable or connections, or
- The device is faulty.

If the CONNECT software does not perform as expected, see CONNECT's internal help system (press the F1 function key from inside CONNECT). In all other cases, please refer to the supplier.