NBS-42L User's Manual

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Overview

The NBS-42L is a PCI-bus RS-485 asynchronous serial communication interface card for PCs. Based on Oxford's 16C950 UART, the NBS-42L has several features particularly suited to RS-485 multi-drop networking. Some of the special features are as follows:

- support for the 9-bit character format commonly used in microcontroller networks
- speeds of up to 961,000 bits/second
- built-in ESD protection reduces failures
- full power unit load/driver RS-485 transceiver reduces RFI and cable termination problems
- hardware can automatically perform transmit/receive switching
- jumper selected RS-485 bus termination and automatic biasing

These products are designed for RS-485 and simplex RS-422 networks (and NOT 4-wire RS-485 or 4-wire RS-422 networks).

The NBS-42L is not appropriate for data communication systems that use synchronous serial communication protocols such as HDLC, SDLC and Bitbus. Likewise, Manchester Encoding is not supported by the NBS-42L.

Specifications

Electrical Interface	NBS-42: RS-485, unit load impedance, high drive
Ports	One
Connectors	One DB-9 female with one 3-pin "Phoenix" adapter
UART	Oxford 16C950, 14.7456 MHz clock oscillator
Data Rate	Up to 961,000 bits/second
PCI Bus Interface	3 volt, 32 bit, PCI rev. 2.1 compliant PLX9030
Operating Temperature Range	0 to 70 C
Power Consumption	400 mA typical at 3 volts (obtained from the PCI bus)
Dimensions	120 mm (length) by 65 mm (height)
Regulatory Approvals (see Compliance Appendix)	USA: Class A digital device Canada: Class A digital apparatus CE Mark

Configuration

Configuration of an NBS-42L card is very simple. The I/O address range and IRQ for the NBS-42L will be automatically set by your PC's BIOS, greatly simplifying card configuration and reducing the probability of resource conflicts.

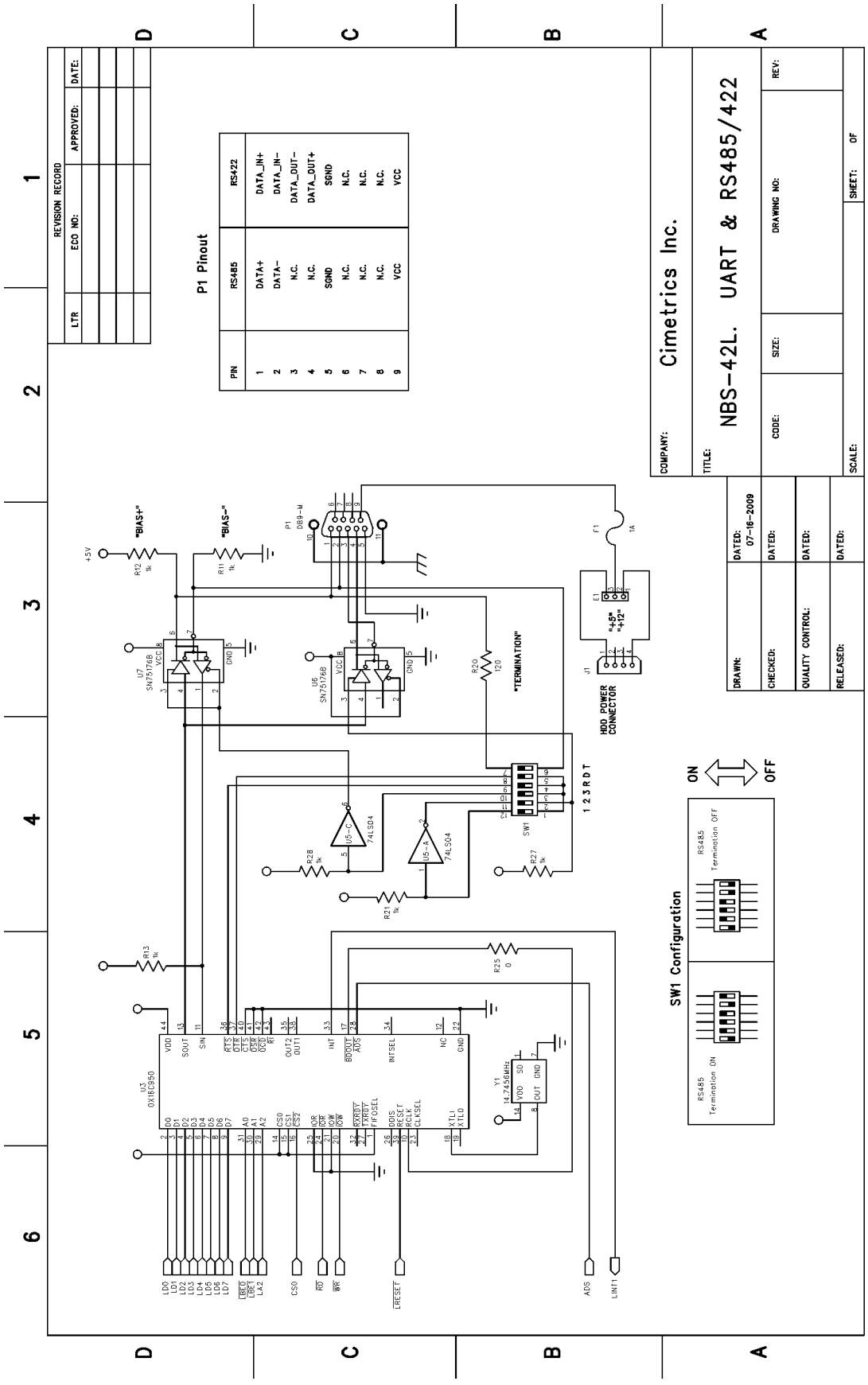
Before you configure an NBS-42L card, you need to answer the following questions:

1. Will the card provide RS-485 bus termination? (See the section "Understanding RS-485".)
2. Will the card provide RS-485 bus biasing? (See the section "Understanding RS-485".). The NBS-42L provides built-in biasing, and is not configurable in this sense.
3. Can the card operate at the required data communication speed? (See the section "Communication Speed".)

To enable RS-485 bus termination on the card, make sure that SW1--T is ON. Otherwise, SW1-T should be OFF.

RS-485 bus biasing is permanently enabled on the card.

If you need data communication at a speed that is not possible with the supplied crystal oscillator, you may need to install a TTL crystal oscillator that operates at a different frequency. Note that there are two crystal oscillators on the NBS-41/42, and the one labeled "Y1" affects the communication speeds that the UART can use. The frequency range supported by the OX16C950 UART is described elsewhere in the documentation.


REVISION RECORD
LTR
ECO NO:
APPROVED:
DATE:
P1 Pinout
PIN
RS485
RS422
1 DATA+ DATA_IN+
2 DATA- DATA_IN-
3 N.C. DATA_OUT-
4 N.C. DATA_OUT+
5 SGND SGND
6 N.C. N.C.
7 N.C. N.C.
8 N.C. N.C.
9 VCC VCC
COMPANY:
Cimetrics Inc.
TITLE:
NBS-42L. UART & RS485/422
CODE:
SIZE:
DRAWING NO:
REV:
SCALE:
SHEET:
OF
DRAWN:
DATED:
07-16-2009
CHECKED:
QUALITY CONTROL:
RELEASED:
"BIAS+"
"BIAS-"
"TERMINATION"
HDD POWER CONNECTOR
SW1 Configuration
RS485 Termination ON
RS485 Termination OFF
ON
OFF
1 2 3 R D T
U3 0X16C950
U5-C 74LS04
U5-A 74LS04
U6 SN75176B
U7 SN75176B
Y1 14.7456MHz
P1 DB9-M
F1 1A
E1 "+5" "+12"
J1
LD0 LD1 LD2 LD3 LD4 LD5 LD6 LD7
LBEO LBE1 LA2
CS0
RD
WR
LRESET
ADS
LINT1

Understanding RS-485 and RS-422

This section discusses standards for serial data communication: what they are and how they work. Over the years, a number of industry standards have been developed to cope with a broad range of communications problems; you are probably already familiar with the RS-232 standard in its many incarnations. For this reason, we will use the RS-232 as a basis for comparison throughout this section. This discussion will center on RS-422 and RS-485. Unlike the RS-232 standard, which includes specifications for both the electrical and mechanical properties of the interface problem, RS-422 and RS-485 are Electronics Industry Association (EIA) standards that describe and specify only the *electrical* characteristics of that problem.

Note that none of the above-mentioned standards recommends or specifies a protocol in any way. A communication protocol such as Cimetrics Technology's Nine-bit Serial Protocol must be used in conjunction with these standards.

RS-422

In 1975 the EIA introduced RS-422, a standard which uses differential (balanced) data transmission in one direction along a transmission line. A differential signal is represented by the voltage difference between two conductors of the transmission line (not by the voltage from each of the conductors to ground). In RS-422 the driver (transmitter) is at one end of the line with up to 10 receivers on the line and a 100-ohm termination resistor at the other end. The RS-422 standard is typically used in full duplex mode with one twisted pair of wires for sending and another twisted pair of wires for receiving data.

RS-422 offers greatly improved characteristics over RS-232 in noise immunity, speed, and distance capabilities.

COMPARISON OF RS-232, RS-422, RS-485			
PARAMETER	RS-232	RS-422	RS-485
TRANSMISSION MODE	SINGLE-ENDED	DIFFERENTIAL	DIFFERENTIAL
MAX CABLE LENGTH	50'	4000'	4000'
MAX NUMBER DRIVERS	1	1	32
MAX NUMBER RECEIVERS	1	10	32
MAX DATA RATE	20K BITS/S	10M BITS/S	10M BITS/S
DRIVER Z_{OUT} POWER OFF	300 OHMS	60K OHMS	120K OHMS
RECEIVER LOAD IMP.	3K - 7K OHMS	>4K OHMS	>12K OHMS
RECEIVER SENSITIVITY	+/- 3V	+/- 200mV	+/- 200mV
LOAD IMPEDANCE	3K - 7K OHMS	100 OHMS	60 OHMS
COMMON MODE RANGE	+/- 25V	-0.25V to +6V	-7V to +12V

RS-485

In 1983, the EIA approved RS-485, a new differential transmission standard considered by many to be an extension of the existing RS-422 standard. RS-485 specifies the electrical characteristics of receivers and drivers that are intended to operate in a balanced multi-point or party-line configuration. The RS-485 network is designed to support 32 receivers and drivers operating over twisted-pair wire terminated at both ends by 120-ohm resistors. The resistors should be at the extreme ends and all nodes should be directly connected (daisy chained) to the network or connected to it with very short stubs.

Although several nodes can be connected to an RS-485 bus, only one may transmit at any given time. If two or more nodes attempt to transmit at the same time, a collision will result, causing garbled data. The RS-485 receiver and driver components are typically designed to tolerate this fault condition for a limited amount of time, but it should be avoided.

It is possible to construct RS-485 networks containing more than 32 devices. Of course, RS-485 repeaters may be used to connect multiple RS-485 network segments. Recently some integrated circuit manufacturers (e.g. Maxim and Linear Technology) have begun offering RS-485 chips that have much higher impedance than minimum required by the EIA specification (12 kilohms). These high-impedance components put less of a resistive load on the RS-485 bus, allowing you to connect more than 32 devices to a single RS-485 bus. The NBS-42L however has a unit-impedance RS-485 transceiver that has an impedance of at least 12 kilohms and a correspondingly higher driver/sink current than most fractional load transceivers..

Proper operation of the RS-485 interface circuits may require a signal return path between circuit grounds of the devices. This signal return path may be provided by a third wire, or by connecting all devices to an earth reference. When this path is provided by a third wire, the wire should be connected to the device through some resistance (100 ohms in the NBS-42L) in order to limit current. Care must be taken not to form ground loops. For detailed information concerning grounding, consult the RS-485 standard and appropriate local, national, and international electrical codes.

UARTS AND BIAS RESISTORS

The RS-485 voltage standard as defined by the EIA does not specify the output level of a receiver when no input is applied to the line. The RS-485 threshold voltage between high and low logic levels is defined with a +/- 200mV indeterminate area around the nominal threshold of 0 volts (i.e., zero potential difference voltage between the two lines). When the transmission line is properly terminated, and no transmitters are activated, the voltage level on the transmission line usually floats in this indeterminate area. Any noise picked up on the line may modulate the transmission line in this threshold region. Depending on the characteristics of the RS-485 line receiver, random data may appear at the UART receiver.

This random information wreaks havoc with traditional UARTs. These UARTs are designed to interpret a line in the mark (high) state as an idle condition, unless good (non-random) data is available. The UARTs view the first one to zero transition as a start bit, normally used to synchronize the rest of the byte. Random noise appears as false start bits and data, possibly causing the network to malfunction.

To get around this floating line condition of RS-485, a differential bias can be applied to the transmission line. When no transmitters are on the line, this technique can be used to push the line out of the threshold area into the high state. Different biasing techniques have been successfully used on RS-485 lines. In a network where the length and characteristic impedance of the line are not known, DC biasing is the preferred method. A simple voltage divider is often used to hold the differential line in a state that produces a “one” logic state at the output of the RS-485 line receiver.

Most RS-485 serial products that employ UARTs provide a DC bias resistor network on the card. When one has more than one card on a network, however, the presence of more than one bias source is problematic for several reasons:

1. Additional bias networks affect the impedance of the transmission line;
2. Bias networks often do not have the same polarities or voltage levels, especially if the devices were produced by different manufacturers. Though in general it is expected that DATA+ is biased with a positive voltage and DATA- is biased with a zero or negative voltage.

The general tolerance for voltage on either data line (+ or -) is to be between -7VDC and +12VDC each specified to a precision of about 0.2VDC, and in general there is, for properly biased and terminated networks, no problem for 3.3VDC or 5VDC or 12VDC line drivers. The key to well conditioned communications is not going outside the absolute range on either data line, and getting the differential above the 200mV threshold.

The Cimetrics Technology NBS-42L are designed with weak bias resistors so that if another bias source already exists, the Cimetrics bias networks will have little effect, but some level of biasing will always be available.

According the standard global biasing in the network should be about 500 Ohms. The NBS-42L uses 1 kOhm (locally). This means that any other device which has global biasing (with 500 Ohms, for instance the NBS-42), the global biasing should be disabled. The user must decide on biasing based on the setup of the global network.
For instance -
1. NBS-42L + 32 local devices, with each device having 32k local biasing meets (coincidentally) the exact definition of the specification.
2. NBS-42L + N local devices without biasing, it is acceptable for most real cases.
3. Etc.
Many small (less than four devices), short distance (under ten meters), low-speed (under 9600 baud) networks might work without biasing or termination, but it is more of a happy accident than the rule, especially if there is ambient electrical/ground noise.

Termination resistors should be placed only at the ends of the transmission line. There should be ONLY TWO SUCH RESISTORS ON THE ENTIRE NETWORK. More than two will substantially lower the impedance of the line and will hinder the line drivers. On the NBS-42L you can place a 120 ohm termination resistor on the RS-485 bus by setting “T” to the on position on SW1 switch array.

Communication Speed

The NBS-42L can operate over a wide range of communication speeds. The Oxford 16C950 UART on the NBS-42L supports speeds of up to 961,000 bits/second. In addition, the hardware/OS platform may further limit the maximum practical speed. There is also an inverse relationship between the RS-485 cable length and the maximum speed (see the EIA-485 standard for further information).

The actual speeds that the UART supports depends on the frequency of the crystal oscillator (the component labeled "Y1 = 14.7456 MHz") as follows:

s = CrystalOscillatorFrequencyInHz divided by (16 x n)

In the above equation, *s* represents the data communication speed in bits/second, and *n* is an integer value that can range from 1 to 65,535 (the divisor). Furthermore, speed *s* has an upper limit of 961,000 bits/second (with n = 1). For example, with the supplied 14.7456 MHz crystal oscillator, the UART can operate at the following speeds (in bits/second) and many others:

- 461,000 (*n* = 2)
- 230,000 (*n* = 4)
- 115,200 (*n* = 8)
- 4,800 (*n* = 192)
- 57,600 (*n* = 16)
- 38,400 (*n* = 24)
- 9,600 (*n* = 96)
- 8.79 (*n* = 65,535)

For two asynchronous serial devices to communicate, it is not necessary for them to operate at exactly the same speed. Our experience is that virtually all UARTs can tolerate a 2% discrepancy, and many can tolerate a 3% discrepancy.

Connecting the NBS-42L to an RS-485 Network

The NBS-42L has one external connector that can be used to connect the card to an RS-485 network. It is a 9-pin "DB-9" connector and included is a 3-pin "Phoenix" connector adapter. The following table contains the functions for the pins of the connectors. *Note that the RS-485 data lines are polarized, so take care not to reverse them. If reversed, damage is unlikely, but incorrect operation is very likely!*

Function	DB-9 Pin #	Phoenix Pin #
RS-485 + (non-inverting)	1	1
RS-485 – (inverting)	2	2
Network Common *	5	3

* The NBS-42L is directly connected between the network common pin and the PC's ground.

Programming

The NBS-42L uses Oxford's 16C950 UART, which includes many special features not commonly found in common UARTs. Many of our customers have chosen Oxford-based RS-485 interface cards because they need one of these features in their application, such as support for the 9-bit character format commonly supported for networking in microcontrollers.

Depending on your chosen operating system, it is possible for you to write programs or device drivers that directly access the registers of the 16C950. However, you may be able to save development time by using an existing device driver. If you plan to use the NBS-42L on a PC running a version of Microsoft Windows, contact Cimetrics to see if an appropriate device driver is available.

For those of you who want to directly program the NBS-42L, you will need to read the datasheet for the Oxford OX16C950 UART. You may also want to consult references on the PCI bus and the PLX PCI 9030 controller used on the NBS-42L, as well as the RS-485 transceiver SN75176B (see References).

RS-485 Driver Control

On an RS-485 network, only one device should transmit at a time (see the section "Understanding RS-485 and RS-422"). Therefore devices that are not actively transmitting data should put their RS-485 drivers into a high-impedance state so as to avoid interference with any other transmissions.
On the NBS-42L, the RTS output from the OX16C950 UART is connected to the RS-485 driver enable input on the RS-485 transceiver (see NBS-42L Schematic Diagram). The RS-485 driver may be enabled/disabled under software control or automatically by the OX16C950 UART. Note that it takes several microseconds for a change in RTS to be reflected on the RS-485 bus, with the exact value depending on the characteristics of the RS-485 driver and the RS-485 bus capacitance. If software control is desired, the device driver should write a '1' value to the RTS bit in the OX16C950's Modem Control Register prior to transmission and a '0' value immediately after transmission is complete. Hardware control can be enabled by configuring the OX16C950 UART for the automatic mode of modem handshaking.

Appendix - Regulatory Compliance Notes

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Federal Communications Commission (FCC) Statement

This equipment has been tested and found to comply with the limits for Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in such case the user will be required to correct the interference at the users expense

As such, if this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient the receiving antenna.
Increase the separation between the equipment and the receiver.
Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
Consult the dealer or an experienced radio/TV technician for help.

Warning
This is a Class A Product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures to prevent or correct the interference.
Always use cabling provided with this product if possible. If no cable is provided or if an alternate cable is required, use high quality shielded cabling to maintain compliance with FCC/EMC directives.

Industry Canada Emission Compliance Statement

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Avis de conformité aux normes d'Industrie Canada

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

EMC Directive Statement

Products bearing the CE Label fulfill the requirements of the EMC directive (89/336/EEC) and of the low-voltage directive (73/23/EEC) issued by the European Commission.
To obey these directives, the following European standards must be met:

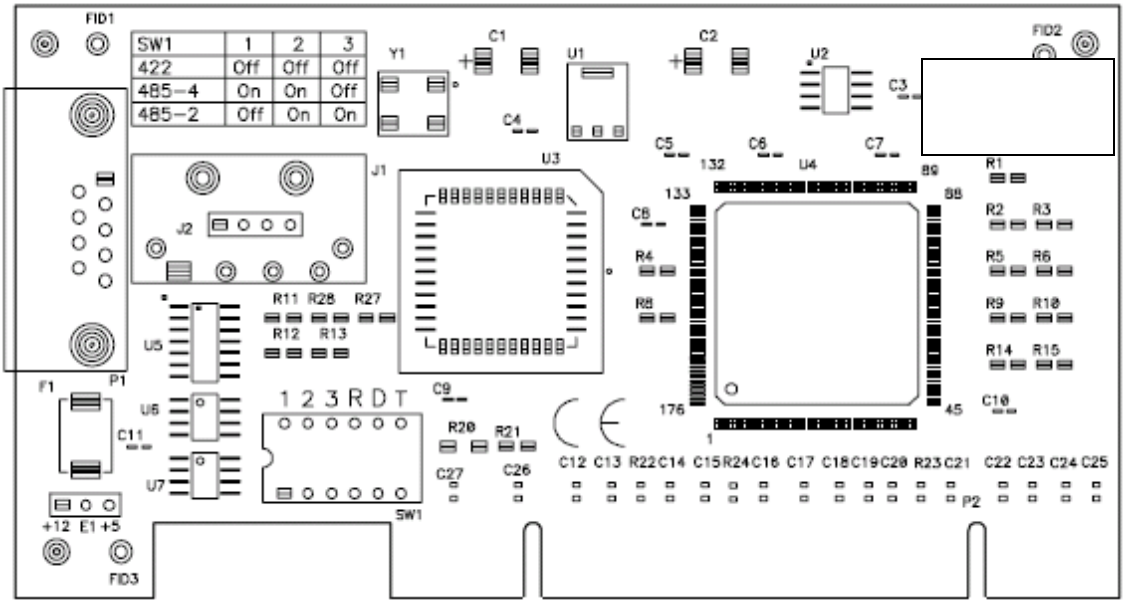
EN55022 Class A - “Limits and methods of measurement of radio interference characteristics of information technology equipment”

EN55024 – “Information technology equipment Immunity characteristics Limits and methods of measurement”.

EN60950 (IEC950) - “Safety of information technology equipment, including electrical business equipment”

Appendix – Board Layout

Silkscreen



Parts (typical)
Y1 = 14.7456 MHz Oscillator
U3 = Oxford OX 16C950-PCC60-B
U4 = PLX 9030 – AA60PI F
U6,U7 = TI 75176B