interX User Manual
Revision 0.1.4

XDIMAX Ltd

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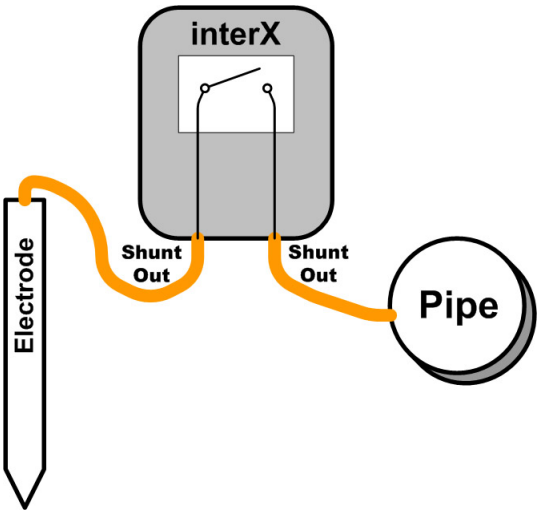
Contents

1 Overview

interX was originally developed as a measurement instrument for industrial and trunk pipeline anodic or cathodic protection systems. interX allows facilitate measurement of galvanic parameters (instant-off polarized potentials, pipe-to-soil potential) across a wide range of timing cycles. It is used to make synchronous disconnect and reconnect of protection electrodes (anode or cathode) or rectifiers from/to buried underground pipeline to perform measurements. Required number of interX interrupters can be installed over miles of pipeline without any distance or line of sight limitations. Being programmed to the desired on/off time intervals all units will synchronously perform the same operation cycles over predefined period of time.



The picture above shows how interX can be connected to pipeline anti-corrosion protection circuit. Having a number of interX being connected the same way to electrodes over the pipeline and one connected to the rectifier you will get ultimate solution to make required measurements of the anti-corrosion protection system parameters. All interX devices will disconnect electrode or rectifier from the pipeline exactly at the same time and will connect them back again exactly at the same time. This will continue during whole measurement period that can lasts a number of days. During all this period synchronization between units will stay unchanged. In other words there will be no timing drift between units.

interX can be widely used in many other applications that require synchronous operations spread over wide geographical area. Operations themselves are not only limited to short/open shunt. interX has I/O ports and optional peripheral devices (like analog to digital and digital to analog converters, non volatile memory, current monitor, Infrared transceiver) that can be programmed to perform desired complex operation.

For better understanding of interX functionality and abilities please read Section Functional Description

1.1 Key Features

- Under 1 millisecond unit to unit divergence
- Max switching power 60W
- Battery operated
- Easy configurable via RS232 terminal

1.2 interX Package Content

Standard interX package contains following items:

- interX device

- GPS Antenna with 5m coaxial cable

- RS232 Cable

- Two Shunt Cables

For non battery driven applications interX package will contain AC-DC power supply adapter

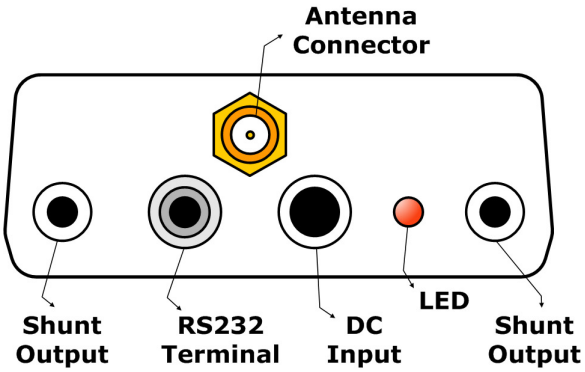
- AC-DC Power Supply Adapter

The exact interX package content is subject to change. It can be extended for customized interX version. Please contact XDIMAX or it's representatives to get up to date information and/or request extensions to standard package.

1.3 interX Front Panel

Shunt Outputs are connected to latch relay. Shunt Outputs can be closed (short connected to each other) or open (disconnected from each other). For pipeline trunk measurement shunt outputs may be connected between electrode and pipeline or electrode and ground.

Antenna Connector is used to connect GPS antenna provided in interX package. GPS antenna has 5 meters coaxial cable. It has to be mounted in open space to increase interX precision and reduce power consumption.



RS232 Terminal output is used to connect interX to PC RS232 port. Additional information about interX RS232 terminal can be found in Section RS232 Terminal .

DC Input is used for connecting external power supply adapter in non battery driven mode. Power supply adapter is provided in interX package. If you are going to use your own power supply please look at the Section Power Supply Adapter Requirements .

LED is a small red light indicator. Information about it can be found in Section LED Indicator .

1.4 interX Bottom Side

On bottom side of interX there are battery holder compartment and on-off push button.

Battery holder compartment has sliding cover that can be opened to replace interX batteries. In time of normal operation to transportation battery holder cover should be closed.

The on-off countersunk push button on bottom side is used to turn on or turn off interX . Button can not be pressed with finger but requires pointed object. While button is pressed LED Indicator on front panel is unconditionally on

To turn interX on press button for at least 4 seconds

To turn interX off press button for at least 2 seconds

2 Functional Description

interX is an integration of powerful I/O controller and GPS module. This internal structure of interX defines its main functionality - **"Perform I/O operations in high precision real time moments synchronous with other interX units"**.

In default interX configuration I/O operation is to open or short-circuit shunt outputs. Shunt outputs are internally connected to latch relay. interX CPU provides high or low signal to relay and thus opens or short-circuit shunt outputs.

interX timing is based on GPS outputs. GPS provides real time information - GPS Time and Pulse-Per-Second (PPS) signal. PPS is four microsecond wide positive pulse synchronized with respect to UTC (Universal Coordinated Time). The PPS timing accuracy is $\pm 50ns$ when valid position fixes are being reported. GPS Time is a number of seconds elapsed from the January 6, 1980. Based on GPS Time and PPS interX CPU can decide what I/O operation to perform and when exactly

Figure 1 on page 7 illustrates functionality of the four interX units set. Each unit is powered up at some moment. After power up unit waits for GPS initialization. GPS is considering fully functional after it starts to make position fixes. It means GPS can calculate it's position coordinates and all timing information is at maximum precision. GPS initialization time depends on many factors. In general GPS module has to get tracking of at least 4 satellites to start doing position fixes. After GPS is on and "doing position fixes" interX CPU can start operations. Decision to open or close shunt relay at every specific moment is taken by CPU according to the following simple formula:

$$Phase = GPS\_Time \bmod (To + Tc)$$

$$Output = \begin{cases} closed & \text{if } Phase < Tc \\ open & \text{if } Phase >= Tc \end{cases}$$

Tc,To - Closed,Open Time (sec)

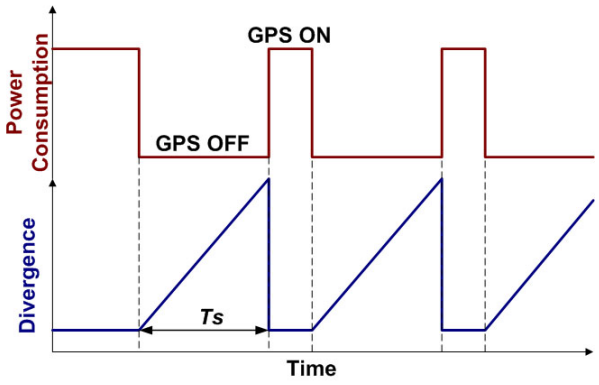
After decision is taken actual signal to shunt relay will be strobed by following PPS signal. This way high precision synchronization will be achieved. Within next PPS period CPU will get new GPS_Time (increased by one second) and will take new decision. And so on ...

Parameters Tc and To are configurable. They can be set via RS232 terminal (Section RS232 Terminal). Time resolution (granularity) for Tc and To in standard interX configuration is 1sec.

2.1 Precision vs. Power Consumption

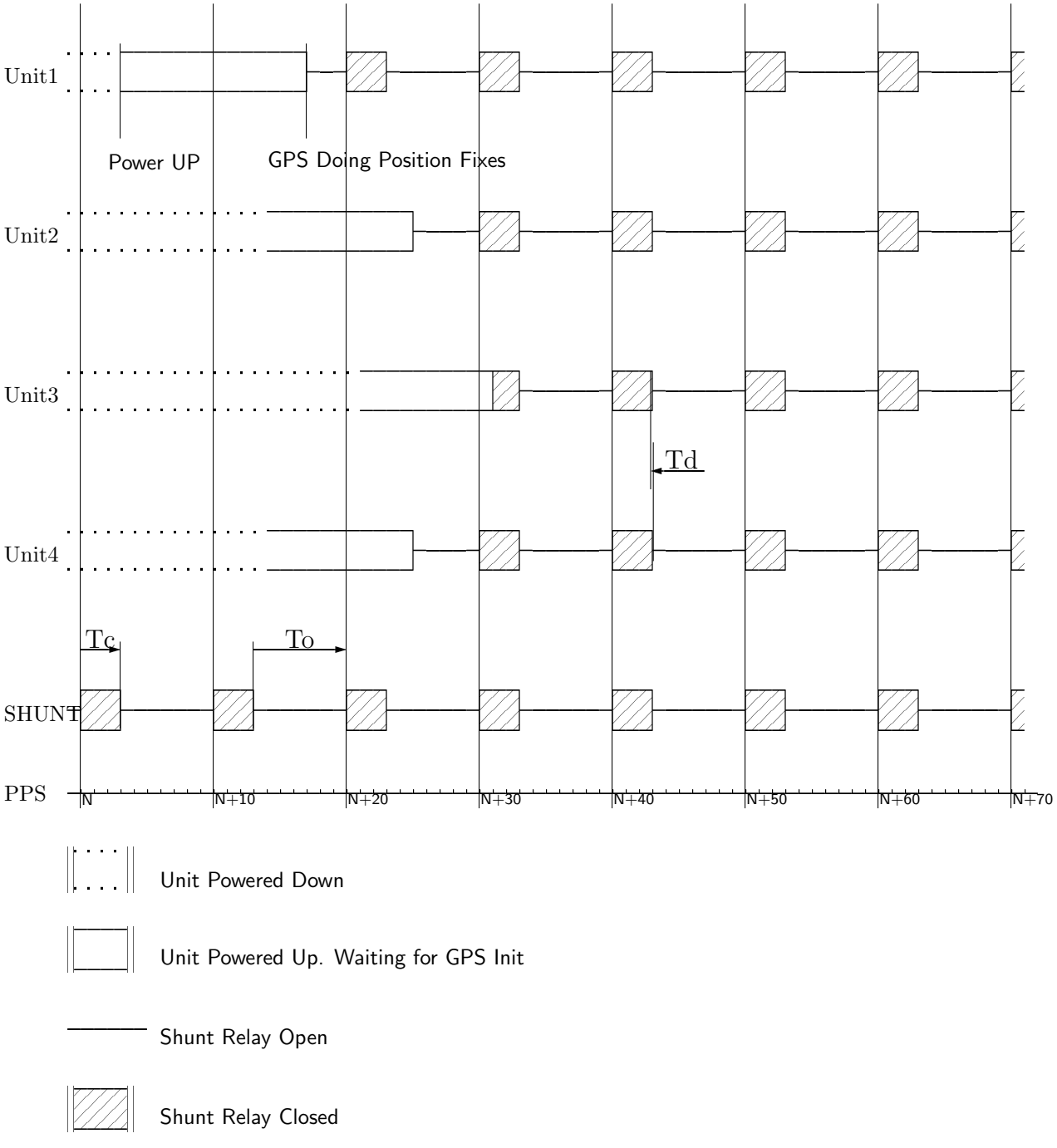
As you can see on figure 1 Td denotes possible divergence between two interX units. In non battery driven mode or without entering power saving mode interX Td depends on PPS precision ($\pm 50ns$) and CPU interrupt latency ($120 \pm 60ns$) and totally can be less then $230ns$.

In battery driven mode interX can be configured to enter power saving mode to reduce total power consumption and increase work time before changing or recharging battery. In power saving mode interX CPU temporary turns off GPS module and use it's own clock for synchronization. After Ts minutes GPS is turned on for minimal time required to synchronize CPU clock with PPS. Because CPU clock is not as stable as PPS signal the more time GPS is off and CPU clock is used the bigger divergence will grow up. From the other side the longer GPS module is



powered off the less power will be consumed by unit. Configurable parameter Ts - time the GPS module can be powered off defines trade-off between precision and power consumption.

Figure 1: interX timing



2.2 RS232 Terminal

interX configuration can be done via RS232 terminal program (like HyperTerminal or Term95). Terminal session can be started only after interX powered up. To enter terminal session following steps required.

1. Open Terminal program
2. Configure RS232 port (see Section RS232 Port Settings)
3. Connect RS232 cable from interX to PC
4. Turn on or restart interX
5. If everything is connected and configured right you will see in terminal window countdown from 9 to 0 (9876543210). **Press ENTER before counter gets to zero** Countdown will stop, interX will enter terminal session and will show prompt character '>'

```
987654
>
```

2.2.1 RS232 Port Settings

interX requires following RS232 port settings:

Bits per second	9600
Data bits	8
Parity	ODD
Stop bits	1
Flow control	None

2.2.2 'p' Command

SYNOPSIS

p

DESCRIPTION

Print current To,Tc,Ts settings as hexadecimal numbers. To,Tc values are in seconds, Ts in minutes.

EXAMPLE

Just type 'p'

```
>p
To=0A
Tc=05
Ts=03
>
```

In this example
$To = 0A = 10sec$,
$Tc = 5sec$,
$Ts = 3min$

2.2.3 'o' Command

SYNOPSIS

o $< Time >$

DESCRIPTION

Set To. $Time$ must be hex number 00 to FF that denotes 0 to 255 second value.

EXAMPLE

Set To to 0f=15 second

```
>o0f
>
```

2.2.4 'c' Command

SYNOPSIS

c $< Time >$

DESCRIPTION

Set Tc. $Time$ must be hex number 00 to FF that denotes 0 to 255 second value.

EXAMPLE

Set Tc to 0A=10 second

```
>c0A
>
```

2.2.5 's' Command

SYNOPSIS

s $< Time >$

DESCRIPTION

Set Ts. $Time$ must be hex number 00 to FF that denotes 0 to 255 minutes value.

EXAMPLE

Set To to 14h=20 min.

```
>o14
>
```

2.2.6 'g' Command

SYNOPSIS

g

DESCRIPTION

End terminal session and run application. After issuing this command interX will start normal operation and will not echo or respond terminal commands

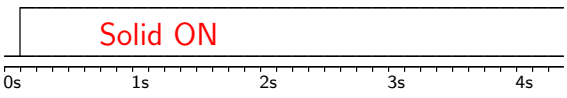
2.3 Low Battery State

In battery driven mode interX will monitor battery charge capacity (supplied voltage and current) If battery charge fails below threshold required for normal operation interX will enter Low Battery State. In this state only LED Indicator is functional and LED will continuously blink to indicate Low Battery State (see Section LED Indicator). To return interX to normal operation it's batteries have to be exchanged.

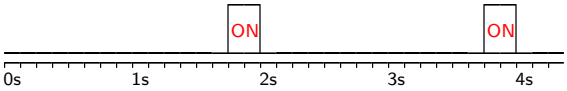
2.4 LED Indicator

interX LED provides special on/off sequences to indicate different states of the interX CPU and GPS module. Diagrams below show LED sequences and their meaning

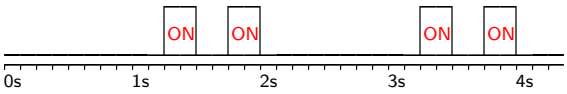
Antenna not Connected or Damaged



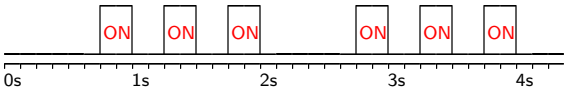
None or One Satellite Visible



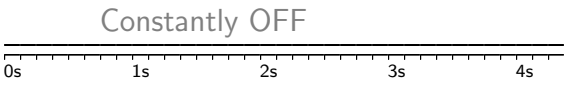
Two Satellites Visible



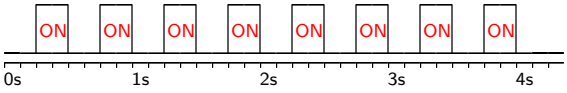
Three Satellites Visible



GPS doing position fixes



Low Battery State



3 Electrical Characteristics

Parameter	Symbol	Condition	Min	Typ	Max	Units
Rating						
Battery Type		Battery Driven Mode		AA		
Single Battery Voltage	Vbat	Battery Driven Mode	1.2		1.7	V
Input DC Voltage		Power Supply Mode	5	9	14	V
Precision		Ts=0	0.1	0.2	0.8	ms
		Ts=20			30	ms
Shunt Relay Parameters						
Contact Resistance	Rc	Relay Closed			75	$m\Omega$
Switching voltage		AC			125	V
		DC			220	V
Switching Current					2	A
Switching Power					60	W
Set Time		Closing			4	ms
Release Time		Opening			4	ms
Expected life		1A 30V DC	$2x10^5$			times

3.1 Power Supply Adapter Requirements

Input Voltage	110-120V or 220-240V
Output Voltage	7-12V
Output Current	100mA (or more)
Polarity	Plus Inside (+)
Plug Type Barrel	5.2x2.1mm