Q.Sonic®
Installation,
Operation, and
Maintenance Manual
Document Code: 01.09.01A.02/2/I
# Contents

Preface ............................................................................................................7  
Introduction ................................................................................................7  
Warranty .....................................................................................................7  
About Your Q.Sonic® Documentation ........................................................7  
What's Included in This Manual? ...............................................................8  
Typographical Conventions .......................................................................8  
Warning Messages ....................................................................................9  
Abbreviations .............................................................................................9  
References .................................................................................................9  

1 The Q.Sonic® ultrasonic gas flow meter .............................................11  
1.1 Introduction ........................................................................................11  
1.2 System characteristics .......................................................................11  
1.3 Q.Sonic® meter benefits .....................................................................12  
1.4 Q.Sonic® configurations .................................................................12  
  1.4.1 Q.Sonic® meter types .................................................................12  
  1.4.2 Q.Sonic® with Remote Unit ....................................................13  
  1.4.3 Q.Sonic® with Flow computer ..................................................13  
1.5 Q.Sonic® applications .........................................................................13  
1.6 Inspection services and certifications ................................................13  
1.7 Calibration ..........................................................................................14  
1.8 Exchanging parts of Q.Sonic® metering system ................................14  

2 Theory of Operation ............................................................................15  
2.1 Introduction ........................................................................................15  
2.2 Flow velocity measurement ...............................................................15  
2.3 Volume flow calculation .....................................................................17  
  2.3.1 Calculation of volume flow at line conditions .............................17  
  2.3.2 Calculation of volume flow at base conditions...........................17  

3 System description..............................................................................19  
3.1 Introduction ........................................................................................19  
3.2 Spool Piece ........................................................................................21  
3.3 Transducers .......................................................................................21  
3.4 Signal processing unit .........................................................................24  
  3.4.1 PROTRAN and PROTRAN-xa-i transducer interface board ....28  
  3.4.2 PROSON-II or ProDSP micro-controller board ......................28  
    3.4.2.1 Additional features of the ProDSP ...................................28  
    3.4.2.2 Optocoupler outputs .....................................................29  
  3.4.3 C-Module micro-controller board (optional, PROSON-II only) ..29  
  3.4.4 Fuse Module protection board (PROSON-II only) .................29  
  3.4.5 Explosion proof housing and cable glands ..............................29  
3.5 Remote Unit .......................................................................................30  
3.6 Parameter Set-up...............................................................................30  
  3.6.1 PROSON-II, ProDSP Configuration ...........................................30  
  3.6.2 Module Information ....................................................................31  
  3.6.3 Burst Parameters .........................................................................31  
    3.6.3.1 Single burst (SB) : ............................................................31  
    3.6.3.2 Repeated burst : .............................................................31  
    3.6.3.3 Coded multiple burst (ProDSP with Protran (5) XA-(i) only): .32
5.4.1 Monitoring the Q.Sonic® ..........................................................56
  5.4.1.1 Manual selection of the used metertype...............................56
  5.4.1.2 Using the “Autodetect Meter Type” option.............................57
  5.4.2 Real Time Clock .....................................................................58
  5.4.3 Passwords. .............................................................................59
    5.4.3.1 Master Password ..............................................................59
    5.4.3.2 User Passwords ...............................................................60
    5.4.3.3 Setting the password .........................................................61
  5.4.4 Verifying the Parameter Set-up .................................................62
  5.4.5 Adjusting the final factor .........................................................68
4.7 External wiring ...........................................................................47
  4.7.1 Systems with a Flow Computer ...............................................47
    4.7.1.1 Connecting the SPU to the Flow Computer .......................47
    4.7.1.2 Flow Computer power supply ..........................................47
  4.7.2 Interfacing to data acquisition systems ....................................47
  4.7.3 Stand-alone SPU systems: power supply, communication link....48
    4.7.3.1 Frequency output .............................................................48
    4.7.3.2 Current output .................................................................48
    4.7.3.3 Digital outputs .................................................................48
    4.7.3.4 Serial interface(s) .............................................................49
    4.7.3.5 Line termination .............................................................50
  4.7.3.5 Line termination .............................................................50
4.8 Installing the Parameter Set-up ..................................................50
4.9 Commissioning ...........................................................................54
  4.9.1 Cold commissioning (Factory Acceptance Test) .......................54
  4.9.2 Hot commissioning (Calibration) .............................................55
5 Operation ......................................................................................56
  5.1 Introduction ...............................................................................56
  5.2 Operating the SPU ......................................................................56
  5.3 Operating the Remote Unit .........................................................56
  5.4 Operating the Q.Sonic® with the UNIFORM software....................56
    5.4.1 Monitoring the Q.Sonic® .......................................................56
      5.4.1.1 Manual selection of the used metertype.........................56
      5.4.1.2 Using the “Autodetect Meter Type” option......................57
    5.4.2 Real Time Clock ..................................................................58
    5.4.3 Passwords ............................................................................59
      5.4.3.1 Master Password ..........................................................59
      5.4.3.2 User Passwords ............................................................60
      5.4.3.3 Setting the password ......................................................61
    5.4.4 Verifying the Parameter Set-up ..............................................62
    5.4.5 Modifying the Parameter Set-up ..........................................64
    5.4.6 Adjusting the final factor .......................................................68
5.4.7 Embedded data logger ................................................................. 68
5.4.8 Totalizers .................................................................................. 70
5.4.9 Communications Ports ............................................................... 70
5.4.10 Collecting data with UNIFORM's built-in data logger .............. 73

6 Maintenance, troubleshooting, and repair .......................................... 76
6.1 Introduction .................................................................................... 76
6.2 Maintenance ................................................................................. 76
   6.2.1 Inspection of measured data .................................................. 76
6.3 Pulse shape check ......................................................................... 79
   6.3.1 Sample view .......................................................................... 79
   6.3.2 Steps to export the found sample view data: ......................... 80
   6.3.3 Collect multiple samples ...................................................... 81
6.4 Troubleshooting ............................................................................ 83
6.5 Repair ............................................................................................ 84
   6.5.1 Replacement of (parts of) the SPU electronics ...................... 84
      6.5.1.1 Tools and spare parts ...................................................... 85
      6.5.1.2 Dismounting the SPU electronics .................................. 85
      6.5.1.3 Disassembly/inspection of the SPU electronics ............. 85
      6.5.1.4 Mounting the SPU electronics ...................................... 86
   6.5.2 Replacement of (parts of) the Remote Unit ............................ 87
6.6 Transducer Replacement ................................................................ 87
   6.6.1 Tools and spare parts ............................................................ 88
   6.6.2 Extraction procedure for non retractable Transducer models ...88
   6.6.3 Installation procedure for non retractable Transducer models ..89

7 Storage and shipping ......................................................................... 92
7.1 Introduction ................................................................................... 92
7.2 Procedure(s) ................................................................................. 92

8 Q.Sonic® meter types ....................................................................... 94
8.1 Introduction ................................................................................... 94
8.2 Transducer Connections .............................................................. 94
8.3 Path layouts .................................................................................. 94
8.4 Output Wiring Diagrams .............................................................. 101
8.5 Nameplates/labels ....................................................................... 103

9 Wiring of the USM ........................................................................... 106
9.1 Introduction .................................................................................. 106
9.2 Glands and cable types ............................................................... 106
9.3 PCB Connections .......................................................................... 106
   9.3.1 PROSON-II terminals ......................................................... 107
   9.3.2 C-module terminals ............................................................ 107
   9.3.3 ProDSP terminals .............................................................. 108
   9.3.4 Technor terminal connections .......................................... 108

10 Electrical Parameters ...................................................................... 110
10.1 Intrinsic safe Protran-xa-i ............................................................ 110

11 Glossary ......................................................................................... 112

12 Notes: ............................................................................................. 116

Figures

Figure 2-1: Ultrasonic measuring line .................................................. 15
Figure 3-1: Example of a Q.Sonic® system overview (with Remote Unit) .19
Figure 3-2: Example of a Q.Sonic® system overview (with flowcomputer) .20
Figure 3-3: Example of a Q.Sonic® system overview (Stand-alone SPU) .20
Figure 3-4: Measuring path types ....................................................... 21
Figure 3-5: Model Kx Transducer (flanged) ........................................ 22
Figure 3-6: Transducer model Lx (retractable under pressure).........................23
Figure 3-7: Transducer housing model A2 for retractable model Rb5 transducer ..................................................................................................................23
Figure 3-8: Transducer model Rb5 (retractable under pressure)....................23
Figure 3-9: Signal Processing Unit “Series III” (stand alone SPU system)........24
Figure 3-10: Signal Processing Unit “Series III” (system with a model 2000 Flow Computer)...............................................................................................................25
Figure 3-11: Signal Processing Unit “Series III” (stand-alone SPU system Series III with C-module analogue I/O and PTZ).................................................................25
Figure 3-12: Signal Processing Unit “Series IV with Protran” (stand alone SPU system)......................................................................................................................26
Figure 3-13: Signal Processing Unit “Series IV with Protran” (system with a model 2000 Flow Computer).....................................................................................26
Figure 3-14: Signal Processing Unit “Series IV” (stand-alone SPU system) (system with a model 2000 Flow Computer)...............................................................27
Figure 3-15: Signal Processing Unit “Series IV” (system with a model 2000 Flow Computer)...............................................................................................................27
Figure 4-1: Placement in the pipeline ................................................................46
Picture 1: RS-485 line termination of the port by means of dipswitches, left: line open, right: line terminated (black = rocker or high part of the switch)................50
Table 1: Overview of the password access. ..................................................61
Figure 8-1: Q.Sonic®-3 transducer connections ...........................................95
Figure 8-2: Q.Sonic®-3 series III transducer connection details....................96
Figure 8-3: Q.Sonic®-3 series IV transducer connection details..........................96
Figure 8-4: Q.Sonic®-4c transducer connections........................................97
Figure 8-5: Q.Sonic®-4 series III transducer connections details.................98
Figure 8-6: Q.Sonic®-4 series IV transducer connections details.................98
Figure 8-7: Q.Sonic®-5 transducer connections ........................................99
Figure 8-8: Q.Sonic®-5 Series III transducer connections details.............100
Figure 8-9: Q.Sonic®-5 Series IV transducer connections details.............100
Figure 8-10: C-Module outputs ..................................................................101
Figure 8-11: PROSON-II Optocoupler outputs ..........................................102
Figure 8-12: ProDSP Optocoupler outputs .................................................102
Figure 8-13: Nameplates spoolpiece (example only) ....................................103
Figure 8-14: Nameplates SPU (example only) ...........................................104
Figure 8-15: Nameplates SPU xai (example only) .........................................104
Figure 8-16: Nameplates transducer (example only) ....................................104
Figure 9-1: PROSON-II connections ..........................................................107
Figure 9-2: C-module connections ...............................................................107
Figure 9-3: ProDSP connections .................................................................108
Figure 9-4: Technor box .............................................................................108
Preface

Introduction

This manual describes the installation, operation, and maintenance of the Q.Sonic® types ultrasonic gas flow meter.

This manual contains information for proper operation and maintenance of this product. It also contains important instructions to prevent accidents and serious damage before commissioning, during operation, and to ensure trouble-free operation in the safest possible way. Before using the products read this manual carefully, familiarise yourself with the operation of the product, and strictly follow the instructions.

If you have any questions, or need further details of specific matters concerning this product, please do not hesitate to contact one of our staff members. (See the address information on page 2)

This manual is based on the latest information. It is provided subject to alterations. We reserve the right to change the construction and/or configuration of our products at any time without obligation to update previously shipped equipment.

Warranty

The warranty provisions stipulated in the manufacturer’s Terms of Delivery are applicable to the product. The manufacturer shall have no obligation in the event that:

♦ Repair or replacement of equipment or parts has been required through normal wear and tear, or by necessity in whole or part by catastrophe, or the fault or negligence of the purchaser;
♦ The equipment, or parts, have been maintained or repaired by other than an authorised representative of the manufacturer, or have been modified in any manner without prior express written permission of the manufacturer;
♦ Non-original parts are used;
♦ Equipment is used improperly, incorrectly, carelessly or not in line with its nature and/or purpose;
♦ The product is used with unauthorised equipment or peripherals, including, but not necessarily limited to, cables, testing equipment, computers, voltage, etc.

The manufacturer is not responsible for the incidental or consequential damages resulting from the breach of any express or implied warranties, including damage to property, and to the extent permitted by law, damage for personal injury.

About Your Q.Sonic® Documentation

The Q.Sonic® documentation delivered with the meter consists of:

♦ Manuals:
  ◊ Installation, Operation and Maintenance Manual (this document)
  ◊ UNIFORM getting started (also see help file in Uniform)
♦ Drawings:
  General arrangement drawing(s)
What’s Included in This Manual?

This section of the preface gives an overview of the contents of this manual:

Chapter 1 - *The Q.Sonic® Ultrasonic Gas Flow Meter*

Chapter 2 - *Theory of Operation*

Chapter 3 - *System Description*

Chapter 4 - *Installation and Commissioning*

Chapter 5 - *Operation*

Chapter 6 - *Maintenance, Troubleshooting and Repair*

Chapter 7 - *Storage and Shipping*

Chapter 8 – *Q.Sonic® meter types*

Chapter 9 – *Wiring of the USM*

Chapter 10 – *Electrical Parameters*

Chapter 11 – *Glossary*

Chapter 12 – *Notes*

Typographical Conventions

This manual employs consistent visual cues and some standard text formats to help you locate and interpret information easily.

**Symbol** | **Meaning**
--- | ---
▲ | Signals the beginning of a procedure.
■ | Signals a procedure that has only one step. Also used to signal the end of a multi-step procedure.
1 2 3 … | Signal the steps of a procedure.
▷ | Signals the beginning of a sub-procedure.
☐ | Signals a sub-procedure that has only one step. Also used to signal the end of a multi-step sub-procedure.
1 2 3 … | Signal the steps of a sub-procedure.

**Type Style** | **Meaning**
--- | ---
*italic* or *bold* | Used to emphasise a word or phrase.
**Bold italic** | Used for terms that appear in the glossary, for references within this manual, and for references to other documents.
"command" | Typewriter style is used for commands that you must type at your equipment, and for responses from equipment, for example “Write Set-up to FlowMeter” command.
<br> | The name of a key on a (PC) keyboard, for example <F1>.
Warning Messages

Warning!
A warning signifies hazards or unsafe practices that could result in severe personal injury or death.

Caution!
A caution signifies hazards or unsafe practices that could result in minor personal injury or product or property damage.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>AEIA</td>
<td>American Electrical Industries Association</td>
</tr>
<tr>
<td>AGC</td>
<td>Automatic Gain Control</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>ATEX</td>
<td>Atmosphères Explosibles</td>
</tr>
<tr>
<td>CE</td>
<td>Comité Européen de Normalisation</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>FM Approvals</td>
<td>Factory Mutual Global technologies LCC</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute for Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>KEMA</td>
<td>Institute for approvals</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>NMI</td>
<td>Nederlands Meetinstituut</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PTB</td>
<td>Physikalisch-Technische Bundesanstalt</td>
</tr>
<tr>
<td>RU</td>
<td>Remote Unit</td>
</tr>
<tr>
<td>SPU</td>
<td>Signal Processing Unit</td>
</tr>
<tr>
<td>TIP</td>
<td>Transducer Interface Processor</td>
</tr>
<tr>
<td>UNIFORM</td>
<td>Ultrasonic Flow meter Configuration and Monitoring software</td>
</tr>
<tr>
<td>V.o.S.</td>
<td>Velocity of Sound</td>
</tr>
</tbody>
</table>

References

1. Q.Sonic®: Communication Protocol (Measured Data), Instromet Ultrasonics B.V.
3. Q.Sonic® Storage and shipping, Instromet Ultrasonics B.V.
4. Calibration and sealing manual, Instromet Ultrasonics B.V.
5. UNIFORM Getting started, Instromet Ultrasonics B.V.
7. Transducer Retraction Tool, Instromet Ultrasonics B.V.
8. Healthcare monitoring, Instromet Ultrasonics B.V.
9. Recalibration procedures, Instromet Ultrasonics B.V.

The above mentioned documents can be obtained from Instromet Ultrasonics B.V (see page 2)
1 The Q.Sonic® ultrasonic gas flow meter

1.1 Introduction

The Q.Sonic® is a high quality, multi-path ultrasonic gas flow meter from Instromet Ultrasonics B.V. This type of gas flow meter has been specifically designed for custody transfer measuring applications that demand a high degree of accuracy and reliability.

The Q.Sonic® has been legally authorised for fiscal metering by many countries all over the world. Some of the countries are:

- The Netherlands
- Germany
- Czech Republic
- Indonesia
- Canada
- Malaysia
- Austria
- China
- Russia
- And many others

1.2 System characteristics

The Instromet Q.Sonic® meter is a highly sophisticated multipath ultrasonic meter integrated into a spoolpiece. It is available in different designs; a 3, 4 and a 5-path configuration. Two of the paths in each of the designs are swirl paths. The unique combination of single reflective and double reflective ultrasonic paths provides excellent flow profile representation, which, when integrated, results in very high accuracy velocity measurement. This accuracy is maintained even when the flow conditions are less than ideal. The Q.Sonic® also has the capability of bi-directional measurement with equal accuracy in both directions.

The transducers are positioned so that there is only a minimal protrusion into the gas stream. This minor protrusion creates no pressure loss, however, it ensures that the time measurement is truly representative of the flowing stream only, and is not affected by stagnated gas in the transducer port.

As a part of the manufacturing process, after the meter has been fabricated and fully assembled, it is dry calibrated. The dry calibration procedure, which is performed under very controlled conditions, provides an electronic means of verifying or fine-tuning the meter geometry (i.e. path length and path angles) originally determined with mechanical measurement tools. The result of this dry calibration procedure is the ability for Instromet to manufacture the meter with a reproducibility of better than ±0.1% and a measurement error of less than 0.5% for the Q.5 (0.7% for the Q3), prior to any flow calibration at a test facility. After calibration at a test facility and installation in the line, the meter error is in the range of ± 0.3% or better. (Based on 10D of straight pipe upstream of a Q4, Q5 and 20D of straight pipe upstream of a Q3 meter, all meters with 3D of straight pipe downstream.)

Depending on the type of transducer chosen, the meter is designed to operate in the 100 to 2100 kPa (15 to 300 psig) or 1500 to 17200 kPa (220 to 2500 psig) pressure ranges.

Although the meter body length has been standardised to match the length of turbine meter bodies if possible, the fabrication of the body allows for custom lengths. The meter is currently available in sizes from 4 to 64 inches.
1.3 The Q.Sonic® meter benefits

The Q.Sonic® features some important benefits when compared to other common measuring techniques (for example, orifice plates, turbine meters, vortex meters and venturi meters), such as:

- Large dynamic range of about 1:100, or greater.
- Highly insensitive to asymmetrical, pulsating or rotating flows (swirl).
- Negligible gas flow resistance, thus negligible pressure drop.
- Capable of bi-directional flow measurement.
- Highly insensitive to wet and/or untreated production gas
- Virtually no maintenance required.
- Accuracy; better than 0.3% when calibrated and installed.
- Sour gas capable (up to 10% sour gas components)

1.4 The Q.Sonic® configurations

The Q.Sonic® exists in several configurations:

- 3-Path ultrasonic gas flow meter, generally for 4" pipe diameter and larger, with a measuring error ≤±0.7%(uncalibrated) of the measured value.
- 4-Path ultrasonic gas flow meter, standard for 4"-16" pipe diameter, larger upon request, with a measuring error ≤±0.5%(uncalibrated) of the measured value.
- 5-Path ultrasonic gas flow meter, generally for 12" pipe diameter and more, with a measuring error ≤±0.5%(uncalibrated) of the measured value.
- With Remote Unit for custody transfer applications according to approvals in the Netherlands, Germany and Czech Republic.
- With flow computer (refer to specific certificate for custody transfer applications).
- With a local display on the meter for custody transfer (refer to specific certificate for custody transfer applications).
- Without Remote Unit in other applications.
- With switchbox and CheckSonic electronics as redundant system to form a TwinSonic®

1.4.1 The Q.Sonic® meter types

There are 2 different meter types for the Q.Sonic®. These are the Q.Sonic®-QL meter and the Q.Sonic®-Q meter types. The following difference defines those types:

- Q.Sonic®-QL meter measures Volume flow at line conditions.
- Q.Sonic®-Q meter has the option to use Pressure and Temperature inputs for PTZ correction to measure Volume flow at base conditions. (This option is at this moment not possible for Custody transfer and under development for the series IV.)

See also chapter 8 Q.Sonic® meter types.
The custody transfer approval documents of the various countries contain rules and limitations regarding the configuration, marking and sealing of the Q.Sonic® meters. The requirements and regulations regarding the use of the Q.Sonic® ultrasonic gas flow meter in custody transfer applications are stated in documents (original or later version) such as:

- B13 dispensation of the Dutch Ministry of Economic Affairs;
- 1.33-7.241-IUT 95.01 PTB Germany
- Migas, Indonesia
- AG0470, Canada
- SIRIM, Malaisia
- OE98-G810, BEV Austria
- TCM 143/98 2943, CMI Czech Republic
- PA 99-F132, China
- BE.C 29004A No 17936, Gost Rusia
- HR Z-18-1027, Croatia
- Approval pending France
- Approval pending Italy
- And many others.

1.4.2 Q.Sonic® with Remote Unit

A so-called Remote Unit (RU) can be a part of the system. The Remote Unit functions as a totaliser, display, alarm and security unit.

In series IV electronics it is not possible to use the Remote Unit, instead a local display can be used.

1.4.3 Q.Sonic® with Flow computer

A so-called flow computer (e.g. a model 2000) can be a part of the system. Flow computer functions as a totalizer, display, alarm and security unit. Other manufacturers' flow computers may be used; refer to the manufacturer for advice if there is a flow computer that is suitable.

1.5 Q.Sonic® applications

The most important applications for the Q.Sonic® are custody transfer and storage of natural gas. An example of the first is the use of a Q.Sonic® together with a turbine meter in metering and regulator stations, and export stations. This application involves measurement in one direction only.

An application in which the unique bidirectionality of the ultrasonic measuring technique plays an important role is underground gas storage. Direct benefit is achieved from the reduced required space and materials for the metering section. Additionally, the Q.Sonic® is well suited for wet gas and offshore applications, where the severe measuring conditions require a system that restores itself.

1.6 Inspection services and certifications

The most important components of the Q.Sonic® are installed in the hazardous area, and therefore need to satisfy national and international safety requirements.

Certified standard components such as explosion proof housings and cable glands are used with the Q.Sonic®. The parts developed by Instromet Ultrasonic Technologies, such as transducers and printed circuit boards are tested and certified by institutes like KEMA or FM-Global.
1.7 Calibration

When using the Q.Sonic® in custody transfer applications, some countries demand (by law) a calibration from a certified calibration institute, supervised by an inspector of weights and measures. Facilities generally used for calibrations of Q.Sonic® meters are Bernoulli Laboratorium of N.V., Nederlandse Gasunie in Westerbork (NL), the PIGSAR GH45 of Ruhrgas AG in Dorsten (D), and the TransCanada Calibrations Ltd. (Can). These installations are accredited by Nmi and PTB.

The calibrated measuring range depends on the Q.Sonic®'s diameter. Due to the very high capacity of large meters the actual flow range in which the meter can be calibrated often depends on seasonal gas transportation. During the calibration the ultrasonic gas flow meter is compared with standards that are traceable to national or international standards.

The results, the relative error (as measured), the adjust factor, and the Parameter Set-up of the Q.Sonic® are issued on a calibration certificate that is stamped and signed by an inspector of weights and measures.

1.8 Exchanging parts of Q.Sonic® metering system

The different parts of the Q.Sonic® metering system like: Transducers (identical types), electronic boards, cables, etc, can be exchanged without any problem. The digital programmed pulse shape and pulse identification of the meter is always identical. Therefore the electronic- and transducer products need no adjustment. This means that re-programming or re-calibration of the meter after exchanging any identical part of the Q.Sonic® metering system is not necessary.

Spare parts of the Q.Sonic® metering system must be supplied by Instromet Ultrasonics B.V. After exchanging parts of the Q.Sonic® metering system the present “calibration” sealing must be renewed. See the “Calibration and Sealing Manual”.

2 Theory of Operation

2.1 Introduction
An ultrasonic flow meter is an inferential measurement device that consists of ultrasonic transducers that are typically located along a pipe’s wall. The transducers are inserted into the piping using a gas tight mechanism. Ultrasonic pulses are alternately transmitted by one transducer and received by the other one. Figure 2-1 shows a simple geometry of two transducers, ‘A’ and ‘B’, at a sharp angle "ϕ" with respect to the axis of a straight cylindrical pipe with diameter “D”. The Q.Sonic® employs reflection paths, where the acoustic pulses reflect one or more times off the pipe wall. See Figure 3-4: Measuring path types for a diagram of this design.

![Figure 2-1: Ultrasonic measuring line](image)

2.2 Flow velocity measurement
The acoustic pulses are crossing the pipe like a ferryman crossing a river. Without flow, they propagate with the same speed in both directions. If the gas in the pipe has a flow velocity different from zero, pulses travelling downstream with the flow will move faster, while those travelling upstream against the flow will move slower. Thus, the downstream travel times "t_D" will be shorter, while the upstream ones "t_U" will be longer as compared when the gas is not moving. The following equations illustrates the computation of these times, where:

- \( t_D \) the downstream travel time.
- \( t_U \) the upstream travel time.
- \( L \) the straight line length of the acoustic path between the two transducers.
- \( c \) is the speed of sound.
- \( v \) is the average gas velocity.
- \( \phi \) the angle between the gas flow and ultrasonic signal.

\[
\begin{align*}
  t_D &= \frac{L}{c + v \cdot \cos \phi} \\
  t_U &= \frac{L}{c - v \cdot \cos \phi}
\end{align*}
\]

Equation 2-1 downstream travel time
And

\[
L = \frac{D}{\sin \phi}
\]
Equation 2-3 acoustic pathlength
The travel times are measured electronically. From the difference the flow velocity $v$ is calculated by the following equation:

$$v = \frac{L}{2 \cos \phi} \left( \frac{1}{t_D} - \frac{1}{t_U} \right)$$

Equation 2-4 gas velocity

Generally speaking, the flow velocity is not constant over the pipe’s cross section. In steady swirl-free flow through long straight cylindrical tubes, the flow velocity is a function of the radial position only. This function, usually called the fully developed velocity profile, can be approximated by a semi-empirical power law:

$$v(r) = v_{\text{max}} \left( 1 - \frac{r}{R} \right)^n$$

Equation 2-5

where $n$ is a function of the Reynolds number and pipe roughness.

For smooth pipes $n$ is calculated as follows:

$$n = 2 \log_{10} \left( \frac{Re}{n} \right) - 0.8$$

Equation 2-6

The flow velocity as calculated by Equation 2-4 is the line-integral along the path:

$$v_L = \frac{L}{L} \int_L v(r) dL$$

Equation 2-7

In other words, the velocity perceived by the instrument equals the average, along the acoustic path, of the fluid velocity component in the direction of the path. Normally, a user is interested in the bulk mean velocity $v_m$ of the medium, which means the velocity averaged over the cross section $S$ of the pipe

$$v_m = \frac{L}{S} \int_S v(r) dS$$

Equation 2-8

If $v$ only has a component perpendicular to $S$, the bulk mean velocity $v_m$ is computed from

$$v_m = k_c v_L$$

Equation 2-9

where $k_c$ denotes the so-called correction factor defined by

$$k_c = \frac{L}{S} \int_S v(r) dS$$

Equation 2-10

which can be computed once $v(r)$, $L$, and $S$ are known. Because $v(r)$ is a function of the Reynolds number, the correction factor is a function of the Reynolds number too.
The Q.Sonic® features an “Adjust Factor”, which allows adjustment of the meter after flow calibration. The adjust factor is applied to the bulk mean velocity:

\[ v_m = f_{\text{adjust}} \cdot k_c \cdot v_L \]

**Equation 2-11**

The Q.Sonic® performs quasi-simultaneous time-of-flight measurements on its 3-, 4- or 5-path matrix to measure flow. The high degree of symmetry, combined with the bi-directional time-of-flight measurements, ensures a very accurate spatial sampling of the flow profile, thus resulting in high accuracy, even when measuring pulsating flows, or distorted flow profiles. The above mentioned symmetries also allow the Q.Sonic® to measure bi-directional flow with equal accuracy.

### 2.3 Volume flow calculation

The Q.Sonic® has the option to give volume flow information. The Q.Sonic® QL type meters only give volume flow at line conditions. The Q.Sonic® Q type meters give volume flow at base conditions. The volume flow at base condition output of the Q.Sonic® is not accepted for use in custody transfer.

#### 2.3.1 Calculation of volume flow at line conditions

The volume flow at line conditions \( Q_{\text{Line}} \) is the (adjusted) profile-corrected gas velocity \( v_m \) multiplied by the internal cross section \( A \) of the spool piece:

\[ Q_{\text{Line}} = v_m \cdot A = v_m \cdot \frac{\pi D^2}{4} \]

**Equation 2-12**

Where \( D \) is the inner diameter of the spool piece.

#### 2.3.2 Calculation of volume flow at base conditions

The volumetric flow at base conditions \( Q_{\text{Base}} \) calculated as follows:

\[ Q_{\text{Base}} = \frac{z_0}{z} \cdot \frac{P}{P_0} \cdot \frac{T_0}{T} \cdot Q_{\text{Line}} \]

**Equation 2-13**

Where:

- \( z_0, P_0, T_0 \) are compressibility factor, pressure and temperature at base (or reference) conditions, and
- \( z, P, T \) are compressibility factor, pressure and temperature at line (or metering) conditions.

It is possible to use the SGERG, AGA NX-19 or the approximation calculation methods for base volume calculations. Virtually any compressibility calculation method can be approximated; however, gas composition, pressure and temperature range must be known beforehand.

The Q.Sonic® calculates the compressibility factor (z) from the measured pressure and temperature and its compressibility approximation coefficients (‘a1’ through ‘a6’ in the parameter set-up).

The approximation method is used as standard for the Q.sonic

\[ z = \left(a_1 T^2 + a_2 T + a_3\right) \cdot p^2 + \left(a_4 T^2 + a_5 T + a_6\right) \cdot p + 1 \]

**Equation 2-14** approximation method
A set of approximation coefficients for a specific metering application can be ordered from Instromet.

The following information is required for computing these six coefficients:

- Maximum and minimum gas pressure under flow conditions
- Max and minimum gas temperature under flow conditions
- Average Specific Gravity (Relative Density)
- Gas composition (Average mole percentage for CO₂ and N₂)

By setting the Q.sonic’s approximation coefficients to zero, the base volume calculation can be reduced to a simple volume correction:

\[ Q_{\text{Base}} = k_z \cdot \frac{P}{P_0} \cdot \frac{T_0}{T} \cdot Q_{\text{Line}} \]

\textbf{Equation 2-15}

Where \( k_z \) is the quotient of \( z_0 \) and \( z \).

The actual \( z \) as calculated by the Q.Sonic®, with the approximation coefficients ‘a1’ through ‘a6’ set to zero, always equals 1, so the only way to correct for the pre-set value of \( z \) is to program the Q.Sonic® PTZ parameter ‘20’ with \( k_z \).

Please refer to the UNIFORM “help file” for more information on this feature.
3 System description

3.1 Introduction

The Q.Sonic® consists of the following main parts:

- A **spool piece** with 2 nozzles for each of its 3, 4 or 5 measuring paths.
- 3, 4 or 5 **pairs of transducers**. Each transducer is connected by an armoured coaxial cable to the SPU.
- The **Signal Processing Unit** (SPU), an explosion proof housing with the electronic circuits. The SPU is mounted on (or close to) the spool piece.
- An optional **Remote Unit** (only applicable for meters with series III electronics) or **Flow Computer** *(i.e. model 2000)*: an interface and display unit at a maximum distance of 700m in the control room.
- An optional **Local Display** in the SPU on the series IV electronics.

An example of the system with Remote Unit is shown in Figure 3-1. An example of the system with a Flow Computer is shown in Figure 3-2, Figure 3-3 shows an example system without Remote Unit, these last two systems are generally referred to as a “Stand-alone SPU” systems.

![Figure 3-1: Example of a Q.Sonic® system overview (with Remote Unit)](image_url)
Figure 3-2: Example of a Q.Sonic® system overview (with flowcomputer)

Figure 3-3: Example of a default Q.Sonic® system (Stand-alone SPU)
3.2 Spool Piece

The spool piece is the part of the Q.Sonic® that is mounted in the piping system. In the spool piece several measuring paths are incorporated. Two transducers are required for each measuring path. There are two measuring path types in the Q.Sonic®: paths with single reflection (axial paths) and paths with double reflection (swirl paths). Figure 3-4 shows the measuring path types.

![Figure 3-4: Measuring path types](image)

3.3 Transducers

The ultrasonic signals required for the flow measurement are generated and received by ultrasonic transducers.

Piezoelectric transducers employ crystals or ceramics that are set into vibration when an alternating voltage is applied to the piezoelectric element. The vibrating element generates sound waves in the gas. Since the piezoelectric effect is reversible, the element will become electrically polarised and produce voltages related to the mechanical strain, when the crystal is distorted by the action of incident sound waves. Because the acoustic impedance of the gas is much smaller as the acoustic impedance of the piezoelectric element, and to maximise the acoustic efficiency, a matching layer is employed between the gas and the piezoelectric element.
Transducer models for various applications exist, such as:

- **Model K**: Standard transducer for a pressure range of 15-450 bar (217 to 6525 PSI) and temperature from -20 to +80°C (-4 to 176 F) (see Figure 3-5).
- **Model L**: Transducer for a pressure range of 15-138 bar (217 to 2001 PSI), suitable for exchange under pressure, and temperature range from -20 to +80°C (-4 to 176 F) (see Figure 3-6).
- **Model M**: Transducer with housing as Model K and L but for low-pressure applications: 1-20 bar (14.5 to 290 PSI) and a temperature range from -20 to +60°C (-4 to 140 F).
- **Model N**: Transducer with housing as Model K but for high temperature applications from -20 to +100°C (-4 to 212 F).
- **Model P**: Transducer with housing as Model K and L but for applications with high ultrasonic noise levels.
- **Model A(n)Rb**: Transducer for a pressure range of 15-150 bar (217 to 2175 PSI), suitable for exchange under pressure, and temperature range from -20 to +80°C (-4 to 176 F) (see Figure 3-7).

Remarks:

- Transducers are certified components (EEx m / EEx me).
- The parts of a transducer, including the cable and connector, form a single, integrated unit.
- The cable length of the transducer forms an integral part of a tuned circuit and may not be changed under any circumstances!
- The replacement of a transducer has no influence on the accuracy (calibration) of the meter.
- A transducer does not contain serviceable parts, and must be replaced as a unit.

Caution!

A transducer contains no serviceable parts. Do not disassemble, unscrew or tighten any part of the transducer. Do not change the length of the transducer cable. The model A(n)Rb5 is partly serviceable. The transducer element Rb5 can be serviced.

![Figure 3-5: Model Kx Transducer (flanged)](image-url)
Figure 3-6: Transducer model Lx (retractable under pressure)

Figure 3-7: Transducer Model Rb with housing model A2 for retractable model Rb5 transducer element.  

Figure 3-8: Transducer element model Rb5 (retractable under pressure)
3.4 Signal processing unit

The Signal Processing Unit (SPU) consists of a Transducer Interface Processor-Module (TIP) in an explosion proof housing on (or near) the spool piece.

The series III TIP-Module consists of the following printed circuit boards:

- **Fuse Module**,  
- **PROSON-II**,  
- **PROTRAN (1, 3 or 5)**  
  optional 
- **C-Module** for analogue I/O and PTZ connections.

The series IV TIP-Module consists of the following printed circuit boards:

- **ProDSP**,  
- **converter**  
- **PROTRAN (1, 3 or 5)**  

*Or*  
- **ProDSP**  
- **PROTRAN-xa(-i)**

The Tip module interfaces the transducers and controls the measuring process, respectively. The **PROSON-II** and **ProDSP** micro-controller boards process the measured values, calculate volume flow, and interface to the outside world (i.e. flowcomputer). Figure 3-9 to Figure 3-11 show the Signal Processing Unit for Q.Sonic® systems with different possible SPU configurations.

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**Figure 3-9:** Signal Processing Unit “Series III” (stand alone SPU system)
Figure 3-10: Signal Processing Unit “Series III” (system with a model 2000 Flow Computer)

Figure 3-11: Signal Processing Unit “Series III” (stand-alone SPU system Series III with C-module analogue I/O and PTZ)
Figure 3-12: Signal Processing Unit “Series IV with Protran” (stand alone SPU system)

Figure 3-13: Signal Processing Unit “Series IV with Protran” (system with a model 2000 Flow Computer)
Figure 3-14: Signal Processing Unit “Series IV” (stand-alone SPU system)

Figure 3-15: Signal Processing Unit “Series IV” (system with a model 2000 Flow Computer)
3.4.1 PROTRAN and PROTRAN-xa-i transducer interface board

The PROTRAN (1,3,5) board contains the analogue circuits for transmitting and receiving single burst ultrasonic sound pulses.

The PROTRAN-xa (max 4 path) board contains the analogue circuits for transmitting and receiving multiple burst ultrasonic sound pulses according to a code for improved signal recognition and detection in a noisy environment.

The PROTRAN 5-xa-I (max 5 path) board contains the analogue intrinsic safe circuits for transmitting and receiving multiple burst ultrasonic sound pulses according to a code for improved signal recognition and detection in a noisy environment.

(The intrinsic safe transducer connections are marked blue.)

For a more detailed explanation of “Burst” see 3.6.3.1 to 3.6.3.3

These boards also contain the components of the receiver’s Automatic Gain Control (AGC). Depending on the type of Q.Sonic® (3-, 4- or 5-path), a PROTRAN, PROTRAN-xa or PROTRAN-xa-i with the appropriate number of transducer connections is used.

3.4.2 PROSON-II or ProDSP micro-controller board

The SPU’s processor board can be the PROSON-II or the ProDSP, these are micro-controller systems that interface the PROTRAN, PROTRAN-xa or xa-i (and the optional C-Module on the PROSON-II).

The main tasks of the PROSON-II and ProDSP are recognition and quality analysis of the received sound pulses, time-of-flight measurement, the calculation of the speed of sound, gas velocity and the output of the data to the outside world.

The PROSON-II and ProDSP process the measured data: they combine the measured data from the individual ultrasonic paths, and calculate volume flow. These data are then passed to an external unit (e.g. Remote unit, Flow Computer or data acquisition system) using the RS485/RS232 serial interfaces.

(For Series III versions (PROSON-II based) that use an additional C-Module for an analog I/O and PTZ correction, the data is passed on to the C-Module.)

The PROSON-II and ProDSP PCB also contain a DC/DC-converter, which converts the external supply voltage to the SPU-internal supply voltage(s).

3.4.2.1 Additional features of the ProDSP.

The ProDSP has implemented some on board predefined databuffers to support increased diagnostic capabilities and provide audit trail and verification tools. For applying date and time stamps a real time clock has been added to the circuitry. Also two extra, free configurable i/o ports are added.
3.4.2.2 Optocoupler outputs.

Stand-alone SPU systems may also use the PROSON-II or ProDSP optocoupler outputs to interface to the outside world. These 4 programmable outputs can give out information such as:

- **Frequency output**: opto-coupler (open collector).
- **Data Valid output**: opto-coupler (open collector), conductive when the Q.Sonic® is fully operational, high-impedance otherwise.
- **Flow Direction output**: opto-coupler (open collector), conductive for forward flow, high-impedance for reverse flow.
- **Partial Failure**: opto-coupler (open collector), conductive when at least one path is not operational.
- Or combinations as: inverted frequency or frequency for forward flow and Data Valid

3.4.3 C-Module micro-controller board (optional, PROSON-II only)

The SPU's third PCB, the optional C-Module, is a micro-controller system that controls several optional digital and analogue outputs and the analogue pressure and temperature inputs for the PTZ correction. These data are then combined with the PROSON-II data to calculate the normalised volume flow. See also Q.Sonic®: Communication Protocol (Measured Data).

Stand-alone PROSON-II SPU systems may also use the C-Module optocoupler (fixed definition) frequency output, the current output and the digital status outputs to interface to the outside world:

- **Frequency output**: opto-coupler (open collector).
- **Current output**: 0/4-20 mA.
- **Data Valid output**: opto-coupler (open collector), conductive when the Q.Sonic® is fully operational, high-impedance otherwise.
- **Flow Direction output**: opto-coupler (open collector), conductive for forward flow, high-impedance for reverse flow.

3.4.4 Fuse Module protection board (PROSON-II only)

The **Fuse Module** is a printed circuit board that provides transient protection and a filter for high frequency noise on the power supply.

3.4.5 Explosion proof housing and cable glands

The SPU-electronics are mounted in an EEx(d)-class flameproof (also called explosion proof) housing. Typical EEx(d) housings are:

- EEx(d) housing with ATEX-approval. Other specifications:
  - Copper-free cast light alloy.
  - EEx d IIB T6. (IIC Optional)
  - IP-67 ingress protection classification.
  - ATEX approved cable glands.

- EEx(d) box. Other specifications:
  - SS 316.
  - IP-66 ingress protection classification.
  - EEx de IIB T6. (IIC Optional)
  - ATEX approved cable glands.
3.5 Remote Unit

The Remote Unit is Q.Sonic® ultrasonic gas flow meter's interface and display unit for the series II electronics (or “emulated series II mode” by series III). The Remote Unit contains three printed circuit boards, control and display elements and an interface panel. The Remote Unit has a 19” (3 HE) housing.

The Remote Unit receives the SPU’s measured data through a serial data link (RS-485) and makes this information available to the user:
- Visually: LCD, indication lamp.
- Electrically: Frequency output, current output, digital status outputs.
- Acoustical.

The Remote Unit also contains the power supply for the SPU. The Remote Unit is available in two versions: with a supply voltage of 24 VDC or 230 VAC.

More information about the Remote Unit can be found in the Users manual for the Remote Unit. See also Remote Unit users manual.

3.6 Parameter Set-up

The Q.Sonic®’s operation is controlled by a programmable set of parameters, for example, spool piece geometry, initial settings for measurement control, input/output scaling, etc., which are stored in the SPU’s non-volatile memory.

A complete set of parameters, called Parameter Set-up, is divided into the following sections:
- Meter Configuration;
- Module Info;
- Burst parameters;
- Spool piece Parameters;
- V-Module Parameters;
- Velocity Profile Correction;
- Calibration Coefficients;
- Substitution;
- Adjust Factor;
- Linearization;
- Low Pass Filter Set-up;
- Low Flow Cut-off Set-up;
- P&T Input Parameters;
- PTZ correction;
- Current Output Set-up;
- Frequency Output Set-up;
- Total Volume Counters Set-up

These sections can slightly vary depending on the type of electronics used. (Series III = PROSON-II pcb, Series IV = ProDSP pcb)

In the next chapters the parameters are explained.

The PC-based UNIFORM software (see 3.7) is available to compile (or modify) a parameter set-up and to install it in the Q.Sonic® using the flow meter’s serial interface. The UNIFORM software may also be used to monitor the Q.Sonic®’s operation, and features a data logger to collect data for off-line processing.

3.6.1 PROSON-II, ProDSP Configuration

The initial parameters to determine the function of the electronics are set by the factory. These values can not be altered without changing the properties of the meter.
The initial parameters can only be changed by authorised people. Unauthorised changes in these values will result in a checksum error message and will be rejected.

The parameters are protected by means of a 10 position BCD switch on the processor board. (or jumper on the C-module)

In series IV electronics an extra password verification is build in to protect against unauthorised changes of the parameters.

A supervisor password for temporarily access can be supplied by Instromet Ultrasonics B.V. upon request.

### 3.6.2 Module Information

A non editable field returning information about the meter like serial number, electronics type, software version.

Example:

![Module Information Screen]

### 3.6.3 Burst Parameters

A burst is the signal transmitted as a result of one single transducer excitation, generating a typical wavelet of about 5 periods according to the operating frequency of the transducer. (100 or 200kHz.)

The burst parameters describe the transmitted wave form construction, the next excitations are possible.

#### 3.6.3.1 Single burst (SB)

(Equal to the series III Single pulse excitation)

The excitation method consisting of firing one burst, wait until this signal is received and sampled, calculation of travel time based on wavelet detection.

#### 3.6.3.2 Repeated burst

(Equal to the series III repetitive pulse excitation) The excitation method consisting of firing one burst, wait until this signal is received and sampled, precalculation of the signal strenght, check on ADC overflow.

Repeat the proces "n" (Number of multiple bursts) times;

Firing one burst, wait until this signal is received and sampled, a precalculation of the signal strenght and check on ADC overflow is made and the signal is summed.

Calculation of measured value, travel time based on wavelet detection.
3.6.3.3 Coded multiple burst (ProDSP with Protran (5) XA-(i) only):
The excitation method consisting of sending a time-coded sequence of single burst signals. The interval between burst signals is essentially shorter than acoustic travel time. The received train of signals is sampled, decoded and the original pulse is reconstructed. Calculation of measured value and travel time based on wavelet detection.

3.6.3.4 Repeated coded multiple burst (ProDSP with Protran (5) XA-(i) only):
The excitation method consists of the repeated sending of a time-coded sequence of single burst signals. The signal is received and sampled, a precalculation of the signal strength and a check on ADC overflow is made.

Repeat the process “n” (Number of multiple bursts) times; Firing a time-coded burst, the signal is received and sampled, precalculation of the signal strength, check on ADC overflow and summon the signal.

Reconstruct the original pulse from received train of coded signals. Calculation of measured value and travel time based on wavelet detection.

The big difference between a ProDSP with Protran(5)-xa-(i) and a ProDSP, converter with a Protran-1/3/5 combination is the Protran XA feature of enhanced noise immunity using coded multiple burst and repeated coded multiple burst. We can apply signal to noise ratio enhancement using the repeated burst method.

When the series IV unit is set to operate in Coded Multiple Burst mode this setting is prepared and performed in the factory as part of the “Factory Acceptance Test” and during “Dry Calibration”. The user should not need to or attempt to change these parameters. Therefore these parameters are factory settings having restricted access.

➤ Using Coded Multiple Burst

1 Use the UNIFORM menu’s “Flowmeter”, “Setup”, “Burst Parameters”.
3.6.4 Spool piece parameters

The spool piece parameters describe the flow meter's geometry:

♦ Diameter: This is the spool piece’s true inner diameter. It is used in the (Reynolds number based) velocity profile correction, and for conversion of flow velocity to volume flow.

♦ Path Length: This is the length of the acoustic path between the two transducers. In the series III and IV electronics there are separate entries for axial and swirl paths or for each individual path.

♦ Beam Angle: This is the angle between the acoustic path and the axis of the spool piece. In the series III and IV electronics there are separate entries for axial and swirl paths or for each individual path.

Example for a 3 path meter:

![Image of spool piece parameters settings]

3.6.5 V-Module parameters

The V-Module parameters basically control the Q.Sonic®'s measurement process. Several parameters are considered application-specific, others are device-specific:

![Image of V-Module parameters settings]
Application-specific parameters:

◊ V.o.S Range: The velocity of sound (V.o.S) depends on gas composition and metering conditions (temperature and pressure). This range should be set according to the metering application.

◊ Gas Velocity Range: This is the expected range of gasflow velocities in the metering application.

The V.o.S. and gas velocity ranges are used by the control and signal processing circuits, to calculate the time windows in which received pulses are expected to be valid, and to validate received pulses during low-level processing. The V.o.S and gas velocity ranges should be set somewhat wider than the expected (or theoretical) ranges:

◊ The V.o.S. range’s lower (upper) limit should be set to 90% (110%) of the expected lower (upper) limit.

The default factory settings after the FAT are from 300 m/s to 500 m/s.

◊ The gas velocity range depends on the metering application and is usually supplied by Instromet (along with other prescribed parameter settings) in the Q.Sonic® documentation.

If no gas velocity range is specified, use a default range of −40 m/s to +40 m/s.

The V.o.S. and gas velocity ranges do not affect the Q.Sonic®’s accuracy if set according to these rules.

Device-specific parameters:

◊ Sample Rate: This parameter controls the number of elementary measurements (as described in chapter 2) per second.

◊ Timing Constant: This is a low-level control parameter, which depends on the hardware (electronics, transducers) of the meter and is factory set.

◊ Pulse Length: This is an initial, factory set control parameter, which depends on the hardware (electronics, transducers) of the meter and is factory set.

Example:
3.6.6 Velocity profile correction

These parameters control the conversion from line-averaged flow velocity (as calculated from the time-of-flight measurements along the acoustic path) to the bulk mean velocity of the medium (the velocity averaged over the cross section of the pipe). Refer to chapter 2, Theory of Operation, for more information about this conversion.

The velocity profile correction parameters are:

- Reynolds number computation:
  - Density: Density of the gas at line (metering) conditions.
  - Dynamic Viscosity: Dynamic viscosity of the gas at line (metering) conditions.

The density and dynamic viscosity settings are not critical. In practice, a deviation of a factor 2 results in an almost imperceptible error. Fixed settings for density and viscosity cover a large range of gas composition, pressure and temperature. Apply the rules below to derive these settings:

- Determine the minimum and maximum values of density ($\rho_{\text{min}}$, $\rho_{\text{max}}$) and dynamic viscosity ($\eta_{\text{min}}$, $\eta_{\text{max}}$) over the expected range of gas composition, pressure and temperature.
- Use in the Q.Sonic® for both density and dynamic viscosity the logarithmic average of these values:

$$\rho = \sqrt{\rho_{\text{min}} \cdot \rho_{\text{max}}}$$

Equation 3-1

and

$$\eta = \sqrt{\eta_{\text{min}} \cdot \eta_{\text{max}}}$$

Equation 3-2

- Profile Correction Coefficients: Two sets of 6 coefficients each, labelled 'p1' through 'p6', are used by the flow meter to calculate the Reynolds-dependent profile correction factor. The two sets of coefficients are required for separate profile corrections on axial and swirl paths.

Example:

![Q.Sonic® 3 Series IV UL Meter (Stand-alone MPU)](image)
3.6.7 Calibration coefficients

The calibration coefficients are arranged in a matrix (6 rows, 4 columns). The Q.Sonic® uses these coefficients to combine the results of the individual measuring paths in such a way that an optimal measuring result is obtained over a large range of flow conditions.

Example:

![Calibration Coefficients Matrix]

3.6.8 Substitution (ProDSP)

In case of a path failure, the loss of accuracy can be minimized using the path substitution feature. When activated a substitute value will be derived from the remaining paths. The basis is the ratio's between the gas velocity ratio’s before the path was lost. Path substitution setting are factory settings and have restricted access.

Three parameters effect the way path substitution works. Parameters 1 and 2 determine the weights of operational paths for estimating the failing path. The 3rd parameter limits the gas velocity range where path substitution is allowed.

- **Using path substitution**

  1. Use the UNIFORM menu’s “Flowmeter”, “Setup”, “Edit”, “Path Substitution”.

![Path Substitution Settings]
Set the desired settings and “Apply on Flowmeter”.

The settings on this sheet are factory settings, the operator of the meter should have no need to change nor attempt to make any modifications to the values as displayed.
The Path Substitution is an extra option that needs to be purchased separately. It may not be available in (all) systems.

3.6.9 Adjust factor

The adjust-factor is used to ‘adjust’ the Q.Sonic® ultrasonic flow meter. Also see chapter 2.3 (“Volume flow calculation”).
There are optional forward and reverse flow adjust factors for the Series-IV meters.

3.6.10 Linearization (ProDSP)

The meter error curve can be corrected using a 10 point linearization with linear interpolation. A linearization can be made for both flow directions independently. For each flow direction the meter errors to be corrected can be entered for 10 flow rates (or less). The linearization can be enabled or disabled.
To activate the linearization option or to enter data, access rights can be obtained to this function by a password according to table 1 page 60; password1 or password2 are required for this operation.

Enable linearization or enter the necessary data.

Use the UNIFORM menu’s “Flowmeter”, “Setup”, “Edit setup”, “linearization”.
2. Set the desired settings and “Apply” on the meter.

### 3.6.11 Low Pass Filter Set-up

These parameters are used to average some of the meter’s measured data (i.e. V.o.S., flow velocity, and volume flow). This feature is useful when there are significant fluctuations in metering conditions within a short period of time. The filter will smooth the output to minimise spikes as a result of fluctuations.

### 3.6.12 Low Flow Cut-off Set-up

These parameters are used to force the measured value(s) for volume flow (as output by the meter) to zero if the (absolute value of the) measured flow velocity is below the programmable low-cut threshold. Note that the measured flow velocity (as output by the meter) is not affected.
3.6.13 P&T Input Parameters (only PROSON-II with C-module)

These parameters are applicable in installations where actual volume as determined by the meter is to be corrected to a set of base (or reference) conditions (i.e. the meter, as opposed to a separate flow computer, is calculating the corrected volume). This feature requires 4-20 mA signals for pressure and temperature transmitters and an SPU configured for these inputs. This feature applies to all meters designated as “Q” type meters instead of “QL”. The C-Module has to be used for this option.

Example:
3.6.14 PTZ correction Parameters (only PROSON-II with C-module)

In combination with the P&T input parameters the Volume correction parameters are used to calculate the volume flow. The calculation in the meter is made depending on the chosen Mode, Base Conditions and compressibility Setup.

Example:

3.6.15 Current output set-up (only PROSON-II with C-module)

The Q.Sonic® features a programmable analogue (0/4-20 mA) output. This output is programmable with respect to measured value, range of the measured value, and output current range. The current output connection is only available with the optional C-module.

The Current Output Set-up consists of the following parameters:

♦ Output Value: The current output can be programmed to output one of the measured values listed below:
  ◊ V.o.S;
  ◊ Profile-corrected gas velocity;
  ◊ Volume flow (at line conditions).
  ◊ Volume flow (at base conditions, PTZ versions only).
♦ Output Value Range / Current Range: Mapping constants to convert the range of the selected measured value to current:
  ◊ The output value's lower limit maps to the current range's lower limit;
  ◊ The output value's upper limit maps to the current range's upper limit;
  ◊ Invalid measured data maps to 'Error' current.
♦ Low-cut Option: The current output features a low cut-off feature: If enabled, the output remains at the lower current limit for measured values between the output value range's lower limit and the Low Cut Value.
**Note:** The current output uses the absolute value of the measured value that was selected! If you are using the current output to represent, for example, gas velocity (or volume flow), the flow direction can NOT be represented by the current output itself. However, the flow direction is ALWAYS available at the digital Flow Direction Output.

**Example:**

![Image of Frequency Output Set-up](image)

**3.6.16 Frequency output set-up**

The Q.Sonic® features a programmable frequency (impulse) output. This output is programmable with respect to measured value, range of the measured value, and output frequency range.

The Frequency Output Set-up consists of the following parameters:

- **Output Value:** The frequency output can be programmed to output one of the measured values listed below:
  - V.o.S;
  - Profile-corrected gas velocity;
  - Volume flow (at line conditions);
  - Volume flow (at base conditions, PTZ versions only).

- **Output Value Range / Frequency Range:** Mapping constants to convert the range of the selected measured value to frequency:
  - The output value's lower limit maps to the frequency range's lower limit;
  - The output value's upper limit maps to the frequency range's upper limit;
  - Invalid measured data maps to 'Error' frequency.

- **Low-cut Option:** The frequency output features a low cut-off facility: If enabled, the output remains at the lower frequency limit for measured values between the output value range's lower limit and the Low Cut Value.
**Note:** The frequency output uses the absolute value of the measured value that was selected! If you are using the frequency output to represent, for example, gas velocity (or volume flow), the flow direction can NOT be represented by the frequency output itself. However, the flow direction is ALWAYS available at the digital Flow Direction Output.

![Image of Q.Sonic® IV Q. Meter (Stand-alone SPU)](image)

### 3.6.17 Total Volume counter configuration

The Q.Sonic® with Remote unit features programmable totalizers. These counters are programmable with respect to measured value and resolution. The total volume counter configuration consists of:

- **Output value:**
  - Actual volume flow (volume flow at line conditions),
  - Corrected flow (volume flow at base conditions)

- **Counter resolution:** the value of one counter unit.

### 3.7 UNIFORM software

The UNIFORM software is a tool that allows you to configure and monitor Instromet ultrasonic gas flow meters with your personal computer. This manual contains a limited description of UNIFORM. See the **UNIFORM “help file”** for a more detailed description.
3.7.1 What is UNIFORM?

UNIFORM is a tool to configure and monitor Instromet ultrasonic gas flow meters such as the Q.Sonic®, the CheckSonic™, the FlareSonic™, and the P-Sonic®. UNIFORM uses the ‘virtual instrument’ concept to transform your PC to a measuring instrument with a nice and easy-to-use Graphical User Interface.

UNIFORM offers you a variety of services:
♦ Configuration: the UNIFORM software allows the operator to read, modify and write the flow meter’s operational parameters in the device. The entire set of operational parameters is called a parameter set-up. Parameter set-ups can be saved to (loaded from) your PC’s hard disk.
♦ Monitoring: UNIFORM software has on-line displays for the operational status and measured data.
♦ Data Logging: UNIFORM software features a versatile data logger that allows you to collect measured data for of line data processing.

3.7.2 What is needed to run UNIFORM

The UNIFORM software has been developed for a (or fully compatible) personal computer with windows operating system. The minimum system requirements to run UNIFORM successfully are:
♦ An IBM PC AT, PS/2, or fully compatible personal computer with the Intel P-166 processor (or higher), and at least 64Mb RAM.
♦ A hard disk with 5 MB of free disk space, CD-rom player and a 3.5” floppy disk drive.
♦ An IBM SVGA, or compatible graphics adapter.
♦ A SVGA monitor.
♦ Two serial ports, or one serial port and a dedicated mouse port.
♦ A Microsoft, IBM PS/2, or fully software-compatible mouse.
♦ Windows® 9x, 2000, NT4 or XP operating system.
An RS-485/RS-232C converter capable of:

- Bi-directional data transmission.
- 4800 baud data rate; note that the converter must be capable of 9600/19200/38400 baud if you want to utilize a higher baudrate than the default of 4800 for communication with your flow meter.
- Half-duplex operation with user transparent (automatic) bus direction control: UNIFORM does NOT use the serial port's modem control signals, so the converter must deduce its bus direction control signals from the data stream itself.
(This page intentionally left blank)
4 Installation and commissioning

4.1 Introduction
This chapter describes installation and commissioning of the Q.Sonic® ultrasonic gas flow meter.

4.2 Inspect your shipment
It is very important to check the shipment of your ultrasonic flow meter equipment. At least a visual inspection of surfaces, flanges and transducer cables should be performed. In case of damage, contact Instromet Ultrasonic Technologies immediately. (see page 2)

4.3 Spool piece installation
4.3.1 General installation
The Q.Sonic® (spool piece, transducers and SPU) is shipped in a wooden box. Remove the top panel nails or the marked screws and disassemble the box. Remove the transport straps from the spool piece, then move the ultrasonic flow meter (using the lifting lugs) to the installation site. Install the spool piece according to end user’s company regulations.

4.3.2 Position in the pipeline
For the best performance the Q.Sonic® meter should be installed in the pipeline according the positioning data as shown in Figure 4-1: Placement in the pipeline.

Figure 4-1: Placement in the pipeline
4.4 Transducer installation

The Q.Sonic® transducers have already been mounted on the spool piece prior to the Factory Acceptance Test. Thus there are no specific installation instructions to the end user regarding this subject. Refer to chapter 6 or the manual supplied with the spare transducers for information and instructions about transducer maintenance.

4.5 SPU installation

The Q.Sonic® SPU has already been mounted on the spool piece prior to the Factory Acceptance Test. Thus there are no specific installation instructions to the end user regarding this subject. Refer to chapter 6 or the SPU manual supplied with the spare SPU for information and instructions about SPU maintenance.

4.6 Flow Computer installation

The Flow Computer has a standard 19" housing and is generally installed in the control room. The preferred location for the Flow Computer is the 19" console.

4.7 External wiring

The cable connections and grounding for the Q.Sonic® are usually installed by a specialized company. The required connection procedures are described in chapter 9.

4.7.1 Systems with a Flow Computer

4.7.1.1 Connecting the SPU to the Flow Computer

A combined power supply and communication cable between the SPU and the Flow Computer can be used: e.g. 3x2 wire (min. Ø0,5 mm) twisted-pair, max. 700m, max. 2,5 Ω/wire.

Armoured shielded cable is recommended to provide protection against mechanical damage and electrical interference:

♦ Connect the electrical shielding to the signal ground of both the SPU and the Flow Computer.
♦ The mechanical protection should be connected to the cable gland of the SPU and to the Flow Computer's protective ground.

4.7.1.2 Flow Computer power supply

The unit requires a 230Vac or 24 VDC powersupply (or 230 VAC power supply with converter) depending on design.

Please ensure a continuous powersupply by means of an Un-interruptable Power Supply (UPS)system to overcome failures due to powerdisruptions of the supplyline.

4.7.2 Interfacing to data acquisition systems

The following interfaces to data acquisition systems (such as flow computers) are available:

♦ Frequency output (0-10 kHz)
♦ Current output (0/4-20 mA) (PROSON-II with the optional C-module)
♦ Digital outputs:
  ◊ Data Valid output (relay or opto-coupler)
  ◊ Flow Direction output (relay and/or opto-coupler)
  ◊ Partial Failure (opto-coupler)
  ◊ Or combinations of settings (programmable)
♦ serial interface(s): RS-485 or RS-232
4.7.3 Stand-alone SPU systems: power supply, communication link

The SPU requires a 24 V\textsubscript{DC} power supply.

A combined power supply and communication cable between the SPU and the external equipment can be used:

- e.g. 2x2 wire (min. Ø 0.5 mm) twisted-pair max. 700m, max. 5Ω/wire. Armoured shielded cable is recommended to provide protection against mechanical damage and electrical interference:
  - Connect the electrical shielding to the signal ground of both the SPU and the external equipment.
  - The mechanical protection should be connected to the cable gland of the SPU and to the external equipment's protective ground.

4.7.3.1 Frequency output

The frequency output is a programmable (by means of the UNIFORM software) opto-coupler impulse output. This output is programmable with respect to:

- Measured value,
- Range of the measured value, and
- Output frequency range.

The frequency of the pulse signal has a maximum of 10 kHz and a fixed duty-cycle of 50%. The frequency output is a non-active output and needs therefore to be externally powered (see also appendix A Figure 8-11: PROSON-II Optocoupler outputs and Figure 8-12: ProDSP Optocoupler outputs). The frequency output has a voltage limit of 30V\textsubscript{DC} and a nominal current of 10 mA.

4.7.3.2 Current output

The current output is a programmable (by means of the UNIFORM software) 0/4-20mA output. This output is programmable with respect to:

- Measured value,
- Range of the measured value, and
- Output current range.

The current output is an active output and needs therefore not to be externally powered (see also appendix A Figure 8-10: C-Module outputs). The maximum load impedance is 400 Ohms.

4.7.3.3 Digital outputs

The Q.Sonic\textsuperscript{®}'s digital outputs (DataValid, FlowDirection) are opto-coupler and/or relay outputs:

- Q.Sonic\textsuperscript{®} (Stand-alone SPU):
  - DataValid: opto-coupler output.
  - FlowDirection: opto-coupler output.
  - Partial Failure: opto-coupler output
The following applies to the digital outputs:

- **Data Valid:**
  - Conductive: the Q.Sonic® is OK.
  - High impedance: the Q.Sonic® is not functioning within its rated accuracy, caused by ultrasonic or electrical interference.

- **Flow Direction:**
  - Conductive: the Q.Sonic® is measuring forward flow.
  - High impedance: the Q.Sonic® is measuring reverse flow.

- **Partial Failure:**
  - Conductive: at least one of the Q.Sonic® paths has a failure.
  - High impedance: the Q.Sonic® has no errors.

The opto-coupler outputs are non-active outputs and need therefore to be externally powered (see also Figure 8-10: C-Module outputs, Figure 8-11: PROSON-II Optocoupler outputs and Figure 8-12: ProDSP Optocoupler outputs). The opto-coupler outputs have a voltage limit of 30V DC and a nominal current of 10 mA.

### 4.7.3.4 Serial interface(s)

The serial interface(s) depend(s) on the type of Q.Sonic® electronics

- **Stand-alone SPU series III:**
  - RS-485 for configuration and monitoring (with PC, UNIFORM software and a RS-485/RS-232C converter) or digital communication with an Instromet model 2000 flow computer.

- **Stand-alone SPU series IV:**
  - RS-485 primarily for configuration and monitoring, (com1, Direct, 4800, none, fixed values)
  - RS-485 secondary (free configurable)
  - RS-232C primarily (free configurable)
  - RS-232C secondary (free configurable)

The RS-232C outputs can be set to different functions.

- **For configuration and monitoring.** See also Q.Sonic®, Communication Protocol (Measured Data).
- **For communication with a data processing unit according to the dedicated Gasunie protocol.** See also Q.Sonic®, Digital Communication: OSM-06-E Protocol.
4.7.3.5 Line termination

Every transmission line has to be terminated with the right impedance. Certainly with long lines, like with RS 485 connections, a correct line termination is important. In transmission lines without termination, the signal reflects at the end of the cable. This reflection interferes with the original signal so a cacophony of signals is seen at the receiver.

In practice the line is terminated at the last meter in the RS485 multidrop network with a resistor.

- The Series-IV meters are standard equipped with a selectable line termination for each RS 485 port. On the ProDSP printed circuit board ‘dipswitches’ are placed at each RS 485 port.

Picture 1: RS-485 line termination of the port by means of dipswitches, left: line open, right: line terminated (black = rocker or high part of the switch)

4.8 Installing the Parameter Set-up

This paragraph describes the procedure to install or adjust the Parameter Set-up in your Q.Sonic®.

Caution.
The Parameter Set-up has already been installed in the factory. The Set-up can also be protected against changes. This is usually done after a calibration. Alterations of the parameters may only be made by qualified persons.

Equipment needed to install the Parameter Set-up:
- The Q.Sonic® ultrasonic meter, already mechanically and electrically installed.
- A PC with UNIFORM software.
- For the ProDSP series IV a password is needed which can be obtained from Instromet Ultrasonics B.V.
- Resource(s) for (serial) communication with the Q.Sonic®:
  - In case of a Q.Sonic® with Stand-alone SPU:
    - A twisted-pair communication cable.
    - In case the RS-485/RS-232C converter is NOT designed like a PC insertion board (for desktop computers), a “1-on-1” RS-232C-cable with 9 pin Sub-D-connectors is required (or a 9 to 25 pin cable, depending upon converter and PC requirements).
  - In case of a Q.Sonic® with Remote Unit:
    - A “1-on-1” RS-232C-cable with 9 pin Sub-D-connectors.
  - In case of a Q.Sonic® with a model 2000 Flow Computer:
    - A 0-modem cable with 9 pin Sub-D-connectors.
Now install the set-up:

Installing the set-up:

1. Preparation: Setting up the equipment:
   - Connect the Q.Sonic®'s RS-485 data link to the RS-485/RS-232-Converter, then connect the converter to the PC.
   - Start the UNIFORM software and select the type of instrument that you have via “Flowmeter”, “Instrument Selection”, “connection settings”, select the used comm. port (comm.1, direct, 4800, N) and use the “Autodetect” button in the “Flowmeter” menu.
   - Select the most suitable meter from the displayed list.

2. Power up the equipment (Q.Sonic®, PC, converter).

It is also possible to select the meter manually:
Make sure the hardware protection (a 10 pos. rotary switch on the ProsonII or ProDSP in pos 7 or jumper for c-module open) is disabled. See the UNIFORM Online help for a more detailed description.

If the meter has series III electronics, switch the Q.Sonic® to the so-called Programming Mode: in the "FlowMeter" menu, use the "Programming Mode" command. As long as the meter is in programming mode no measurements are made.

For Series IV electronics the “on the fly” programming possibility can be enabled by a user password which can be obtained from Instromet Ultrasonics B.V. The meter keeps measuring during the programming.
3 Compile the Parameter Set-up:
   ① Use the "Set-up" menu's "Edit" command to activate the Edit Set-up Pop-up Panel.
   Alternatively, an editing session can be started by using:
   ◊ A set-up file on disk ("File" menu, "Open" command), or
   ◊ The set-up already stored in the Q.Sonic®'s non-volatile memory ("FlowMeter" menu, "Setup" "Read" command).

   ![Edit Set-up Pop-up Panel]

   ② Edit all desired sections displayed in the Edit Set-up Pop-up Panel's selection list.

   ![Parameter Setup Window]

   ④ Install the set-up in the Q.Sonic®: use the "FlowMeter" menu's "Setup", "Write" command.
If the electronics is series III, switch the Q.Sonic® back to the so-called **Normal Mode**: use the "FlowMeter" menu’s "Normal Mode" command.

The Series IV electronics automatically returns back to normal mode.

The Q.Sonic® should now operate as intended. The operation can be monitored by using UNIFORM's Monitor Panel and associated options and facilities.

### 4.9 Commissioning

The commissioning of the Q.Sonic® ultrasonic gas flow meter can be divided into two parts: "cold" and "hot" commissioning.

#### 4.9.1 Cold commissioning (Factory Acceptance Test)

During cold commissioning the the meter is pressurized with a known gas composition, at a known temperature and pressure, because in most cases the Q.Sonic® will not be able to measure under atmospheric conditions (depending on the type of transducer used). A thorough functional test is performed with the meter pressurised at 10 to 20 bar air or nitrogen during the cold commissioning.

After checking the polarity of the supply voltage (by means of measurement), the SPU (24 VDC) of the Q.Sonic® can be switched on. The start-up check sequence takes several seconds, then the serial communication will be activated. This can be verified by means of opening the explosion proof housing of the SPU. The indicator LED’s on the PROSON-II / ProDSP or the optional C-Module flash at a rate of 1 Hz.

**Warning!**

Before opening the SPU housing, to be able to check the SPU indicator LED’s, obey the rules and regulations that apply to hazardous area operations.

By means of a PC and UNIFORM software, or on the LCDisplay of the meter or Remote Unit, the performance and AGC Levels/Limits per measuring line and the zero flow are checked, assuming there is sufficient pressure in the meter. A technician of Instromet will, if this has been agreed, verify measurements and check the system performance. This can only be done when the meter is pressurised.
4.9.2 Hot commissioning (Calibration)

The hot commissioning is in most cases the last test of the Q.Sonic® and is witnessed by a representative of the client and, if required, by an inspector of weights and measures for the official sealing. Under this condition there is process gas in the pipe and a flow test is be performed. The performance, AGC Levels/Limits and zero flow are checked again. A known gas flow is ran through the Q.Sonic® and the indicated measured value can be checked against the standards. Most Q.Sonic® meters are calibrated gas flow meters, so the measured value is reliable without exception. Furthermore, the interaction with the flow computer can be tested.

After the Q.Sonic® is approved for operational use by all parties, the inspector of weights and measures seals the meter according to procedure, and the system is transferred to the customer, issuing the certificate of acquisition.
5 Operation

5.1 Introduction
This chapter describes the operation of the Q.Sonic® ultrasonic gas flow meter.

5.2 Operating the SPU
The SPU does not contain operation elements and consequently can only be operated "by remote control", for example by means of a Remote Unit, or a PC with UNIFORM software.

5.3 Operating the Remote Unit
The operation of the Remote Unit is menu driven by means of a LCD (2 lines of 40 characters each) and a set of function keys (F1 through F5). The complete description on how to operate the Remote Unit can be found in the Instromet, Remote Unit User’s Guide, Instromet Ultrasonics B.V.

5.4 Operating the Q.Sonic® with the UNIFORM software
This section explains some useful procedures when using the UNIFORM software:

♦ Monitoring the Q.Sonic®
♦ Passwords
♦ Verification of the Parameter Set-up
♦ Modification of the Parameter Set-up
♦ Collecting data with the built-in data logger

Refer to the UNIFORM Online help for a detailed description of the UNIFORM software.

5.4.1 Monitoring the Q.Sonic®

Use the procedures described below to monitor your Q.Sonic®.

5.4.1.1 Manual selection of the used metertype:

Monitoring the Q.Sonic®
1. Start UNIFORM
2. Select the comm port:
   “flowmeter”, “Instrument selection”,
   “connection settings”, (to start always use the comm1 port and Uniform setting: comm1, direct, 4800, N)
3. Use the UNIFORM menu’s “Flowmeter”, “Instrument Selection” and select your Q.Sonic® model in the pull down menu.

Make sure that the correct Q.Sonic® model is selected. The selected meter type is displayed in the title bar at the top of the screen.

Example:

Uniform - Q.Sonic-3 Series-IV QL Meter

4. Use the monitor panel and its associated options/functions to monitor your Q.Sonic®.

5.4.1.2 Using the “Autodetect Meter Type” option:

UNIFORM versions have the option to automatically detect your meter type (SIII via port SIV via port “A”. By using this function, the software determines the most logical meter types that can apply to the parameter set-up stored in the attached meter.

Use the procedure described below to detect your Q.Sonic® meter configuration.

- Autodetect Meter Type

1. Select the comm port: “flowmeter”, “Instrument selection”, “connection settings”, (to start always use the comm1 port and Uniform setting: comm1, direct, 4800, N)

2. In the “Flowmeter” menu choose “Auto Detect”.
After questioning the attached meter, the program will give a list with all possible selections.

Choose the selection that is most appropriate for your Q.Sonic® and confirm your selection.

5.4.2 Real Time Clock.
The real time clock provides the necessary data needed to add date and time stamps to the data collected in the data buffers.
In order to be allowed to modify these values, access rights according to password1 password2 or password3 are required. (see table 1 page 60)

Adjusting the real time clock

Use the UNIFORM menu's "Flowmeter", "Miscellaneous Functions", "Real Time Clock", "Real Time Clock Edit".
5.4.3 Passwords.
The functions and settings in the meter are protected on different levels. The customer can use “user passwords”; All, level1 to level 4 and for maintenance there is a “master password”. (see table 1 page 60)

5.4.3.1 Master Password.
After the mechanical unlocking of the meter with the BCD switch you gain access to all functions and settings, including factory settings, by using a “master password”. This master password can also be used to overwrite lost or corrupted passwords.
In specific situations Instromet Dordrecht can make this master password available for a owner, user or operator of a meter, but it will only be valid for one specific meter serial number on one specific date.
For generating the master password, the serial number and date/time from the meter are needed!

Collecting date and serial information

1. Use the UNIFORM menu “Flowmeter”, “Setup”, “Read”, “Edit”, “Module info”.

2. Write down the serial number and leave the screen by “cancel”

3. Use the UNIFORM menu’s “Flowmeter”, “Micellaneous Functions”, “Real Time Clock”, “Real Time Clock Edit”.

Use “Get” to collect the actual ProDSP time.
Adjust the time and date.
Click “Set” and “Done” to confirm and leave the clock set menu.
5 Write down the time and date.
6 Click done to leave the clock set menu.
The information needed to get a supervisor password for the day from Instromet Ultrasonics is complete.

5.4.3.2 User Passwords.

Access to functions, is possible using a “user password”. This user password is divided in to five levels with different access privileges.

The Instromet Ultrasonics meters are delivered with default settings for the password levels 1 to 4. It is strongly recommended to change these passwords after final installation in the field.

The table on the next page is an overview of the access privileges;
<table>
<thead>
<tr>
<th>Command</th>
<th>Function description</th>
<th>Level</th>
<th>Hardware controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Meter Configuration&quot;</td>
<td>Instromet</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Module Info&quot;</td>
<td>Instromet</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Flowmeter Serial Number&quot;</td>
<td>Instromet</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>Module info,</td>
<td>&quot;Flowmeter Identification&quot;</td>
<td></td>
<td></td>
</tr>
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<td>&quot;Spool Piece&quot;</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;V-Module&quot;</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Profile Correction&quot;</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Substitution&quot;</td>
<td>Instromet</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Calibration&quot;</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Adjust Factor&quot;</td>
<td>Instromet, Maintenance engineer, Calibration engineer</td>
<td>S, 1, 2</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Linearization&quot;</td>
<td>Instromet, Maintenance engineer, Calibration engineer</td>
<td>S, 1, 2</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Low Flow Cut-off&quot;</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Frequency Output&quot;</td>
<td>Instromet, Maintenance engineer, Calibration engineer</td>
<td>S, 1, 2</td>
<td>Y</td>
</tr>
<tr>
<td>&quot;Burst Parameters&quot;</td>
<td>Instromet</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>Normal Mode</td>
<td>Everyone, no password required</td>
<td>S, 1, 2, 3, 4, All</td>
<td>N</td>
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<td>Programming Mode</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>N</td>
</tr>
<tr>
<td>Scope Mode</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>N</td>
</tr>
<tr>
<td>Output Test (in Programming Mode)</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>N</td>
</tr>
<tr>
<td>Manual / Automatic Gain Control</td>
<td>Instromet, Maintenance engineer</td>
<td>S, 1</td>
<td>N</td>
</tr>
<tr>
<td>Set the Real Time Clock</td>
<td>Instromet, Maintenance engineer, Calibration engineer, Measurement supervisor</td>
<td>S, 1, 2, 3</td>
<td>N</td>
</tr>
<tr>
<td>Read Embedded data logger</td>
<td>Instromet, Maintenance engineer, Measurement supervisor, Measurement engineer</td>
<td>S, 1, 3, 4</td>
<td>N</td>
</tr>
<tr>
<td>Clear Embedded data logger</td>
<td>Instromet, Maintenance supervisor</td>
<td>S, 3</td>
<td>N</td>
</tr>
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<td>Sample View</td>
<td>Instromet, Maintenance engineer</td>
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<td>N</td>
</tr>
<tr>
<td>Multiple Pulse Collection (based on Sample View)</td>
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<td>N</td>
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<td>Cocooning</td>
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<td>Change password level 1,</td>
<td>Instromet, Maintenance engineer</td>
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<td>N</td>
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<td>Maintenance engineer</td>
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<td></td>
</tr>
<tr>
<td>Change password level 2,</td>
<td>Instromet, Calibration engineer</td>
<td>S, 2</td>
<td>N</td>
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<td>Calibration engineer</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Change password level 3,</td>
<td>Instromet, Measurement supervisor</td>
<td>S, 3</td>
<td>N</td>
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<td>Measurement supervisor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change password level 4,</td>
<td>Instromet, Measurement engineer</td>
<td>S, 4</td>
<td>N</td>
</tr>
<tr>
<td>Measurement engineer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Overview of the factory settings of the password access.

It is advised to change the default “passwords1 to password4” once the unit is installed!!

5.4.3.3 Setting the password.

ientes:

- Use the UNIFORM menu “Flowmeter”, “Passwords”, “User Password”.
5.4.4 Verifying the Parameter Set-up

Use the procedure described below to verify your Q.Sonic®'s Parameter Set-up.

- Parameter Set-up verification
  1. Start UNIFORM.
  2. Make sure that the correct Q.Sonic® model is selected. The selected meter type is displayed in the title bar at the top of the screen.

Example:

```
Uniform - [Q.Sonic-3 Series-IV QL Meter]
```

Use the UNIFORM menu's "Flowmeter", "Instrument Selection" and select 'your' Q.Sonic® model in the pull down menu.
Read the Parameter Set-up back from the Q.Sonic®: use the “FlowMeter”, “Set-up”, “Read” command.

Verify the set-up:

1. Use the “File” menu’s “Print preview” command to view the parameters.
2. Compare the parameters with the print-out of the master set-up.

Example: Series IV electronics

```
****************************
* Ultrasonic Flowmeter *
* Configuration Information *
* -------------------------- *
* Instromet Ultrasonic Technologies *
****************************

UNIFORM Settings:
-------------------
Instrument Type: 44
> 'Q.Sonic-5 Series-IV QL Meter (Stand-alone SPU)'
COM settings: UNIFORM common-to-point 4800,N,8,1

Parameter Setup:
-----------------

Process Configuration:
-----------------------
Instrument Type: 44
> 'Q.Sonic-5 Series-IV QL Meter (Stand-alone SPU)'
Parameter 1: 0x8002
Parameter 2: 0x50
Parameter 3: 0x0064
Parameter 4: 0x07
Parameter 5: 0x51A9
Parameter 6: 0x0001

Model Information:
-------------------
Flowmeter Serial Number: 0
Software Version: 0
Flowmeter Identification:

Burst Parameters:
------------------
Pulse High Time: 40
Pulse Low Time: 40
Number of Pulses: 2
Emission Start Time: 25
Emission Stop Time: 23
Number of Single Bursts: 1
Number of Multiple Bursts: 1
```

UNIFORM features an automated verification procedure. A master set-up file on disk (saved with the “File” menu’s “Save...” command) is required.

Automated Parameter Set-up verification

1. Start UNIFORM.
2. Make sure that the correct Q.Sonic® model is selected. The selected meter type is displayed in the title bar at the top of the screen:
   - Example: [Box: UNIFORM - Q.Sonic-3 Series-IV QL Meter (Stand-alone SPU):...]
   - Use the UNIFORM menu’s “Flowmeter”, “Instrument Selection” and select your Q.Sonic® model in the pull down menu.
3. Load the master Parameter Set-up disk file into UNIFORM's memory: use the “File” menu’s “Open...” command.
Verify the set-up: use the “FlowMeter” menu “Setup”, “Verify” command. UNIFORM now reads the set-up sections from the Q.Sonic® and compares them with the master set-up that was loaded from the disk.

The following screen will be displayed:

5.4.5 Modifying the Parameter Set-up

Use the procedure described below to modify the parameter setup your Q.Sonic®'s Parameter Set-up.

Caution!

Some parameters must be set to the factory defaults. Refer to your other Q.Sonic® documentation for the required values of these parameters.

Parameter Set-up modification

1. Start UNIFORM.
2. Make sure that the correct Q.Sonic® model is selected. The selected meter type is displayed in the title bar at the top of the screen.
   Example:
   
   ![Uniform - Q.Sonic-3 Series-IV QL Meter (Stand-alone SPU);]

   Use the UNIFORM menu’s “Flowmeter”, “Instrument Selection” and select your Q.Sonic® model in the pull down menu.
3. If the meter has series III (or older electronics), switch the Q.Sonic® to the so-called Programming Mode: in the “FlowMeter” menu, use the “Programming Mode” command. Make sure the hardware protection is disabled (rotary switch ProsonII, ProDSP or jumper on the C-module). See the UNIFORM On line help for a more detailed description.
For **Series IV** electronics the “on the fly” programming possibility can be enabled by a user/supervisor (one day) password which can be obtained from Instromet Ultrasonics B.V. The measuring is continued during programming.

Read the Parameter Set-up from the Q.Sonic® into UNIFORM’s memory: use “FlowMeter”, “Set-up”, “Read”.
**Note!** Instromet strongly recommends to save the flowmeter’s current parameter set-up for archiving. Use the “File” menu’s “Save as…” command to save the parameter set-up to disk. Use a meaningful unique filename in order to simplify future reference to set-up files of the flowmeter’s.

**5.** Edit the Parameter Set-up:

1. Select “Setup” from the “Flowmeter” menu, then choose “Edit”.

2. Edit the desired item(s): click the appropriate set-up section tab-sheet(s) and enter the desired value(s) for the items that need to be modified.

3. After editing the desired item(s), click the <OK> button.

4. To store the info: “File”, “save as” Instromet recommends using a meaningful unique filename in order to simplify future reference to set-up files of your flowmeter’s.

(Example for series IV)
Install the set-up in the Q.Sonic®:

1. Open the flowmeter menu, point to “Setup” and choose “Write”.
2. An alert dialog box appears
3. Click the <Yes> button to start writing to the flowmeter. The “Writing Flow Meter Setup” status window shows the progress of the operation.

If the electronics is series III, switch the Q.Sonic® back to the so-called Normal Mode: use the “FlowMeter” menu’s “Normal Mode” command.

Series IV returns back to normal mode automatically after the write operation.
To protect the settings from being changed you must put the BCD switch in position “0” after finishing the above procedure.

The Q.Sonic® should now operate as intended. You may monitor its operation using UNIFORM’s main flow meter window and its associated options.

**Note:** Instromet recommends you to save the flowmeter’s parameter set-up for archiving or “audit trail” purposes. Use the “File” menu’s “Save as...” command to save the parameter set-up to disk. Instromet recommends using a meaningful unique filename in order to simplify future reference to set-up files of your flow meter’s.

In case of modifying a flowmeters parameter setup, you are advised to save the parameter setup as found (step 3 of this procedure, and also to save the parameter setup “as left” (after step 3 or step 6).


5.4.6 Adjusting the final factor

The procedure to change the final factor is equal to changing the parameters.
This procedure should be performed by an inspector of weights and measures to modify the final factor in your Q.Sonic®’s Parameter Set-up.
For Series IV it can be done with the factory set “password2” or a masterpassword* from Instromet.

In short:

1. Unlock the meter by putting the BCD switch into position “7” and gain access to the parameter file by the password (Series IV) or programming mode (series III).
2. Select “Setup” from the “Flowmeter” menu, then choose “Edit”.
3. Go to tab “Adjust factor”.
4. After editing the desired item(s), click the “Apply on Flowmeter” and <OK> button.
5. After you finished adjusting the Final Factor put the BCD switch back into position “0” and seal the meter.
6. Restart the meter and check the parameter file.

*) to be obtained from instromet engineer

5.4.7 Embedded data logger.

In order to have access to the data stored in the buffers in the embedded data logger, access rights according to password1, password3 or password4 are required.
Clearing databuffers in the embedded data logger is only permitted with password3.

Reading the embedded databuffers

1. Use the UNIFORM menu’s “Flowmeter”, “Embedded Datalogger”, “Retrieve Data”.
The meter reads the databuffers

Message returned by the meter

2. Set the data to retrieve with the pulldown menu:

3. "Get" the data and export/save as "CSV"
Repeat these steps as many times as you need, selecting the desired databuffer every time

5.4.8 Totalizers.

The values stored in the totalizer registers can be accessed in various ways:

- **Reading the totalizers**

  - Use the UNIFORM menu’s “Flowmeter”, “Miscellaneous”, “Read volume counters”.

  ![Flowmeter menu](image)

  ![Volume Totals](image)

The data can also be accessed by means of serial communication, both with the Uniform and the Modbus protocol. All totalizer values can be presented formatted as a 7 digit floating point value or as a 8 digit integer value.

5.4.9 Communications Ports.

The Series IV unit has 4 serial ports for data communication, referenced as A, B, C and D.

Ports A and B conform to RS 232, ports C and D conform to RS 485.
Transmission (baud) rates are selectable as 4800, 9600, 19200 or 38400, port A is limited to 4800 baud only.

Port C and D can be used with a “party line” configuration, for both ports, when required, a line terminating resistor can be connected to the line by means of DIP-switches.

Ports B, C and D support both the “Uniform protocol” and the Modbus RTU protocol. Port A is limited to support the “Uniform protocol” only.

**Setting the baud rate and communication protocol**

1. Use the UNIFORM menu’s “Flowmeter”, “Miscellaneous Functions”, “ComConfig”.

A dialog box is opened to allow the settings of the communication ports.
2. Set port to change with the pulldown menu:

3. Select the protocol with the pulldown menu

4. Select the baudrate with the pulldown menu

5. “Reset” the meter by turning the power off and on to activate the settings.

Note: When using the Modbus protocol it is required that the meter can be identified by means of an “address”. One meter has one address that has to be used on all ports operating with the Modbus protocol. Addresses are numbers within the range from 1 to 247.

Be aware: when using modbus a line termination is needed. (hardware switch) (see 4.7.3.5)
NOTE: For this task it is necessary to have access rights with password1

5.4.10 Collecting data with UNIFORM’s built-in data logger

Use the procedure described below to collect measured data of your Q.Sonic® with UNIFORM’s built-in data logger:

1. Obtaining a data log
   a. Start UNIFORM.

2. Make sure that the correct Q.Sonic® model is selected. The selected meter type is displayed in the title bar at the top of the screen.
   Example: Use the UNIFORM menu’s “Flowmeter”, “Instrument Selection” and select your Q.Sonic® model in the pull down menu.

3. Read the Parameter Set-up from the Q.Sonic® into UNIFORM’s memory: use the FlowMeter Menu’s “Flowmeter”, “Set-up”, “read” command.
   In the UNIFORM V3.0 versions, the program automatically requests to read the parameter set-up from the meter when the data logger is started. This is at point 3 in this description.

4. Use the “Data Logger Tool Bar” to make a log.
Select the name of the log file: press the data logger's "File" button, and use the File Select Pop-up to enter a file name.

Start the data log by pressing the data logger's "Record" button. In UNIFORM a request will be made to retrieve the parameter set-up from the meter. Always confirm with "Yes" to have the actual parameters stored in the logfile.

Quit logging by pressing the data logger's "Stop" button.
Notes:

♦ Step 6 (starting the logger):

   After the setup is read from the meter, the logger can be paused, this is particularly useful be able to insert “comment” into the log file before starting to record data.

♦ Suspending the logging temporarily:

   The data logger can be suspended ('paused') temporarily by pressing the "Pause" button. Re-start the logger by pressing "Pause" again.

♦ Adding comments to the log file:

   Comment can be added to the log when the logger is ‘paused’; press the “Comment” button and enter your comment text in the pop-up screen. An arbitrary number of lines can be added by using the “Comment” button repeatedly. When finished, press “ok” and “Pause” again to start/continu logging.
6 Maintenance, troubleshooting, and repair

6.1 Introduction

This chapter is divided into three parts:
♦ Maintenance: Section 6.2 describes periodic inspection and maintenance of the Q.Sonic® ultrasonic gas flow meter.
♦ Troubleshooting: Section 6.3 outlines how to pinpoint a problem when the Q.Sonic® is malfunctioning.
♦ Repair: Section 6.5 describes replacement of parts of the Q.Sonic® ultrasonic gas flow meter. Section 6.5 describes replacement of the transducers.

There is a difference in signal processing between the series III and series IV meter electronics, therefore some values may look totally different. For maintenance on a remote unit or a flow computer, refer to its related manual.

6.2 Maintenance

The Q.Sonic® ultrasonic gas flow meter contains no moving parts. The transducers are the only components that are in contact with the gas medium. The materials used for the transducers are resistant to the conditions that were clearly specified for the measuring instrument. As a result the transducers and the electronics are virtually maintenance free.

However, Instromet recommends inspection of the Q.Sonic® at regular intervals, for example every week or month. In case of degradation of the meter, appropriate measures can be taken before a serious failure occurs.

6.2.1 Inspection of measured data

Trend analysis on the meter’s measured data (comparison of recent measured data with results from a past period of time) generally gives a good indication of the meter’s condition.

It is good engineering practice to record some of the measured data with regular intervals. The built-in data logger of the UNIFORM software may assist you for this task. Refer to section 5.4.10 (“Collecting data with UNIFORM’s built-in data logger”) for instructions about UNIFORM’s data logger.
The following general rules apply to the measured data:

- **Sample Rate**: The process of travel time measurement for all paths is repeated a number of times per second. This number is called Sample Rate. Typically this is a stable value of about 15 with a variation of -1.

  The sample rate is programmable to be anything between 1 and 100Hz. However, the actual sample rate may be lower than the programmed value since, particularly with large size meters, the travel times of the ultrasonic pulses in the gas do not allow for the programmed sample rate. The Q.Sonic® will then adjust the sample rate to the highest possible value. The highest possible sample rate is not necessarily the best setting for optimum performance. Although the sample rate is not critical, a value of about 15 samples/second is recommended.

- **Performance** or **Number of accepted pulses** for series-III, series IV and “series III compatible Mk. IV” meters is the pulse acceptance rate, for Performance expressed as a percentage for the pulses transmitted each second. Each transducer transmits a number of pulses each second. To be accepted as a valid received pulse by the signal processing system, each pulse must arrive within a small time window, be of sufficient strength, and match a unique waveform signature. The percentage of accepted pulses is shown as an average value of all measuring paths, and for each individual path.

  At zero flow the performance should be close to 100% (not less than 90%). At higher flow rates the performance of individual paths may drop to 60% because of flow-induced attenuation of the ultrasonic pulses. Even with a performance as low as 20%, at a sample rate of 15, the accuracy of the gas flow measurement is maintained. It is recommended to consult the manufacturer (or manufacturer’s representative) if a path persistently has a performance lower than 40%.

- **Velocity of Sound**: The Q.Sonic® calculates the speed of sound in the gas, based on the measured travel times and the programmed spool piece geometry. This value may be compared to the (theoretically) expected value, for example as calculated using the AGA-8 equations of state. The difference between measured and expected value can be as little as 0.25%, provided that gas composition, temperature and pressure are precisely known.

- **Gas velocity** (zero flow measurement): When there is no flow through the meter, i.e. the block valve(s) are closed, the corrected gas velocity should randomly fluctuate between ±0.025 m/s and average very close to zero. During a sunny day the warm walls of the meter will cause small thermal convection currents to circulate inside the meter. The ultrasonic meter may actually measure these very slow currents as an increase in the random fluctuations.
Presentation of AGC-levels and AGC-Limits
For technical reasons the presentation of AGC-level and AGC-limit values has been changed in the SeriesIV electronics.
The AGC levels/limits displayed can have the following values:
Series III electronics: 0 to 65025
Series IV electronics: 0 to 63 with firmware up to D1.03
                                100 to 65535 from firmware D1.04 and up

In the Series III values used to be presented based on a linear scale having values ranging from 1 tot 65025.
Based on the technology implemented in the new designed ProDSP it was more logical to display values according to a logarithmic scale having values ranging from 1 to 63.
In the Software D1.04 the presentation of the AGC levels and limits is adapted to the old presentation and has a range from 100 to 65635.
♦ **Swirl Angle:** This value indicates the amount of swirl measured by a Q.Sonic® ultrasonic flow meter, expressed in degrees. Positive swirl angles signal clockwise swirl; negative swirl angles signal counterclockwise swirl. The meter functions OK if the angle is in between -20 and +20 degrees, if this value is bigger please consult Instromet Ultrasonics for advise.

Notes:
- Path numbers of axial and swirl paths:
  - Q.Sonic®-3:
    - Axial path = 2
    - Swirl paths = 1 and 3
  - Q.Sonic®-4:
    - Axial paths = 1 and 4
    - Swirl paths = 2 and 3
  - Q.Sonic®-5:
    - Axial paths = 1, 3 and 5
    - Swirl paths = 2 and 4
- The metering conditions should be compatible when comparing actual measured data with recorded data.

6.3 Pulse shape check

6.3.1 Sample view.

In order to use sample, view access rights according to password1 are required. (see table 1 page 60) Sample view opens a window that allows selection of a specific transducer for the received waveform to be viewed. Similar to an oscilloscope with a delayed time base function, a portion of the signal can be selected to be displayed by setting a “start sample” point and the amount of “samples” to be taken.

► **Using sample view**

- Use the UNIFORM menu’s “Flowmeter”, “Miscellaneous Functions”, “Sample view”.

![Sample view window](image)
2 Select the desired transducer with the pulldown menu.

3 Fill in the “Start Sample” window point and the length of the “Samples”.

4 Set the “increment”.

5 Press “trigger” to collect the sample.

6.3.2 Steps to export the found sampleview data:

1 Click in the sample view screen to select the window.
2 Make the screen monochrome by pressing the “S”.
3 Press “Shift + C” to get the following export menu.
6.3.3 Collect multiple samples

In order to use the “collect multiple samples” feature, access rights according to password1 are required.

- **Using Multiple Pulse Collection**

  - Use the UNIFORM menu’s “Flowmeter”, “Micellaneous Functions”, “Multiple Pulse Collection”.

Select the desired transducers with the checkboxes.

Fill in:
- "Window Start" point
- "Window Size"
- "Consecutive repetitions in a collection"
- "Minutes between collections"
- "Number of collections"

Press "Get".

The file will be stored as ".CSV", supply the name and place to store.
6.4 Troubleshooting

This investigation should follow a failure of some kind or any suspected error. This can be an occasional error or a total failure of the instrument. In case of an occasional error a log file should be made while the error occurs. An analysis can be made on the basis of these data.

(If there is a difference between the series III and series IV both criteria are mentioned)

When there is a major failure the cause can be sought guided by the following symptoms:

♦ Performance is zero,
  Series III: AGC Level is running from low to high (does not level off around a certain value).
  Series IV: AGC Level is stable at 63 or level=limit.
  The meter receives no ultrasonic pulses. A transducer or the transducer interface may be damaged.

♦ Performance is zero,
  Series III: AGC Level is stable
  Series IV: AGC Level = AGC Limit
  The meter receives “ultrasonic” pulses, but rejects them. A transducer or the transducer interface may be damaged.

♦ Performance is low,
  Series III: AGC Level is higher than normal: A fuse of the transducer interface protection may be blown. Check the fuses, and exchange (with the proper type and value) if necessary.

♦ AGC Limit is close to the AGC Level: The meter receives ultrasonic pulses, but detects severe ultrasonic or electrical noise. This may cause errors on measured gas velocity (and thus volume flow) and measured speed of sound. Electrical noise can be caused by an external source; this effect is not flow dependent. Check cable shielding. Ultrasonic noise can be caused by regulating valves (particularly when operated at a large pressure drop). This effect is flow dependent.

♦ Failing frequency/current/status output:
  ◊ If the meter transmits serial data, the output may be damaged.
  ◊ If there is no serial data, check if the meter’s TxD LED is flashing in 1-second intervals. If so, the communication port may be damaged. If the LED is not flashing, switch the meter off and back on. If the LED remains off, the meter may be damaged. If the meter is working correctly now, contact Instromet when this problem occurs frequently.

Other guidelines:
♦ If the meter has one of these symptoms once in a while, try to capture the failure in a log file. Refer to 5.4.10 (“Collecting data with UNIFORM’s built-in data logger”) for instructions about UNIFORM’s data logger).
♦ Check if all values are within the programmed parameters ranges
♦ Check cables and connections.
♦ Check interfaces and barriers at user side.
♦ Check power supply
Contact Instromet Ultrasonics B.V. if the problem can not be solved.
6.5 Repair

This section of the manual explains how to replace parts of the Q.Sonic® ultrasonic gas flow meter:

» Transducers
» (Parts of the) SPU electronics

Caution!

These procedures require special equipment and skills, and therefore must not be performed by untrained or unauthorised personnel. Please contact Instromet B.V. to make an appointment for a service engineer.

6.5.1 Replacement of (parts of) the SPU electronics

The SPU electronics in the EEx(d) housing are mounted mechanically with nylon PCB clips metal spacers and electrically with flat cables:

Series III electronics:

» Horizontal:
  ◊ Bottom: PROTRAN transducer interface board
  ◊ Middle: PROSON-II micro-controller board
  ◊ On top panel: Fuse Module, if no C-Module is used
  ◊ (optional )Top: C-Module micro-controller board

» Vertical, when a C-Module is used:
  ◊ Fuse Module

Series IV electronics with PROTRAN:

» Horizontal:
  ◊ Bottom: PROTRAN transducer interface board
  ◊ Middle: PROTRAN converter PCB
  ◊ Top: PRODSP micro-controller board

Series IV electronics:

» Horizontal:
  ◊ Bottom: PROTRAN-xa transducer interface boards
  ◊ Top: PRODSP micro-controller board

Parts of the SPU can be replaced without problems, provided that the appropriate hardware and software versions are used. The product numbers can be found on the PCB and start with 901-xx-xxxx. The software version used in series III is mentioned on the label of the EEPROM. In series IV electronics you can check the software version via Uniform.

This will not affect the measuring characteristics and the accuracy (and as a consequence the calibration) of the Q.Sonic® ultrasonic gas flow meter.

Warning!

Obey the rules and regulations that apply to hazardous area operations and those with respect to custody transfer regulations (sealing).
6.5.1.1 Tools and spare parts

For replacement of (parts of) the SPU electronics you need:

♦ Small screwdriver (series III, 3mm; series IV, 3 and 2.5mm)
♦ Hexagon screwdriver 5.5mm
♦ Multi-meter
♦ Spare parts (printed circuit boards, fuses, etc.).

Note: Instromet recommends purchase of a spare set of SPU electronics if minimal down-time of the Q.Sonic® is required.

6.5.1.2 Dismounting the SPU electronics

Warning!
Obey the rules and regulations that apply to hazardous area operations.

Caution!
Remember; always make a backup copy of the parameter file stored in the SPU. This can be done with the Uniform Software via the RS485/232 connection with the PC. See the Uniform user guide.

Dismounting the SPU electronics

1. Switch off the SPU power supply, and protect against undesired switching on.
2. Open the explosion proof housing of the SPU.
3. Check if the cables are tagged before disconnecting all cable connectors from the printed circuit boards. (If not: attach a tag with position number)
4. The bottom circuit board PROTRAN (xa) is connected with several nylon PCB support clips to the metal plate of the explosion proof housing. Unlock the clips and remove the PCB set carefully from the EEx d housing. If further disassembly/inspection is desirable, take the SPU electronics into a safe zone.

6.5.1.3 Disassembly/inspection of the SPU electronics

Disassembly/inspection of the SPU electronics

1. Dismount/inspect the Fuse Module on series III:
   1. Remove the four bolts from the top panel.
   2. Disconnect the power supply connector from the PROSON-II board.
   3. Replace the Fuse Module, if necessary.

OPTIONAL

2. Dismount/inspect the C-Module on series III
   1. Remove the four circuit board spacers.
   2. Release the flat cable connector to the PROSON-II board from the flat cable header. Use a screwdriver to lift it carefully.
   3. Replace the C-Module, if necessary.
3 ▶ Dismount/inspect the PROSON, ProDSP  
   (Disconnect the powersupply of the ProDSP)  
   ① Remove the next four circuit board spacers.  
   ② Release flat cable connector to the PROTRAN, ProDSP board from the flat cable header.  
   ③ Replace the PROSON, ProDSP, if necessary.  

4 ▶ Dismount/inspect the PROTRAN (XA)  
   ① Remove the next four circuit board spacers and the metal protection cover.  
   ② Remove the remaining four circuit board spacers.  
   ③ Check the fuses on the PROTRAN.  
   ④ If necessary replace the PROTRAN.  

6.5.1.4 Mounting the SPU electronics

Warning!  
Obey the rules and regulations that apply to hazardous area operations.

Caution!  
Check the hardware and software versions of the spare parts to be replaced before assembling the SPU electronics. The product numbers can be found on the PCB and start with 901-xx-xxxxx. The software version used in series III is mentioned on the label of the EEPROM. In series IV electronics you can find the software version on the PCB label or check the software version via Uniform. If they are not the same, contact Instromet Ultrasonics B.V. for further information.

Mounting the SPU electronics:
1 Assemble the printed circuit board set by using procedure 6.5.1.3 Disassembly/inspection of the SPU electronics in reverse order.  
2 Mount the printed circuit board set in the explosion proof housing by using procedure 6.5.1.2 “Dismounting the SPU electronics” in reverse order and close the EEx d box before applying power to the meter.  
3 Verify/program the parameter set-up: if the PROSON-II, ProDSP board and/or C-Module board is replaced, make sure that the SPU contains the correct set-up. Use procedure 5.4.4: “verifying the Parameter Set-up” to verify the set-up, and use procedure 4.8: “Installing the Parameter Set-up“ to program the set-up.
6.5.2 Replacement of (parts of) the Remote Unit

Parts of the Remote Unit (supply module, printed circuit boards, LCD-module, counter modules) can be replaced without problems, provided that the appropriate hardware and software versions are used, without affecting the measuring characteristics and the accuracy (and as a consequence the calibration) of the Q.Sonic® ultrasonic gas flow meter. See Remote Unit users manual for detailed information.

6.6 Transducer Replacement

Each transducer is a separate component of the Q.Sonic® that can be replaced independently.
During production, each transducer, is tested (also the spare parts), to comply with the set norms. This means that though paired up to acoustic paths, each transducer can be substituted without degradation to the measuring properties and accuracy (thus the calibration) of the Ultrasonic Gas Flow Meter.

Caution!
For replacement of transducers that are designed to be replaced under pressure refer to the separate applicable Transducer retraction mechanism Users Guide for detailed information on the replacement procedure of these types of transducers.

Warning!
For replacement of transducers that are NOT designed to be replaced under pressure refer to the separate Installation Instructions delivered with the transducers. Below a general guidance procedure for transducer replacement is given.

Carefull!
- The following general procedures apply to the nonretractable transducer types. There are specific (dis)assembling instructions available for each transducer; See the Installation Instructions delivered with the transducers.
- Do not use any pneumatic or hydraulic tools when assembling transducers!
  This is possible on heavy flange connections (such as Model N) in high-pressure mains. A torque of 120 Nm for standard M16 transducer bolts is adequate.
6.6.1 Tools and spare-parts

In general the following tools are required for the disassembly of standard transducers (not retractable under pressure):

- Gas detector
- Small screwdriver (Series III: 3mm and Series IV: 2.5mm for the Phoenix connectors)
- Socket spanner
- Wrench
- Torque wrench (suitable for 120 Nm)
- Transducer bolts (see construction drawing), or wire-end-nuts (see construction drawing).
- Gasket set (delivered with the transducer).
- Silicone grease for the gaskets (e.g. Molykote 111).
- New Cable glands (can be ordered from Instromet Dordrecht).
- Tie-wraps
- Cleaning agent (for example: alcohol).
- Non-static cleaning cloth

6.6.2 Extraction procedure for non retractable Transducer models

Warning!

When executing any work, comply with the regulations that are specifically stipulated applying, to pressurised installations in a potentially explosive danger area (as the case may be). Follow the instructions delivered with the spare transducers!

The extension procedure is as follows:

1. Preliminary preparation:
   1. De-pressurise the gas line
   2. Disconnect the power supply to the SPU and protect against any possible power connections.
   3. Open the SPU EEx(d)-enclosure on the spool piece.

2. Disconnect the cable connections.

Caution!

The length of the transducer cables MUST NOT be altered.

- Loosen the cable connection:
  1. Locate cable connection from the (to be) extracted transducer to the PROTRAN-(XA)-card.
  2. Remove the accompanying tie-wraps.
  3. Dismantle the accompanying cable gland from the EEx d enclosure.
  4. Using a horizontal motion, pull the green Phoenix Contact connector out of the print part.
  5. Remove the connector from the cable.
  6. Pull the cable out of the EEx d enclosure and remove the cable gland.
Removing the Transducer: See the instructions delivered with the transducer!

1. Dismantle the four transducer bolts or wire-end-nuts.
2. Take the transducer out of the spool piece in the direction of the nozzle.

6.6.3 Installation procedure for non retractable Transducer models

Warning!

When executing any work comply to the regulations that are specifically stipulated applying, to pressurised installations in a possible explosive danger area (as the case may be). Follow the instructions delivered with the spare transducers!

The installation procedure is executed as follows:

1. Preliminary preparation:
   1. Using a non-static cleaning cloth and a little alcohol clean the reference-surface of the nozzle and the transducer.
   2. Rub in a little silicone grease on both new O-rings.

2. Installing the Transducer:
   1. Install the gaskets in the flange of the new transducer.
   2. Remove the red safety cap from the transducer.
   3. Slide the transducer into the nozzle.

Note. Be careful that the gaskets do not fall out of the flange when installing the transducer. The grease helps to prevent this.

   4. Mount the four transducer bolts (M16) span the bolt cross-wise to a torque of 120 Nm.

Caution!

The length of the transducer cables MUST NOT be altered.

1. Assemble the NEW glandparts in the right sequence onto the cable.
2. Feed the cable into the EEx(d)-enclosure.
3. Assemble the NEW cable gland, ensuring a reliable mounting of the outer shield in the gland.
4. Assemble the Phoenix Contact connector on to the cable. Take care that the position of the cores are correct. From above the red core should be on the left and the white core on the right (see Appendix A, e.g. Figure 8-2: Q.Sonic®-3 series III transducer connection details).
5. Slide the connector on the appropriate print-header of the PROTRAN (XA)-card.
Finishing work:

1. Close the EEx d enclosure
2. Bind the transducer cables together using tie-wraps.
3. Re-pressurise the pipeline and check for any possible leaks.
4. Switch the power supply of the SPU on again and check the functioning of the Ultrasonic Gas Flow-meter.
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7 Storage and shipping

7.1 Introduction

This chapter describes storage and shipping of the Q.Sonic® ultrasonic gas flow meter.

7.2 Procedure(s)

Refer to document: “Q.Sonic® Storage and shipping”, for storage and shipping of the Q.Sonic® ultrasonic gas flow meter.
Doc code: 01.09.01A.35.2
8 Q.Sonic® meter types

8.1 Introduction
This appendix contains figures of (details of) the Q.Sonic® ultrasonic gas flow meter.

8.2 Transducer Connections
The transducer connections are shown in Figure 8-1: Q.Sonic®-3 transducer connections through Figure 8-9: Q.Sonic®-5 Series IV transducer connections details:

Q.Sonic®-3: Figures
◊ Figure 8-1: Q.Sonic®-3 transducer connections
◊ Figure 8-2: Q.Sonic®-3 series III transducer connection details
◊ Figure 8-3: Q.Sonic®-3 series IV transducer connection details

Q.Sonic®-4: Figures
◊ Figure 8-4: Q.Sonic®-4c transducer connections
◊ Figure 8-5: Q.Sonic®-4 Series III transducer connections details
◊ Figure 8-6: Q.Sonic®-4 Series IV transducer connections details

Q.Sonic®-5: Figures
◊ Figure 8-7: Q.Sonic®-5 transducer connections
◊ Figure 8-8: Q.Sonic®-5 Series III transducer connections details
◊ Figure 8-9: Q.Sonic®-5 Series IV transducer connections details

8.3 Path layouts
The Q.Sonic® 3 meters are fitted with 2 swirl and one axial path
Path 1 and 3: Swirl
Path 2: Axial

Figure 8-1: Q.Sonic®-3 transducer connections
Figure 8-2: Q.Sonic®-3 series III transducer connection details

Figure 8-3: Q.Sonic®-3 series IV transducer connection details
The Q.Sonic® 4 meters are fitted with 2 swirl and 2 axial paths
Path 2 and 3: Swirl
Path 1 and 4: Axial

Figure 8-4: Q.Sonic®-4c transducer connections
Figure 8-5: Q.Sonic®-4 Series III transducer connections details

Figure 8-6: Q.Sonic®-4 series IV transducer connections details
The Q.Sonic® 5 meters are fitted with 2 swirl and 3 axial paths
Path 2 and 4: Swirl
Path 1,3 and 5: Axial

Figure 8-7: Q.Sonic®-5 transducer connections
Figure 8-8: Q.Sonic®-5 Series III transducer connections details

Figure 8-9: Q.Sonic®-5 Series IV transducer connections details
8.4 Output Wiring Diagrams

Figure 8-10: **C-Module outputs** shows the wiring diagrams of the Q.Sonic®’s outputs of the C-Module:
- Frequency output
- Current output
- Digital output (Flow Direction, Data Valid)

Figure 8-11: **PROSON-II Optocoupler outputs** shows the wiring diagrams of the Q.Sonic®’s outputs of the PROSON-II board:
- Optocoupler output 1 to 4

Figure 8-12: **ProDSP Optocoupler outputs** shows the wiring diagrams of the Q.Sonic®’s outputs of the ProDSP board:
- Optocoupler output 1 to 4

---

**Figure 8-10: C-Module outputs**
**Series III**

**Figure 8-11:** PROSON-II Optocoupler outputs

**Series IV**

**Figure 8-12:** ProDSP Optocoupler outputs
8.5 Nameplates/labels

Nameplates and labels are used to identify the product and to provide details on the specific product. Together with the product manual it specifies how to use the product.

Spoolpiece nameplates:
1. Example of the standard Instromet nameplate
2. Design data nameplate, in accordance with applicable design code (ASME, ADM, Stoomwezen)
   a. Instromet Nameplate
   b. Nameplate acc. ASME
   c. Nameplate acc. AD-Merkblatter
   d. Nameplate acc. Stoomwezen

![Image showing examples of nameplates]

**Figure 8-13:** Nameplates spoolpiece (example only)
The SPU is equipped with one nameplate:

![Nameplates SPU](image)

Figure 8-14: Nameplates SPU (example only)

The Transducer is equipped with one nameplate:

![Nameplates transducer](image)

Figure 8-16: Nameplates transducer (example only)
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9 Wiring of the USM

9.1 Introduction
This chapter supplies information for correct wiring of the meter in the field. In the next figures information can be found for the green Phoenix connectors from the PCB for the PROSON-II, C-module, ProDSP and the connection terminal of the Technor box.

9.2 Glands and cable types
The meters will be equipped with four M20 size holes for EEx certified glands. Standard two Pepper glands and two blind plugs are mounted.

Information on the glands and specific mounting instructions can be found on the websites of the suppliers:
For example: Peppers information on www.peppers.co.uk

<table>
<thead>
<tr>
<th>Std</th>
<th>Standard gland</th>
<th>Gland type</th>
<th>Inner sheet</th>
<th>Outer sheet</th>
<th>Armour acceptance</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑</td>
<td>Yes Peppers</td>
<td>CR1B/16/M20</td>
<td>3.4 - 8.4 mm</td>
<td>9 -13.5 mm</td>
<td>0.15 - 0.25</td>
<td><a href="http://www.peppers.co.uk">www.peppers.co.uk</a></td>
</tr>
<tr>
<td>Project no</td>
<td>Gland brand</td>
<td>Gland type</td>
<td>Inner sheet</td>
<td>Outer sheet</td>
<td>Armour acceptance</td>
<td>Website</td>
</tr>
<tr>
<td>..........</td>
<td>............</td>
<td>............</td>
<td>........ mm</td>
<td>........ mm</td>
<td>................</td>
<td>..........</td>
</tr>
</tbody>
</table>

It is advised to use suitable Armoured shielded cable to provide protection against mechanical damage and electrical interference.

**Important:** Use a cable with suitable resistance, diameter, cores and length.

Limits:
- SPU : Voltage at the TIP terminal: Min 12Vdc Max 30Vdc.
- RS-485 : cable: 2 x 2 wire (min 0.5mm²)
  Twisted Pair, max. 700m, max. 2.5 Ohm/wire
- RS-232 : cable: 3 x 2 wire (min 0.5mm²)
  shielded max. 15m, max. 2.5 Ohm/wire
- Opto-Coupler : Ext. supply at the Phoenix terminal: max 30Vdc, 12mA

9.3 PCB Connections
The tables on the next pages show the terminal connections.

<table>
<thead>
<tr>
<th>PROSON-II</th>
<th>C-module</th>
<th>ProDSP</th>
<th>Technor terminal PROSON-II</th>
<th>Technor terminal C-module</th>
<th>Technor terminal ProDSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑</td>
<td></td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>9.3.1</td>
<td>9.3.2</td>
<td>9.3.3</td>
<td>9.3.4</td>
<td>9.3.4</td>
<td>9.3.4</td>
</tr>
</tbody>
</table>
9.3.1 PROSON-II terminals

<table>
<thead>
<tr>
<th>RS232</th>
<th>limits</th>
<th>Sub D 9 pol</th>
</tr>
</thead>
<tbody>
<tr>
<td>RxD</td>
<td>Receive data</td>
<td>Max 15m</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>TrX</td>
<td>Transmit data</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opto coupler outputs</th>
<th>Max 30Vdc Max 12mA</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C3 Collector (+)</td>
<td>Default setting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E3 Emitter (-)</td>
<td>Flow direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4 Collector (+)</td>
<td>Default setting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E4 Emitter (-)</td>
<td>Partial failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1 Collector (+)</td>
<td>Default setting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1 Emitter (-)</td>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2 Collector (+)</td>
<td>Default setting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2 Emitter (-)</td>
<td>Data valid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RS485</th>
<th>Max 700m</th>
<th>0,5mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>line B</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>line A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power supply</th>
<th>Max 500mA at 12Vdc</th>
<th>Max 280mA at 24Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 12/30 Vdc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 0Vdc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 9-1: PROSON-II connections

For projects it is possible to have an other setup of the opto-couplers. The following values are applicable for the project:

<table>
<thead>
<tr>
<th>Proj no</th>
<th>Hex</th>
<th>Opto 1</th>
<th>Opto 2</th>
<th>Opto 3</th>
<th>Opto 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9.3.2 C-module terminals

<table>
<thead>
<tr>
<th>Frequency out</th>
<th>Optocoupler (Max 30Vdc Max 50mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 0</td>
<td>Pulse</td>
</tr>
<tr>
<td>+ + Pulse</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RS485</th>
<th>Max 700m</th>
<th>0,5mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>line B</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>line A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current output</th>
<th>D/A converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 0</td>
<td></td>
</tr>
<tr>
<td>+ 0-20mA or 4-20mA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure input</th>
<th>Connect gnd's when Active sensor is used</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND Ground</td>
<td></td>
</tr>
<tr>
<td>In Input</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature input</th>
<th>Connect gnd's when Active sensor is used</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND Ground temp input</td>
<td></td>
</tr>
<tr>
<td>In Input</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
<th>Optocoupler (Max 30Vdc Max 100mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data valid</th>
<th>Optocoupler (Max 30Vdc Max 100mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Figure 9-2: C-module connections
9.3.3 ProDSP terminals

### RS232-B
- **Receive data**
- **Ground**
- **Transmit data**

#### Opto coupler outputs
- **C4**: Collector (+)
- **E4**: Emitter (-)
- **C3**: Collector (+)
- **E3**: Emitter (-)
- **C2**: Collector (+)
- **E2**: Emitter (-)
- **C1**: Collector (+)
- **E1**: Emitter (-)

<table>
<thead>
<tr>
<th><strong>Limits</strong></th>
<th><strong>Sub D 9 pol</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max 15m</td>
<td>pin 3</td>
</tr>
<tr>
<td></td>
<td>pin 5</td>
</tr>
</tbody>
</table>

### RS232-A 4800/N/Uniform
- **Receive data**
- **Ground**
- **Transmit data**

<table>
<thead>
<tr>
<th><strong>Limits</strong></th>
<th><strong>Sub D 9 pol</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max 15m</td>
<td>pin 3</td>
</tr>
<tr>
<td></td>
<td>pin 5</td>
</tr>
</tbody>
</table>

### RS485-D
- **Line B**
- **Line A**

<table>
<thead>
<tr>
<th><strong>Limits</strong></th>
<th><strong>Sub D 9 pol</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max 700m</td>
<td>pin 3</td>
</tr>
<tr>
<td>0,5mm²</td>
<td>pin 5</td>
</tr>
</tbody>
</table>

### Power supply
- **+12/30 Vdc**
- **Ground**
- **0Vdc**

### RS485-C
- **Line B**
- **Line A**

<table>
<thead>
<tr>
<th><strong>Limits</strong></th>
<th><strong>Sub D 9 pol</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max 700m</td>
<td>pin 3</td>
</tr>
<tr>
<td>0,5mm²</td>
<td>pin 5</td>
</tr>
</tbody>
</table>

---

**Figure 9-3**: ProDSP connections

For projects it is possible to have an other setup of the opto-couplers. The following values are applicable for the project:

<table>
<thead>
<tr>
<th><strong>Proj no</strong></th>
<th><strong>Hex</strong></th>
<th><strong>Opto 1</strong></th>
<th><strong>Opto 2</strong></th>
<th><strong>Opto 3</strong></th>
<th><strong>Opto 4</strong></th>
</tr>
</thead>
</table>

---

9.3.4 Technor terminal connections

### Technor terminal

<table>
<thead>
<tr>
<th><strong>Technor terminal</strong></th>
<th><strong>PROSON-II</strong></th>
<th><strong>C-module</strong></th>
<th><strong>ProDSP</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Ground</td>
<td>Ground</td>
<td>C4 FD + (default)</td>
</tr>
<tr>
<td>15</td>
<td>RS-232 RxD</td>
<td>NC</td>
<td>E4 FD - (default)</td>
</tr>
<tr>
<td>14</td>
<td>RS-232 Gnd</td>
<td>NC</td>
<td>E3 DV+ (default)</td>
</tr>
<tr>
<td>13</td>
<td>RS-232 TxD</td>
<td>NC</td>
<td>E3 DV- (default)</td>
</tr>
<tr>
<td>12</td>
<td>DV + (default)</td>
<td>DV - (fixed)</td>
<td>C2 PF+ (default)</td>
</tr>
<tr>
<td>11</td>
<td>DV - (default)</td>
<td>DV + (fixed)</td>
<td>E2 PF- (default)</td>
</tr>
<tr>
<td>10</td>
<td>FD + (default)</td>
<td>FD - (fixed)</td>
<td>C1 freq +</td>
</tr>
<tr>
<td>9</td>
<td>FD - (default)</td>
<td>Freq - (fixed)</td>
<td>E1 freq -</td>
</tr>
<tr>
<td>8</td>
<td>Freq + (default)</td>
<td>Freq + (fixed)</td>
<td>RS485-D B</td>
</tr>
<tr>
<td>7</td>
<td>Freq - (default)</td>
<td>Freq - (fixed)</td>
<td>RS485-D A</td>
</tr>
<tr>
<td>6</td>
<td>PF + (default)</td>
<td>Current -</td>
<td>RS485-C B</td>
</tr>
<tr>
<td>5</td>
<td>PF- (default)</td>
<td>Current +</td>
<td>RS485-C A</td>
</tr>
<tr>
<td>4</td>
<td>RS485 B</td>
<td>RS485 B</td>
<td>+12/30 Vdc</td>
</tr>
<tr>
<td>3</td>
<td>RS485 A</td>
<td>RS485 A</td>
<td>0Vdc</td>
</tr>
<tr>
<td>2</td>
<td>0Vdc</td>
<td>0Vdc</td>
<td>0Vdc</td>
</tr>
<tr>
<td>1</td>
<td>+12/30 Vdc</td>
<td>+12/30 Vdc</td>
<td>Ground</td>
</tr>
</tbody>
</table>

**Figure 9-4**: Technor box
For projects it is possible to have an other setup of the opto-couplers. The following values are applicable for the project:

<table>
<thead>
<tr>
<th>Proj no</th>
<th>Hex</th>
<th>Opto 1</th>
<th>Opto 2</th>
<th>Opto 3</th>
<th>Opto 4</th>
</tr>
</thead>
</table>


10 Electrical Parameters

10.1 Intrinsic safe Protran-xa-i (Terminals K1 … K10)

Output circuit in type of protection intrinsic safety EEx ib IIA, only for connection to a certified intrinsically safe circuit, with following maximum values:

\[ U_o = 20 \text{ V} \]
\[ I_o = 72 \text{ mA} \]
\[ P_o = 350 \text{ mW} \]

IIA

\[ C_o = 5.5 \mu\text{F} \]
\[ L_o = 46 \text{ mH} \]
11 Glossary

**Automatic Gain Control (AGC)** The ultrasonic pulses employed by the Q.Sonic® are attenuated as they travel from the transmitting transducer to the receiving transducer. The attenuation depends on the distance between the transducers, gas density, absorption, etc. The received signals must be amplified in order to present the time-of-arrival detector with suitable signal levels. The Q.Sonic® measures the strength of the received signals, and adjusts the amplification automatically.

**Checksum** A unique value calculated from the low level parameter settings that is used as a protection against changes of these low level parameter settings.

**C-Module** A microprocessor controlled electronic (sub-)system, which is an optional part of the SPU of the Remote Unit:
- The C-Module in the SPU has signal processing, communication, protection and interface tasks.
- The C-Module in the Remote Unit has communication, protection and interface tasks.

**Current Output** This is the Q.Sonic®’s analogue (0/4-20mA) output. This output is programmable with respect to:
- Measured value,
- Range of the measured value, and
- Output current range.

**Data Valid Output** This is an open-collector digital output signalling the Q.Sonic®’s (in-)ability to measure flow:
- Low impedance: the flow measurement is OK
- High impedance: the Q.Sonic® cannot measure flow with the rated accuracy.

**Flow Direction Output** This is an open-collector digital output signalling the direction of the measured flow. The output has a low (high) impedance at forward (reverse) flow.

**Frequency Output** This is the Q.Sonic®’s open-collector impulse output. This output is programmable with respect to:
- Measured value,
- Range of the measured value, and
- Output frequency range.

**Fuse Module** This is one of the print cards of the SPU. The Fuse Module contains components for supply current control and protection.

**Half-duplex** A type of information exchange strategy between two communicating devices whereby information (data) may be exchanged in both directions alternately.

Note: In a full-duplex system data may be exchanged in both directions simultaneously.
Low level The low level parameters are these parameters that determine
the function of the electronics. Changes to these parameters can only
be made by Instromet personnel. The low level parameters are
protected with a checksum value. Changes made to one of these
parameters will result in a Checksum error and cannot be
implemented.

Mode of Operation The Mode of Operation determines the flow meter's
functional characteristics. Examples are Normal Mode (in which the
Q.Sonic® operates as a flow meter) and Programming Mode (in
which the Q.Sonic® can be programmed for is flow meter task).

Non-volatile memory This is a kind of computer memory that retains its
information even with the power turned off. The Q.Sonic® uses this
kind of memory to store its parameter set-up.

Normal Mode This is the mode of operation in which the Q.Sonic® performs
its 'normal' task: flow measurement.

Parameter Set-up The Q.Sonic®'s operation is controlled by a
programmable set of parameters, for example spool piece geometry,
low level measurement control, input/output scaling, etc., which are
stored in the SPU's non-volatile memory. The complete set of
parameters is called the parameter set-up.

Party line Line used for more than one signalsource. Signal is switched or
send on demand.

Programming Mode A dedicated mode of operation, in which the Q.Sonic®
does NOT perform its 'normal' task (flow measurement), but is ready
for (re-)programming of its parameter set-up, input calibration, and
various functional (hardware) tests.

PROSON-II One of the TIP's printed circuit boards. The PROSON-II is a
microprocessor system. It controls the measurement process,
performs low-level signal processing and controls the communication
with either the C-Module, Remote Unit or the outside.

PRODSP One of the TIP's printed circuit boards. The PRODSP is a
microprocessor system. It controls the measurement process,
performs low-level signal processing and controls the communication
with either the Flow Computer or the outside.

PROTRAN One of the TIP's printed circuit boards. The PROTRAN
interfaces the ultrasonic transducers, and contains the analogue
circuitry for signal conditioning.

PROTRAN Converter One of the TIP's printed circuit boards. The
PROTRAN converter interfaces the ProDSP with the PROTRAN.

PROTRAN-XA One of the TIP's printed circuit boards. The PROTRAN-XA
interfaces the ultrasonic transducers, and contains the analogue
circuitry for signal conditioning.

Remote Unit The Remote Unit forms the indication and interface unit of the
Q.Sonic® ultrasonic gas flow meter.
RS-232C Standards laid down by the American Electrical Industries Association for interfacing a digital device to a by a telephone company supplied modem. RS-232C is also used as an interface standard for connecting a peripheral device, such as a visual display unit or a serial printer, to a computer.

RS-485 Interface standard for serial communication with larger range, higher speed and improved noise immunity with respect to RS-232C. Suitable for multi-point communication.

RS-485/RS-232 Converter Device for connecting equipment with an RS-485 serial interface to equipment with an RS-232C interface. The converter performs the conversion between the electrical signals.

Service Mode (High/Low Level) Dedicated mode(s) of operation, reserved for manufacturing purposes. Not recommended for regular operation of the Q.Sonic®.

Signal Processing Unit (SPU) A part of Instromet's ultrasonic flow meters: an explosion proof housing, containing the flow meter's Transducer Interface Processor (TIP). The SPU is mounted on (or close to) the spool piece.

Spool piece This is the part of the Q.Sonic® that is mounted in the piping system.

Supervisor Mode Dedicated mode of operation, reserved for series-II meters to give the VoS and Raw gas velocity per path in the output data-stream. These outputs are standard for the Series-III meters and the AGA-9 compatible meters.

TIP The Transducer Interface Processor (TIP) is the microprocessor-controlled electronics system, which is part of the SPU. The TIP interfaces with the transducers and controls the measuring process, calculates the flow and controls the signal interfacing.

Transducer The ultrasonic signals required for the flow measurement are generated and received by transducers. Piezoelectric transducers employ crystals or ceramics that are set into vibration when an alternating voltage is applied to the piezoelectric element. The vibrating element generates sound waves in the fluid. Since the piezoelectric effect is reversible, the element will become electrically polarised and produce voltages related to the mechanical strain, when the crystal is distorted by the action of incident sound waves.

Because the acoustic impedance of the gas is much smaller than that of the piezoelectric element, to maximise the acoustic efficiency a matching layer is employed between the fluid and the piezoelectric element.

Twisted pair A type of transmission medium consisting of two insulated wires twisted together to improve its immunity to interference from other (stray) electrical signals that may otherwise corrupt the signal being transmitted.

**V-Module** A microprocessor-controlled electronic (sub-)system, which is part of the TIP. The V-Module interfaces the ultrasonic transducers, and controls the measurement process. Low-level signal processing is another task of the V-Module.
12 Notes: