
Daniel Measurement & Control
超声波流量计计量系统培训
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Daniel Measurement & Control
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丹尼尔气体超声波流量计简介

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基本概念

- 1、超声波计量系统的任务
- 准确测量经过在气体输送管道中安装的超声波流量计的天然气量
- 2、天然气的特性
- 可压缩性，根据天然气所受压力、温度和天然气组成的不同，其可压缩的程度也不同
- 3、怎样衡量天然气的量
- A，体积计量：将经过超声波流量计的、在实际输送状况下的天然量转换为某一指定状态（标准状态）下的天然气量
- B，能量计量：将经过超声波流量计的、在实际输送状况下的天然气量转换为该气量燃烧后可以发出的热量

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天然气计量系统的基本组成

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天然气计量系统的基本组成

- 1、工况流量测量仪表（如气体超声波流量计）
- 用于测量在管道中实际输送状态下的天然气流量
- 2、温度、压力测量仪表（如温度、压力变送器）
- 用于测量管道实际输送气体的状态
- 3、天然气组成分析仪表（如气相色谱分析仪）
- 分析管道中输送的天然气成份，用于计算天然气的可压缩程度或天然气的可发热程度
- 4、计量二次仪表（如流量计算机）
- 综合上述测量结果，计算出满足贸易交接要求的量值

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Daniel Ultrasonic Meter

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丹尼尔超声波流量计的发展历史

- 八十年代初期, 英国煤气公司开始研发四通道的超声波流量计
- 1986: 英国煤气公司授权Daniel公司作为唯一的开发商,进一步开发该类型流量计的工业领域的应用
- 1989: 第一台模拟电路超声波流量计顺利出厂,在英国开始销售并用于商业计量
- 1993: ***DANIEL***公司采样自动增益控制和数字信号处理技术改善了流量计的电子单元,提高了信号的保真度和流量计的精度
- 1994: ***DANIEL***引入防爆的Mark II电子处理装置
- 2005: ***DANIEL***将Mark II升级为MarkIII电子处理装置

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丹尼尔超声波流量计的发展历史

- 1998: ***DANIEL***开发出可在线拆装的超声波探头器并可提供在线带压拆装工具
- 2000: 中油西南分公司采用7台***DANIEL***高级超声波流量计用于贸易计量，向重庆和四川的大型天然气用户供气。
- 2001：大庆油田天然气公司采用7台***DANIEL*** 中级超声波流量计用于储气库和内部管线计量。

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在高含硫,带有凝析液天然气中使用超声波流量计与孔板流量计的比较

- 精度
  - 高级超声波流量计精度:优于0.5%,并可免实流标定
  - 普通超声波流量计: 1%
  - 与孔板和涡轮流量计相比，精度不易受气质和分层的影响
  - 孔板流量计在内部肮脏的情况下,计量数据会呈负偏差.DANIEL 超声波流量计即使在表体内部有大量污垢的情况下,仍能保持高精度.

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在高含硫天然气中使用超声波流量计与孔板流量计的比较

- 高含硫气体对仪表的寿命影响
  - 硫化氢腐蚀孔板表面,造成金属件疲劳,缩短寿命,具严重的安全隐患.超声波内部没有可动部件,经过特殊处理的内表面,可以耐受H2S的侵蚀,可延长维护保养的时间间隔.
  - 无插入管道内部的部件, 即使管道中有残渣也不会损坏仪表的任何组件.

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在高含硫天然气中使用超声波流量计与孔板流量计的比较

- 较低的运行成本
  - 不影响流体的正常流动
  - 无节流件，压损小
  - 不用加压
- 低安装成本
  - 高容量
  - 高量程比 (可达100:1)
  - 降低了对上下游直管段的要求

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DANIEL高级超声波气体流量计

特点及技术规范

- 高精度：精度达到　+/-0.1%(经过实流标定)
  重复性优于+/-0.2%
- 专用于贸易交接
- 多通道可检测流体的多个剖面
- 多通道提供了必要的冗余能力，独特的声道替补技术使流量计在某一声道故障的情况下，仍能基本正常工作
- 精确的设计和在加工制造过程中的质量控制

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DANIEL高级超声波流量计

特点和技术规范

- 声速,温度,气体运行状况的测量是相对独立的
- 特别适用于高压气体,一般最低工作压力为10(4～5)bar
- 常见流量计的直径, 100mm - 600mm (4”-36”)
- 最高压力可达ANSI #2500(约42MPa)

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高级超声波气体流量计

应用场合

- 长输管线
- 集气系统
- 海洋天然气
- 压气站
- 气体处理工厂
- 高压管线
- 输配管网

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普通气体超声波流量计

- 单声道或双声道
- 短管安装
- 主要用于非贸易交接
- 较高级超声波流量计更经济
- 新安装现场尤其适用
- 适用于原料天然气的计量

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普通气体超声波流量计

特点和技术参数

- 精度可达 ±1%
- 常见尺寸, 100mm - 600mm (4”-24”)
- 压力可达 ANSI #2500
- 推荐流速, 最大100英尺/秒(30m/s), 最小3英尺/秒(0.9m/s), 可延伸至, 1英尺/秒(0.3m/s).

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普通气体超声波流量计

应用场合

- 非贸易交接的场合
- 比对
- 储气罐的测量
- 海洋天然气的计量
- 原料天然气的测量

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超声波流量计的基本原理

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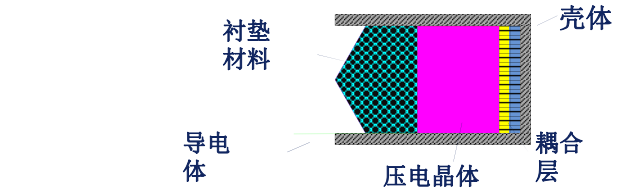
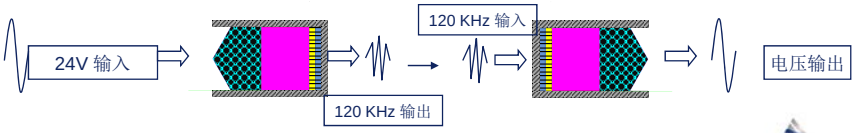
超声波流量计探头





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时间直通式原理的技术特点

- *DANIEL* 超声波流量计是时间直通式超声流量计
  - 声波由一个探头发射另一个接收，不经管壁反射
  - 声波由上游向下游传输的时间(由于声波被气流推动)小于声波由下游向上游传输的时间(声波被气流反向阻挡)
  - 这两个时间之差与气流的速度存在某种对于关系
  - 从上下游测得的传输时间可以计算出气流的平均速度和声波的速度

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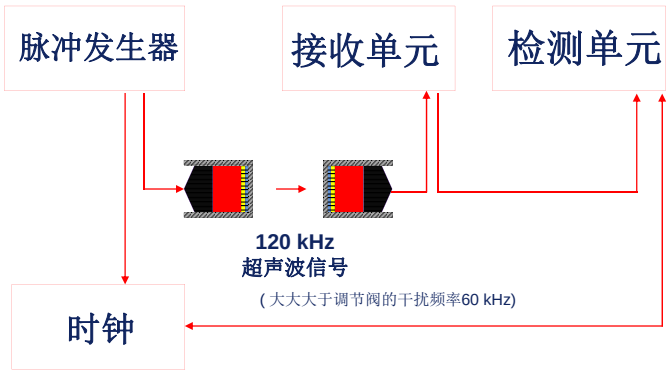
时间直通式测量原理

本安型传感器信号检测回路



100 MHz 晶振

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超声波流量计

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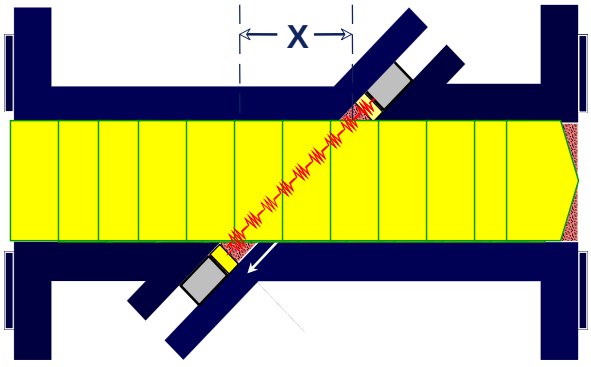

传输时间 .007

△ = .003

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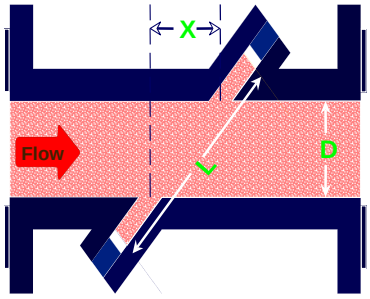
高级超声波流量计流量方程

任 意 一 对 传 感 器

$$t1 = \frac{L}{c - v(x/L)}$$

$$t2 = \frac{L}{c + v(x/L)}$$



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流量方程

流量从上述方程中求出

$$v = \frac{L^2}{2x}\frac{(t1-t2)}{t_1 t_2}$$

$$c = \frac{L}{2}\frac{(t_1+t_2)}{t_1 t_2}$$

v = 流体速度
c = 声速

t_1 = 上游传输时间
t_2 = 下游传输时间

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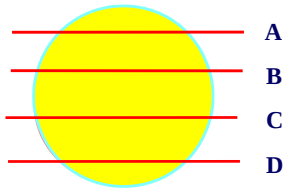
超声波流量计的计算

多通道即多路流速测量



多通道流量计

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超声波流量计的计算

Equation 5-4 Average Weighted Gas Flow Velocity

$$V_{AvgWtd} = \sum_{ActiveChords} Wt_{chord} V_{chord}$$

where

V_{AvgWtd} = average weighted gas flow velocity (m/s) (**AvgWtdFlowVel**)

Wt_{chord} = chord weight (dimensionless) (**WtA** ... **WtD**)

V_{chord} = chord average gas velocity (m/s) (**FlowVelA** ... **FlowVelD**)

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超声波流量计的计算

Equation 5-5 Chord Proportion Calculation

$$Prop_{chord} = \frac{V_{chord}}{V_{AvgWtd}}$$

where

$Prop_{chord}$ = chord proportion (dimensionless)

V_{chord} = chord velocity (m/s)

V_{AvgWtd} = average weighted gas flow velocity (m/s) (**AvgWtdFlowVel**)

超声波流量计的计算

Equation 5-6 Updating Chord Proportion Bin Data Values

$$AvgVel_{ChordBin_{n+1}} = \frac{(AvgVel_{ChordBin_n} \cdot (NumVals - 1)) + V_{chord}}{NumVals}$$

$$AvgProp_{ChordBin_{n+1}} = \frac{(AvgProp_{ChordBin_n} \cdot (NumVals - 1)) + Prop_{chord}}{NumVals}$$

where

$AvgVel_{ChordBin_{n+1}}$ = chord bin (n+1)st average velocity (m/s)

$AvgVel_{ChordBin_n}$ = chord bin nth average velocity (m/s)

$NumVals$ = update factor data point (dimensionless)

V_{chord} = chord velocity (m/s)

$AvgProp_{ChordBin_{n+1}}$ = chord bin (n+1)st average proportion value (dimensionless)

$AvgProp_{ChordBin_n}$ = chord bin nth average proportion value (dimensionless)

$Prop_{chord}$ = chord proportion (dimensionless)

超声波流量计的计算

Equation 5-7 Estimating Average Flow Velocity Using Proportion Values

$$V_{AvgWtd_{est}} = \frac{\sum_{\substack{Non-Failed \\ Chord(s)}} V_{chord}}{\sum_{\substack{Non-Failed \\ Chord(s)}} InterpProp_{chord}}$$

where

$V_{AvgWtd_{est}}$ = estimated average weighted flow velocity (m/s)

V_{chord} = (non-failed) chord velocity (m/s)

$InterpProp_{chord}$ = (non-failed) chord interpolated proportion value (dimensionless)

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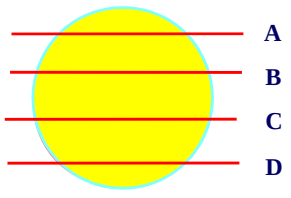
几何权重因子

权重因子仅取决于探头的几何分布情况!



多通道流量计

W_a= 0.1382
W_b= 0.3618
W_c= 0.3618
W_d= 0.1382

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流态剖面流态矫正

对单通道和双通道流量计来说

$$CF = 1 + \frac{0.242}{LOG(0.2703\frac{WR}{D} + \frac{0.835}{\mathrm{Re}^{0.8}}}$$

CF = 矫正系数

WR =管壁粗糙度

Re = 雷诺数

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如何确保超声波流量计的精度

- 精确的几何加工尺寸和精密的传感器定位
- 仪表的整体化技术贯穿于设计的全部过程中，整体铸造钢制表体，减少焊缝接口，有效减少表体热胀冷缩对计量的影响
- 时间直通式测量原理本身具有较高的精准度，不受表体内部光滑程度或污垢的影响。
- 对流体剖面特性及流场,流态的检测,并采用精确的数学模型进行补偿

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时间直通式测量原理的精确性

- 电子时钟的稳定性
- 连续测量与流体状态相关的声波脉冲
- 对电子元件和传感器引起的信号滞后给予恰当的补偿

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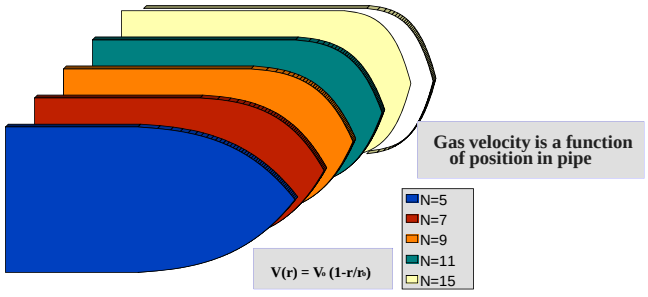
对不同流态的气体进行动态补偿

流体剖面特性

Power law velocity profile



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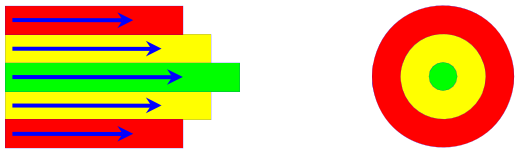
将流速简化为三个区域
Profile and Area Representation



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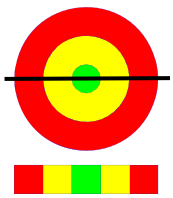
每个声道所代表的流速与平均流速的对应关系



Individual Path Velocity is Average for that Path

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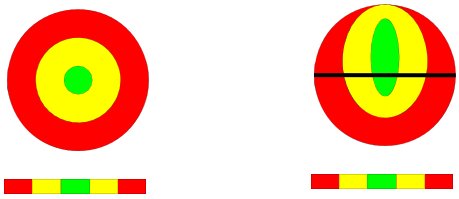
通过圆心的声道对流态的曲解

- 不同流体形态，测得速度却是相同的
- 测得的速度夸大了气体流动的平均速度
- 由于角度造成的错误



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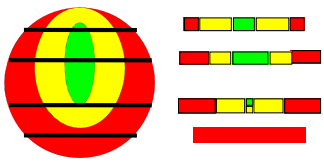
平行的四声道测量流速

- 每个声道不通过圆心，减少对流态的夸大
- 平行的四个声道互相补偿，有效测量流速



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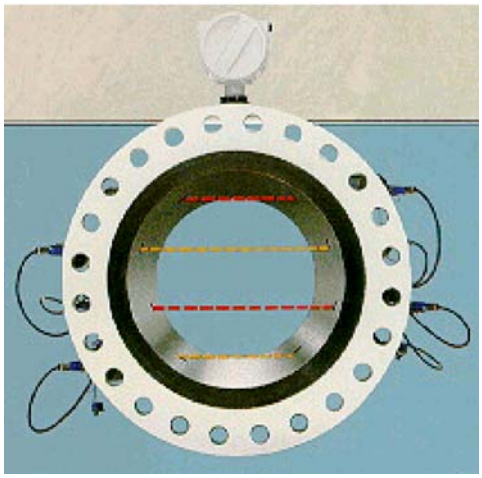
Crossflow flash

→ Crossflow ..\rk57x43.qt

气体高级超声波流量计



四通道流量计

多通道流量计算

流量计算的步骤

- → 测量每个通道的声波传输时间
- → 计算每个通道的速度
- → 计算平均速度
- → 流速乘以截面积

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流量计算准确的关键问题

- → 流量流速测量的结果对表体几何尺寸的要求
- → 有关流体的全部计算结果取决于对声波传输时间的测量
- → 传输时间的测量取决电子器件的性能
- → 有效消除旋涡和不对称流的影响。(安装及角度）

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丹尼尔超声波流量计的核心技术特点

New “J” Mount Components

New “J” Mount Assembly

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Benefits of New “J” Mount and Chordset

- Easier to assemble
- Better alignment on re-assembly
- Smaller design permits more compact meters
- Chordset less expensive for customer
- Easier to assemble and disassemble
- Better moisture protection than previous unit

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Mark III Electronics

- The Mark III is the new generation in the Daniel Ultrasonic Meter (USM) electronics. The new Mark III replace the entire Mark II electronics and preamp. The new design will work with all Daniel USMs. The Mark III will mount directly on the meter body just as the Mark II. The housing of the Mark III will be similar to the Mark II. The Mark III will be interchangeable with existing Ultrasonic meters in the field currently using Mark II electronics.

Advantages (MARK-III vs MARK-II)

- Single board design for increased reliability.
  - Mark II used 4 boards.
- 133 Mhz 32 bit processor with co-processor.
  - Mark II used 4Mhz 8 bit processor.
- One second Update times for all outputs.
  - Mark II was 5 seconds.
- Single program for all meter functions.
  - Mark II used two programs.
- Faster transducer firing. SeniorSonic fires all transducers more then 30/sec.
  - Mark II fired all transducers 4/sec.
- ¼ second updates available on frequency output for flow control advantages.
- More flexibility for frequency and DO configuration
- Voltage input range is auto-sensing 10.4-36 VDC operation – <=8 watts

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DANIEL 3D Demo FLASH

- ..\LiqUSMLaunch.exe

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USM MARK-III

Hardware

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Hardware View

CPU Side

Termination Side

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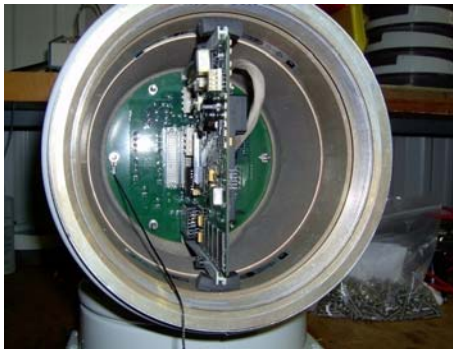
Mark III CPU with I.S. in Housing



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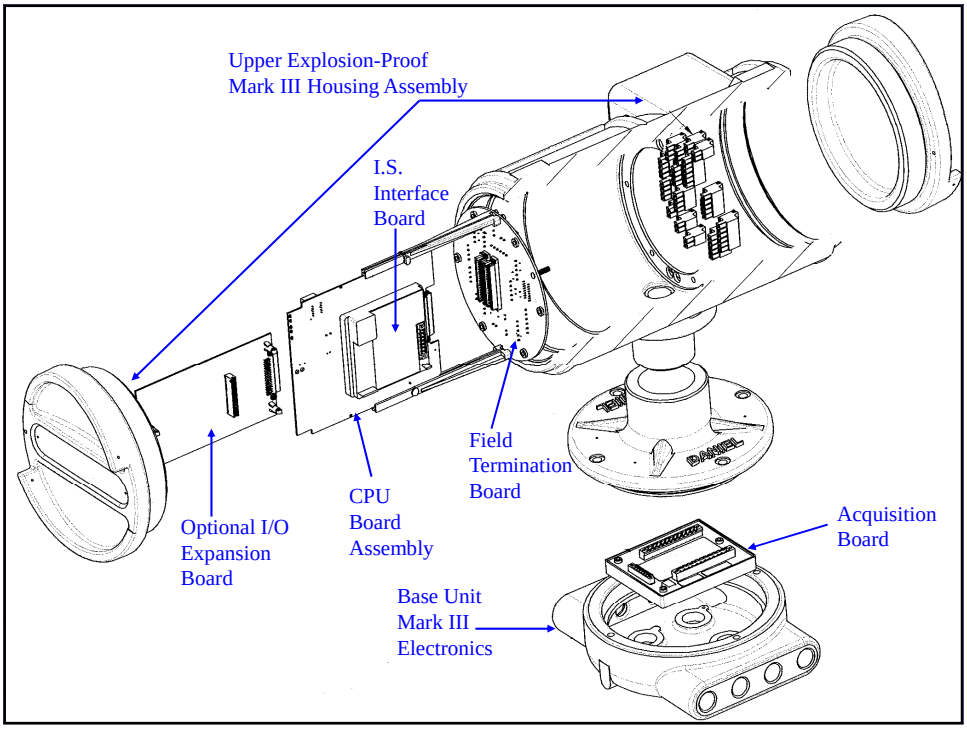

CPU

Front View

Rear View

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CPU

CPU Board Components

- AMD ELANsc520 486 Processor – 133MHz
- 8Mb/1MB Boot Flash
- 64Mb/8MB Storage Flash
  Upgradeable to to 16MB
- 16 MB SDRAM w/ECC
  Upgradeable to 32MB
- 32kbyte FRAM (Ferroelectric RAM) nonvolatile memory
- Altera ACEX EP1k50 FPGA – 66MHz and 33MHz clock
- SMSC LAN91C96I Ethernet Controller
- Real Time Clock with Backup
- Voltage Monitoring (2.5V, 3.3V, and 5V rails)

DANIEL

EMERSON. Process Management

CPU

- The CPU board consists of several switches used for setting the communications and outputs (frequency and digital).

DANIEL®

EMERSON. Process Management

CPU

- SW1

  -This switch is used for selecting Port A to be used as RS232 or RS485.

- RS232

  1,2,3,4 - RS232 Position

- RS485

  1,2,3,4 - RS485 Position

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EMERSON. Process Management

CPU

- SW2
  - This switch is used for selecting Port B to be used as RS232 or RS485.
- RS232
  - 1,2 - RS232 Position
- RS485
  - 1,2 - RS485 Position

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EMERSON. Process Management

CPU

- SW3
  - This switch is used for selecting Port A and Port B to be used as full or half duplex
- Port A

Full Duplex
  - SW3-1 - Full Position

Half Duplex
  - SW3-1 - Half Position

- Port B

Full Duplex
  - SW3-2 - Full Position

Half Duplex
  - SW3-2 - Half Position

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EMERSON. Process Management

CPU

- SW4

  - This switch is used in conjunction with SW1 for selecting Port A to be used as RS232 or RS485
- RS232

  1,2 - RS232 Position
- RS485

  1,2 - RS485 Position

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EMERSON. Process Management

CPU

- SW5

  - This switch is used in conjunction with SW2 for selecting Port B to be used as RS232 or RS485
- RS232

  1,2 - RS232 Position
- RS485

  1,2 - RS485 Position

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EMERSON. Process Management

CPU

- SW6

  - This switch is used for selecting Outputs Group 1 as an open collector or as a TTL 0-5 Vdc.

- Digital Output 1A

  Open Collector SW6-1 - OC Position
  TTL SW6-1 - TTL Position

- Digital Output 1B

  Open Collector SW6-2 - OC Position
  TTL SW6-2 - TTL Position
  (TTL 0: <0.7 vmax 10mA ; 1: >3.5v max 10mA 内供电)

- Frequency Output 1A

  Open Collector SW6-3 - OC Position
  TTL SW6-3 - TTL Position

- Frequency Output 1B

  Open Collector SW6-4 - OC Position
  TTL SW6-4 - TTL Position

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EMERSON. Process Management

CPU

- SW7

  - This switch is used for selecting Outputs Group 2 as an open collector or as a TTL 0-5 Vdc.

- Digital Output 2A

  Open Collector SW7-1 - OC Position
  TTL SW7-1 - TTL Position

- Digital Output 2B

  Open Collector SW7-2 - OC Position
  TTL SW7-2 - TTL Position

- Frequency Output 2A

  Open Collector SW7-3 - OC Position
  TTL SW7-3 - TTL Position

- Frequency Output 2B

  Open Collector SW7-4 - OC Position
  TTL SW7-4 - TTL Position

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EMERSON. Process Management

CPU

- S2

  - This switch is used for write protection, enable DHCP server, and set Port B to default settings for 2 minutes.

- S2-1
  Open Port B normal operation
  Closed Port B to Default Settings for 2 minutes
  (19200, 8, N, 1, ID=32)
- S2-2
  Open Disable DHCP Server on Ethernet Port
  Closed Enable DHCP Server on Ethernet Port
- S2-3
  Not Used
- S2-4
  Open Write Protected
  Closed Write Enabled

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EMERSON. Process Management

CPU

- LEDs
- There are 6 LEDs on the front side of the CPU board.

LED 1	Green	Normal Metrology Mode
	Red	Non Metrology Mode
LED 5	Flashing	Data Received From Acquisition Board
LED 2,3,4,6		For Future Use

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EMERSON. Process Management

CPU

LEDs

There are 5 LEDs on the rear side of the CPU board.

Port A RX	Green	Receive Data Active
Port A TX	Green	Transmit Data Active
Port B RX	Green	Receive Data Active
Port B TX	Green	Transmit Data Active
Ethernet	Green	Ethernet Active

DANIEL

EMERSON. Process Management

CPU

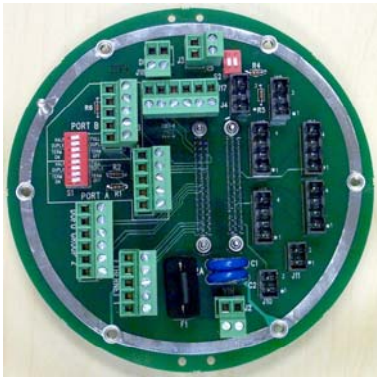
I.S. Board

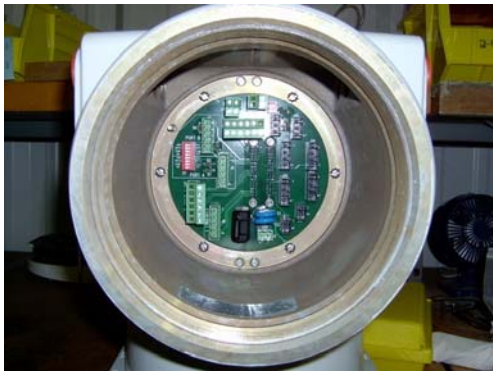
- The I.S. board is used to isolate power and communication signals to the acquisition board in order to meet intrinsic safety requirements. The I.S. board is mounted on the rear side of the CPU board. The board has a cable connector that allow for cable connection to the acquisition board.

DANIEL

EMERSON. Process Management

Field Connection Board





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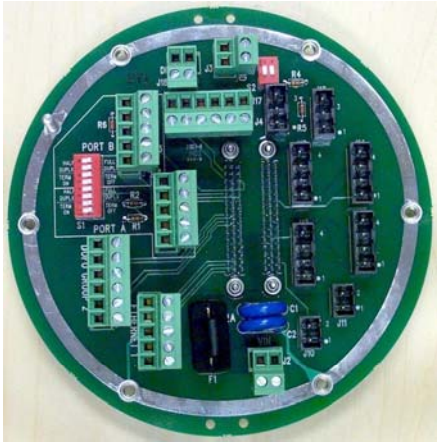
EMERSON. Process Management

Field Connection Board



- The field connection board is used to terminate all inputs and outputs to external devices.

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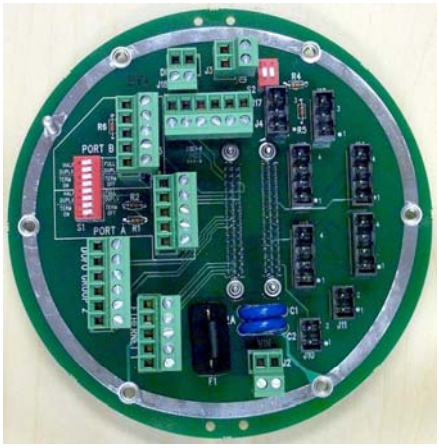
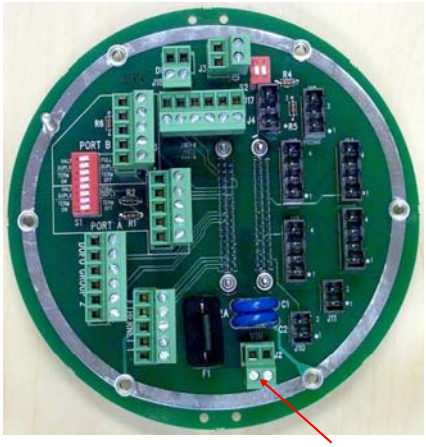
EMERSON. Process Management

Field Connection Board



- The field connection board has several connectors

Field Connection Board

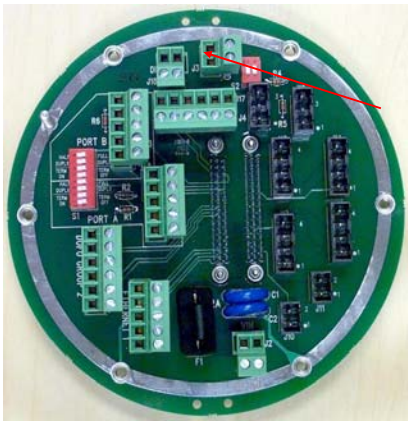


- J2
- J2 is used for the incoming supply voltage.
- Power

  J2-1 - 12-24 Vdc

  J2-2 - 12-24 Vdc Return

Field Connection Board



- J3
- J3 is used for the Chassis Gnd
- Chassis Ground
  - J3-1 - Chassis Gnd
  - J3-2 - Chassis Gnd

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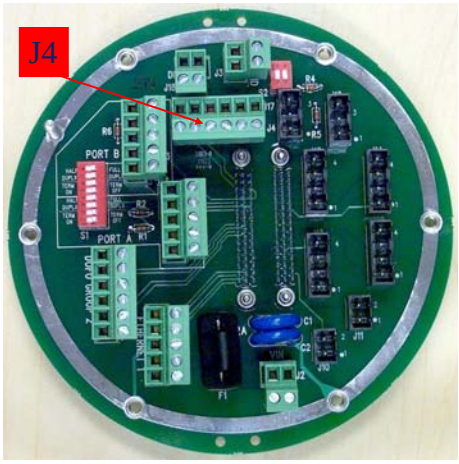
EMERSON. Process Management

Field Connection Board



- J4
- J4 is used for the Outputs Group 1
- Outputs Group 1
  - J4-1 Digital Output 1B
  - J4-2 Digital Output 1A
  - J4-3 Group 1 Common
  - J4-4 Group 1 Common
  - J4-5 Frequency Output 1B
  - J4-6 Frequency Output 1A

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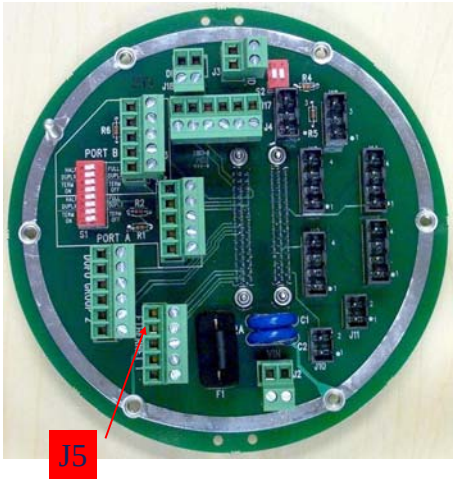
EMERSON. Process Management

Field Connection Board



- J5
- J5 is used for the Outputs Group 2
- Outputs Group 2

J5-1 Digital Output 2B
J5-2 Digital Output 2A
J5-3 Group 2 Common
J5-4 Group 2 Common
J5-5 Frequency Output 2B
J5-6 Frequency Output 2A

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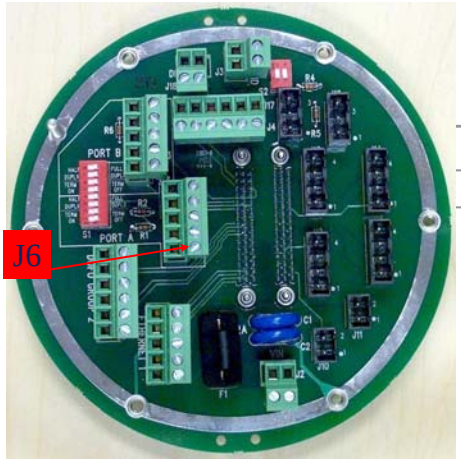
EMERSON. Process Management

Field Connection Board



- J6
- J6 is used for Port A
- Port A

	232	485 Full	485 Half
J6-1	RX	RX+	RX/TX+
J6-2	TX	RX-	RX/TX-
J6-3	COM	COM	COM
J6-4	RTS	TX+	RX/TX+
J6-5	CTS	TX-	RX/TX-

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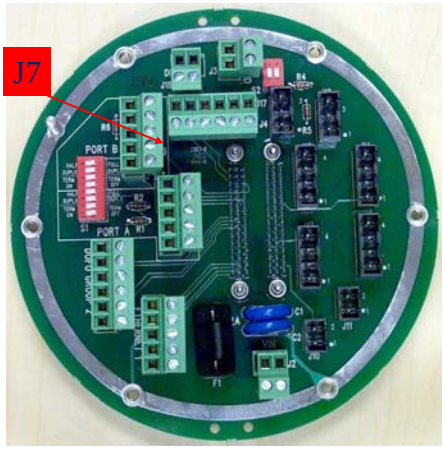
EMERSON. Process Management

Field Connection Board



- J7
- J7 is used for Port B
- Port B

	232	485 Full	485 Half
J7-1	RX	RX+	RX/TX+
J7-2	TX	RX-	RX/TX-
J7-3	COM	COM	COM
J7-4		TX+	RX/TX+
J7-5		TX-	RX/TX-

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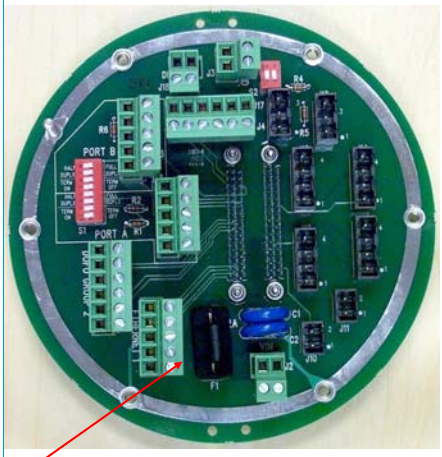
EMERSON. Process Management

Field Connection Board



J8

- J8
- J8 is used for Ethernet
- Ethernet

J7-1 TX+
J7-2 TX-
J7-3 Chassis Gnd
J7-4 RX+
J7-5 RX-

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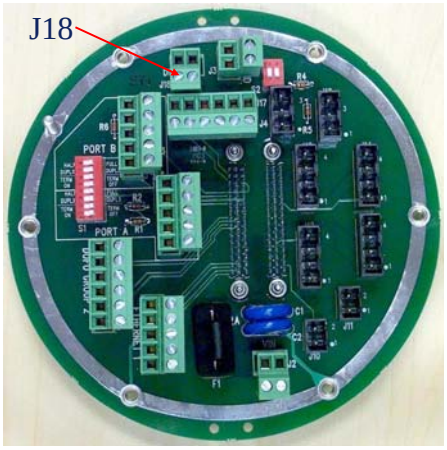
Field Connection Board



- J18
- J18 is used for Digital Input
- Digital Input

J18-1	Digital In +
J18-2	Digital In -

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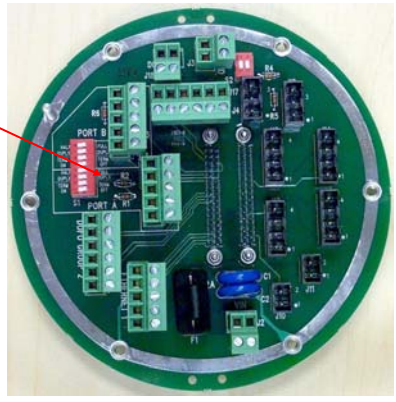
EMERSON. Process Management

Field Connection Board



- S1
- S1 is used for Port A and Port B to set up the communication to RS232 or RS485 full or half duplex.
- Port A

RS232

S1-1,2,3,4	Off

RS485 Full

S1-3,4	Off	
S1-1,2	On	Termination On
S1-1,2	Off	Termination Off

RS485 Half

S1-3,4	On	
S1-1,2	On	Termination On
S1-1,2	Off	Termination Off

For RS232 Communication 485 must be OFF and Duplex Setting must be FULL.

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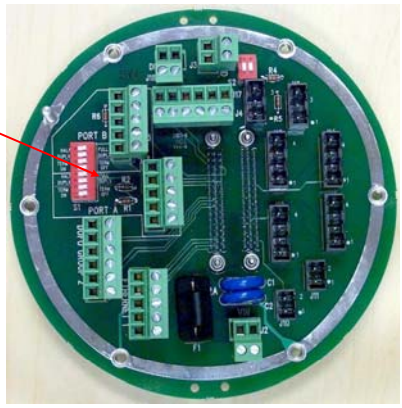
EMERSON. Process Management

Field Connection Board



- S1
- S1 is used for Port A and Port B to set up the communication to RS232 or RS485 full or half duplex.
- Port B

RS232
S1-5,6,7,8 Off

RS485 Full
S1-7,8 Off
S1-5,6 On Termination On
S1-5,6 Off Termination Off

RS485 Half } Termination On
S1-7,8 On
S1-5,6 On Termination On
S1-5,6 Off Termination Off

For RS232 Communication 485 must be OFF and Duplex Setting must be FULL.

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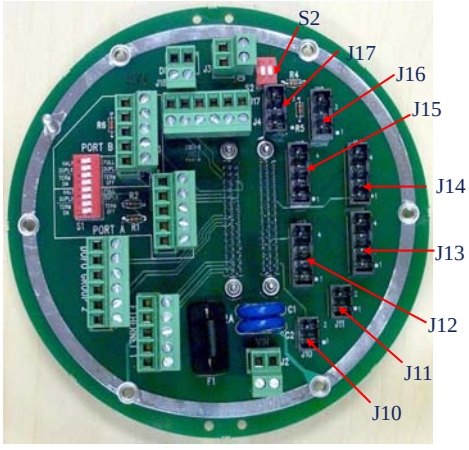
Field Connection Board



- Connectors J10-J17 (black connectors) and S2 requires the Mark III option board.

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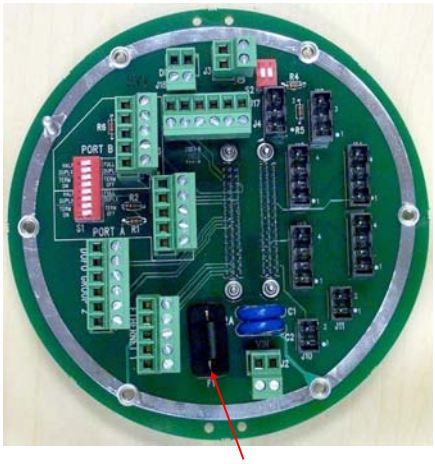
Field Connection Board



- The field connection board is equipped with a power fuse. The fuse is on the plus side of the incoming power. The fuse is rated at 2 amps.

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Acquisition Board

- The acquisition board is used to transmit and receive signal from the transducers, amplify and digitize received transducer waveforms, and send sampled waveform packets back to the CPU for processing upon request.

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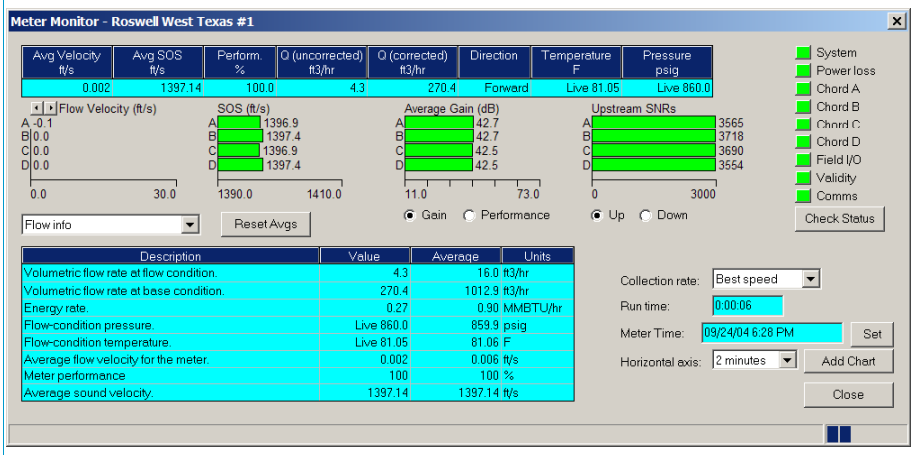
CUI 4.21 Developed to Support Mark III



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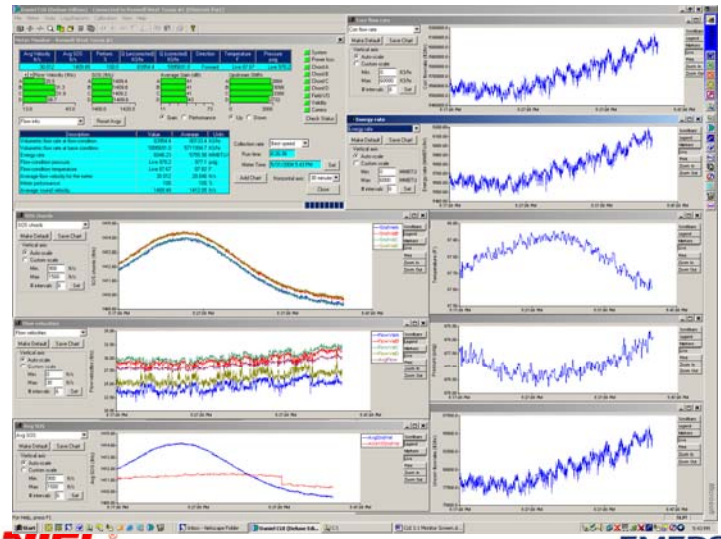
New 4.21 CUI Software



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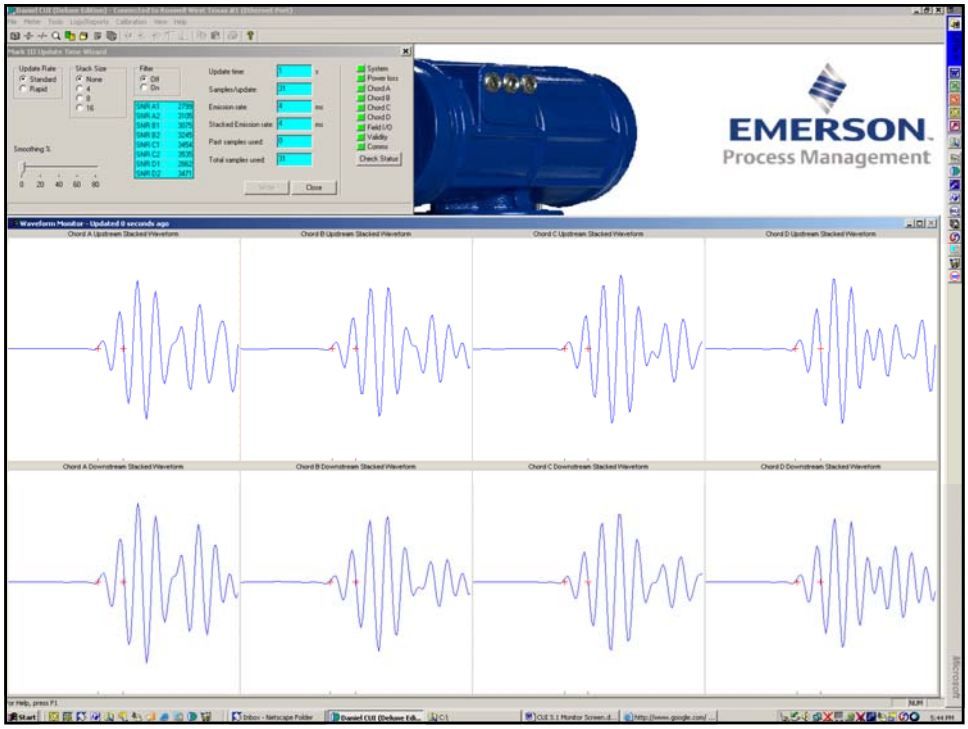

Basic CUI 4.21 Features

- → Primarily developed to support Mark III
- → Works with Mark II (fully replaces CUI 2.0)
- → Available in two different versions (Std & Deluxe)
- → Requires Win 98 (or later) due to Ethernet
- → Fast, one second updates for Monitor screen
- → Fast, one second updates for Maintenance Log
- → Provides many new features for Mark II & III

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Process Management

Highlights of CUI 4.21 New Features

- → Supports both serial & Ethernet for Mark III
  - – RS-232 Serial up to 115 kbps
  - – RS-485 Serial up to 38.4 kbps (full duplex only)
  - – Ethernet at 10 Mbps
- → Serial connectivity (RS 232/485) only for Mark II
- → Improved meter directory for quicker connections
  - – More flexibility in configuring
  - – Permits up to 3 communication settings per meter
- → Provides wizard for control valve applications
  - – Makes configuring simple

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Highlights of CUI 4.21 New Features

- → Transducer exchange wizard for both Mark II & III
  - – Includes transducer, holder and stalk
- → Improved screen for expanded gas composition
  - – Supports all 21 AGA 8 components
- → Numerous enhancements to other screens
- → Ability to see real-time waveforms – both raw and stacked simultaneously
- → Will have a full-function emulator mode

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Thanks!