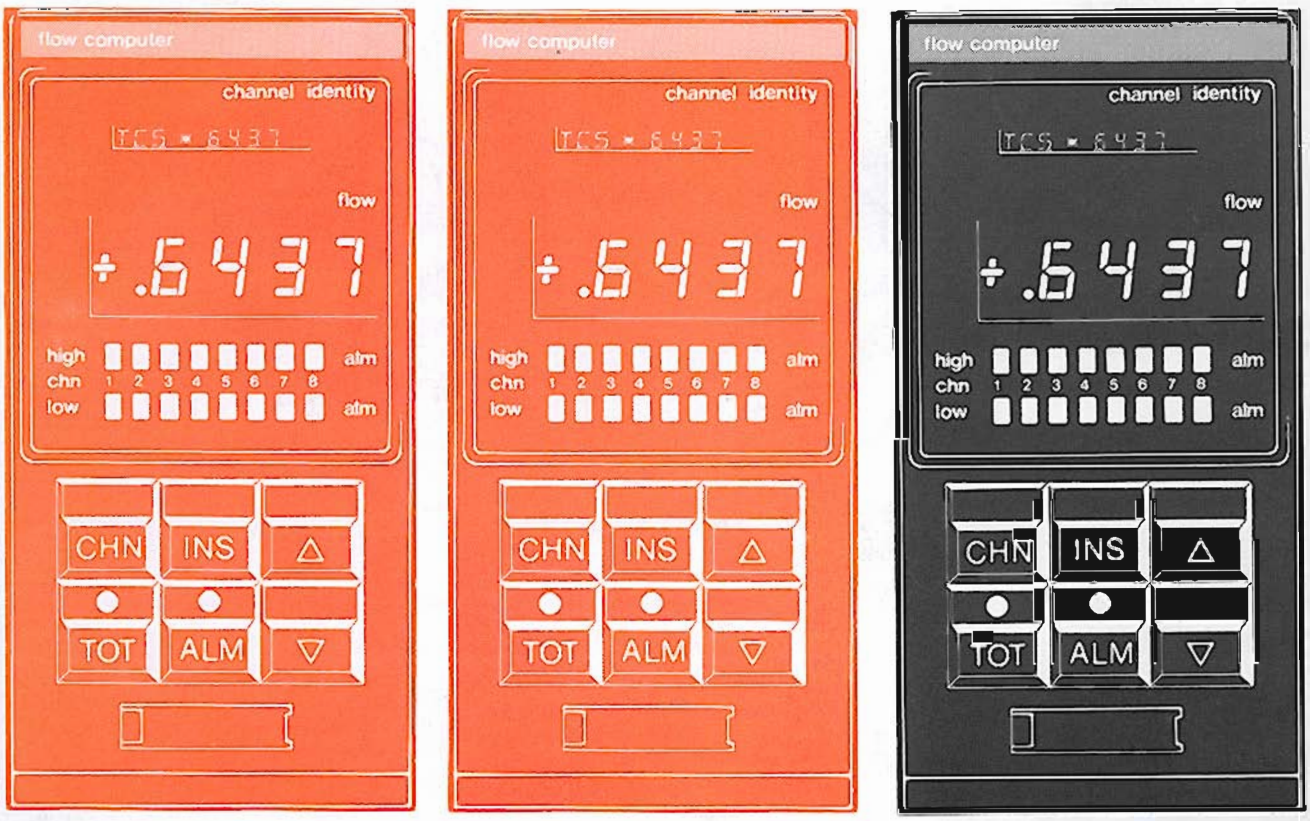
8-channel flow monitor & flow computer

TCS

system 6000

6436
6437



product specification

6436 & 6437: Features

- 6436 — Low Cost Simple 8-channel Integrator and monitor 6437 — Full Flow Computer features
- Multi-channel economy. 4 or 8 channels.
- Simple hand-held terminal configuration for uncorrected flows.
- Interactive question-and-answer program for configuring standard flow forms.
- Full Forth programmability (6437).
- Alphanumeric display of channel identity.
- 8-digit totalisation with arithmetic functions.
- 8-channel analogue, or 4-channel pulse/frequency plus 4-channel digital inputs.
- Calculates and displays Mass or Referenced Volumetric flow rate through Orifice Plates, (ISO 5167) Turbine Meters, etc. (6437).
- Compensates for and displays: temperature, static pressure/direct density inputs (6437).
- Compressibility compensation (6437).
- Optional calculated flow output.
- Optional flow alarm outputs.
- Flow additions/subtractions (6437).
- Optional pulse-totalising output.
- Remote monitoring via a single serial link.
- Field-proven hardware with two-year warranty.
- Compatible with System 6000 range.

Description

The 6436 Flow Monitor & 6437 Flow Computer utilise modern technology to calculate the mass or referenced volumetric flow rate of liquids or gases using Orifice Plates, Vortex Meters, Turbine Meters, etc.

Each channel of the 6437 accepts up to three analogue inputs. The primary input, which is always present, can be either pulse or analogue depending on transducer type, e.g. Turbine, Vortex or differential pressure from an Orifice Plate. The remaining two inputs are optional and provide a static pressure/direct density input and a temperature input.

One optional output is provided for each channel and may be used to retransmit the calculated flow (analogue output option) or as an alarm output or for pulse totalising (digital output option).

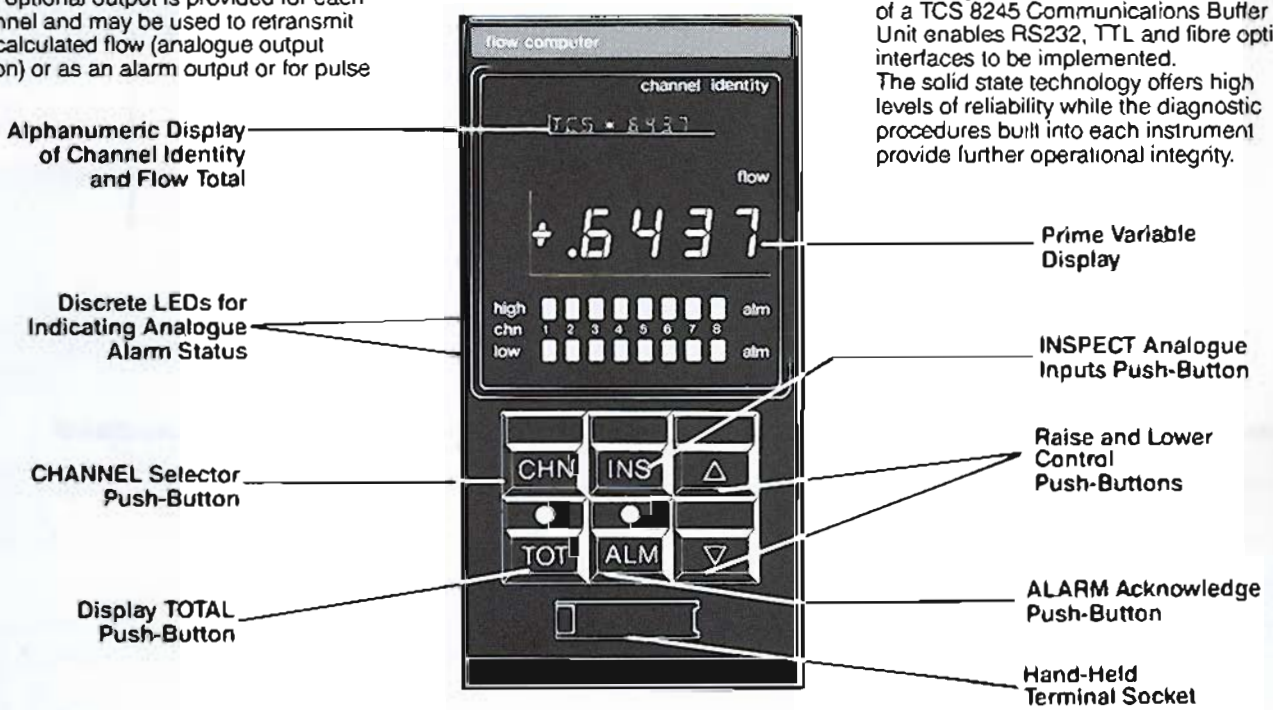
The characteristics of each flow channel may be set up by the method best suited to the complexity of the configuration.

- For simple flow equations, and limited parameter changes, use a hand-held terminal (6436 or 6437).
- For more involved standard flow equations use an external terminal (VT100 equivalent) and the resident menu-style question-and-answer configuration program (6437).
- Special algorithms may also be written in Forth, and installed in the 6437, via an external terminal.

The front panel may be used to select any of the active channels for inspection, and display the calculated flow or any of the 3 analogue inputs on the large 7-segment display. An 8-character alphanumeric display provides indication of channel identity and can be used to display the flow total for that channel.

Supervision and monitoring of the 6436/7 is made particularly simple by the provision of a communications interface. This allows an intelligent device to monitor or update any of the calculation parameters of a network of 6436/7 instruments via an RS422 serial bus using a standard ANSI protocol. Use of a TCS 8245 Communications Buffer Unit enables RS232, TTL and fibre optic interfaces to be implemented.

The solid state technology offers high levels of reliability while the diagnostic procedures built into each instrument provide further operational integrity.



Operator displays and controls

Operator displays

Digital Readout
(for calculated flow rate and all analogue inputs) 4-digit, orange LED display with sign and decimal point.

Alarm Indication
Absolute high or low flow rate alarms for all active channels indicated simultaneously by two rows of 8 red LEDs.

Alphanumeric Display
(for channel identity, flow total and on-line diagnostic messages) 8-character, red LED display.

Operator controls

Channel Selection
1 non-illuminated push-button (CHN) used in conjunction with Raise/Lower push-buttons to select any one of up to 8 active channels for display.

Alarm Acknowledge
1 illuminated push-button (ALM), with integral red LED, used to acknowledge an alarm condition on the currently displayed channel. The LED indicates the collected alarm status of all active channels.

Display Selection
1 non-illuminated push-button (INS) used in conjunction with Raise/Lower push-buttons to select an analogue input of the currently displayed channel for inspection.
1 illuminated push-button (TOT), with integral yellow LED, used to select the flow total of the currently displayed channel for inspection. LED on indicates normal totalisation for that channel.

Function Selection
2 non-illuminated push-buttons Raise (▲) and Lower (▼) used in conjunction with CHN, INS and TOT push-buttons as described above.

Applications

The powerful combination of sophistication with flexibility means that the 6436/7 instruments are suitable for most flow monitoring applications using the standard configuration program.

The full Forth interpreter allows total flexibility for programming batch control functions — special calculations, etc. All System 6000 instruments use standard voltage and current levels for their analogue and digital interfaces. The 6437 has up to three inputs per channel whose functions vary depending on the type of flow meter and density correction being used. The examples below show some of the many alternative configurations.

As well as monitoring the flow-derived variable (e.g. differential pressure) and secondary variables (e.g. temperature), the 6437 uses the values of a number of constants in order to compute correctly the mass or referenced volumetric flow rate (ISO 5167 form). These are entered via the hand-held terminal which gives authorised personnel ready access to the values. All such constants are accessible over a supervisory serial link and can be written in remotely by another intelligent device.

The 6436 and 6437 may be equipped with one of two output options which provide either a retransmitted calculated flow signal or a flow totalisation pulse output that can be used to drive an external counter for additional display. The pulse output may be used instead as an alarm output. Where associated input or output signal conditioning is required, the appropriate units from the TCS range of plug-in modules can be easily packaged with the 6436 and 6437.

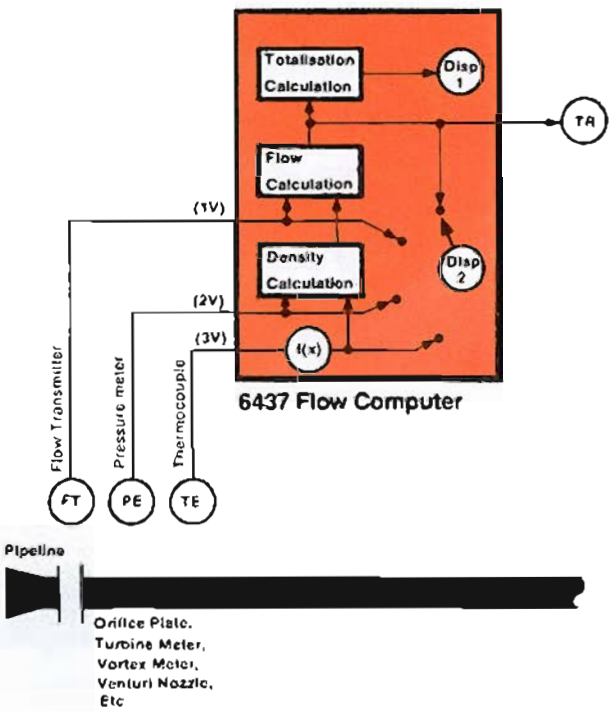
Auxiliary modules are also available to provide extra digital or analogue bargraph displays of variables and the Chessell range of chart recorders is plug-compatible with the TCS module system.
The simplified version — 6436 — is provided for non-compensated flow integration.

Typical Applications

- **Multi-Channel Energy Monitoring.**
- **Multi-Tariff Metering.**
- **Multi-head Orifice Plate Flow Indication/Totalisation.**
- **Batch Calculation.**
- **Compressibility Correction.**
- **Blending.**

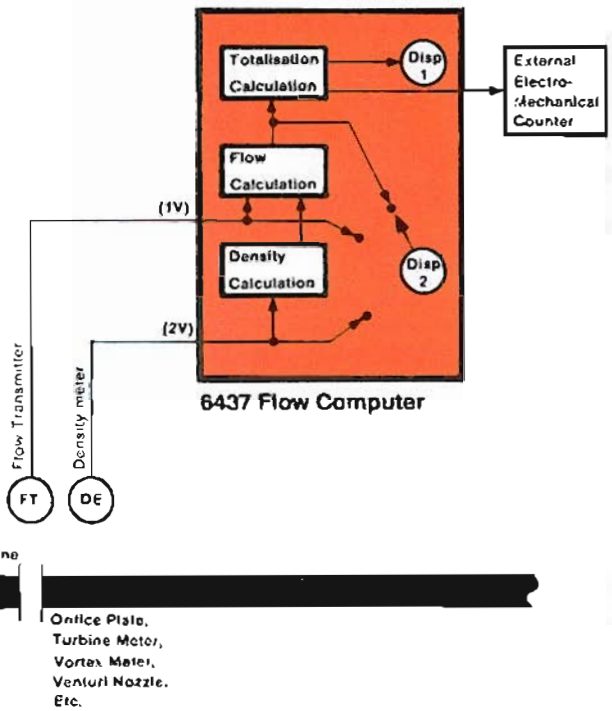
Flow measurement and totalisation — Gas/Liquid

Gas Example



Flow Measured From Orifice Plate, Turbine Meter, Vortex Meter, Venturi Nozzle, etc. with Temperature and Pressure Correction and Retransmitted Flow (0-10V).

Liquid Example



Flow Measured From Orifice Plate, Turbine Meter, Vortex Meter, Venturi Nozzle, etc. with Densitometer Correction, plus Pulse Output to External Totalising Converter.

Flow calculations

General Forms of Equations Available via Configuration Program (6437).

Transducer	Calculation Form
Turbine Meter	FL(computed) = 1C×2C×1V×DCT
GILFLO Orifice Meter	FL(computed) = 1C×2C×1V×$\sqrt{\ }$ DCT
Orifice Meter	FL(computed) = 1C×2C×$\sqrt{1}$V×$\sqrt{}$DCT
User Equations (FORTH)	FL(computed) = Special Forth programmed algorithm

N.B. All combinations of 1V and $\sqrt{1}$V and DCT, $\sqrt{}$DCT, $\frac{1}{DCT}$, $\sqrt{\frac{1}{DCT}}$ are available where: DCT = Density Correction Term; FL = Calculated Flow; 1V = Primary Input; 1C = Constant; 2C = Constant } Calculated by the configuration program

Density Correction

DCT may be selected from the following forms:

Direct Density Input

DCT = Measured value, 2V; or
Internal constant, 2K.

First Order Gas Equation with Compressibility Factor

$$DCT = \frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}$$

where 2V = Secondary Input (or Internal Constant)
3V = Tertiary Input (or Internal Constant)
TO = Reference Temperature (Absolute)
PO = Reference Pressure (Absolute)
SG = Relative Density (Specific Gravity)
TA = Offset to Absolute Zero from Temperature Measurement Scale Zero
PA = Offset to Absolute Zero from Pressure Measurement Scale Zero
XO = Base Compressibility (a Value of 0 disables the Compressibility Factor)

Compressibility Factor 0°C < TF < 40°C and PF < 70Bar

$$ZF = 1 + b(PF + PA) + c(PF + PA)^2$$

$$b = (3C + (4C \times TF) - (5C \times TF^2)) \times 10^{-5}$$

$$c = (6C + (7C \times TF) + (8C \times TF^2)) \times 10^{-8}$$

3C, 4C, 5C, 6C, 7C, 8C = Scaling Factors

Second Order Gas Equation

$$DCT = 3C \times \frac{1 + 5C \times 10^{-2} \times (2V + PA - PO) + 6C \times 10^{-5} (2V + PA - PO)^2}{1 + 7C \times 10^{-3} \times (3V + TA - TO) + 8C \times 10^{-7} (3V + TA - TO)^2}$$

5C and 6C — Pressure constants are calculated by the Configuration Program
7C and 8C — Temperature constants are calculated by the Configuration Program

Examples

Orifice Plate with temperature and static pressure

$$FL = 1C \times 2C \times \sqrt{1V \times \frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}}$$

Turbine Meter with direct density input

$$FL = 1C \times 2C \times 1V \times 2V$$

Vortex Meter with temperature input

$$FL = 1C \times 2C \times 1V \times \left[\frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF} \right]$$

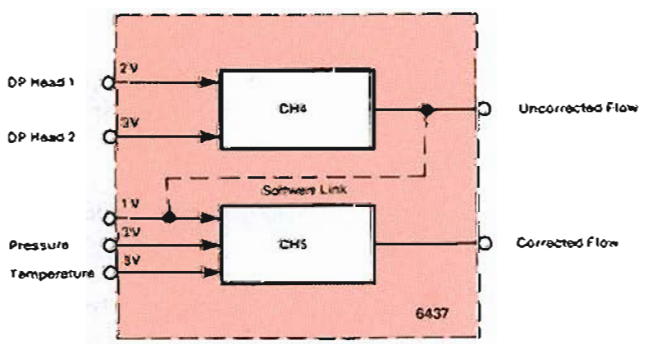
Direct Flow Input

$$FL = 1C \times 2C \times 1V \times 2K$$ (1C, 2C and 2K set to 1)

Examples These examples illustrate the instrument capabilities only and many other configurations are possible.

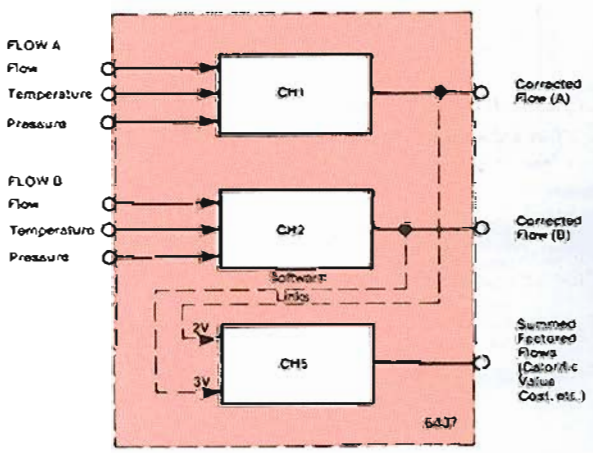
Dual Head Orifice Plate

The low Flow Range (DP1) and high Flow Range (DP2) are conditionally selected in CH4 and corrected for temperature/pressure variations in CH5.



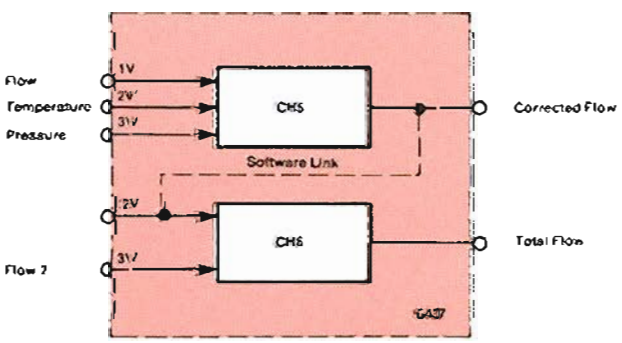
Multi-Tariffing

CH5 totalises the added factored flows providing indication of energy usage, fuel costs, etc.



Flow Manipulations

Outputs of flow calculation channels may be software patched to the inputs of unused channels.



The Density Correction Term, DCT, may be set to allow:

- Addition of Factored Flows.
- Selection of Factored Flow with either Low Range Clipped to Zero, or High Range Cut-Off.

e.g DCT=Term 1 + Term 2

IF 2V < 3C
THEN Term 1 = (2V + 5C) × 6C
ELSE Term 1 = 0

IF 2V > 4C
THEN Term 2 = (3V + 7C) × 8C
ELSE Term 2 = 0

N.B. 2V, 3V could be either Real Inputs, Software Patched Inputs or Constants.

Software Specification

Programming Language (6437)

Stack-oriented, FORTH-like language with enhancements for input/output, timing etc.

Program Memory

8K byte RAM
8K byte EEPROM

Database

62 instrument parameters
2 Tag parameters per channel
24 channel status parameters (analogue inputs)
8 channel status parameters (analogue outputs)
4 channel status parameters (pulse inputs)
8 channel status parameters (digital outputs)
16 timers
64 variables

Data Format

32 bit floating point with optimisation for logical data, flags etc.

Timer precision: 1 bit corresponds to 2 milliseconds (Max count about 7 weeks).

Program Creation

```
: BGRND
    :
    :
:
: FLOW 'n'
    :
    :
;
```

Line Editor

BACKSPACE
TAB
DELETE

Operating Modes

Command Mode	: DC1 (CTRL Q)
CMD ??	: Z
Scroll	: W
Enter +	: L
Enter –	: M
Programming Mode	: DLE (CTRL P)
Program Execution	: Word BGRND is executed at power up.
Termination	: ESCAPE terminates program execution or Edit mode and resets error condition.

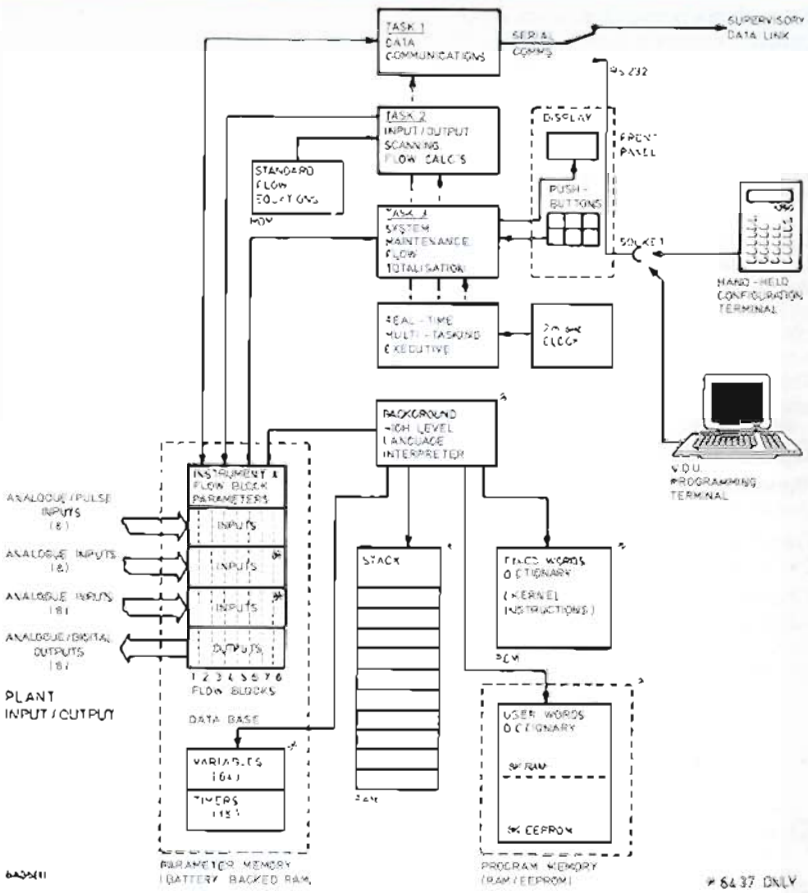
Programming Terminal Utilities

Load
- Initiate (to 6437) : STX (CTRL B)
- Terminate (to 6437) : ETX (CTRL C)

Save
- Initiate (to 6437) : ENQ (CTRL E)
- Terminate (from 6437): ETX (CTRL C)

Error Reporting

Database and Forth Error Codes



Fixed Words Dictionary

Arithmetic

+
–
*
/
ABS
MAX
MID
MIN
MINUS
SQR
SQRT
SIN
COS
ATAN
ATAN 2
DCT1
DCT2
DCT3
DCT4
E
EXP
LN
MOD9
PI
INT
TOTAL +
TOTAL –

Logical

AND
OR
XOR
NOT

Comparison

<
>
=
0 >
0 <

Display Control

TAG."
TAG.
GETCN
SETCN

Input/Output

GETAN
SETAN
GETPAR
SETPAR
GETTOT
SETTOT

Global Variable

GETVAR
SETVAR
DIFVAR
SUMVAR

Timer

GETTIM
SETTIM
+TIM

Terminal Input/Output

KEY
NUMBER
EMIT
."
.
SPACE
CR
LF
BS
FS
NL
#
$

Stack Manipulation

DROP
DUP
OVER
PICK
ROLL
ROT
SWAP

Control Structures

DO . . . LOOP
I
LEAVE
DO . . +LOOP
BEGIN . . . REPEAT
BEGIN . . . UNTIL
IF . . . ENDIF
ELSE
CASE . . . ENDCASE
OF . . . ENDOF
ELSOF . . . ENDOF

System Utilities

WINDOW
FWORDS
UWORDS
ULIST
FORGET
INSERT
NEW
RUN
HALT
STORE
RECALL
CLEAN
TRA-ON
TRA-OFF
CONFIG
HEXDUMP

Communications

Every System 6000 microprocessor based instrument is fitted with an RS232 port and an RS422 port for serial data communications. The RS232 port is available via a front-panel socket and is used for the 8260 Hand-held programming terminal. The RS422 port is available on the module rear connector pins and is bussed onto the supervisory data link common to all modules. All parameters that can be monitored via the 8260 terminal can also be accessed and updated via the supervisory data link.

Hand-held terminal

Each System 6000 instrument can be set up using a plug-in 8260 Hand-held terminal. Every parameter is accessed by means of a simple 2-character command mnemonic and all data are entered directly in engineering units. This technique ensures the accuracy and security of parameter settings.

Specification

Transmission Standard
2-wire RS232/V24 (± 12V)

Data Rate
300 baud.

Character Length
10 bits made up of:
1 start + 7 data + 1 parity (even) + stop.

The photograph shows an 8260 terminal plugged into the front panel of a 6436. A full list of the available command parameters is given in the 6436/7 Facts Card.

Programming Terminal

Applications and Configuration Programs may be entered using any RS232/Teletype-compatible VDU plugged into the front panel socket of the 6437. This allows statement entry, editing and listing in Program mode as well as the parameter configuration facilities normally available in Command (Hand-held Terminal) mode.

More extensive facilities are provided by the 8261 Programming Terminal based on the Epson PX8. This allows off-line creation, documentation and disk/tape storage of applications programs using a word processing package. Programs may be block down-loaded to the 6437.

Datalink Specification

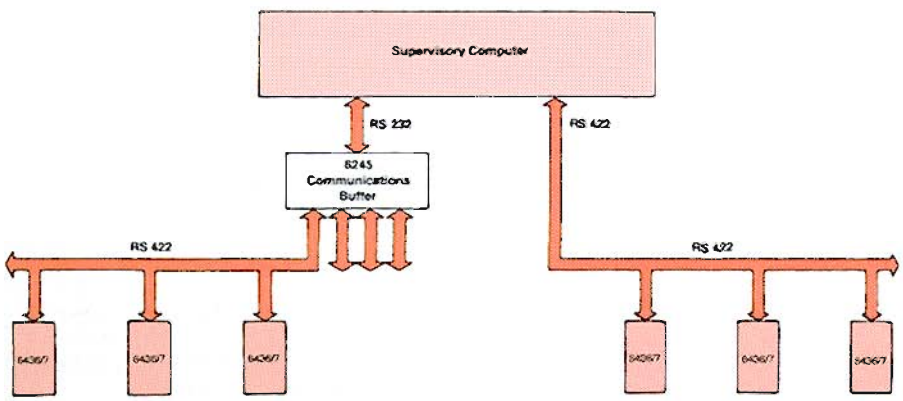
Transmission Standard Character Length
As for Hand-held Terminal.

Data Rate
Selectable from 110, 300, 600, 1200, 2400, 3600, 4800 or 9600 baud.

Multi-drop supervisory link

Every System 6000 instrument contains an RS422 communications port which enables it to send and receive command parameters over a simple four-wire link connected to other intelligent devices. The use of RS422 and the transmission of information in ASCII or Binary data format makes it particularly easy to communicate with the 6436/7.
To hook the 6436/7 into a distributed instrumentation system requires no modification to the instrument and no further expenditure on options. The four-wire link is simply connected up so that the 6436/7 becomes part of the system.

The illustration shows how an array of 6436/7s can be directly connected to a supervisory computer which has an RS422 serial port. If the computer only has an RS232 serial port then an 8245 Communications Buffer Unit can be used to carry out the required RS232 to RS422 conversion as shown.



Specification

Transmission Standard
4-wire RS422 (0-5V)

Line Impedance
120-140 ohm twisted pair.

Line Length
4000 ft max. (at 9600 baud).

Number of Units/Line 16.

Data Rate
Selectable from 110, 300, 600, 1200, 2400, 3600, 4800 or 9600 baud.

Character Length (ASCII/Binary)
10/11 bits — 300 to 9600 baud.
11/12 bits — 110 baud (2 stop).

Protocol

All microprocesor based instruments in the System 6000 range employ a standard ANSI protocol known as BI-SYNCH. The exact form of BI-SYNCH implemented within System 6000 corresponds to the American National Standard specification:

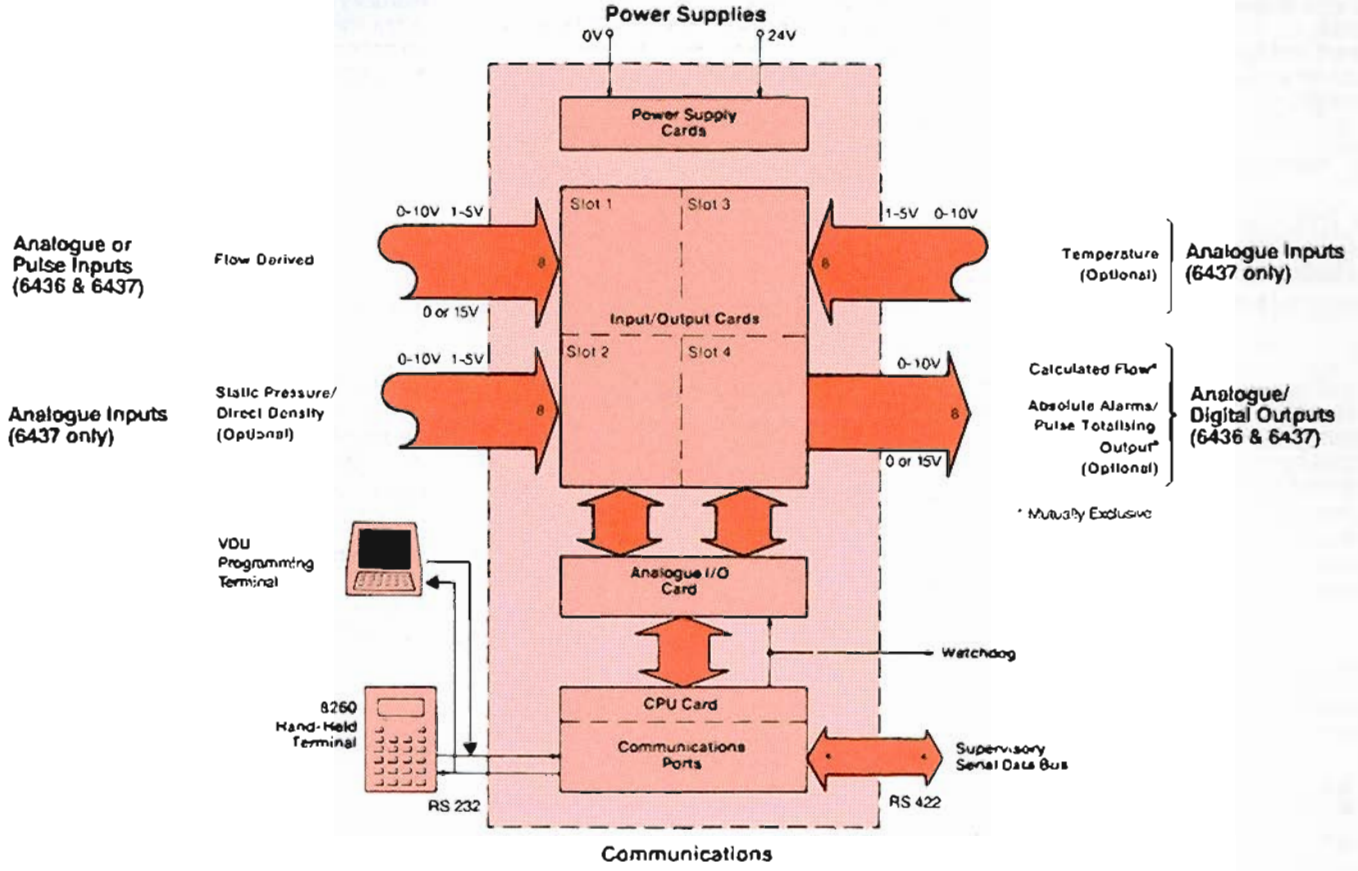
ANSI – X3.28 – 2.5 – A4 Revision 1976

TCS has implemented both an ASCII and Binary version of this protocol within each instrument.

The ASCII mode is simplest to use as all data are transmitted in ASCII characters.

The Binary mode offers a 4 to 1 increase in transmission speed by compressing the data into a binary format, and also supports additional features like Multi-Parameter and Enquiry Polling.

Input/Output signals



Analogue inputs

Number of Channels
8 direct non-isolated inputs plus 16 optional inputs.

Channel Functions
Slot 1, channels 1 to 8 = flow derived inputs.
Slot 2, channels 1 to 8 = static pressure/direct density (optional).
Slot 3, channels 1 to 8 = temperature (optional).

Input Signal Levels
Inputs are 0-10V or 1-5V range (4-20mA with external resistors.)

Resolution
12 bit binary ADC(.025%) hardware applied to inputs.
15 bit binary representation obtained after digital input filtering and signal averaging giving resolution of 1 digit in ±9999.

Accuracy
± 1 LSB typ. over 0-50°C range for hardware.
± 1 digit of reading for 0-4000 range,
± 2 digits of reading for 0-8000 range,
± 3 digits of reading for 0-9999 range, after input filtering.

Sampling Rate
ADC samples each input every 496ms. (8 channels enabled).

Input Impedance
1Mohm pull-down to 0V on all channels.

Input Signal Processing
Linear (normal or inverse)
Normalised square root.
Type J, K, T, S, R, E, B thermocouples.
Platinum resistance thermometers.
User specified linearisation functions.

Pulse Inputs

Number of Channels
4 direct non-isolated inputs to counter positive edge triggered (Count up only).

Channel Functions
Slot 1, only channels 1 to 4 = flow derived inputs.

Input Voltage Levels
5V to 15V = Logic 1
0V = Logic 0
with hysteresis of 200mV.

Input Waveform
Square wave to maximum frequency. Pulse train with minimum pulse width 15μ sec.

Input Frequency Range
(Range software selectable).
0.0001Hz to 10kHz

Accuracy
Average rate measured to 0.025% of reading. No pulses missed.

Input Sampling Rate
300ms for frequencies greater than 10Hz. The input signal period, for frequencies less than 1 Hz.

Input Impedance
100kohm pull-down to 0V gives 150μA logic one current.

Input Signal Processing
Linear (normal or inverse).
User specified linearisation functions.

Digital inputs

Number of Channels
4 non-latched non-isolated inputs

Channel Functions
Slot 1, only channels 5 to 8.

Input Voltage Levels
15V = logic one
0V = logic zero.

Input Impedance
100kohm pull-down to 0V (gives 150μA logic one current).

Input Sampling Rate
All inputs sampled once every 62ms.

Analogue outputs

Number of channels
8 optional direct non-isolated outputs.

Channel Functions
Slot 4, channels 1 to 8 = calculated flow output (optional and mutually exclusive with common absolute alarms/pulse totalisation digital outputs).

Output Signals Levels
Direct outputs are 0-10V range.

Output Circuit Type
Medium-term analogue sample-and-hold circuits preceded by DAC.

Output Resolution
12 bit binary (.025%) giving minimum analogue voltage steps of 2.5mV.

0-10V Output Accuracy
± 1 LSB typ. over 0-50°C range.

Sample and Hold
DAC updates each output every 496ms. (8 channels enabled).

Output Drift Rate under Watchdog Failure Conditions
½mV/sec maximum (equivalent to 1% of full scale in 3 minutes).

Output Drive Capability
± 5mA for direct voltage outputs.

Digital outputs

Number of Outputs
8 optional non-isolated outputs plus Watchdog.

Outputs Functions
Slot 4, outputs 1 to 8 = common absolute alarms/pulse totalisation (4Hz max.) (optional and mutually exclusive with calculated flow analogue outputs).

Output Voltage Levels
15V = logic one.
0V = logic zero.

Output Drive Capability
2k2 open-collector pull-up to +15V supply, maximum logic zero sink current = 16mA.

Output Update Rate
Each channel alarm output is updated every 496ms (8 channels enabled).

Power supplies

Input Voltage
(May be unsmoothed, full-wave rectified AC).
20-30 V DC recommended operating range.
19-35V DC absolute maximum input limits

Input Current
500mA without hand-held terminal.
650mA with hand-held terminal.
Input Fuse Rating
2A.
Power Failure Detect Threshold
When input voltage falls below 16.5 ± 2V.

Memory Standby Battery
3.0V Lithium type.
160mAh rating.
8-10 year shelf life.
5 year life typical on continuous standby.

Ordering information

Basic Instrument

6436 or 6437 — 8 Channel Flow Monitor or Flow Computer is fitted either with a pulse input card or analogue input card as follows:

/PULSE-IN*
4-way pulse input card providing four flow inputs each with density correction calculation if appropriate. (Four additional "pseudo" input channels may be software patched from the other output channels.)

/AN-IN*
8-way analogue input card providing eight flow inputs each with density correction calculations if appropriate.

/CMP1 (6437 only)
8-way Analogue input card providing:
Either 1) Variable direct density compensation.
or 2) Variable pressure in compensation calculation for each channel.

/CMP2 (6437 only)
Additional 8-way Analogue input card providing variable temperature in compensation calculation for each channel.

/RFL†
Additional 8-way Analogue output card providing retransmitted calculated flow facility for each channel.

/ALMPLS†
Additional 8-way Digital output card providing:
Either 1) Common absolute flow rate alarms.
or 2) Pulse totalisation outputs for each channel.

†* **These options are mutually exclusive.**

Example

6437/PULSE-IN/CMP1/CMP2/RFL: Flow Computer employing four channel pulse inputs with temperature and pressure inputs for density compensation, plus retransmitted calculated flow output.

Mechanical details

All System 6000 microprocessor based instruments are supplied in 72mm wide metal housings fitted with front-panel fascias and catch handles for module retention. They may be used with a wide variety of rack and panel mounting hardware as illustrated in the examples below.

7950 system

The 7950 Universal Packaging System enables up to six 6436/7 instruments, or combinations of micro-based modules, Matric modules, and Chessell recorders, to be fitted into a single 19 inch sleeve, which may be rack or panel mounted.

The 7950 system is also available with a panel mounting option in three other widths: 72mm, 144mm, and 216mm, for mounting 1, 2, or 3 6436/7 units respectively.

Customer screw terminal blocks are protected by an optional hinge-down rear cover, which may itself incorporate built-in (8750) mains power units, available in all width options.

7950 sleeve

	6-way	1-way
width:	482	105
height:	177	177
depth:	380	423

Overall dimensions in mm of housings illustrated:

Panel cut-out dimensions in mm.

	6-way	1-way
width:	448.2	88.2
height:	166.3	166.3

Details

For further details refer to:
6436/7 Eight-channel Flow Monitor & Flow Computer Technical Manual.

6436/7 Facts Card
6436/7 User Guide

7950 Universal Packaging System: Product Specification.

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Advanced Instrumentation

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