LOW-POWER FLOW COMPUTERS

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INTRODUCTION

As we enter the second decade of use of Low Power Flow Computers (LPFCs), we do so with significantly different hardware, software, economics and motivating forces.

These differences are worthy of close examination, as they ultimately will affect all of us in this industry.

In order to focus on the majority of applications for LPFCs, we will limit this discussion to those operating on battery only or batteries with recharging systems.

We will particularly focus on the stand-alone flow computing RTUs and their measurement and control functions.

Remote communication, data gathering, data concentration, editing, automatic billing and remote gas system control are of such importance in this era of low gas prices as to be a virtual requirement for staying efficient enough to be competitive. These considerations significantly effect the selection criteria of LPFC hardware, software, telemetry and gas control schemes.

LPFC REQUIREMENTS

These compact electronic measurement systems are usually expected to operate at sites where no commercial power exists.

They must *ALWAYS* have:

- a self-contained power source
- the ability to take inputs from transmitters or transducers
- the ability to perform accepted calculations
- the ability to log or transmit data (usually both)
- the ability to display select data on-site (via a display or hand held device or both)

They must *ALWAYS* be:

- accurate
- reliable
- Hazardous Area Safe
- easy to operate (user friendly)
- easy to field repair by subassembly changeout
- easy to calibrate by field personnel
- a better overall investment than the alternatives

These are tough general criteria to meet and have been an ongoing challenge to the best resources in the instrumentation industry.

The evolution over the last decade has produced, by conventional measurement standards, a series of field computers which provide an impressive list of functions for the investment.

LPFC PRIMARY FUNCTIONS

The primary function of a typical LPFC is to *MEASURE* or *CONTROL* a fluid within a pipeline.

Measurement

An LPFC typically has the MINIMUM ability to measure:

- Temperature
- Differential Pressure
- Static Pressure
- Pulses from a pulse output flowmeter

From these primary inputs the MINIMUM calculations performed are usually:

- Volume Rate
- Volume Total
- Average Differential Pressure (if required)
- Average Temperature
- Average Static Pressure

Control

An LPFC usually has the MINIMUM ability to control (via solid-state contact closures):

- Composite samplers
- Additive injectors
- Alarm annunciation

(MAXIMUM configurations often become very sophisticated. We will examine some of those configurations in the application section.)

THE LPFC HARDWARE

In the first decade of LPFCs the industry produced various dedicated Electronic Flow Meters, known as EFMs. Remote Terminal Units, known as RTUs, were routinely applied as remote flow computing devices. Each of these units has its appropriate application, with some overlap.

EFMS

These units are primarily dedicated to fast flow rate calculation, totalization and flow data logging for production, gathering, transmission, storage and distribution of natural gas. The hardware of an EFM is usually a package consisting of:

1. The microprocessor I.C. and its master clock time base circuitry.

2. Random Access Memory (RAM) for temporary math intermediate results, user data bases, and storage of "logged" numbers, events, alarms, etc. This is usually "Battery-Backed."

3. Read Only Memories (ROMS) used in EFM's are the Programmable Read Only Memory, or PROM type. Either or both of ultra-violet light erasable (EPROM or uvPROM) or Electrically Alterable and Reprogrammable Read Only Memory (EEPROM) is employed to hold (without power) the resident math package, calculation routines, data acquisition and handling chores, report and communication formatting, display and print formatting and basically any function that appears "hard-wired" into the machine. Most new designs incorporate "Flash-Ram."

4. Analog to digital converters, or "ADCs" are commonly called the "A to D." These devices are successive approximation, Delta Sigma, or continuous integration I.C.'s which convert an analog signal to a digital number.

It is considered that a high accuracy A-D with at least 12 bit conversion should be used in precision measurement. "12 bit" conversion means 12 significant binary bits, which gives you 2^{12} number combinations or 1 part in 4.096. 1 part in 1,000 is 1/10th percent, therefore, 1 part in 4,096 is just over 1/40th of one percent conversion accuracy. Although, as I.C. technology improves, 16 bit A-D's will be common.

5. Power supply circuitry which usually includes regulation, isolation, current limiting, over and under voltage protection and generation of the multiple DC voltages a typical microprocessor measurement system requires. The power supply may or may not incorporate the power source charge control circuitry used to keep rechargeable batteries charged via a solar array, thermoelectric generator or (where commercial or generator power is available and preferred) an AC to DC power supply.

The EFM hardware, regardless of vendor, should include some generally similar features which a user should be aware of and expect to see in a good EFM system.

These general features are as follows:

1. Charge source precision regulation for rechargeable systems.

2. A tight sealed NEMA weatherproof enclosure with an internal desiccant pack.

3. An onboard D.C. supply which will power up external transmitters should the user prefer external to internal units to gain the conventional zero and span adjustments in addition to the software set limits.

4. Complete surge protection on all input and output loops. This should incorporate some combination of varistors, clamping diodes and current limiting resistors. The better units will incorporate all of these on each I/O.

5. A ready point or "lug" to provide a ground wire to bleed off any induced charges from area lightning ground surges, etc.

6. A mechanism to allow physical security via a padlock or similar locking device.

7. The EFM should have an official rating of intrinsic safety and be placarded with the rating agency's sticker. EFM's are usually available with a 1D2 rating and some are available with 1D1 ratings. (Class 1, Division 1; System or Entity).

8. A local display (usually an LCD).

Depending on the manufacturer used, the display may be on and visible continuously for walk up or drive by inspection or the display may be in a sleep mode to conserve power and require a manual push button to be activated in order to be read.

9. The D.C. power source is usually a rechargeable battery but may be a non-rechargeable cell.

10. A recharge source, typically a photovoltaic "solar cell."

11. The transducers or transmitters required for the application.

These may be low power transmitters, transducers or a combination of both.

12. A digital data port and cable to couple a handheld terminal unit or MS-DOS laptop for setup, calibration and local data extraction.

13. A hardware kit including mounting brackets, clamps, cables, etc.

14. A set of operation manuals and in most cases a full set of operational software program diskettes. Some vendors provide software as a

separately purchased item and will not be part of the "ALL PUT TOGETHER" package. Some vendors may require a licensing fee. These points should be addressed prior to procurement.

THE LPFC SOFTWARE

EFM applications require various levels of software in order to be a real asset to a measurement system. The overall fit of the entire software package to the operation, maintenance, data acquisition, data editing, data communication and end usage is typically a more paramount decision point than the primary hardware. The EFM version of a LPFC overall software package must have as a MINIMUM:

1. The onboard control software for the microprocessor.

2. The compatible first-level data acquisition software (for the hand held terminal or laptop unit).

To be a truly useful measurement system the additional software that should be available is:

3. REMOTE DATA ACQUISITION software. This would typically be a program which interprets the communication protocol and allows a local, or central computer, to perform two way communication with one or a group of EFMs. This program should allow automatic timed polling for a select group of data as defined at setup. It should also allow the option to select incoming REPORTING BY EXCEPTION when alarms or unscheduled events occur.

   The remote data acquisition package must allow formatting for printed reports, printer type setup, intermediate telemetry matching of baud rate, number of bits per data word, stop bit selection, parity checking, received data editing and file generation for storage on diskette or hard disk. An EXPORT function should be incorporated to allow an easy way to send the accumulated data via modem to a central main computer for billing, control or multi-user access.

The EFM application of LPFCs produces a tremendous amount of data.

The volume of data which resides on magnetic media can be an easily accessed and used asset; or it can be a nightmare of continuously growing proportion.

The difference between this desirable and highly undesirable situation lies in the user's ability to MANAGE the data. An excellent overall software package should incorporate this management function and allow the user to:

1. EDIT data by viewing the data text and inserting corrected numbers and comments.

2. SELECT the spreadsheet of choice and automatically format the row and column locators.

3. RECALCULATE edited data automatically. I.E.: Entering a gas gravity from the analyzed result of a composite sampler and automatically recalculating every hourly or daily report line for the previous month.

4. CONDENSE data prior to exporting it to a main computer or printing a final report. A prime example is the requirement to calculate, log and store hourly data (for operational history) and reduce each contract day's twenty-four hourly report lines to a single daily summary for billing purposes.

5. PRESENT HISTORICAL TRENDS in the form of graphs with easy selection of which variable or variables to plot and allow the user to easily set the ranges for a comfortable visual presentation with adequate resolution.

The descriptions in the HARDWARE and SOFTWARE sections above are the "system" descriptions of the expectations of an Electronic Flow Metering application of a Low Power Field Computer. An "all-put-together" EFM system package may typically incorporate all of these items.

RTUS

Remote Transmitter Units (RTUs) have basically similar microprocessor systems and have historically been used at remote sites to monitor a large number of field inputs. The typical priority of an RTU is the internal housekeeping of scanning a large number of inputs and making control decisions and reporting data via telemetry. The RTU may control valves, injectors, samplers, compressor, prime movers, motor starts, etc. from onboard instruction sets or may do so as a transparent slave from a remote host computer via modem interface through land line, cellular phone, microwave radio, satellite transceivers or combinations of these transmission medias.

Large control RTUs typically do not put high priority to high speed flow calculations and fluid state equations as is the highest priority for EFMs. EFMs are available with a significant amount of control functions and RTUs have evolved in the last decade toward greater dedication to calculations. As time progresses the deadband between the application of an EFM LPFC and a RTU LPFC has narrowed. It is, in fact, common for vendors to apply EFMs as small RTUs and oversize RTUs as flow computers. This has posed some user confusion. Where do you draw the line between "under capable" and "over priced"? Only a few companies have approached the solution to this dilemma. Companies that fully realize the financial gains of electronic metering and remote site control continuously shop and custom specify the hardware and software options their system needs. Custom hardware or software can be an extremely expensive proposition.

TELEMETRY

Hardware and software is of obvious first level importance. When assembling a gas measurement system incorporating numerous LPFCs in remote areas, the relay of data from field to central is the next level of importance and typically may be harder to accomplish than the measurement and control functions. The common available techniques are:

1. PHONE MODEMS: When land line phone service is available, this is the least expensive option. A 202 or 212 series modem is usually used and typically operates between 300 baud and 1200 baud. The great majority are 1200 as that speed is usually adequately fast and less expensive than higher speed modems. Line powered modems are usually NOT INTRINSICALLY SAFE and must be placed outside the hazard zone and make a safe entry into the hazard zone via safety barriers. Some LPFC manufacturers have custom designed modems with listed intrinsically safe modem-to LPFC loops that do not require the additional expense of separate intrinsic safety barriers. The LPFC considered for use with a modem should have the auto-dial/ auto-answer feature built into its operating software. This makes modem hook-up relatively easy.

2. CELLULAR PHONE MODEMS: In areas where land line hookup is unavailable, if the LPFC site is within a "CELL" area, then cellular phone modems may be an obvious choice. These are offered by many companies as commercial powered, and some offer solar powered units. BE AWARE that some special features will be needed for a remote cellular digital data phone modem system. It should include:

   - Call outbound security via a preauthorized phone number list. This will avoid unauthorized personal calls.
   - Automatic hang-up timer after a short non-activity period.
   - Data integrity handling via cyclic redundancy checks ensuring good integrity during high private usage peak hours.
   - Similar to line powered phone modems; you will typically need to install the cellular modem in the safe area and have the loop enter the hazardous area via a safe area interface unit.

3. MICROWAVE RADIO MODEMS: When a microwave system "backbone" of towers, repeaters, etc. is in place, it may be cost effective to use solar powered microwave packages. These can be adapted to voice trunking systems but are typically the 900 mhz data band. Spectrum space licensing must first be accomplished and depending upon the area's congestion; may be readily attainable or extremely difficult to obtain.

4. SPREAD SPECTRUM RADIO: Or unlicensed radio is being used for small cluster group applications.

5. LOW ORBIT SATELLITE SYSTEMS: This type of technology has the potential for not only lowering the cost for remote communications, but the ability to add any metering site to a SCADA Host system. Until all of the satellites have been installed for global coverage, we will just have to wait.

These technologies above will usually, in some mix-or-match combination, get the data home. In remote areas where land lines are not available, a microwave "backbone" would be too expensive, cellular cells are non-existent and telemetry is STILL a necessity; satellite data systems have recently become practical. Clusters of LPFCs in far remote regions can use low wattage solar powered microwave to single-hop to a omni directional transceiver attached to a solar powered satellite system and the data can be relayed (bidirectionally) to the system's earth station. It is then buffered and placed on the phone system allowing access from any phone via modem and having data present upon demand from the remotest areas. The LPFC can be sent control functions such as remote valve positioning via the microwave/satellite combination system. Any combination of these technologies may become an integral part of a LPFC measurement and control system. A general familiarization with these technologies will make transition to them easier in the event that you become involved in the use of networked LPFCs, whether they fall into the category of EFM or RTU.

APPLICATIONS OF LPFCS

When the application involves ONLY functioning as a flow metering device and the LPFC is equipped to only do that function in terms of input/output it is usually referred to as an EFM. When the LPFC also includes additional input/output which can be used to monitor and control other site functions not integral to the basic flow measurement, (usually via user designated status inputs and assignable control closure output, as well as additional analog input/output and extra digital ports) it enters the category of RTU. This is especially true when the LPFC meeting this description has ready interface to telemetry systems and the software support and communication protocol to support the additional functions. Let's examine some applications:

Inputs	Outputs
Analog Status	Analog Control
Digital Port	

THE FUTURE OF LPFCS

The INTERNET will more than likely play a major role in bringing remote monitored flow computers into the hands of small and large oil and gas firms. This will eliminate the large expense of having to own and operate expensive communication networks. Such a generic approach will force manufacturers to agree on issues such as communication protocols and radio interfaces. These protocol issues are now being addressed as the industry has already adopted "ENRON MODBUS" for a standard remote link protocol.

EFMs have typically been designed, produced, marketed and serviced by companies specializing in flow measurement. RTUs have typically been provided by companies specializing in SCADA systems. The future will without fail draw the EFM and RTU descriptions closer together. The inevitable LPFC is a complete building block system that has ALL the choices available to specify from the minimum flow meter or simplistic control function to a complete site automation package.

Significant advances in technologies in the last few years have generally not appeared in the field yet due to the lag time of design, beta testing, safety certification evaluation time and market inertia. The near future will inevitably offer very compact, low power EFM/RTU building block systems which will allow "purchase menu building" remote measurement and control systems.

Second decade technology will take advantage of powerful low power microprocessors, 16 and 32 bit machines, very high density memory chips, ultra high accuracy analog to digital converters, improved battery technologies, high speed data transfer, and take advantage of the first decade's experience of what was right and wrong with pure EFMs and RTUs and hybrid or "overlapped" function EFMs and RTUs. These systems will be a quantum leap for the LPFC business and dramatically simplify large-scale measurement and control system design headaches for the end users.