

ANGI Series II

CNG DISPENSER

Technical Function Manual

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Document Revision History.

Original release:

Wrote description of sequence operation. Copied basic parameter and variable descriptions from the MCDS technical document that are duplicated in the Series II dispenser.

Revision 1:

Added descriptions of variables and parameters particular to the Series II dispenser.

Revision 2:

Rearranged document under better content headings. Completed the description of all variables, parameters, and miscellaneous registers found in the Series II dispenser. Added descriptions of the serial communication link protocol.

Revision 3:

Added descriptions of new parameters and functions for dispenser program revisions 3.82 and 3.83.

Revision 4:

Added descriptions of new parameters and functions for dispenser program revisions 4.00.

Revision 5:

Corrected value of meter_mass_cal parameter. Correct value = 10000. Value was 1000.

Revision 6:

Added new signal config bit 31 definition meter_9739_type and new error code E12 for program revisions 3.87 and 4.02.

Revision 7:

Added new signal config bit 24 limit_pmax and new error codes F29, F30, and F32 for program revisions 3.90 and 4.05. Added parameters overfill_factor and pressure_dip for rev. 3.90 and 4.05.

1 ANGI SERIES II Operation

1.1 ANGI SERIES II Description

The ANGI SERIES II is a microprocessor controlled single or two hose dispenser sequencer. Two hose dispensers come with the option of a shared supply (single valve / meter) or an independent supply (dual valve / meter). The single meter configuration allows for only one hose to operate at a time while the dual meter configuration allows for simultaneous use of both hoses. The software uses independent sequence functions of each hose for both configurations. The software contains two fill algorithms: 1) A pressure target algorithm based on a summary of the American Gas Association (AGA) supercompressibility tables that calculates a temperature compensated value for final fill pressure based on measured ambient temperature. An empirical value is derived to compensate for the effect of compression heating. 2) A mass target algorithm based on the Gas Technology Institute (GTI) temperature compensated gas density formula. Compression heating is figured into the mass target formula based on a mass to pressure rise measure of tank size.

The empirical value is derived from Table 1 of a paper titled "Microprocessor Control of Natural Gas Vehicle Fast Fills" by Dr. E. J. Farkas of the Canadian Gas Research Institute presented at the 1992 International Gas Research Conference.

The ANGI SERIES II control hardware consists of a Hitachi SH1 microprocessor running a single dedicated program that operates the hardware and contains the sequencer algorithms. The program is written in the C programming language and compiled with a GNU compiler (RPC-GNU). The micro resides on a pc board with 1 Meg of RAM and 512K of EEPROM. It is attached to an interface pc board that holds the necessary 24v inputs, outputs, 120v triac outputs, 4-20mA analog inputs, RS485 com ports, pulse counters, real time clock, LCD display power loss ride through, and ESD relay driver output. One RS232 monitoring and programming port resides in the electrical cabinet for service use. One electrically isolated RS485 com port is provided for a multidrop connection for remote access monitoring. Mass flow is measured by Micromotion core processor flow meters that connect to the system by an RS485 link using a RTU Modbus protocol. Update rate is 40 ms. Customer interface is an ANGI proprietary LCD display connected by an RS485 link using a custom ASCII character protocol. Update rate is 100 ms. A keypad for price entry is provided for the attendant behind locked door access. Pressure is measured by four 20 mA sensors. All components external to the main electrical panel are connected through off-the-shelf, intrinsically safe current limiting barriers.

1.2 Measurement Units

Engineering units used in the Series II ANGI dispenser control program are SI units.
Common units are:

g	gram	mass
MPa	megapascal	pressure
g/s	gram per second	flow
g/cm ³	grams per cubic centimeter	density
K	Kelvin	temperature
s	seconds	time
mV	milliVolts	electromotive force
mA	milliAmps	electric current
□	ohm	electric resistance

Other units mentioned are:

Mass:

Kg	Kilograms
LB	Pounds
EGal	Gasoline equivalent gallon
Eliter	Gasoline equivalent liter
SCM	Standard cubic Meter (at atmosphere)

Pressure:

Bar	barometric pressure
PSI	Pounds per square inch

Flow:

Lbs/min	Pounds per minute
SCFM	Standard cubic feet per minute (at atmosphere)

Temperature:

C	degrees Celsius
F	degrees Fahrenheit

Mass conversion table

1 gram	1Kg	1 LB	1 EGal	1 Eliter	1 SCM	=
1	1000	453.6	2567.4	667.7	769.1	Grams
0.001	1	0.4536	2.5674	0.6677	0.7691	Kg
0.0022	2.205	1	5.66	1.4720	1.6955	Lbs.
0.0003895	0.3895	0.1767	1	0.2601	0.2998	EGal
0.0014977	1.4977	0.6793	3.8451	1	1.1519	Eliter
0.0013002	1.3002	0.5898	3.3382	0.8682	1	SCM

Pressure conversion table

1 MPa	1 Bar	1 PSI	=
1	0.1	0.006895	MPa
10	1	0.06895	Bar
145.04	14.504	1	PSI

Flow conversion table

1 g/s	1 lbs/min	1 SCFM	=
1	7.5597	0.36296	G/s
0.13228	1	0.04801	Lbs/min
2.7551	20.828	1	SCFM

Temperature conversion table

°C (Degrees Centigrade)	K (Kelvin)	°F (Degrees Fahrenheit)
$^{\circ}\text{C} = ^{\circ}\text{C}$	$\text{K} = ^{\circ}\text{C} + 273.16$	$^{\circ}\text{F} = ^{\circ}\text{C} \times 1.8 + 32$
$^{\circ}\text{C} = \text{K} - 273.16$	$\text{K} = \text{K}$	$^{\circ}\text{F} = \text{K} \times 1.8 - 459.69$
$^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$	$\text{K} = (^{\circ}\text{F} + 459.69)/1.8$	$^{\circ}\text{F} = ^{\circ}\text{F}$

1.3 Sequencer Operation

A normal fill sequence operates in the following way with the pressure target algorithm:

- 1 The process starts assuming the hose is pressurized from the previous fill. The control program notes a pressure drop in the fill hose if the nozzle valve is opened and the hose pressure equalizes with the vehicle's tank pressure. This sets up a sequence decision before the handle is turn on to start filling. A pressure drop indicates that the fill valve has opened to the vehicle tank. This sets a pressure drop flag in the program.
- 2 When the handle is operated, a discrete, hardwired signal is provided to tell the fuel management system a fill is requested at that dispenser (authorize). The system waits for an authorization signal from the fuel management system if it not present. When the authorization signal arrives or is already present, the sequence proceeds after one second. If the signal does not arrive within 2 minutes, the system shuts down and ignores the authorization signal from then on. The dispenser handle must be cycled to start again. If the preset sale feature is used the display will prompt the user for a final sale entry after the one second delay. A mass target stop point will be calculated from the entry based on the price-per-unit value.
- 3 With the handle on and the authorization signal present, the system is now in the fill sequence mode. A discrete hardware signal is provided to indicate this (filling). If the handle or authorization signal is removed from now on, the system will shut down immediately. The system will only restart when the handle is cycled and authorization is reapplied in step 2 above.

The system checks the state of the hose pressure drop flag. If a pressure drop flag is off, a "hose check" sequence is ran to test whether the nozzle valve is opened or closed. The sequencer turns on to high bank valve for 2 seconds or until the mass delivered is greater than a set parameter `hose_mass`. This pressurizes the hose if the hose valve is closed. (The `hose_mass` parameter should reflect the total amount of mass the hose can hold up to the maximum pressure at the lowest temperature).

If more mass as flowed through the hose than the parameter `hose_mass` and the pressure difference between before the charge and after does not indicate filling just a hose, it is assumed that a vehicle is connected to the hose and that the hose valve is open. The mass that was delivered is counted on the quantity display total and is assumed to be in the vehicle tank.

If less mass as flowed through the hose than the parameter `hose_mass` and the pressure difference between before the charge and indicates just a hose was filled, the system waits for a pressure drop. It is assumed the nozzle valve is closed. The mass that was delivered is not counted on the quantity display total. If

no pressure drop occurs within 2 minutes, the system shuts down and waits for the dispenser handle to be cycled.

- 4 When a pressure drop has occurred, the system waits for the pressure and flow to settle. The mass delivered in this wait period is not counted on the quantity display total. The pressure is considered settled when the instantaneously measured pressure is within bounds to a pressure over time averaging value. The flow is considered settled when it is under a low cutoff value. After the pressure and flow are settled, the pressure sensor value is stored. This is assumed to be the pressure in the vehicle tank. The ambient temperature value is also stored.

Initial_pressure = Pressure

Initial_temperature = temperature

If the flow does not settle after 10 seconds, the system faults assuming a leak or faulty meter reading.

- 5 The program takes the initial tank pressure and ambient temperature values and iteratively calculates the temperature compensated full tank pressure using the supercompressibility tables. This result is the full tank pressure after compression heating is dissipated. Next an empirical temperature-pressure factor for compression heating multiplied to the above full tank pressure value. This factor generates the final target pressure. The fill sequence will stop at this pressure and end the fill. The pressure in the tank is expected to settle to a value after the gas cools off to the ambient temperature. This should give a standard “full tank mass” regardless of the ambient temperature. This final target pressure is checked against an absolute maximum value for the tank and is limited to the maximum value to keep from over-pressurizing the tank. Then the initial pressure is checked to 95% of the final target pressure to determine whether the tank is already close to full. If it is, this condition is flagged and the fill is aborted. The system now will fill the vehicle tank to the final target pressure.

PFinal_target (pmax)

- 6 The system now will fill the vehicle tank to the low bank target pressure. The low bank target is set lower than the final target by a static difference:

Pto_mid = 3MPa (typically)

PLow_target = PFinal_target – Pto_mid

The system opens the solenoid valve to the low bank. The program checks for flow. The program will skip the low bank step if no flow is detected. It is assumed the valve is stuck. The following initial resistance calculations are postponed for the next bank. Maximum flow rate and pressure are recorded when the flow rate has peaked and is steady, i.e. not increasing and also after 2 seconds. From the

difference between flowing pressure, static pressure, and the maximum flow rate, a vehicle fill line resistance is calculated from the following equation:

Pflowing: pressure recorded by the sensor upstream of the hose during max flow.

Pstatic: pressure at end of the hose.

Pstatic = Initial_pressure

Resistance = (Pflowing - Pstatic) / flowrate^2

Note that under sonic flow conditions, the pressure differential through the line cannot be more than 56% of Pflowing (for natural gas) even though the tank pressure may be below this pressure (see *fluid flow theory*).

If Pflowing - Pstatic > Pflowing * 56% then Resistance = Pflowing * 56% / flowrate^2

Init_resistance = Resistance

The resistance is calculated at the beginning of the fill at maximum detected flow after 2 seconds from the low bank start. The resistance calculation stops when subsonic flow conditions are reached. If the subsonic condition already exist, the resistance is calculated once at the start at maximum flow after 2 seconds.

Throughout the fill, the tank pressure can be estimated using the following equation:

Tank pressure: theoretical pressure in the tank. Only valid in the subsonic flow condition.

Tank pressure = Pflowing - Resistance * flowrate^2

- 7 If the mass flow rate drops below a preset limit (normally 50g/s **SlowFlo**) or when the estimated tank pressure is at the Plow_target pressure, the sequencer shuts off the lowbank valve. A sample of the supply pressure is recorded right before the valve is closed.

low_ibpressure: supply pressure sample at bank stop

low_ibpressure = Pflowing

- 8 The system waits for the pressure and flow to settle. If the pressure and flow does not settle after 10 seconds the program faults assuming a leak or erroneous flow value. The pressure between bank fills is measured and assumed to be the vehicle tank pressure.

Low_tank = pressure (from sensor with valves off no flow)

- 9 The vehicle tank pressure is compared against the last recorded target pressure before the sequencer left low bank. Their difference from the supply pressure is used to calculate a percentage error in the resistance value previously used. The error is used to correct the previous resistance value. The error and new resistance are recorded.

Resist_error = (low_ibpressure - PLow_target) / ((low_ibpressure - Low_tank)

New_resistance = Resistance * Resist_error

Mid_resistance = New_resistance

- 10 The mid bank valve is turned on to resume the fill. A mid bank target is calculated.

Pto_hi = 1.5MPa (typically)

Pmid_target = PFinal_target - Pto_hi

- 11 If the mass flow rate drops below a preset limit (normally 45g/s **SmidFlo**) during the mid bank fill or when the estimated tank pressure at the Pmid_target pressure, the sequencer turns off the midbank valve. A sample of the supply pressure is recorded right before the valve is closed.

mid_ibpressure: supply pressure sample at bank stop

mid_ibpressure = Pflowing

- 12 Again, the system waits for the pressure and flow to settle. If the pressure and flow does not settle after 10 seconds the program faults assuming a leak or erroneous flow value. The pressure between banks is measured and assumed to be the vehicle tank pressure.

Mid_tank = pressure (from sensor with valves off no flow)

- 13 The vehicle tank pressure is compared against the recorded last calculated tank pressure before the sequencer left mid bank. Their difference from the supply pressure is used to calculate a percentage error in the resistance value previously used. The error is used to correct the previous resistance value. The error and new resistance are recorded.

Resist_error = (mid_ibpressure - PMid_target) / ((mid_ibpressure - Mid_tank)

New_resistance = Resistance * Resist_error

High_resistance = New_resistance

- 14 The highbank valve is opened. A high bank target is calculated.

Pto_full = 0.25MPa (typically)

PHigh_target = PFinal_target – Pto_full

- 15 When the estimated tank pressure is at the PHigh_target pressure or If the mass flow rate drops below a preset limit (normally 40g/s **ShiFlo**) during the high bank fill, the sequencer shifts to the off position. The highbank valve is closed. A sample of the supply pressure is recorded right before the valve is closed.

high_ibpressure: supply pressure sample at bank stop

high_ibpressure = Pflowing

- 16 After pressure and flow have settled, the tank pressure is measure for the last time.

High_tank = pressure (from sensor with valves off no flow)

- 17 The vehicle tank pressure is compared against the recorded last calculated tank pressure before the sequencer left high bank. Their difference from the supply pressure is used to calculate a percentage error in the resistance value previously used. The error is used to correct the previous resistance value. The error and new resistance are recorded. The fill is complete.

Resist_error = (high_ibpressure – PHigh_target) / ((high_ibpressure – High_tank)

New_resistance = Resistance * Resist_error

Final_resistance = New_resistance

Final_pressure = High_tank

- 18 After the fill is complete or if an abnormal shutdown occurs, the system will update the totalizers and data in the fill log. The totalizers and fill log are stored in non-volatile memory. A discrete signal is provided to indicate the fill is complete to the fuel management system (done). The signal to indicate the system is in fill mode (filling) is turned off. The mass quantity display count and sale amount is frozen.

If a preset sale amount is entered the fill will stop when the accumulated mass value hits a calculated target. All other stop and target conditions are ignored, as the mass stop target becomes the highest priority. The target is calculated from the preset sale entry, the current mass flow, a static mass amount parameter, and a duration parameter. The bank fill is stopped an amount before the desired target is reached. The fill then “coasts” to the final amount. The actual sale amount is limited to the entered preset sale amount. The parameters can be adjusted for the best accuracy.

Stop_Mass = (Sale_Preset / Price_per_Unit) * grams_per_unit i.e. final target

Coast_mass = mass_flow * coast_factor - coast_adder i.e. stop look-ahead

Stop_Target = Stop_Mass - Coast_mass

When Mass >= Stop_Target -> close valve to stop fill

Final_sale = Round_and_Limit ((stop_mass / grams_per_unit) * price_per_unit)

Anytime the system is shutdown by an error, or an error occurs while the system is idle, a discrete signal is provided (error or event). Error codes will be put in the pressure readout portion of the user LCD display to indicate which error(s) is present or have happened during a fill. Fill sequence errors are cleared when the handle is turned to the start position. Present hardware errors remain on the display until they are fixed. Hardware errors will not allow a fill sequence to start.

2 System Parameters

2.1 System Parameters General Description

System parameters allow calibration changes to be made on the system. These changes are only allowable when vehicles are not being filled from the dispenser. System parameters should only be adjusted when absolutely necessary and by a trained technician.

Note: It is possible to cause the dispenser miss-operate by altering system variables.

System parameters can be adjusted using the ANGI SERIES II monitoring program loaded on a Windows based computer. The monitor program connects to the dispenser control through a standard 9-pin RS232 cable to the computer serial port. Computer without a 9-pin serial port can use a USB to serial port converter. System parameters can also be adjusted using the or through the dispenser's keypad and LCD display running with program rev. 3.06 or higher. See section 5.

IMPORTANT: ONLY VALUES WITH (*) SHOULD BE CHANGED, UNLESS BY AN ANGI TECHNICIAN

2.2 System Parameters Common to Both Hoses

#	Parameter	Default	Function
0	Sdpmax	45.6	(%) This value should be calculated from the ratio of specific heats (k) for natural gas used. It is the maximum pressure drop under sonic flow conditions at the fill line exit point. May need recalculation if composition is abnormal. $Sdpmax = (2/(k + 1))^{k/(k - 1)}$
1	Smmfactor	2.5700	(g/pulse) This is the Micromotion pulse calibration factor when using a mass pulse input train. Set to 2.57 for D38 meter (2.57g/pulse).
2	Spccrit	4.59	(MPa) This is the critical pressure of the natural gas used. May need recalculation if composition is abnormal.
3	Stccrit	194.1	(K) This is the critical temperature of the natural gas used. May need recalculation if composition is abnormal.
4	Smw	17.51	(g/mol) This is the weighted average molecular weight of the natural gas used. May need recalculation if composition is abnormal.
5	Smax%	135.0	(%) Maximum percentage over temperature compensated pressure allowed in hose. Pressures above $Smax * Pmax$ will shut down the filling process. Set at 135%
6	Sdelay	2.00	(sec) A set delay after a valve is turned on before pressure and flow measurements are used for resistance calculations and stop targets. Allows for the flow to accelerate and stabilize.
7	Stank_dwell	1.00	(sec) This is the minimum time dwell between tank shifts for allowing the pressure and flow to settle before making a tank pressure measurement. (obsolete / not used)
8	Spressttle	0.25	(MPa) This is the window of immediate pressure reading to a slow integrated pressure average to detect whether the pressure has settled.
9	Testbits	0	(numb) Diagnostic bits that turn internal functions on and off. This parameter function is normally disabled in the controller's program.
10	Smass_unit	0	(numb) This value selects the mass quantity display unit from a list of commonly used units. The g/unit conversion is placed in the Smassconv parameter. 0 = custom, 1 = Lbs, 2 = Kg, 3 = EGals, 4 = Eliters, 5 = SCM.
11	Smassconv	2567.4	(g/unit) This is the value to display custom mass units other than the selection available in Smass_unit parameter.
12	Smass_decimal	3	(numb) This is the number of decimal points in the mass quantity display field.
13	Ssale_decimal	2	(numb) This is the number of decimal points to display in the total sale display field.

#	Parameter	Default	Function
14	Pulses_per_qty	1000	(ppu) This number calibrates the mass pulse output. The value determines the number of pulses per mass display unit. Example if display = 1.000 Kg then 1000 would send 1 pulse per gram.
15	Pulses_per_sale	100	(ppu) This number calibrates the sale pulse output The value determines the number of pulses per sale display unit. Example if display = 1.00 \$ then 100 would send 1 pulse per penny.
15	Qty_frequency	100	(Hz) Sets maximum pulses per second out of the mass pulse output.
17	Sale_frequency	25	(Hz) Sets maximum pulses per second out of the sale pulse output.
18	Temperature_sim	294.1	(K) Sets the temperature used by the internal fill simulator.
19	Tank_size	2500	(ft3) Sets the water volume size of the simulated tank.
20	Resist_sim	260.0	(Pa_s2/g2) Sets the hose resistance used by the internal fill simulator.
21	low_sim	31.00	(MPa) Sets the simulated low bank pressure.
22	mid_sim	31.00	(MPa) Sets the simulated mid bank pressure.
23	high_sim	31.00	(MPa) Sets the simulated high bank pressure.
24	Time_zone	x	(numb) holds the time zone for where the dispenser is in the world. -12 to + 12. Eastern Standard Time = -5.
25	Serial_number	x	(numb) Serial number of the dispenser
26	Spc_baud	803 hex	(numb) Encoded number that sets the baud rate, parity, data bit size, and stop bit size for serial port 5 RS485 link.
27	Sprice_decimal	3	(numb) Fixes the decimal point place on the display if use_price_decimal signal configuration bit is on.
28	Spc_com_timeout	400	(ms) Sets the Gilbarco Comm link non-response time out.
29	Overfill_factor	10	(%) Threshold for indicating an overfill a percent above final target. Shared by both hoses. (Rev. 3.90 and 4.05)

2.3 Hose Specific System Parameters Program Rev 3.xx

A	B	Parameters	Default	Function
30	70	SlowFlo	50.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from low bank to mid bank.
31	71	SmidFlo	45.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from mid bank to high bank.
32	72	ShiFlo	40.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from high bank to off.
33	73	StopFlo	35.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from top bank to off in a four bank system.
34	74	Sdrop	1.00	(MPa) When the difference between a slow integrator of hose pressure and instantaneous pressure reaches this value, the drop flag will be set. This indicates to the system that a vehicle has been connected and the fill-valve has been opened causing a pressure drop in the hose.
35	75	Slow	1.00	(g/s) Low mass flow detection level for sequence progression. The flow level is checked after a valve is shut off. The sequence is aborted if still above this value for 10 seconds. Unused in rev. 3.06 and earlier.
36	76	Sburst	400.00	(g/s) Above this gas flow rate it is assumed that the hose has burst. The valves are shut off if the flow rate remains above this value for more than 1 second. The fill is aborted.
37	77	Sstartdel	50.00	(sec) If the handle is operated but a pressure drop is not detected when the fill-valve on the end of the hose is opened, this is the wait time before the system cancels the fill.
38	78	Smode	2 (*)	(unitless) A hose mode selection. Mode 0 is for 16.5 MPa (2400psi) systems. Mode 2 is for 20.7 MPa (3000psi) systems. Mode 4 is for 24.8 MPa (3600psi) systems.
39	79	Temp_cal	x	(K/dac) This is the coefficient used to scale the analog temperature probe input.
40	80	Temp_freeze	x	(dac) This is the value of the 10bit digital to analog converter value at freezing 0 C (32 F).
41	81	No_Flow_Time	0.00	(Sec) This value sets a time delay before switching banks on detecting low flow. Program rev. 3.82.
42	82	press_dac_zero	181	(dac) This is the value of the 10bit digital to analog converter value at 0 Mpa (4 mA)
43	83	press_dac_range	52000	() This is the value of the scaler to convert the pressure input to 34.50 Mpa (5000psi)

A	B	Parameters	Default	Function
44	84	flow_dac_zero	0	(dac) This is the value of the 10bit digital to analog converter value at zero flow: 181 if 4 mA, 0 if 0 volts.
45	85	flow_dac_max	900	(dac). This is the value of the 10bit digital to analog converter value at max flow.
46	86	flow_cal	350.00	(g/sec) This is the value of the scaler to convert the analog flow input to 340.00 g/sec
47	86	meter_temp_cal	10	(ratio) This is the value to scale Micromotion temperature floating point register value to the system value. 1.000000 C to 1.0 C
48	88	meter_flow_cal	100000	(ratio) This is the value to scale Micromotion flow rate floating point register value to the system value. 1.000000 Kg/sec to 1.00 g/sec.
49	89	meter_mass_cal	10000	(ratio) This is the value to scale Micromotion mass floating point register value to the system value. 1.000000 Kg to 1 g.
50	90	press_unit	2	(numb) Selects the pressure units on the LCD display. 0 = Bar, 1 = %, 2 = PSI
51	91	signal_config	x	(numb) Individual bits that selects signal sources and optional functions. (See Table)
52	92	lowtarget	100 (*)	(%) A hose value as a percentage of final pressure target to stop the low bank fill. An alternative to Ato_mid.
53	93	midtargt	100 (*)	(%) A hose as a percentage from final pressure target to stop the mid bank fill. An alternative to Ato_high.
54	94	hightarget	100 (*)	(%) A hose value as a percentage final pressure target to stop the high bank fill and complete An alternative to Ato_full.
55	95	valve_off_dwell	0.80	(sec) This is the value to compensate for the off delay some types of valves i.e. air actuated valves. The flow continues for a specific time after the signal is removed from the valve. 0 for fast-action valves.
56	96	to_mid	3.00 (*)	(MPa) A hose value subtracted from final pressure target to stop the low bank fill.
57	97	to_high	1.50 (*)	(MPa) A hose value subtracted from final pressure target to stop the mid bank fill.
58	98	to_full	0.25 (*)	(MPa) A hose value subtracted from final pressure target to stop the high bank fill and complete
59	99	press2_dac_zero	181	(dac) This is the value of the 10bit digital to analog converter value at 0 Mpa (4 mA) for the redundant check pressure sensor.

A	B	Parameters	Default	Function
60	100	press2_dac_range	52000	(numb) This is the value of the scaler to convert the pressure input to 4.50 Mpa (5000psi) for the redundant check pressure sensor.
61	101	press2_trip	200	(MPa) This is the fault trip value of the difference between the main pressure sensor and the secondary pressure sensor.
62	102	bank_time_limit	120 / 360	(sec) Maximum allowable time for a bank to be on. The sequence will shift to the next bank if this time is exceeded.
63	103	mass_calibrate	1.0000	(ratio) Mass measurement correction factor.
64	104	pressure_trip	30.34	(MPa) Static overpressure trip. Set 100 MPa below safety relief valves.
65	105	delay_adjust_limit	1.50	(MPa) A limit to the extra pressure added by a valve delay. Set to 0 for fast acting valves.
66	106	pmax_fixed	24.80	(MPa) Fixed final pressure target, no temperature compensation. Default value is for 3600 PSI.
67	107	min_resist	40.0 10.0*	(Pa_s2/g2) Minimum hose resistance limit. Maximum resist limit = 10 x Minimum resist limit.(added rev. 3.05) * indicates a high flow transit setting.
68	108	hose_mass	100 400*	(g) The amount of mass held by the hose at max pressure. Used for determining an open nozzle valve after a hose charge. The second value * is for high flow transit dispensers. (added rev. 3.05) * indicates a high flow transit setting.
69	109	Pressure_dip	400	(MPa/sec) Threshold to detect a sudden hose pressure drop during the fill. (rev 3.90)

Hose Specific System Parameters Program Rev 4.xx

A	B	Parameters	Default	Function
30	75	SlowFlo	50.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from low bank to mid bank.
31	76	SmidFlo	45.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from mid bank to high bank.
32	77	ShiFlo	40.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from high bank to off.
33	78	StopFlo	35.00 (*)	(g/s) Below this gas flow rate, the dispenser will switch from top bank to off in a four bank system.
34	79	Sdrop	1.00	(MPa) When the difference between a slow integrator of hose pressure and instantaneous pressure reaches this value, the drop flag will be set. This indicates to the system that a vehicle has been connected and the fill-valve has been opened causing a pressure drop in the hose.
35	80	Slow	1.00	(g/s) Low mass flow detection level for sequence progression. The flow level is checked after a valve is shut off. The sequence is aborted if still above this value for 10 seconds. Unused in rev. 3.06 and earlier.
36	81	Sburst	400.00	(g/s) Above this gas flow rate it is assumed that the hose has burst. The valves are shut off if the flow rate remains above this value for more than 1 second. The fill is aborted.
37	82	Sstartdel	50.00	(sec) If the handle is operated but a pressure drop is not detected when the fill-valve on the end of the hose is opened, this is the wait time before the system cancels the fill.
38	83	Smode	2 (*)	(unitless) A hose mode selection. Mode 0 is for 16.5 MPa (2400psi) systems. Mode 2 is for 20.7 MPa (3000psi) systems. Mode 4 is for 24.8 MPa (3600psi) systems.
39	84	Temp_cal	x	(K/dac) This is the coefficient used to scale the analog temperature probe input.
40	85	Temp_freeze	x	(dac) This is the value of the 10bit digital to analog converter value at freezing 0 C (32 F).
41	86	No_Flow_Time (Rev. >= 3.82)	0.00	(Sec) This value sets a time delay before switching banks on detecting low flow.
42	87	press_dac_zero	181	(dac) This is the value of the 10bit digital to analog converter value at 0 Mpa (4 mA)
43	88	press_dac_range	52000	() This is the value of the scaler to convert the pressure input to 34.50 Mpa (5000psi)

A	B	Parameters	Default	Function
44	89	flow_dac_zero	0	(dac) This is the value of the 10bit digital to analog converter value at zero flow: 181 if 4 mA, 0 if 0 volts.
45	90	flow_dac_max	900	(dac). This is the value of the 10bit digital to analog converter value at max flow.
46	91	flow_cal	350.00	(g/sec) This is the value of the scaler to convert the analog flow input to 340.00 g/sec
47	92	meter_temp_cal	10	(ratio) This is the value to scale Micromotion temperature floating point register value to the system value. 1.000000 C to 1.0 C
48	93	meter_flow_cal	100000	(ratio) This is the value to scale Micromotion flow rate floating point register value to the system value. 1.000000 Kg/sec to 1.00 g/sec.
49	94	meter_mass_cal	10000	(ratio) This is the value to scale Micromotion mass floating point register value to the system value. 1.000000 Kg to 1 g.
50	95	press_unit	2	(numb) Selects the pressure units on the LCD display. 0 = Bar, 1 = %, 2 = PSI
51	96	signal_config	x	(numb) Individual bits that selects signal sources and optional functions. (See Table)
52	97	lowtarget	100 (*)	(%) A hose value as a percentage of final pressure target to stop the low bank fill. An alternative to Ato_mid.
53	98	midtargt	100 (*)	(%) A hose as a percentage from final pressure target to stop the mid bank fill. An alternative to Ato_high.
54	99	hightarget	100 (*)	(%) A hose value as a percentage final pressure target to stop the high bank fill and complete An alternative to Ato_full.
55	100	valve_off_dwell	0.80	(sec) This is the value to compensate for the off delay some types of valves i.e. air actuated valves. The flow continues for a specific time after the signal is removed from the valve. 0 for fast-action valves.
56	101	to_mid	3.00 (*)	(MPa) A hose value subtracted from final pressure target to stop the low bank fill.
57	102	to_high	1.50 (*)	(MPa) A hose value subtracted from final pressure target to stop the mid bank fill.
58	103	to_full	0.25 (*)	(MPa) A hose value subtracted from final pressure target to stop the high bank fill and complete
59	104	press2_dac_zero	181	(dac) This is the value of the 10bit digital to analog converter value at 0 Mpa (4 mA) for the redundant check pressure sensor.

A	B	Parameters	Default	Function
60	105	press2_dac_range	52000	(numb) This is the value of the scaler to convert the pressure input to 4.50 Mpa (5000psi) for the redundant check pressure sensor.
61	106	press2_trip	200	(MPa) This is the fault trip value of the difference between the main pressure sensor and the secondary pressure sensor.
62	107	bank_time_limit	120 / 360	(sec) Maximum allowable time for a bank to be on. The sequence will shift to the next bank if this time is exceeded.
63	108	mass_calibrate	1.0000	(ratio) Mass measurement correction factor.
64	109	pressure_trip	30.34	(MPa) Static overpressure trip. Set 100 MPa below safety relief valves.
65	110	delay_adjust_limit	1.50	(MPa) A limit to the extra pressure added by a valve delay. Set to 0 for fast acting valves. (See valve_off_dwell parameter)
66	111	pmax_fixed	24.80	(MPa) Fixed final pressure target, no temperature compensation. Default value is for 3600 PSI.
67	112	min_resist	40.0 10.0*	(Pa_s2/g2) Minimum hose resistance limit. Maximum resist limit = 10 x Minimum resist limit.(added rev. 3.05) * indicates a high flow transit setting.
68	113	hose_mass	100 400*	(g) The amount of mass held by the hose at max pressure. Used for determining an open nozzle valve after a hose charge. The second value * is for high flow transit dispensers. (added rev. 3.05) * indicates a high flow transit setting.
69	114	coast_factor (Rev. >= 4.00)	1.200	(sec) A factor for calculating the look-ahead mass stop point for the preset sale feature. It is multiplied by the current mass flow to get a mass amount in grams. This mass amount is subtracted from a calculated mass target for the entered sale amount. This parameter is adjusted to get the actual mass ran close to the target.
70	115	coast_adder (Rev. >= 4.00)	15	(g) An amount added to the look-ahead mass described above to adjust the accuracy of low flow stops.
71	116	Pressure_dip	400	(MPa/sec) Threshold to detect a sudden hose pressure drop during the fill. (rev 4.05)
72	117	spare		
73	118	spare		
74	119	spare		

2.4 Signal Configuration Parameter Bit Definitions

The system parameters for the “B” hose are identical to the “A” hose. The variable name begins with a “B” instead of an “A.”

Bit	Name	Typ.	Function
0	Use_meter_mass_flow	On	The mass flow signal comes from the flow meter’s mass flow variable by the RS485 meter Comm link
1	Use_meter_vol_flow	Off	The mass flow signal comes from the flow meter’s volume flow variable by the RS485 meter Comm link. (not normally used).
2	Use_analog_mass_flow	Off	The mass flow signal comes from the 4-20Ma/0-5V analog input.
3	Use_meter_volume_total	Off	The mass signal comes from the flow meter’s resetable volume totalizer. (not normally used).
4	Use_meter_mass_total	On	The mass signal comes from the flow meter’s resetable mass totalizer.
5	Use_pulse_mass_counter	Off	The mass signal comes from the pulse counter input from a meters pulse output.
6	Use_meter_temperature	Off	The temperature used for target calculation comes from the meter’s internal gas temperature probe. (not to be used).
7	Use_analog_temperature	On	The temperature used for target calculation comes from the ambient temperature probe.
8	Use_right_handle	x	The right handle digital input is enabled if “On” for the hose on the right side of the dispenser.
9	Use_left_handle	x	The left handle digital input is enabled if “On” for the hose on the left side of the dispenser.
10	Use_dual_display	x	“On” if there are two displays per hose. “Off” if there is one display.
11	Use_sale_preset (Rev. >= 4.00)	Off	On to enable the sale preset feature.
12	Use_auth1_input	On	Enables the authorization 1 digital input. “Off” bypasses input.
13	Use_auth2_input	Off	Enables the authorization 2 digital input. “Off” bypasses input.
14	Use_auth3_input	Off	Enables the authorization 3 digital input. “Off” bypasses input.
15	Use_tier_input	Off	Enables the tier digital input to select the price tier. The keypad price tier selection is disabled.
16	Use_pmax_fixed	Off	The target pressure comes from the pmax_fixed parameter, not the temperature compensated value.
17	Use_price_decimal	Off	The decimal point in the price per unit display field is fixed by the Sprice_decimal parameter. “Off” the decimal point is entered with the keypad.

Bit	Name	Typ.	Function
18	Spc_comm_enable	Off	Enables the Gilbarco communication link on Comm 5 RS485 port. "Off" defaults to Monitor link protocol.
19	Use_ored_authorize	Off	Adds the authorize digital input 1 signal to the Comm link authorize for bypass capability.
20	Use_redundant_pressure	Off	Enables the secondary pressure sensor for pressure sensor failure trip.
21	Use_early_check	Off	Enable the hose check function to shut off earlier than the standard 2 second charge if the mass delivered exceeded the hose_mass parameter value.
22	Use_resist_ave	On	Enables the hose resistance calculation to continue through the sonic flow state instead of a one-time calculation at the start of a bank fill. The resistance is averaged over time.
23	Use_comm_authorize	Off	Enables an authorize by the ANGI monitor Comm link
24	Enable_sim_cycle (obsolete, removed)	Off	Enables a demo that has the dispenser perform a simulated filling sequence. The simulation cycles.
24	Limit_pmax (Rev. >= 4.05) (Rev. >= 3.90)	Off	"On" will limit the temperature compensated target pmax to the value in pmax_fixed parameter. Use_pmax_fixed bit must be off to use this feature.
25	Disable_flow_max (Rev >= 3.90)	Off	"On" disables sampling the maximum pressure during the bank start time. The sample is taken at the end of the bank start time. Sample is for resistance calc.
26	Use_price_switch (Rev. >= 4.00)	Off	"On" enables the price entry door switch. Price entry is disallowed if the display door is closed for door mounted keypads.
27	Share_display (Rev. >= 3.84)	Off	"On" for two hose dispensers with one shared display.
28	Use_totalizer	Off	Enables a pulse output on the Demand digital output for an external mechanical totalizer. One pulse per mass unit.
29	Use_remote_valves (Rev >= 3.83)	Off	Changes the function of the "Filling" digital output to go on and off with the valve outputs. Used to cycle a local valve in the dispenser when the bank valve stack is in a remote location away from the dispenser.
30	Use_EH_meter (Rev. >= 4.00)	Off	"On" Enables the flowmeter communication for the Endress-Houser meters. "Off" defaults to MicroMotion meters.
30	Single_bank_valve (Rev >= 3.87)	Off	"On" the sequence uses only the high bank output for one bank and sequence step buffer fill systems.
31	meter_9739_type (Rev. >= 3.87)	Off	"On" for MicroMotion 9739 meter communication. 38.4 KBAUD 80 ms update rate.

3 Process Variables

3.1 Hose Operation Variables

The following are the real time process variables used in for the process calculations and measurements. All variables are prefixed with a single capital letter indicating the hose (example: Aflow, Bflow). All variables can be monitored by a computer based monitoring program. The variables are normally write protected. Useful variables are as follows:

status	(numb) State counter during fill sequence (See table).
wait	(0.00 sec) Length of time at current state count .
mass	(0 g) any mass measured during fill.
press	(0.00 MPa) Instantaneous Pressure derived from analog pressure sensor
preslow	(0.00 MPa) time averaged Pressure. Compared to instantaneous pressure.
flow	(0.00 g/sec) mass flow from meter through analog input or meter com link
temp	(0.0 K) ambient temperature from analog input or meter com link.
press_store	(0.00 MPa) Stored initial vehicle pressure.
temp_store	(0.00 MPa) Stored ambient temperature.
pmax	(0.00 MPa) Calculated final pressure target or max limit used in fill
pmax_calc	(0.00 MPa) Temperature compensated pressure target not limited.
tankpress	(0.00 MPa) Estimated tank pressure derived from hose resist and flow.
flow_max	(0.00 g/s) Flow rate used in resistance calculation. Captured at peak steady flow.
press_test	(0.00 MPa) Sonic pressure drop across hose used in resistance calculation.
resist	(0.0 Pa.s ⁻² /g ²) Flow path resistance estimate
press_mem	(0.00 MPa) Memory of the target pressure used in the resistance calculation between banks
flow_analog	(0.00 g/s) Flow rate from analog input.
flags	(hex numb) 32 bit status flag register (See flag definitions).
control	(hex numb) 32 bit internal control Boolean register.(See control definitions).
pchange	(0.00 MPa) Bank change pressure target if using percentage parameters.
flow_analog	(0.00 g/s) flow rate from the 4-20mA/0-5V analog input.
abs_press	(0.00 MPa) Absolute pressure limit selected by mode parameter.
max_moles	(0.00 moles) Mole amount selected by mode parameter.
sim_press_preset	(0.00 MPa) Preset value for the initial tank pressure in the fill simulator.
sim_dpmax	(0.0 %) Sdpmax value used in the fill simulator.
press_delta	(0.00 MPa) difference between supply pressure and tank pressure.
error_reg	(numb) Error Booleans for a fill or system error.

error_code	(numb) Error code that cycles on the display during a fill or system error.
press2_in	(0.00 MPa) 2nd pressure sensor value.
psim	(0.00 MPa) Supply pressure value from fill simulator.
temp_analog	(0.0 K) ambient temperature from analog input.
sonic_pressure	(0.0 Mpa) Pressure level at the hose end where the flow becomes sonic.
press_display	(0000 Mpa/bar/%) Pressure readout on customer LCD display.
resist_temp	(0.0 Pa.s ⁻² /g ²) Temporary holding register for the resistance calculation.
press_target	(0.00 MPa) current pressure target for the active bank.
mass_ran	(0 g) the mass counted for the quantity sold.
qty_pulses	(0 pls) Pulses to send out for the displayed mass quantity delivered.
sale_pulses	(0 pls) Pulses to send out for the total sale.
qty_pulses_sent	(0 pls) real-time output pulse count for the displayed mass quantity.
sale_pulses_sent	(0 pls) real-time output pulse count for the total sale.
total_sale	(\$) Total sale value displayed on LCD customer interface.
total_qty	(mass unit) Total mass value displayed on LCD customer interface.
price_per_unit	(\$/unit) Price displayed on LCD customer interface.
pmax_used	(0.00 MPa) Calculated or fixed final pressure target not limited.
meter_mass_flow_unit	(numb) Coded number for the mass flow units used in the meter.
meter_mass_unit	(numb) Coded number for the mass units used in the meter.
meter_temp_unit	(numb) Coded number for the temperature units used in the meter.
full_mass	(g) estimated tank size in final mass amount. Used only in the bar graph.
tank_mass	(g) estimated mass amount in the tank. Used only in the bar graph.
final_process_count	(numb) number of samples taken by the real-time process monitor.
final_process_mod	(numb) time base samples taken by the real-time process monitor.
process_mod	(numb) sets the time base of the samples taken by the process monitor.
gass_temperature	(0.0 K) gas temperature from the meter.
totalizer_pulses	(0 pls.) pulses to be sent to the external totalizer. Fixed 1 pulse / mass unit.
totl_pulses_sent	(0 pls.) real-time output pulse count output to the external totalizer.
vars55	(numb) spare.
mon_ROM_address	(hex) starting memory location for the run monitor history.
meter_status	(hex) status Booleans from the meter.
sale_preset	(\$) sale preset amount entered from the door keypad. Rev 4.xx.
sale_stop	(numb) sale preset function status.
coast_mass	(grams) the amount of mass subtracted from the stop_mass target . The bank fill is stopped ahead of the target by this amount
stop_mass	(grams) the mass stopping point calculated from the preset sale amount.
actual_mass	(grams) the actual mass ran in a preset sale.

3.11 Status number definitions.

status	Function name	Description
0	system_off	Idle, standing by to detect a “fill_request” bit from the handle turned to the start position. Do nothing if the handle is inhibited by a price change in progress, a keypad function is in use, configure switch 1_1 is on, or during 5 second waiting period if the handle was turned off.
27	handlon	Handle was turned on. Clear the log. Clear all error status. All display segments on for one second. Check authorize signal after one second. Display the authorize number if the signal is not present. Check for unclearable errors, abort if errors are present. Go to 26 if not an error. If there is an error, go to 3.
26	pdyesno	Check for hose pressure drop (nozzle valve was opened). If no drop go to 22. If there was go to 19.
status	Function name	Description
22	fforward	High bank valve on for 2 second hose check.
21	chkmass	Check mass delivered and pressure increase. Decide if the nozzle valve is opened or closed. If closed go to 20. If opened go to 19.
20	waitforpd	Wait for the operator to open the nozzle valve. Abort after a time-out, go to 3 (start_delay). Go to 19 if a pressure drop is detected.
19	recordpt	Check for flow and pressure to settle. If settled, record the pressure as the initial tank pressure and the ambient temperature. Abort to 3 if the flow has not gone to zero after 10 seconds.
18	checkp	Calculate the target pressure. Check the initial tank pressure and abort if it is 95% of the target. Got to 4 if abort. Go to 9 to start the fill.
9	Fillbank (low)	Turn on the low bank valve. If not flowing, proceed directly to the mid bank. Calculate the initial resistance if flowing. Turn off the low bank valve when the pressure target is reached, if the flow is below the low-flow set-point, an error occurs, or if aborted. Take sample readings of the bank pressure, target pressure, and flow just before shutting the valve off. Proceed to the mid bank if not an error or abort. If there is an error or abort, go to 4.
8	Fillbank (mid)	Wait for pressure and flow to settle. If the flow does not settle for 10 seconds, abort to 3. Take a sample of the tank pressure and recalculated the resistance. Abort if the flow does not go to zero after 10 seconds. Turn on the mid bank valve. If not flowing, proceed directly to the high bank. Calculate the initial resistance if flowing and if not calculated previously. Turn off the mid bank valve when the pressure target is reached, if the flow is below the mid-flow set-point, an error occurs, or if aborted. Take sample readings of the bank pressure, target pressure, and flow. Proceed to the high bank if not an error or abort. If there is an error or abort, go to 4.
7	Fillbank (high)	Wait for pressure and flow to settle. If the flow does not settle for 10 seconds, abort to 3. Take a sample of the tank pressure and

		recalculated the resistance. Abort if the flow does not go to zero after 10 seconds. Turn on the high bank valve. If not flowing, go directly to 4. Calculate the initial resistance if flowing and if not calculated previously. Turn off the high bank valve when the pressure target is reached, if the flow is below the high-flow set-point, an error occurs, or if aborted. Take sample readings of the bank pressure, target pressure, and flow. Go to 4.
4	full	Wait for pressure and flow to settle or if waiting for 4 seconds has gone by. Take a final tank pressure sample. Stop accumulating mass counts. Recalculate the resistance. Go to 1.
3	shutd_pause	Wait for pressure and flow to settle or if waiting for 5 seconds has gone by after an abnormal stop. Stop accumulating mass. Go to 2.
status	Function name	Description
2	shutd	Update totalizers and save to the flash memory. Wait for the handle to be turned off.
1	shutdown	Update totalizers and save to the flash memory. Wait for the handle to be turned off.

3.12 Flag Definitions Bits 0 through 31.

drop_flag	Hose pressure drop detected when on.
lost_authorize	Authorization signal was removed during the fill sequence.
quit_flag	Tank is too full to start when on. Shows as an error.
burstd	Excess and unreasonable flow detected when on. Shows as an error.
no_zero_flow	Flow is not going to zero when the valves are off after 10 seconds.
flowing	Flow reached peak after valve is opened when on. Off when valves are off.
lowb4full	Bank shift on low flow when on. Bank shift on pressure target when off.
p3high	Abnormal shutdown on pressure exceeding Sdpmax.
mass_changing	the value of the mass signal from meter is changing at least 1 g/s.
filling	Fill sequence started when on. Fill sequence finished when off.
p3ibhigh	Tank pressure measured between banks > final target.
press_error	Pressure discrepancy between check sensor exceeding Sptrip.
filling	Fill sequence started when on. Fill sequence finished when off.
ratelow	Low bank low flow when on.
ratemid	Mid bank low flow when on.
ratehigh	High bank low flow when on.
ratetop	Top bank low flow when on.
authorized	dispenser is authorized to fill. Rev. 3.07 (was burst in previous revisions)
p1high	Calculated final pressure target exceeds absolute pressure limit when on.

p2high	Supply pressure target exceeds absolute pressure limit when on. Shows as an error.
abort_fill	Handle or authorization removed during fill when on. Shows as an error.
drop_time_out	Time expired waiting for nozzle valve to be opened by the operator.
temperror	Temperature outside operating range when on. Shows as an error.
handle_inhb	Condition exists that prohibits starting a fill sequence when on.
power_loss	Power lost during a fill when on.
display_updated	LCD display is communicating with microcontroller when on.
fill_request	Handle is in the on position or start button has been pushed when on.
lowbank_flag	Lowbank valve is commanded to open when on.
midbank_flag	Midbank valve is commanded to open when on.
highbank_flag	Highbank valve is commanded to open when on.
fill_done	Fill sequence has ended, successfully or in error, when on.
sonic_flow	Flow is over the Sdpmax parameter calc., estimated pressure valid when off.
meter_updated	Mass flow meter communicating with microcontroller when on.

3.13 Control Boolean Definitions Bits 0 through 31.

force_mass_freq	Forces pulses out of the mass pulse output.
force_sale_freq	Forces pulses out of the sale pulse output.
force_comp_bit	Turns the temperature compensation off. Leaves compression heating active.
force_screen_bit	Turns all the LCD segments on.
blank_screen_bit	Turns all the LCD segments off.
simulate_fill	Activates the fill simulator.
sim_preset	Writes a pre-determined tank pressure into the simulated tank. Self clears
first_resist_bit	Indicates the first resistance calculation has been accomplished.
error_bit	Indicates a hardware fault. If the bit is on the sequence will not start.
sim_handle	The handle input for the simulator. Written through the monitor Comm link.
wait_enable	Enables the sequence step timer..
flow_settled_bit	Indicates the flow is below a low threshold (zero) and the pressure is steady.
other_Left	Indicates the left handle is on.
other_Right	Indicates the right handle in on.
handleL_fill	Indicates the dispenser is filling from a left handle input.
handleR_fill	Indicates the dispenser is filling from a right handle input.
send_authorize	Turns on the authorize output when the handle is on and not inhibited.
burst	Indicates the flow has exceeded the burst parameter value. Does not latch.

fill_data_recvd	Indicates the meter communication has responded. Data is valid and ready.
power_on_dwel_bit	On during the first 10 seconds after power-up.
comm_authorize	An authorization signal set or reset by the monitor Comm link.
tank_measured_bit	Indicates the tank pressure has been measured between bank shifts.
choke_bit	Turns the choke output on or off when the fill reaches 95% target.
pressure_broken	Indicates the 4-20Ma pressure signal is below 3.5Ma (broken wire).
pressure2_broken	Indicates the second 4-20Ma pressure signal is below 3.5Ma (broken wire).
save_log	Starts the totalizer save-to-flash memory process.
fill_request	Handle is in the on position or start button has been pushed when on.
fill_acknowledge	Confirms the handle on fill request has been processed.
qty_enable	Enables the mass counter for the display quantity.
meter_mass_twice	Indicates there has been two successful meter comm link reads for the mass.
meter_vol_twice	Indicates there has been two successful meter comm link reads for the vol.

3.14 System Errors: Faults, and Events

The system checks for events and faults in the hardware, data transfer, or fill process occurrences. Error categories are 1: an event is recognized but may or may not shut the fill sequence down, 2: a fill process fault that shuts down the fill sequence, 3: a hardware fault that can shut down the fill sequence or not let the sequence start. These Booleans are in the **error_reg** variable. Error 1 corresponds to bit 0, error 2 to bit 1, etc. These events codes will be displayed as an E#. Fault code will be displayed as an F#. Faults will turn on the hardware error output, events will not (see output bit definitions).

- E1 Bank shift due to hitting low flow target instead of pressure target. (Does not latch). 1.
- F2 Pressure > absolute pressure limit x Smax (135% typical) or fixed pressure_trip. 2.
- F3 Pressure > pressure target x Smax parameter (135% typical). 2.
- E4 Measured tank pressure > target during bank shift, tank is already full. 2.
- E5 Fill was aborted by operator, handle turned off. 2.
- E6 Fill was aborted by removal of the authorize signal. 2.
- F7 Excessive flow, burst hose. 2.
- F8 Flow is not zero for 10 seconds after all valves are off. Valve leak or bad flow signal. 2.
- E9 Hose drop time out. Waited too long for operator to open the nozzle valve. 2.
- E10 Flow meter has internal error or is busy performing a zeroing function. (Does not latch). 1.
- E11 Calibration Switch1_1 is in the ON position. (Does not latch). 3.
- E12 Flow when dispenser is idle (Rev. >= 3.87 and 4.02) (Does not latch). 1.

- F13 Temperature out of working range. 3.
- F14 Main pressure sensor wire disconnected. 3.
- F15 Flow meter serial Comm link loss. 3.
- F16 Display serial Comm link loss. 3.
- F17 Pressure reading discrepancy between main pressure sensor and secondary sensor. 2.
- E18 Gilbarco Comm link overrun. 1.
- E19 Gilbarco Comm link overrun error. 1.
- E20 Gilbarco Comm link parity error. 1.
- E21 Gilbarco Comm link checksum error. 1.
- E22 Gilbarco Comm link data length error. 1.
- E23 Gilbarco Comm link invalid command character. 1.
- E24 Gilbarco Comm link invalid grade accessed. 1.
- E25 Parameter value is different from what is stored in memory. 3.
- F26 Meter mass flow engineering unit is an incorrect type, not Kg/s. (Does not latch). 3.
- F27 Meter mass engineering unit is an incorrect type, not Kg. (Does not latch). 3.
- F28 Secondary pressure sensor wire is disconnected. 3.
- E29 Secondary pressure sensor wire is shorted to supply. 3
- E30 Main pressure sensor wire is shorted to supply. 3
- E31 Undefined.
- E32 Sudden hose pressure dip during fill. 2

3.2 Meter Signal Definitions.

“Meter Signals” are values read directly from the flow meter that is necessary for the fill sequence. All meter values are read when the dispenser is not filling. The “Meter Signal” values, along with the meter_status variable are the only values read during a fill. All are floating point values to six decimal points.

meter_temp	(C) Gas temperature.
meter_flow	(Kg/s) Mass flow.
meter_mass	(Kg) Mass total. Clearable to zero. Cleared at fill start.
meter_vol	(liters) Volume. Clearable to zero. Cleared at fill start.
meter_mass_inv	(Kg) Mass inventory total. Non-clearable. Lifetime total.

3.3 Target Pressure Algorithm Data Values (ANGI algorithm)

This is a description of the data values used in generating the temperature compensated target pressure. These values exist in the system but are not brought out for monitoring.

Psettle	The maximum settled pressure permitted at ambient temperature T1 (MPa)
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Pcounter	The number of iterations used to arrive at Psettle (dimensionless should not exceed 10)
Tcomppc	Compression heating compensation as a percentage increase in Psettle (%)
Startpc	P1 as a percentage of Psettle (%)
Pmaxcomp	This is the compression heating compensated value of Psettle (MPa) $P_{maxcomp} = P_{settle} * [1 + (1 - Startpc) * Tcomppc]$
Pmax	Desired final pressure at end of fill (MPa)
Zpmax	Supercompressibility factor Z at temperature T1, pressure Psettle (%)
Order	Number used in sequencing log record blocks

3.4 Previous Fill Log

This function captures process values during pivotal moments of the fill sequence and stores the results in non-volatile memory record. The end of each normal or aborted fill sequence records pertinent algorithm calculation results and mass/sale amounts and totals. 128 records are backed up for each hose. The logging “wraps around,” writing over the oldest record first. . All these registers are read only. The following is a description of the logged data values useful in troubleshooting the system.

low_target	Tank pressure target to end the low bank fill (0.00 Mpa).
low_tank	Actual tank pressure sample after low bank fill (0.00 Mpa).
mid_target	Tank pressure target to end the mid bank fill (0.00 Mpa).
mid_tank	Actual tank pressure sample after mid bank fill (0.00 Mpa).
high_target	Tank pressure target to end the high bank fill (0.00 Mpa).
high_tank	Actual tank pressure sample after high bank fill (0.00 Mpa).
low_error	Percentage difference between initial resistance and resistance calculated after low bank stop (0.00 %).
mid_error	Percentage difference between low bank resistance and resistance calculated after mid bank stop (0.00 %).
pressure_max	Supply pressure used in initial resistance calculation (0.00 Mpa).
subsonic_press	Pressure drop threshold across the hose at which flow is constant during initial resistance calculation ($0.44 * P_{flowing}$ for natural gas) (0.00 Mpa).
init_flow_max	Peak flow value used in initial resistance calculation (0.00 g/s).
init_ib_pressure	Supply pressure at start of low bank fill (0.00 Mpa).
low_init_resist	Resistance calculated at the start of low bank fill (0.00 Pa_s2/g2).
mid_resist	Resistance recalculated at end of the low bank fill (0.00 Pa_s2/g2).
high_resist	Resistance recalculated at end of the mid bank fill (0.00 Pa_s2/g2).
final_resist	Resistance recalculated at end of high bank fill (0.00 Pa_s2/g2).
init_tank_press	Initial vehicle tank pressure sample (0.00 MPa).
low_ib_pressure	Supply pressure at the end of the low bank fill (0.00 Mpa).
low_tank_target	Target tank pressure value for the low bank stop (0.00 MPa).

low_time	Time spent on the low bank (sec).
mid_ib_pressure	Supply pressure at end of the mid bank fill (0.00 Mpa).
mid_tank_target	Target tank pressure value for the mid bank stop (0.00 MPa).
mid_time	Time spent on the mid bank (sec).
high_ib_pressure	Supply pressure at the end of high bank fill (0.00 Mpa).
high_tank_target	Target tank pressure value for the high bank stop (0.00 MPa).
high_time	Time spent on the high bank (sec).
final_mass	Mass delivered over the entire fill that is counted on the display (g) .
final_pressure	Pressure of the full tank after the high bank stop (0.00 Mpa).
low_stop_mass	Estimated mass change recorded after the low stop (g).
mid_stop_mass	Estimated mass change recorded after the mid bank stop (g).
high_stop_mass	Estimated mass change recorded after the high bank stop (g).
low_stop_flow	Flow recorded at the low bank stop (g/s).
mid_stop_flow	Flow recorded at the mid bank stop (g/s).
high_stop_flow	Flow recorded at the high bank stop (g/s).
low_stop_adj	Pressure increase calculation due to low bank valve delay off (0.00 MPa).
mid_stop_adj	Pressure increase calculation due to mid bank valve delay off (0.00 MPa).
high_stop_adj	Pressure increase calculation due to high bank valve delay off (0.00 MPa).
final_flags	State of flags at end of fill. (numb).
spare44	Not defined (numb).
account1	Recorded sequence events 32 bit (numb) #1.
account2	Recorded sequence events 32 bit (numb) #2
account3	Recorded sequence events 32 bit (numb) #3.
account4	Recorded sequence events 32 bit (numb) #4.
algorithm_type	Number to indicate the algorithm used ANGI = 0, GTI = 1 (numb).
time	Real time clock time stamp at the end of the fill (time).
date	Real time clock date stamp at the end of the fill (date).

3.41 Account Registers Bit Definitions.

No.	Reg-Bit	Status#-Event
0	1-0	27 process started right handle
1	1-1	27 process started left handle
2	1-2	26 pressure drop detected
3	1-3	26 no pressure drop detected
4	1-4	24 waiting short delay
5	1-5	24 low bank on
6	1-6	24 waiting motor delay
7	1-7	24 motor delay time out bank off
8	1-8	24 high flow flag bank off
9	1-9	22 high bank on for hose check
10	1-10	22 high bank off above hose mass

11	1-11	22 hose check time out
12	1-12	22 abort during hose check
13	1-13	22 lost authorize during hose check
14	1-14	21 pressure and flow settled after hose check
15	1-15	21 mass >= hose mass, go record pressure
16	1-16	21 mass < hose mass, wait for hose drop
17	1-17	21 spare
18	1-18	20 waiting for hose drop
19	1-19	20 abort time out start delay
20	1-20	20 detected pressure drop (nozzle valve opened)
21	1-21	20 pressure and flow settled after hose drop
22	1-22	19 waiting for pressure and flow to settled
23	1-23	19 pressure settled
24	1-24	19 flow settled
25	1-25	19 flow not settled 10 sec time out abort
26	1-26	19 initial pressure and temperature measured
27	1-27	19 spare
No.	Reg-Bit	Status#-Event
28	1-28	18 calculating target mode 0 (2400psi)
29	1-29	18 calculating target mode 2 (3000psi)
30	1-30	18 calculating target mode 4 (3600psi)
31	1-31	18 temperature compensation off
32	2-0	18 using calculated pressure target
33	2-1	18 using fixed pressure target
34	2-2	18 spare
35	2-3	18 spare
36	2-4	18 target pressure exceeds absolute
37	2-5	18 using given target
38	2-6	18 tank already > 95% full abort
39	2-7	18 spare
40	2-8	16 resist measure
41	2-9	16 flow maximum during resist measure
42	2-10	16 pressure difference sonic
43	2-11	16 pressure difference subsonic
44	2-12	16 resistance within range
45	2-13	16 resistance exceeds maximum
46	2-14	16 resistance below maximum
47	2-15	16 spare
48	2-16	9 low bank fill all banks off
49	2-17	9 low bank fill flow settled
50	2-18	9 low bank fill low bank on
51	2-19	9 low bank fill resistance increased
52	2-20	9 low bank fill resistance decreased
53	2-21	9 low bank fill waiting Sdelay

54	2-22	9 low bank fill in process
55	2-23	9 low bank fill abort inter-bank pressure high
56	2-24	9 low bank fill change on pressure limit
57	2-25	9 low bank fill change on pressure target
58	2-26	9 low bank fill abort on pressure high
59	2-27	9 low bank fill change on low flow
60	2-28	9 low bank fill time out
61	2-29	9 low bank spare 1
62	2-30	9 low bank spare 2
63	2-31	8 mid bank fill all banks off
64	3-0	8 mid bank fill flow settled
65	3-1	8 mid bank fill mid bank on
66	3-2	8 mid bank fill resistance increased
67	3-3	8 mid bank fill resistance decreased
68	3-4	8 mid bank fill waiting Sdelay
69	3-5	8 mid bank fill in process
No.	Reg-Bit	Status#-Event
70	3-6	8 mid bank fill abort inter-bank pressure high
71	3-7	8 mid bank fill change on pressure limit
72	3-8	8 mid bank fill change on pressure target
73	3-9	8 mid bank fill abort on pressure high
74	3-10	8 mid bank fill change on low flow
75	3-11	8 mid bank fill time out
76	3-12	8 mid bank spare 1
77	3-13	8 mid bank spare 2
78	3-14	7 high bank fill all banks off
79	3-15	7 high bank fill flow settled
80	3-16	7 high bank fill high bank on
81	3-17	7 high bank fill resistance increased
82	3-18	7 high bank fill resistance decreased
83	3-19	7 high bank fill waiting Sdelay
84	3-20	7 high bank fill in process
85	3-21	7 high bank fill abort inter-bank pressure high
86	3-22	7 high bank fill change on pressure limit
87	3-23	7 high bank fill change on pressure target
88	3-24	7 high bank fill abort on pressure high
89	3-25	7 high bank fill change on low flow
90	3-26	7 high bank fill time out
91	3-27	7 high bank spare 1
92	3-28	7 high bank spare 2
93	3-29	4 fill complete wait for settle
94	3-30	4 fill complete
95	3-31	2 abnormal shutdown

96	4-0	1 data recorded wait for handle off
97	4-1	1 spare
98	4-2	0 spare
99	4-3	0 fill denied temperature error (not implemented)
100	4-4	0 drop flag time out (not implemented)
101	4-5	spare
102	4-6	spare
103	4-7	9 low bank burst detect
104	4-8	8 mid bank burst detect
105	4-9	7 high bank burst detect
106	4-10	spare
107	4-11	spare
108	4-12	spare
109	4-13	low bank pressure exceeds Smax
110	4-14	mid bank pressure exceeds Smax
111	4-15	high bank pressure exceeds Smax
No.	Reg-Bit	Status#-Event
112	4-16	low bank pressure exceeds absolute
113	4-17	mid bank pressure exceeds absolute
114	4-18	high bank pressure exceeds absolute
115	4-19	handle shut off during fill
116	4-20	redundant pressure error abort
117	4-21	lost authorize during fill
118	4-22	Spare 119
119	4-23	Spare 120
120	4-24	Spare 121
121	4-25	Spare 122
122	4-26	Spare 123
123	4-27	Spare 124
124	4-28	Spare 125
125	4-29	Spare 126
126	4-30	Spare 127
127	4-31	Spare 128

3.5 Totalizer Data Values

This function captures mass and sale values and at the end of the fill sequence, accumulates the results in their respective totalizers, and stores the results in a non-volatile memory record. 128 records are backed up for each hose. The logging “wraps around,” writing over the oldest record first. All these registers are read only.

total_save_count Number of fills counted since dispenser was put into service (numb).

log_count	Number of hose fills counted since dispenser was put into service (numb).
time_stamp	Real time clock time stamp at the end of the fill (time).
date_stamp	Real time clock date stamp at the end of the fill (date).
id	Hose Id: 0 = A, 1 = B (numb).
total_extend	Value extension of the 4 totalizers beyond 32-bit long word. Each 32-bit totalizer words below get an extended 8-bit part for 40 bits max (numb)
total_sale_tier1	Sale totalizer for tier1 price since dispenser was put into service (\$)
total_mass_tier1	Mass totalizer for tier1 price since dispenser was put into service (g)
total_sale_tier2	Sale totalizer for tier2 price since dispenser was put into service (\$)
total_mass_tier2	Mass totalizer for tier2 price since dispenser was put into service (g)
price_tier_ran	Number indicating which tier was used, 1 or 2 (numb).
total_mass_ran	Mass amount counted for the on display at the end of the fill (g).
total_sale_ran	Sale amount on display at end of the fill (\$).
total_qty_ran	Mass amount on the display at the end of the fill (display mass units).
price_ran	Price on display at the time of the fill (\$).
sale_ran_decimal	Decimal point used in the sale amount on the display (numb).
qty_ran_decimal	Decimal point used in the quantity amount on the display (numb).
price_ran_decimal	Decimal point used in the price amount on the display (numb).
sale_ran_decimal	Decimal point used in the sale amount on the display (numb).
low_cycle_total	Number of lifetime cycles for the low bank valve (numb).
mid_cycle_total	Number of lifetime cycles for the mid bank valve (numb).
high_cycle_total	Number of lifetime cycles for the high bank valve (numb).
total_fault	Number of faults during the sequence (numb).
shift_sale_tier1	Sale totalizer for tier1 price since last cleared by the attendant (\$).
shift_mass_tier1	Mass totalizer for tier1 price since last cleared by the attendant (g).
shift_sale_tier2	Sale totalizer for tier2 price since last cleared by the attendant (\$).
shift_mass_tier2	Mass totalizer for tier2 price since last cleared by the attendant (g).
shift_time_stamp1	Time recorded when tier1 shift was cleared by the attendant (time).
shift_date_stamp1	Date recorded when tier1 shift was cleared by the attendant (date).
shift_time_stamp2	Time recorded when tier2 shift was cleared by the attendant (time).
shift_date_stamp2	Date recorded when tier2 shift was cleared by the attendant (date).
qty_remainder	Decimal mass amount remaining on the display at the end of the fill. Used for the external totalizer. Added to the next fill (display mass units).

3.6 Control Registers

These register variables are to do with hardware and program control. There is a mix of read only, write protected, and read-write types.

action_command Writing a number to this register performs a task (see table). Will be immediately returned to zero by the program. Always accessible.

action_commanded	Displays the number written in the action_commanded register if the action was permitted and valid. Return zero if not permitted or if the number written is not valid. Read only.
io_inputs	Digital input bits from the MCDS Interface board. Read only.
io_outputs	Digital output bits to the MCDS Interface board. Read only.
force_out_off	Register to force the digital output bits off. Normally read only. Write enabled by password unlock and SW1_1 = on.
force_out_on	Register to force the digital output bits off. Normally read only. Write enabled by password unlock and SW1_1 = on.
keyset_0	Number for indicating the keypad button being pushed from display node zero.
keyset_1	Number for indicating the keypad button being pushed from display node one.
main_loop_Boolean	Control bits used by the program (see table).
keyset_2	Number for indicating the keypad button being pushed from display node two.
keyset_3	Number for indicating the keypad button being pushed from display node three.
RTC_time	Time from the real time clock on the dispenser control board. Read / password write.
RTC_date	Date from the real time clock on the dispenser control board. Read / password write.
time_control	Register to control the real time clock. 0 = run. 1 = stop and allow for update. 2 = write new time and restart.. 3 = stop, write, and restart. 4 and greater = ignore and clear time_control to zero.
average_scan	The main loop scan time averaged over one second in microseconds.
maximum_scan	Largest main loop scan time recorded over one second in microseconds.
minimum_scan	Smallest main loop scan time recorded over one second in microseconds.
key_mode	Coded number for a keypad action (see table).
rom_save_addr	Parameter address to lookup a changed parameter. Write.
value_addr	Returned section and offset address of a changed parameter. Read only.
ram_value	Returned parameter value from the RAM memory. Read only.
rom_value	Returned parameter value from the Flash memory. Read only.
trail_list_base	Flash memory address for the audit trail lookup list record.
data_trail_base	Flash memory address for the audit trail changed parameter value record.
pass_number_1	Unlock password register. Always accessible. Write. Read = 0. A valid number unlocks the write protect on the parameters and variables according to an access level. The unlocked state is maintained as long as the Comm link communication is refreshed within 2 seconds. An invalid number locks the write protect.

pass_number_2 Concurrent password register. Always accessible. Write. Read = 0. A special unlock of write protects for some commands and registers. Must be written simultaneously with the data by a Comm link packet. The write protect on these functions immediately re-locks.

access_level A coded number for what range of write protect is unlocked.

backup_ROM The flash memory address for the totalizers values copied during a clear.

3.61 Action Command Code Definitions:

action_command =	Function
0	Do nothing.
1	Refresh the RAM parameter values from the Flash memory. Parameter restore.
2	Do nothing.
3	Write the RAM parameters values to the Flash memory. Parameter save.
4	Clear and initialize the audit trail. Initialize protect must be unlocked and the action command must be accompanied by a pass_number_2 value. For program revs 3.81 and earlier this function only acts one time and will be permanently disabled afterward. See action 27.
5	Refresh the price values from the Flash memory.
6	Loads the process addresses into the process log.
7 - 9	Do nothing.
10	Clear the simulator monitor log in the flash memory.
11	Clear and initialize the totalizers. Initialize protect must be unlocked and the action command must be accompanied by a pass_number_2 value. For program revs 3.81 and earlier this function only acts one time and will be permanently disabled afterward. See action 26.
12	Do nothing
13	Perform a meter zero calibration on hose "A". Disabled when filling.
14	Perform a meter zero calibration on hose "B". Disabled when filling.
15	Clear the meter mass totalizer on hose "A". Disabled when filling.
16	Clear the meter mass totalizer on hose "B". Disabled when filling.
17-19	Do nothing.
20	Authorize the "A" hose by the Comm link. Must be accompanied by a pass_number_2 value = 20.
21	De-authorize the "A" hose by the Comm link. Must be accompanied by a pass_number_2 value = 21.
22	Authorize the "B" hose by the Comm link. Must be accompanied by a pass_number_2 value = 22.
23	De-authorize the "B" hose by the Comm link. Must be accompanied by a pass_number_2 value = 23.
24	Clear hose A fault display. Program rev. 3.82 and higher.

25	Clear hose B fault display. Program rev. 3.82 and higher.
26	Permanently disables action 11. Totalizers can not be cleared afterward. Disabling can not be undone. Program rev. 3.82 and higher.
27	Permanently disables action 4. Audit trail can not be cleared afterward. Disabling can not be undone. Program rev. 3.82 and higher.

3.62 Digital Input Bit Definitions:

Input bit	Terminal	Input Name
0	TB10-77	A_handle_left
1	TB10-76	A_handle_right
2	TB10-75	A_handle_hose_seated
3	TB10-74	A_spare_input
4	TB10-73	B_handle_left
5	TB10-72	B_handle_right
6	TB10-71	B_handle_hose_seated
7	TB10-70	B_spare_input
8	TB3-19	A_authorization_1
9	TB3-20	A_authorization_2
10	TB3-21	A_authorization_3
11	TB3-22	A_tier_2
12	TB3-24	B_authorization_1
13	TB3-25	B_authorization_2
14	TB3-26	B_authorization_3
15	TB3-27	B_tier_2
16	NA	SW1_1
17	NA	SW1_2
18	NA	SW1_3
19	NA	SW1_4
20	NA	SW1_5
21	NA	SW1_6
22	NA	SW1_7
23	NA	SW1_8
24	NA	spare_24
25	NA	spare_25
26	NA	spare_26
27	NA	spare_27
28	NA	spare_28
29	NA	spare_29
30	NA	spare_30
31	NA	spare_31

3.63 Digital Output Bit Definitions:

Output bit	Terminal	Output Name
0	NA	not_defined_0
1	NA	not_defined_1
2	NA	not_defined_2
3	NA	not_defined_3
4	NA	not_defined_4
5	NA	not_defined_5
6	NA	not_defined_6
7	NA	not_defined_7
8	NA	ESD_Active, toggles every program cycle.
9	NA	ESD_Active, toggles every program cycle.
10	TB4-31	A_lowbank_valve, on for low bank fill.
11	TB4-32	A_midbank_valve, on for mid bank fill.
12	TB4-33	A_highbank_valve, on for high bank fill.
13	TB4-35	B_lowbank_valve, on for low bank fill.
14	TB4-36	B_midbank_valve, on for mid bank fill.
15	TB4-37	B_highbank_valve, on for high bank fill.
16	TB1-1	A_choke, on when the A tank pressure is > 90% of the target pressure.
17	TB1-2	A_demand, on when in the A fill cycle.
18	TB1-3	A_filling, on when in the A fill cycle or with the A valve outputs.
19	TB1-4	A_authorize, on when the A handle input is on.
20	TB1-5	A_complete, on at the end of the A fill cycle, off with the A handle off.
21	TB1-6	A_error, on when a fault occurs. An "F" error code will be displayed.
22	TB1-7	B_choke, on when the B tank pressure is > 90% of the target pressure
23	TB1-8	B_demand, on when in the B fill cycle.
24	TB1-9	B_filling, on when in the B fill cycle or with the B valve outputs.
25	TB1-10	B_authorize, on when the B handle input is on.
26	TB1-11	B_complete, on at the end of the B fill cycle, off with the B handle off.
27	TB1-12	B_error on when a B fault occurs. An "F" error code will be displayed.
28	TB2-13	A_sale_pulse_output, pulses when the A sale display value increases.
29	TB2-14	A_mass_pulse_output, pulses when the A mass display value increases.
30	TB2-16	B_sale_pulse_output, pulses when the B sale display value increases.
31	TB2-17	B_mass_pulse_output, pulses when the B mass display value increases.

3.64 Main Loop Booleans Definitions

Spare	Was "get_changes" before rev. 3.06.
not_writing_flash	Indicates the flash memory is not being written to. Allows interrupts
one_sec_os	Turns on once a second for one program scan..
GTI_algorithm	Enables the Gas Institute of Technology algorithm. Turns off ANGI control.
single_meter	Enables the use of one flow meter for two hoses. Connected to SW1_8
calibrate_enable	On when the Comm link password is cleared.
sw1_1_on	Indicates the state of switch1_1. Configuration calibration enable.
display_0_ok	Indicates the display at node 0 is communicating.
display_1_ok	Indicates the display at node 1 is communicating.
audit_sorted	Indicates the audit trail sorting function is finished.
single_step	Single step diagnostic function.
supply_above_22v	On when the controller supply voltage is above 22 volts.
supply_below_21v	On when the controller supply voltage is below 21 volts.
supply_was_ok	Latches on when the supply voltage went above 22 volts.
supply_loss	Latches on when the supply voltage goes below 21 volts and was OK before
supply_loss_ack	Acknowledges the supply voltage drop as a power loss. Saves data.
param_changed	Indicates a parameter value in the program is different that what is stored.
param_scanned	Indicates all the parameters have been check to what is stored in memory.
quick_scan	Not implemented.
fill_A_right	The "A" hose right handle input is acknowledged.
fill_A_left	The "A" hose left handle input is acknowledged
fill_B_right	The "B" hose right handle input is acknowledged
fill_B_left	The "B" hose left handle input is acknowledged
display_2_ok	Indicates the display at node 2 is communicating.
display_3_ok	Indicates the display at node 3 is communicating.
totals_ready	Enable the refresh of the totalizer values from memory. Off when writing.
simulating_fill	Indicates the fill simulator is enabled.
display_totals_bit	Enables the display of the totalizers.
comm_connected	Indicates there is ANGI monitor communication active on Comm 0 or 5.
meter_data_force	Forces the meter communication to read only the meter values used in fill.
tier_display_bit	Selects which price tier to display during price changing.

3.65 Key Mode Code Definitions:

Key_mode	Function
0	Normal run mode.
1	Price set hose “A” tier 1
2	Price set hose “A” tier 2
3	Price set hose “B” tier 1
4	Price set hose “B” tier 2
5	View total sale tier 1. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
6	View total mass quantity tier 1. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
7	View total sale tier 2. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
8	View total mass quantity tier 2 key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
9	View shift total sale tier 1. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
10	View shift total mass quantity tier 1. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
11	View shift total sale tier 2. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
12	View shift total mass quantity tier 2 key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
13	View “A” hose meter totalizer.
14	View “B” hose meter totalizer.
15	View combined mass total of both tiers. key_sub_mode = ‘A’: hose “A” key_sub_mode = ‘B’: hose “B”
16	Save the changes to previously active shift total mode to memory. Go to 0.
17	Enable the view for changing the mass display units.
18	View the audit trail with the displays.
19	View the parameter and variable values with the displays.
20	View the flow meter register values with the displays. Meter_view_stat = 0: “A” meter. Meter_view_stat = 1: “B” meter.

3.66 Access for Write Enable Bit State Definitions:

access_level bit	Parameter, Variable, or Function Type	Switch 1_1
0 (01 hex)	Real Time Clock	Don't Care
1 (02 hex)	Fill parameters, non-mass calibration type.	Don't Care
2 (04 hex)	Mass calibration parameters.	Don't Care
3 (08 hex)	Configuration parameters.	On = Allow / Off = Forbid
4 (10 hex)	Initializing actions.	On = Allow / Off = Forbid
5 (20 hex)	Variables.	On = Allow / Off = Forbid
6 (40 hex)	Price Change.	On = Allow / Off = Forbid
7 (80 hex)	Not Implemented.	Don't Care
8 (100 hex)	Control functions. Always write enabled.	Don't Care
8 (200 hex)	Audit trail clearing lock status. 1 = locked, 0 = not locked.	Don't Care
8 (400 hex)	Totalizer clearing lock status. 1 = locked, 0 = not locked.	Don't Care

3.7 Analog Inputs.

10-bit values from the on-chip analog to digital converter. 0 = 0mA or 0V. 1023 = 20mA or 5V.

AIN0	Analog input 0 input value; 0-1023. "A" flow or second pressure sensor.
AIN1	Analog input 1 input value; 0-1023. "B" flow or second pressure sensor.
AIN2	Analog input 2 input value; 0-1023. "A" pressure.
AIN3	Analog input 3 input value; 0-1023. "B" pressure.
AIN4	Analog input 4 input value; 0-1023. 24vdc power supply voltage.
AIN5	Analog input 5 input value; 0-1023. Temperature probe.
AIN6	Analog input 6 input value; 0-1023. Spare.
AIN7	Analog input 7 input value; 0-1023. Spare.

3.8 Price Values.

These are the registers that retain the price per mass-unit values. Normally read only. Write protect is unlocked with pass_number_1. Write protected if the handle is on.

Aprice_per_unit_t1	"A" hose price for tier 1.
Aprice_per_unit_t2	"A" hose price for tier 2.
Aprice_decimal_t1	"A" hose price decimal point for tier 1.

Aprice_decimal_t2	"A" hose price decimal point for tier 2.
Atier_select_mem	"A" hose active tier number.
Bprice_per_unit_t1	"B" hose price for tier 1.
Bprice_per_unit_t2	"B" hose price for tier 2.
Bprice_decimal_t1	"B" hose price decimal point for tier 1.
Bprice_decimal_t2	"B" hose price decimal point for tier 2.
Btier_select_mem	"B" hose active tier number

3.9 Process Log Addresses.

The process function is a real-time record of the fill process variables during a fill sequence. A maximum of ten variables can be sampled. Any variable on the Series II Monitor program list can be sampled. To sample a variable, the list address for that variable must be written to one of the process addresses before a fill. Samples of ten variables are taken in multiple intervals of 40 milliseconds. The default minimum interval is 40ms (process_mod = 0). The process_mod variable is used to select longer interval samples, process_mod = 1: 80ms, process_mod = 2: 120ms, etc. The process sampling starts when the display is reset to zeros after the all segment test (status = 22, filling = On). The process sampling halts when the fill is finished (status = 2 or 3, filling = off). The final number of samples taken are stored in the variable **final_process_count**. The Series II Monitoring program is used to upload the process log. The process sample function stores only the most current fill data in RAM memory. The data is written over by another fill or lost if the power is removed. The maximum number of sample sets is 6536.

Defaults:

AProcess_1	Amass
AProcess_2	Apressure
AProcess_3	Aflow
AProcess_4	Atemperature
AProcess_5	Atank_pressure
AProcess_6	Aflags
AProcess_7	Aaccount_1
AProcess_8	Aaccount_2
AProcess_9	Aaccount_3
AProcess_10	Aaccount_4
BProcess_1	Bmass
BProcess_2	Bpressure
BProcess_3	Bflow
BProcess_4	Btemperature
BProcess_5	Btank_pressure
BProcess_6	Bflags
BProcess_7	Baccount_1
BProcess_8	Baccount_2
BProcess_9	Baccount_3
BProcess_10	Baccount_4

3.10 Gilbarco Communication Link Variables (spc variables).

The spc_comm functions are part of the Gilbarco communication protocol. Only the A hose variables are shown as examples.

Apump_node	A number indicating the hose number and dispenser number as a communication address. Hose A or B can be odd or even numbers but not the same. Dispensers are identified by increments of 2. Example: Apump_node = 0: A hose dispenser 1, Apump_node = 1: B hose dispenser 1, Apump_node = 2: A hose dispenser 2, Apump_node = 3: B hose dispenser 2, etc. Written by the dispenser.
Apump_status	A coded number indicating the hose state (see table). Written by the dispenser.
Aspc_ident	A bit coded number for indicating what command has been processed.
Aspc_grade	The current fuel grade in use written by the host controller. Only grade 1 is valid in a NGV dispenser. The final letter in the names below x = grade number 1-6. Six sets of grades with eight variables.
Aspc_price1_gx	Price for tier 1. Written by the host controller.
Aspc_price2_gx	Price for tier 2. Written by the host controller.
Aspc_tier_gx	The current price tier in use. Written by the host controller.
Aspc_price_gx	The current price used. Written by the dispenser.
Aspc_vol_gx	The final mass dispensed by a fill in the displayed mass units. Read only.
Aspc_money_gx	The final sale total for a fill. Read only.
Aspc_vol_total_gx	The mass totalizers for both tiers converted into displayed mass units. Read only.
Aspc_mon_total_gx	The sale totalizer for both tiers. Read only.

pump_status code	Description
0	Error.
6	Pump is off. Handle is off.
7	Call for authorization. Handle is on.
8	Authorized. Pump is not on. Handle is off.
9	Busy. Filling in progress. Handle is on and the dispenser is authorized.
10	Transaction complete. Filling is done.
11	Transaction complete. Filling is done. Waiting for the host controller to read the transaction data.

12	Stop. Not a valid state in an NGV dispenser. The stop command will go to 10: Transaction complete.
13	Send data. Host controller writing the price, tier, grade, or reading totals.

4 ANGI Series II Monitor Communication Link Protocol.

4.1 Communication Protocol General Description.

The Series II can be accessed through standard RS232 and RS485 ports using a custom protocol developed at ANGI for a computer program that runs on a Windows based system. This program is referred to as Monitor program throughout this document. The protocol uses the standard 8-bit ASCII code character set with the typical start character, node number, data, checksum, and terminating character. The ASCII code character set represents the characters on a computer keyboard (typewriter), letters, numbers, punctuation, special characters, and Teletype control. The general function of communication is to read or write number or letter character data or perform actions. A set of coded commands is used to accomplish this. There are a number of data areas to access in the dispenser control. Each area is a list of number storage points. They are:

- 1) A "Main" list of parameters and variables.
- 2) Flow meter parameters and variables.
- 3) CPU memory.
- 4) Audit trail data.
- 5) Process logs.

Individual elements like parameter, variable, and memory points are specifically access by their address number. The address number is their place on a list. Example: the 512K byte flash memory begins at address 2000000 hex and ends at 2080000 hex under CPU memory. The "Main" list begins at address 0 and ends at 999. For the most part in the dispenser controller, each point is a 32-bit number or what is called a "long word" in the programming world. These points can hold a number value from 0 to 4294967295.

4.2 Basic Serial Communication.

The serial communication function on a computer port and the Series II control board port transfers data serially one bit at a time at a clocked rate called a BAUD rate. Bits are either a zero or a one. Each bit is sent out of a port at the set clock time. The next bit will be sent out the next clock time and so on. The BAUD rate is how many bits per second are sent. Example: If the rate = 1000 the clock rate is 1 bit every millisecond. 1000 bit can be sent in one second. The ASCII character data is 8-bits long. Any 8-bits of data is contained in a structure of bits that the electronics can recognize. This is so the electronics can definitively transfer one character at a time. The typical "packet" has 10 or 11 bits. The first bit is always a zero. The electronics uses the arrival of this first bit to recognize the start of a packet and to start the timing of the oncoming bits. Next, the 8 bits of data are sent in order from lowest to highest. The next bit is the parity bit. This single bit is used to check weather if any data bit is in error. It is one or zero depending on weather

the count of the one bits in the data are even or odd. For “even parity” the transmitter counts the data bits that are one and sets the parity bit to one if the is an even count. If the receiver counts an even number of data bits that are one, it assumes no error. If it counts an odd number then the receiver indicates a “parity” error. For “odd parity” the parity bit is set to one on an odd count of data bits that are one. For “no parity” this bit is not transmitted or expected to be received. Next is either a single or two stop bits to indicate the packet has ended. These bits are always one. The electronics will then indicate one character has been received and to expect another packet to immediately follow. The structure used by the transmitter must match the structure used by the receiver. If the number of stop bits, parity type selection, or BAUD rates are different between the transmitter and receiver, a “framing” error will occur.

A serial protocol is built from a set of 8-bits of data. Essentially the same job of detecting when this larger level of “packet” begins and ends applies. Some protocols, like ModBus RTU, do this with timing and “quiet” periods. Number data is written right in to the 8-bits. Protocols built with ASCII characters use special characters to indicate the start and stop. Number data are encoded into the letter and number characters. These are called “strings” of characters contained in the packet. Numbers can be represented by decimal characters 0-9 (dec for short), or with hexadecimal characters 0-9 A-F (hex for short). A-F is 10-15. Example: a hex number 1A is $1 \times 16 + 10$ of 26 dec, 12E is $1 \times 256 + 2 \times 16 + 14$ or 302 dec. Another function that is typically part of a protocol is an error checking function usually called a checksum. It is similar to the parity bit in the 8-bit structure. There are many schemes to checksums but they all are put next to the end and generate a number from all the characters sent before. The basic one is to take each character’s ASCII number and exclusive or all of then together. Example the ASCII number for “0” is 30 hex and for “9” is 39. $30 \text{ exor } 39$ is 09. Two characters “09” is tagged on to the end of the packet string. The result is converted to two hex number characters.

4.3 Specific Series II Protocol.

The Series II protocol is an ASCII character protocol that has one start, two node, two action, data, two checksum, and one end character(s). Number data is represented in hex. Special non-letter and non-number characters are used for data control.

Node: the communication address number (0 – 255) to access a particular dispenser on the network.

Action: a coded number that commands the dispenser control to perform a communication task (0-255). Data string: a string with control characters followed by an associated hex number.

The basic string structure is

	ASCII Value hex	ASCII Character	Description
1	01	Start heading	Start character
2	30-39, 41-46	0-9, A-F	Node msb
3	30-39, 41-46	0-9, A-F	Node lsb
4	30-39, 41-46	0-9, A-F	Action msb

5	30-39, 41-46	0-9, A-F	Action lsb
6		0-9 A-F ! @ # \$ % ^ & *	First byte of data string
n		0-9 A-F ! @ # \$ % ^ & *	Subsequent bytes
7+n	30-39, 41-46	0-9, A-F	Checksum msb
8+n	30-39, 41-46	0-9, A-F	Checksum lsb
9+n	0D	Carriage return	End character

The action number specifies the communication function to return. If the action involves acting on variable and parameter values, up to ten addresses can be specified at one time.

Action number	Action performed
0	Echo back node, action, and nothing else.
1	Return with all the particulars that go with an address. Address, type, audit, value, decimal point, unit and name.
2	Read or write a parameter or variable at a specific address. Will return the value, decimal point, and unit code. Will not return a decimal point if the value is a floating-point number.
3	Read or write a parameter or variable at a specific address. Will return the value, decimal point, but not a unit code. Will not return a decimal point if the value is a floating-point number.
4	Returns whatever parameter and variable values, decimal point placements, units, and audit history have changed since the last transmission. The number of values is limited to keeping the response packet under 254 bytes. This function will cycle through all the addresses in sequential order to monitor all changes as long as the action is polled.
5	Returns the values in the "A" hose process log starting at a particular address. As many values are returned that can keep the packet length under 254 bytes.
6	Returns the values in the "B" hose process log starting at a particular address. As many values are returned that can keep the packet length under 254 bytes.
7	Returns with all the particulars starting at a particular address and continues in upward sequential order. Address, type, audit, value, decimal point, unit and name. As much data are returned that can keep the packet length under 254 bytes. For initial listing by the Monitor program.
8	Reads the Flash memory starting from any arbitrary address. Returns values in unsigned long word. A certain count can be specified. If not specified, as many values are returned that can keep the packet length under 254 bytes.
9	Reads the audit trail values.
10	Reads the "A" flow meter register values. Reads a single integer.
11	Reads the "B" flow meter register values. Reads a single integer.
12	Reads the "A" flow meter register values. Reads multiple arbitrary addresses. Converts between integers and floating points.

13	Reads the “B” flow meter register values. Reads multiple arbitrary addresses. Converts between integers and floating points.
----	--

Data string structure control character definitions to the dispenser control:

Character	Function	Following hex number or string.	Example
?	Read a value	At this address	?1E8
!	Write a value	At this address	!1E8
	Or a value to the existing value	At this address	1E8
&	And an inverse value to the existing value	At this address	&1E8
@	Bit address under main address	At this bit	?1E8@4
#	Follow write, or, not and	Provided value	#1234
*	Write decimal point placement	Decimal point value	*3
:	Follow write to bit x of 31	Provide bit placement	:6
\$	Read string	String	\$srghyu
\	Split an address value	Directory address \ item sub-address	34\24

Data string structure control character definitions from the dispenser control:

Character	Function	Following hex number or string.	Example
!	Requested value or string	Is at this address	!1E8
@	Requested bit placement	Is at this bit placement	!1E8@12
#	Requested value	Read value with cast qualifier prefix Prefix = 0: unsigned long Prefix = 2: floating point	#01234
\$	Requested string	Parameter, variable, or bit name	\$Aburst
*	Requested value's decimal	Is the decimal point placement value	*3
&	Requested value's units	Code for the engineering units	&141
	Requested value's type	Letter for parameter, variable, etc. with a number for the audit trail.	D1022

The data string structure is pieced together with the address command first following the value commands. Examples shown exclude the start, checksum, and end characters:

Read the value at address 35E hex dispenser node 1. Action = 3.

To dispenser: 0 1 0 3 ? 3 5 E

Response: 0 1 0 3 ! 3 5 E # 0 1 2 3 4 * 2

The value is an unsigned long 1234 hex (from #01234) with 2 decimal places (from *2). The hex number 1234 is 4660 dec. The displayed decimal value becomes 46.60.

Read the all at address 1F hex dispenser node 5. Action = 1.

To dispenser: 0 5 0 1 ? 1 F

Response: 0 5 0 1 ! 1 F | P 1 0 0 1 # 0 1 C 8 * 1 & 9 6 \$ S d p m a x

The type is "P" for parameter, audit = 1 change, value is 1C8 hex with 1 decimal place, unit code is 96 hex or 140 dec for "%", and the name is "Sdpmax". The displayed number is Sdpmax 45.6 %.

Write a value 432 hex at address 35E hex dispenser node 1. Action = 3. Access permitted.

To dispenser: 0 1 0 3 ! 3 5 E # 4 3 2

Response: 0 1 0 3

The value was 1234 hex with 2 decimal places, the value is now 432 hex still with 2 decimal places.

Write a value 432 hex at address 35E hex dispenser node 1. Action = 3. Access denied.

To dispenser: 0 1 0 3 ! 3 5 E # 4 3 2

Response: 0 1 0 3 ! 3 5 E # 0 1 2 3 4 * 2

The value remains 1234 hex with 2 decimal places, response comes back with the original unchanged value.

Write a decimal point placement at address 35E hex dispenser node 1. Action = 3. Access permitted.

To dispenser: 0 1 0 3 ! 3 5 E * 3
Response: 0 1 0 3

The value was 1234 hex with 2 decimal places, the value is still 1234 hex with 3 decimal places.

Read the value at address 1F hex dispenser node 1. Action = 2.

To dispenser: 0 1 0 2 ? 1 F
Response: 0 1 0 2 ! 1F # 0 1 C 8 * 1 & 9 6

The value is an unsigned long 1C8 hex (from #01C8) with 1 decimal places (from *1) and % units (from &96). The hex number 1234 is 4660 dec. The displayed decimal value becomes 46.60.

Read three sequential values in the flash memory starting at byte address 2001000 hex dispenser node 1. Action = 8. The values are four bytes long.

To dispenser: 0 1 0 8 ? 2 0 0 1 0 0 0 # 3
Response: 0 1 0 8 ! 2 0 0 1 0 0 0 # 4 3 F 6 ! # D 2 F 7 5 ! # 5 4

The three values are 43F6, D2F75, 54 hex. The first exclamation point “!” is followed by the starting address. The first “#” is followed by the value 43F6 read at that address. The second “!” is not followed by a hex number but goes right to the “#” symbol. This implies the next address 2001004. (Addresses from the memory read are incremented by 4 bytes). The second “#” is followed by the next value D2F75. The last “!” and “#” implies address 2001008 with value 54.

Read the “A” meter register values at address 257 dec (101hex) dispenser node 1. Action = 5.

To dispenser: 0 1 0 5 ? 1 0 1
Response: 0 1 0 5 ! 1 0 1 # 2 4 0 C 0 0 0 0 0

The value is a floating point # 40C00000 hex. The float number 4 0 C 0 0 0 0 0 is 1.500000 E+00. The ModBus address is 257 and 258. Each address in the meter is a 16-bit integer value. A floating point value uses two meter addresses to make a 32-bit value.

5 ANGI SERIES II Monitoring Program

The ANGI SERIES II monitoring tool is a Windows based program that gives access to the system parameters, on-line variable monitoring, previous fill result data, actual time process signal recording, and program download capability. It also has pass-through monitoring and parameter editing access to the MicroMotion mass flow meter registers.

The tool connects to the ANGI SERIES II system through a standard RS232 com port found on a typical laptop or desktop computer. The ANGI SERIES II Interface board supplies an RS232 port for monitoring or programming (COM0). It also provides an RS485 port for monitoring only (COM5). Multiple dispensers, up to 32, can be connected on an RS485 network using a unique node address for each dispenser. The monitoring tool and the dispenser communicate with a custom protocol using the ASCII character format. Once connected and on-line, the monitoring tool downloads the parameter and variable names, values, and units from the dispenser microcontroller. It displays them on a master list. Once the download is complete, the monitoring tool will continually retrieve changing system variables

The ANGI SERIES II monitoring tool allows the user to modify system parameters as described in section 2.

System parameters allow calibration changes to be made on the system, only when the system is not sequencing. The system parameters and variables are normally write-protected. The write protect must be unlocked by entering a password. There are different passwords for certain levels of access for 1) setting the real time clock, 2) parameters that effect fill behavior, 3) parameters that affect mass measurement, 4) parameters that effect hardware set-up, 5) influencing operational variables 6) initializing totalizers, and 7) adjusting the price per unit. Levels 4, 5, and 6 must also have the physical switch SW1_1 flipped to the on position from the off position to unlock. Access to this switch is in the main electrical cabinet. The dispenser is inhibited from sequencing any time SW1_1 is on. Changes made to the system parameters are first written to volatile memory (RAM). The system will operate with the changes when SW1_1 is returned to the off position. Changes then must be stored in non-volatile memory (EEPROM) to reload them on power up. This is done with the ANGI SERIES II monitoring tool by clicking on the "save to memory" menu item.

Any changes stored to non-volatile memory are also stored to a change audit trail log. Each set of changes is time stamped. 1024 single changes can be recorded before the log "wraps around." The ANGI SERIES II monitoring tool can download the change log for display and save as a text file.

System parameters should only be adjusted when absolutely necessary. It is possible to completely disrupt the dispenser operation by altering system parameters incorrectly.

6 Parameter Change Audit Trail

The parameter change audit trail is an historical log that retains parameter value changes in non-volatile memory. Any parameter value changed through the communication link will be recorded. The new value is recorded along with a time and date stamp from the on board real-time clock and an overall change count. The trail can keep 1024 changes. Changes beyond a count of 1024 will write over the oldest changes. The change counter will count up to 32768 before wrapping around to zero. The dispenser program continually runs an algorithm that sorts through the trail and groups the changes by the parameter number (see section 2.2 and 2.3 for the numbers). The sorted results can be viewed through the dispenser displays and keypad or downloaded to the PC based monitoring tool. The monitoring tool can save the downloaded results to a text file. The audit trail also records changes to the MicroMotion mass-flow meters if the changes were done through the dispenser control by the monitoring tool (dispenser firmware rev 3.80 or greater). The trail records the ModBus address number of the parameter. In dispenser program revisions 3.81 and lower, there is a one-time audit trail clear function that erases this log and then disables any further erasures. This function is to get rid of parameter adjustments during the dispenser's factory test. Parameter changes recorded after test are all changes done in the field. In dispenser program revisions 3.82 and higher, the clearing and clear-disable functions are separated. The trail can be cleared multiple times until the clear-disable function is activated. Once the clear-disable function is executed the trail can not be cleared ever again. This is accomplished in the dispenser controller.