ControlWave® GFC
Power System Sizing

Emerson Process Management has designed the ControlWave® GFC to use an absolute minimum amount of power while performing measurement and automation operations at remote sites, such as gas wells and metering stations.

We have used the latest in low-power electronics technology, sleep modes, and other methods that allow the application to minimize current draw.

Users will appreciate that they need not skimp on functionality to conserve power. The minimum measurement configuration consumes, on average, only 3 mA at 12 Vdc. ControlWave GFC will also supervise a two-run M&R station or a well site with a current draw that is between 6 mA and 12 mA at 12 Vdc, depending on how many external transmitters are used.

In addition, ControlWave GFC applications typically include an internal radio for wide-area SCADA network communication and process I/O.

To cover a range of configurations that operate up to 30 mA at 12 Vdc, Emerson has designed a choice of integral power systems:

- 6Vdc nominal (7.2Vdc actual), 35 AH lithium battery
- 6Vdc, 7 AH lead acid cell battery with a 1 Watt solar panel
- 6Vdc, 7 AH lead acid cell battery with a 6.5 Watt solar panel
- 12 Vdc, 7 AH lead acid cell battery with a 4.3 Watt solar panel

Each solar power system provides plenty of autonomous time and practically zero drop-out probability, so users can be fully confident in its reliable operation. Lithium battery systems are designed for operating lives between ½ year and 2 years.

Emerson offers a variety of power systems to best meet requirements in the following, overall situations:

- 6Vdc solar/battery power systems provide the lowest purchasing cost for configurations, which don't supply analog loop current and don't use standard model radios. However, 6Vdc systems do allow use of OEM modems or radios and provide a choice of solar panels to minimize costs, e.g. a one-watt panel can be used without a radio.
- The 12Vdc solar/battery power system is intended for use with configurations that do include standard model radios from Freewave and MDS. Also, 12Vdc is required for most transmitters and for loop current.

Lithium battery systems are offered for those installations that are unfavorable to solar power. For instance, if the installation is within a building or structure that makes wiring to a solar panel unfeasible. Also, if you are concerned about theft or vandalism.

Lithium batteries operate well over a wider temperature range than do the lead acid cell batteries, which are used with solar panels. A lithium battery will provide its rated current at temperatures as low as -40 degrees, while a lead acid cell battery is reliable only down to -20 degrees Celsius.

ControlWave GFC users will also appreciate that using AGA8 Detail does not have the major effect it has on less capable processors. Our power system loading no longer even considers the compressibility method because the difference is no more than 0.2 mA!

Overview Of Power System Loading

To determine the sizing information regarding the battery and solar panel, you must first calculate the current draw.

Once you know the current draw, you can quickly determine the autonomous time for a rechargeable lead acid cell battery and the charging current required from the solar panel—and, therefore, the size of the solar panel in terms of watts.

Please note that for a lithium battery, which is not rechargeable, the current draw tells you the lifetime of the battery rather than autonomous time.

The autonomous time tells you how long the battery will run the equipment if there is no charging source. This figure is very important to the power system design because it accounts for two risks:

Weather—the dreaded succession of cloudy days during which the solar panel does not charge the battery. In some areas, the concern is also that the solar panel is covered by snow. This means that the battery must have enough energy to run the equipment without the support of a charging source.

Solar panel failures—If the solar panel is damaged or otherwise fails, the autonomous time tells you how long you have to get out to the site and replace it.

It is up to the user to determine the required autonomous time. Our experience tells us that, due primarily to weather risks, an autonomous time of 10 days is a reasonable minimum figure to use in power system design. Locations that are frequently subject to prolonged periods of cloudiness could require more than 10 days.

Battery Sizing

The autonomous time calculation indicates if the internal battery capacity of 7 AH (or 35 AH capacity for the lithium battery lifetime) is sufficient. If it is not sufficient, an external power source is necessary.

The procedure for determining power system loading encompasses three steps:

1. Determine the current draw in mA.
2. Determine the autonomous time provided by the battery (and whether or not that is acceptable).
3. Determine the minimum required charging current, which tells us the minimum required solar panel rating in terms of watts.

Step 1: Determining Current Draw

Add the current draw for all hardware components in the ControlWave GFC.

Important: It is always best to err on the conservative side when it comes to power estimates. Fractions should be rounded up and estimates of duty cycling should favor longer “on” times.

Factors that affect current draw are as follows:

- CPU and application program loading
- Serial Port Drivers
- 3808 MVT Transmitters
- Modems and Radios
- I/O and Loop Power

CPU and Application Program Loading

The ControlWave GFC CPU is in a sleep mode when idle. To size the load of the CPU (including all base electronics and LCD), please use the following current draw information:

- Base current draw, including the integral MVT and display/keypad with the standard application program operating a single run: 3.0 mA at 12Vdc or 6.0 mA at 6Vdc.
- Additional load per run (to account for the additional CPU execution time): 0.4 mA at 12Vdc or 0.8 mA at 6Vdc.
- Example: Standard application load with two runs enabled: 3.0 + 0.4 additional runs = 3.4 mA at 12Vdc

Serial Port Drivers

ControlWave GFC conserves power by turning RS 232 and RS 485 drivers off when not in use. You should estimate how busy the ports are and add the following figures:

- Not busy: 0.0 mA
- RS 485 very busy: 1.0 mA at 12Vdc or 1.8 mA at 6Vdc per port
- RS 232 very busy: 2.0 mA at 12Vdc or 3.6 mA at 6Vdc per port

"Not busy" describes COM1 (the local PC port) which is normally not in use. "Very busy" describes COM3 when it is communicating via Modbus with an ultrasonic meter and uploading a list once per second.

COM2 (the network port) is normally one extreme or the other. If polling is done hourly, COM2 is not busy. If polling is done once every few seconds and long lists are uploaded each poll, COM2 is very busy.

Power For 3808 MVT Transmitters

Emerson's 3808 MVT transmitters are extremely power-efficient and allow expansion to four meter runs or monitoring of well-site processes with very little current draw. Each transmitter uses less than 2 mA. To calculate current draw for systems in which the ControlWave GFC provides power to the transmitters, please use the following:

- 1.0 mA at 6 or 12Vdc per transmitter
- 0.4 mA at 12Vdc or 0.8 mA at 6Vdc for the RS 485 port (please use this figure instead of the figure listed under "Serial Port Drivers")
- Example: one 3808 MVT transmitter: 1.0 + 0.4 = 1.4 mA at 12Vdc

Modems and Radios

Relative to all other components in ControlWave GFC, modems and radios are very large current consumers. Therefore, managing their operations can make a major difference in the size and cost of the power system components.

Managing operations means taking advantage of the software provisions in ControlWave GFC that allow the modem or radio to be kept either powered down or in its sleep mode for the maximum amount of time.

Power to the OEM modem and radios can be software controlled. The software control, used by the standard application program, is user configurable via web-style PC menu pages.

Unlike ControlWave EFM, ControlWave GFC uses an AUX power control for standard model radios. This control fully removes power from the radio.

Duty cycle assignments are very flexible. You can specify and schedule on time/off time as well as a cycle period.

While the range of duty cycling times is very broad, real-world operations almost always fall into one of the following three general categories: slow duty cycle, fast (or quarter) duty cycle, and constant on.

Slow Duty Cycle – For networks, which call for communication only once during a long period, such as an hour or a day, the radio can operate in sleep mode (or powered-down for OEM radios) most of the time and "wake up" for a very brief time, e.g.

10 – 20 seconds, so it can receive and respond to a poll.

Note that the ControlWave GFC power systems have been sized with slow duty cycle operation in mind.

By operating the radio receiver and transmitter for the minimum time, the overall power consumption is not significantly higher than it is when powered-down, e.g. 2 or 3 mA.

“Slow duty cycle” operation maximizes autonomous time and allows flow computers to operate with the smallest batteries and solar panels. The only disadvantage is that operators do not have access to live information at any time but, rather, have to wait until the next scheduled poll.

Constant-on Operation – This is the other extreme with severe consequences to the power system. Any ControlWave GFC configuration with a radio constantly on will require an external power source.

“Constant-on” operation means that the radio power is always on and is consuming the specified “receive mode” current, e.g. 125 mA. That’s about ten times higher than the base flow computer with slow duty cycle operation.

The advantage of this mode of operation is that the communication network allows access to alarms and other live site information at any time.

Fast Duty Cycle otherwise known as “Quarter Duty Cycle” – This mode of operation is an excellent compromise between the two methods mentioned previously. It allows access via the network at any time, but also significantly conserves power.

Note that use of fast duty cycle generally pushes ControlWave GFC power systems to the limit in terms of autonomous time. Please be very careful sizing systems using fast duty cycle.

Licensed UHF radios can be operated on a quarter duty cycle over a period as short as 2 seconds (over which the radio is on for ½ second). A SCADA host PC using Emerson’s OpenBSI Harvester can be configured to poll flow computers that are operating in fast duty cycle mode. The PC will send a series of poll messages that ensure the flow computer receives one when it is “awake.”

Spread spectrum radios must be turned on for a longer time to allow synchronizing on the network. This time varies by model. Please consult the specifications for the particular radio you are using. For spread spectrum networks, a 15-second on-time with a one-minute period is a feasible quarter duty cycle strategy.

MDS Transnet 900 Sleep Mode

A new feature of the MDS Transnet 900 spread spectrum radio is a sleep mode, which effectively provides operation that is similar to Fast Duty Cycle. In this mode, the radio powers off for approximately 80% of the hops. The user enables sleep mode during configuration of the radio.

Average current draw in this mode is 15 mA—well within the capabilities of the internal power systems in ControlWave GFC. This current draw assumes operation approximating twice per hour. The benefit is, like Fast Duty Cycle, the flow computer can be accessed at any time over the network. The delay time in responding to a poll will be no more than three seconds.

Radio Operation Examples

Current Draw (at 13.8 Vdc) for a one-watt, spread spectrum radio is exemplified by the MDS TransNet 900 Radio:

- Receive: 115 mA
- Transmit: 510 mA
- Sleep: 8 mA

The MDS models 4710 and 9710 are examples of licensed UHF radios with 5-watt ratings (current draw figures are at 13.8 Vdc):

- Receive: 125 mA
- Transmit: 2000 mA
- Sleep: 15 mA

Slow Duty Cycle Licensed Radio

To estimate power for slow duty cycle operation of a licensed radio over an hour, a conservative estimate would include a receive on-time of 30 seconds and a transmit on-time of 2 seconds. The 2-second figure for transmit on-time is appropriate from our experience with EFM systems (please contact technical support if your system transmits long lists every few seconds because the transmitter will be on a significantly longer time).

Factored over the hour, power is calculated as follows:

- Don't factor sleep current because the AUX output turns power off.
- Factor the receive current as 125 mA * 30 seconds / 3600 seconds = about 1 mA
- Factor the transmit current as 2000 mA * 2 seconds / 3600 seconds = about 1 mA but round up to be safe = 2 mA
- Add the two together: 1 + 2 = 3 mA

Note that running the radio receiver and transmitter for short durations so infrequently makes their contributions almost insignificant (about 1 mA in each case)!

Fast Duty Cycle Licensed Radio

To estimate the power for quarter duty cycle, you need to estimate how often the radio will transmit. Since a remote radio will normally transmit only when it responds to a poll, you can use the network polling interval to estimate how often the radio transmits.

Assuming that the radio transmits every five minutes (ie. 300 seconds), calculations are as follows:

- Since the radio is off 3 / 4 of the time, you simply factor in 0 mA for that.
- Receive current factor: 125 mA * 1 / 4 = about 31 mA
- Transmit current factor: 2000 mA * 2 / 300 = about 13 mA
- Total = 44 mA; you might add 1 mA since we rounded-down in all three calculations, above = 45 mA

Fast Duty Cycle Spread Spectrum Radio

For a spread spectrum radio, calculations are similar. For example, operating the Freewave radio on a quarter duty cycle, with assumptions otherwise similar to those made for the licensed radio, calls for the following calculations:

- Receive current factor: 75 mA * 1 / 4 = about 18.8 mA
- Transmit current factor: 500 mA * 2 / 300 = about 3.3 mA
- Total = 22.1 mA

Constant On – Licensed Radio

If the radio is kept on constantly, then a power estimate must factor the receive current plus the transmit current. For example, if the transmitter is operated every five minutes, calculations for a licensed radio are as follows:

- For the receive current factor, simply use the specified 125 mA
- Transmit current factor: 2000 mA * 2 / 300 = about 13 mA
- Total = 138 mA

Since the internal batteries are limited to approximately 30 mA loads to give feasible autonomous times, the above configuration clearly requires an external power system.

Constant On Spread Spectrum Radio

Calculations for a spread spectrum radio are as follows:

- Receive current factor: 115 mA
- Transmit current factor: 510 mA * 2 / 300 = about 3 mA
- Total = 118 mA

Again, an external power system is clearly necessary.

I/O and Loop Power

ControlWave GFC allows you to operate measurement and control loops without the inordinate demand that I/O commonly imposes on the power system. ControlWave GFC I/O features very low power consumption. Often, much of the circuitry is powered down while the CPU is idle.

For analog and digital I/O, low-current or voltage operation modes are available to conserve power that is used to operate loops.

You are still cautioned that supplying loop power could overload the power system (that is, from an autonomous time point-of-view). Use of low-power voltage transmitters, rather than those that operate on 4 – 20 mA loops, makes a significant difference.

While our I/O power specifications are rather extensive, you can avoid the tedium of adding many figures together by applying a few good, conservative shortcuts. You should estimate the base current draw, plus the worst-case loop current draw, for each I/O option.

Also, please remember that loop power for analog I/O is stated as though it is supplied from an external source. However, that loop power could very well originate from the ControlWave GFC power source.

You must be particularly careful if 4 – 20 mA loop power is provided by the internal battery, but via the 24V dc/dc power supply. That's because input current is subject to an efficiency factor between 2 and 5 when it's run through the dc/dc converter.

I/O Examples

Compared to products such as ControlWave EFM, which offers a variety of I/O, ControlWave GFC is relatively simple.

Base power consumption includes discrete I/O, but does not include loop current. For configurations using analog I/O, a base current for that option and loop current must both be factored-in.

For digital inputs and high-speed counter inputs, you can select a low-current mode (66 microamps in the DI and 200 microamps in the counter) or standard operation at 2 mA.

For sizing, you should assume that all inputs are turned "on" at the stated current. Since that current is at 3.3 Vdc, you should divide it by a factor of 3 to obtain the equivalent at 12 Vdc or by 1.5 for a 6 Vdc equivalent.

Note that DO loop current, which could be as much as 100 mA each, is not included. Beware of situations in which the internal battery is expected to provide the output current, as 100 mA will limit autonomous time too severely.

For low-power voltage transmitters operating via an analog input, please use a figure of 9.2 mA at 12 Vdc for each loop.

For transmitters that can run at 4 – 20 mA using 12 Vdc or less, please use 24.3 mA at 12 Vdc per loop. Beware of situations that use transmitters that state they run at 12 Vdc, but with a load in the loop require a higher voltage. The 24 Vdc output is likely required for such situations.

Current use is very low in an I/O example for which the ControlWave GFC is running only DI and counter inputs:

- Base unit: 3 mA at 12Vdc
- Both DI points on at 66 uA: less than 0.1 mA
- Both counters on at 200 uA: less than 0.2 mA
- Total: 3.3 mA

In another example in which low-power transmitters are interfaced via AI points, current use is still very reasonable:

- Base unit with analog I/O option: 5 mA at 12Vdc
- Power to transmitters: 9.2 mA each at 12 Vdc = 18.4 mA
- Total: 23.4 mA

Loop Power With 24 Vdc Supply

Operation of 4 – 20 mA loops via either AI points or the analog output (AO) will almost certainly require an external power source because autonomous time will be too limited.

Nevertheless, it is a convenience that ControlWave GFC includes a 12 Vdc to 24 Vdc converter for these situations.

The dc/dc conversion efficiency factor must be taken into account. Efficiency varies from 40% at a 5 mA load to 80% at a 100 mA load. For the 5 mA load, source current will be 30 mA at 12 Vdc. For the 100 mA load, source current will be 250 mA at 12 Vdc.

For one loop, you should figure that current at 12 Vdc is 67 mA.

Step 2: Calculating the Autonomous Time for the Battery

To determine the autonomous time for the battery in days, follow this simple procedure:

First, convert the battery's amp-hour (AH) rating to amp-days by dividing by 24, ie. 7 / 24 = 0.29.

Then, divide that figure by the total current draw, noting that it should be expressed in amps rather than mA.

Example 1: Single run base unit with slow duty cycle spread spectrum radio:

- Current draw = 3 mA base + 2.2 mA radio = 5.2 mA or 0.0052 Amp.
- Autonomous time = 0.29 / 0.0052 = about 55.8 days

Example 2: Single run base unit with quarter duty cycle Freewave spread spectrum radio:

- Current draw = 3 mA base + 22.1 mA radio = 25.1 mA or 0.0251 Amp
- Autonomous time = 0.29 / 0.0251 = about 11.5 days

While the ControlWave GFC internal battery provides plenty of autonomous time for slow duty cycle operation, fast duty cycle approaches the recommended 10-day autonomous time and leaves very little additional current for operation of I/O or a second run.

The next two examples better illustrate those applications for which the internal power systems are sized.

Example 3: Two-run meter station with discrete I/O for run switching and spread spectrum radio on slow duty cycle—this configuration uses an external 3808 MVT transmitter, but no analog I/O:

- Current draw = 3 mA base + 0.4 mA CPU loading for second run + 2.2 mA radio + 0.4 mA port driver + 1 mA for the 3808 transmitter + 0.1 mA DI current = 7.1 mA
- Autonomous time = 0.29 / 0.0081 = 36 days

Example 4: Same configuration as that in Example 3, but with the analog I/O option and providing power to one low-power transmitter:

- Current draw = 5 mA base + 0.4 mA + 2.2 mA radio + 0.4 ma port driver + 1 mA 3808 + 0.1 mA DI current + 9.2 mA AI current = 18.3 mA
- Autonomous time = 0.29 / 0.0183 = 15 days

Example 5: Same as example 4, but providing power to two low-power transmitters:

- Current draw = 19.3 mA from the prior example + 9.2 mA for the second transmitter = 28.5 mA
- Autonomous time = 0.29 / 0.0285 = 10.2 days

Example 5 betrays the fact that we have designed the internal power system for operation of two low-power transmitters along with discrete I/O and a radio using slow duty cycle.

For the 7 AH battery, a 29 mA load corresponds to an autonomous time of 10 days.

While we have exemplified only 12 Vdc systems so far, you can take advantage of the lower pricing for 6 Vdc power systems if they avoid standard model radios and loop current or transmitters, which require 12Vdc.

Example 6: 6 Vdc 2-run system using one 3808 MVT, analog I/O (but no loop power), and an MDS OEM spread spectrum radio:

- Current draw = 6.2 mA base with analog I/O + 0.8 CPU loading + 0.8 port driver + 1.0 3808 + 6.0 radio = 14.8 mA
- Autonomous time = 0.29 / 0.0148 = 18.4 days

Finally, when are lithium batteries feasible? Normally, they are employed for small current loads so that they need not be replaced too often. For calculations, AH/day for the lithium pack = 35 / 24 = 1.46.

Example 7: 6 Vdc nominal, base unit only:

- Current draw = 6.0 mA
- Life time = 1.46 / 0.006 = 243 days

For a two-run configuration using a 3808 MVT transmitter, current draw is 7.6 mA and the lithium battery pack will last a little over one half year (192 days). For the same system, the dual lithium pack will last over a year.

Important Note on Battery Rating and Lifetime

While TeleFlow users might remember that we used to de-rate the battery AH rating by a factor of 0.5, experience tells us that we no longer need to do that.

Today's lead acid cell batteries continue to meet their AH ratings, even under temperature conditions. However, operation at temperatures toward the limits of the range will significantly reduce the lifetime of the battery. Please refer to the battery data sheet for specifics.

Therefore, instead of attempting to devise a very conservative autonomous time, we advise users to think, instead, in terms of the battery lifetime. While the battery lifetime expectation is normally five years, it could be reduced to as little as two years if operated at the extremes of the temperature range.

Users who still desire to be conservative in sizing the battery can apply a 20% loading factor by multiplying the total current draw by 1.2 and using the result in the autonomous time calculation (that's the same as dividing the amp-hour rating by 1.2).

This practice provides the same result as the solar/ battery power system sizing procedures that are commonly used in the industry. Note that our solar panel sizing procedure in the next step always applies the 1.2 loading factor.

Step 3: Determining The Solar Panel Size

Solar panels are selected in terms of the current they supply at the charging voltage. Ideally, all that current is stored as energy in the battery and can be directly related to the flow computer load on the battery, e.g. if the solar panel supplies 100 mA and the flow computer uses 100 mA, the battery is not discharged at all. Of course, factors must be applied to account for the less-than-ideal, real world operating conditions.

The major sizing factor is that the panel provides current only when the sun is shining, a fraction of each day. The amount of sun-hours/day you can expect depends on the location. Sun-hours/day is technically known as "insolation" and is measured in units of kilowatt-hours/m2/day. Since the solar constant at the earth's surface is approximately 1 kilowatt/m2, these units are often referred to as equivalent (peak) sun hours. The resulting insolation figure is normally for the month in the year with the lowest solar energy received.

At a location rated at 6 sun-hours/day, the solar panel provides its rated current for one quarter (24 hours/6 hours) of the day. Therefore, the solar panel current must be de-rated to one quarter of the specified current.

Then, another factor must be applied to account for the fact that the current provided by the solar panel must charge up the battery as well as operate the flow computer hardware. Since ControlWave GFC systems operate in low-current modes, a factor of 1.2 times the current draw is a good minimum overhead figure for charging purposes.

Important Note on Solar Panel De-rating

TeleFlow users should note that we no longer de-rate solar panel performance by a factor of 0.5. Solar panels actually operate well under less-than ideal conditions such as bright overcast, mixed sun and clouds, and with a film of dirt or dust covering the panel.

We still recommend that you select a solar panel that provides, at minimum, 1.2 times the current draw, as mentioned above, to account for charging current. Note also that the 7 AH battery can be charged with a much higher current, so extra current capacity in the hundreds of mA is feasible.

Users concerned about solar panel failures (or theft) should consider using a higher autonomous time requirement for the battery. This would allow more time to react to the failure and replace the solar panel.

Note that panels are specified in watts, which should be comparable to the rated current multiplied by the charging voltage. However, we have seen some variance and recommend you use the current rating rather than the watt specification.

In summary, sizing the solar panel consists of the following steps:

1. Start with the current load from the battery autonomous time procedure.
2. Look up the sun-hours/day figure for the location (reference the world map).
3. Multiply the current load by 24, then divide by the sun-hour/day figure.
4. Multiply by a factor of 1.2. The result is a current figure, factored for the amount of sunlight, battery charging and zero drop-out probability.
5. Compare this figure with solar panels you are considering. The panel must simply have a specified charging current that is equal to or greater than the figure you calculated.

Let's size the solar panel for a few of the examples used, earlier, to determine the autonomous time for the battery.

Example 1: This configuration is close to that used in Example 5 for the battery, and uses a slow duty cycle radio and I/O. Current draw is 29 mA, the maximum recommended in terms of the autonomous time for a 7 AH battery.

If this system is to be installed in Mumbai, India; San Antonio, Texas; or Oklahoma City (which are all rated at 4 sun-hours per day); the solar panel requirement is calculated as follows:

- Current requirement: 29 mA * 24 / 4 sun-hours per day * 1.2 = 209 mA
- Appropriate solar panel: The 5 Watt solar panel provides 270 mA.

Example 2: This is the same configuration as that used in Example 6 for the battery, a 6Vdc system:

- Current requirement: 15.8 mA * 24 / 4 * 1.2 = 114 mA
- Appropriate solar panel: The 1 Watt solar panel provides 150 mA.

To illustrate how insolation factors-in, let's try to apply the configuration in Example 2 to a location with a rating of 2 sun-hours per day. The current requirement would be twice as much, 228 mA. In this case, the 6.5 Watt solar panel, which provides 525 mA, would be appropriate.

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