

YASKAWA

PUMP MULTIPLEXING WITH VARIABLE FREQUENCY DRIVES

THINK OF IT AS MOVING FROM ONE HOME TO ANOTHER



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This article presents a unique analogy to help you better understand the benefits that variable frequency drives offer when controlling a multiplexing pump system.

MULTIPLEXING IS LIKE... MOVING?

For those new to or familiar with pump multiplexing, here's a different way of looking at it. When multiplexing pumps are controlled by variable frequency drives (VFDs), understanding how the system operates and the benefits it offers can be like moving from one home to another.

TYPICAL OPERATION

First, let's imagine the typical moving process (or in some cases, let's think back to the last time you moved). At the start of the moving process, you're carrying light boxes and don't need a lot of strength to lift and move them.

As you progress, you find that the boxes are getting heavier and heavier, and you'll need more and more strength to lift and carry them. Eventually, you're going to get to boxes and items that are too heavy for you to lift.



Figure 1: A Typical Pump Multiplexing Application

At this point, you may start to consider one of two things - 1) start weightlifting to get stronger so that you can lift more, or 2) call for help. Calling for help is probably going to be your best bet when moving. With another person helping you, you find that the heavy items that you had a hard time lifting seem easier to lift and move. You may even get to a point where you'll need to call a third or fourth friend to lift objects that two people can't lift.

Once you've moved all of your heavy items, you can start thanking your friends for their help and sending them home so they can get some rest. Then, the next thing you know, you're all done and ready for some hard-earned sleep!

So how is that analogous to VFD pump multiplexing? Like the beginning of moving, the demand for water can be low at various times of the day, the middle of the night for example. The pump will rotate slowly (moving light boxes) to generate enough flow to maintain the required pressure.

As the day continues, the demand for water starts to increase (need to move heavier boxes). The increase in demand will result in the pump rotating faster to increase flow, which results in more power needed to accomplish this. Like with maxing out how much weight you can lift while moving, the pump will eventually reach a point where it won't be able to keep up with the demand and will be unable to maintain pressure.

Now, you'll need to start considering one of two things - 1) change the pump out so that it's a higher HP (strength training) or 2) increase the number of pumps in the system, i.e. pump multiplexing (calling for help from friends).

Going on the multiplexing route, if the water demand reaches a point where one pump can't handle it anymore (not enough strength to lift), it'll call for a second pump to turn on and assist (first helpful friend). As the second pump ramps up, the flow of the first pump may start to decrease in speed (lighter feeling item) and require less power to run. If the demand continues to increase (even heavier items), then more pumps (need more friends), will be needed and turned on to meet this demand and

maintain pressure. Eventually, the demand will decrease (less heavy items), and you'll be able to start turning off the additional pumps that were turned on (sending friends home). At some point in the day (or night), it'll be back to a single pump operating. If there's little to no demand needed, the pump can go from rotating at a minimal speed that creates minimal flow and pump lubrication, to a standby mode (sleep).

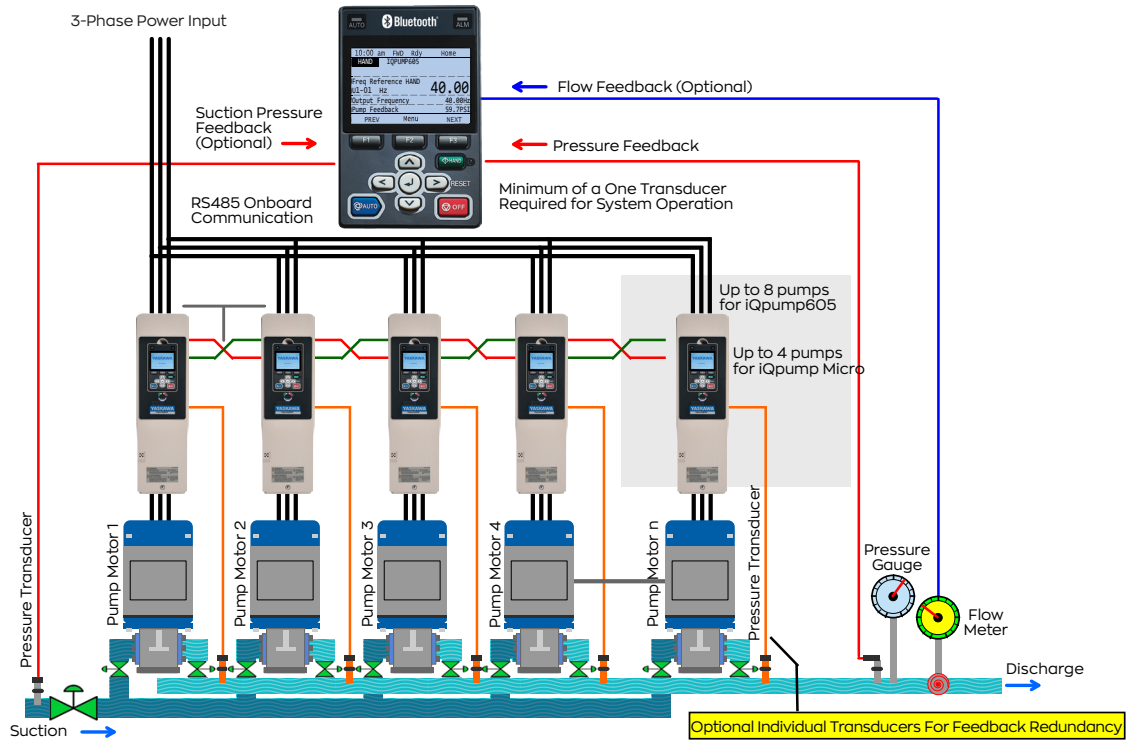


Figure 2: Drive to Drive Multiplexing Setup

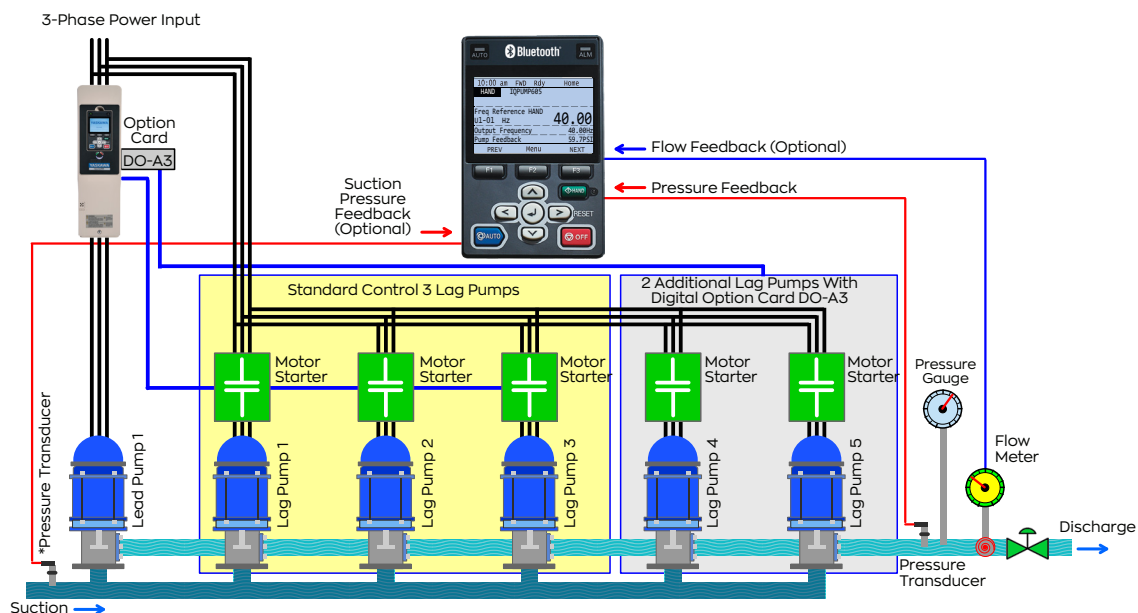


Figure 3: Constant Speed Lag Pump Multiplexing

BENEFITS

Though perhaps a non-conventional way to look at VFD pump multiplexing operation, they certainly have similarities. And like having good friends that can help with moving, a VFD multiplex system has various benefits as well.

When having your friends help, moving an object takes less energy to move. Depending on the number of friends that you have helping, you can move a range of boxes with different weights. And if someone gets tired, they can sit out for a bit. You may also find that one of got hurt during the move and can't help anymore (should have stretched first).

Like using less energy to move heavy objects, VFD multiplexing can help save energy. When operating a pump with a VFD, you can take advantage of the affinity laws, which dictate that flow is directly proportional to pump speed, torque is proportional to the square of pump speed, and power is proportional to the cube of pump speed.



Figure 4: Affinity Laws show that
 $Flow \propto Speed$ / $Torque \propto Speed^2$ / $Power \propto Speed^3$

Multiplexing saves energy like taking a rest between lifting heavy boxes.

When demand exceeds what the system can currently handle (typically one or more pumps operating at full speed, 60 Hz), a new lead pump is brought online to supplement the flow. The new lead pump is then responsible for the regulation of pressure, speeding up and down as needed. To help reduce the energy consumption of the system, the lag pumps are reduced in speed.

To visualize this a little bit better, let's use a duplex system as an example. A new lead pump is brought in and starts operating at 40 Hz to provide the flow necessary to maintain pressure. After the lead pump gets up to speed, the lag pump reduces its speed from 60 Hz to 54 Hz, resulting in an energy reduction of 27%.

But wait, if you reduce the speed of the lag pump, the lead pump will need to run faster to account for the reduction in flow. The lead pump increases its speed from 40 Hz to 46 Hz to make up the flow but this results in an increase of 52% in energy usage. How is this considered energy savings?!

That's one of the inherent problems when trying to look at things purely in percentage. Instead, let's use some discrete values.

A VFD multiplex pump system offers wider flow control, allowing smaller pumps to run efficiently at low demand where a single large pump would struggle.

It also reduces wear by cycling pumps based on usage and provides redundancy.

Example details:

Speed (Hz)	Power (kW)
60	100
54	72.9
46	45.1
40	29.6

Operating point 1 = 60 Hz + 40 Hz -> 100 kW + 29.6 kW = 129.6 kW

Operating point 2 = 54 Hz + 46 Hz -> 72.9 kW + 45.1 kW = 118.0 kW

Comparing operating point 1 and 2, which offer the same amount of flow, you find that point 2 requires 11.6 kW less, or 9% less energy.

The second benefit you have with a VFD multiplex system is the ability to control flow over a wider range (lift a range of differently weighted boxes). Pumps typically have a minimum speed that they need to operate at or above to generate flow and provide proper lubrication to the pump.

By using smaller pumps, you can generate lower flow and maintain pressure when the system demand is not present. A single pump may not be able to do that as well and could result in a large variance in water pressure when the demand for water is low.

A third benefit is pump cycling (tired friend). A VFD multiplex system can use different methods to bring pumps offline when the demand drops. The method can be based on a first-in-first-out (FIFO) or on the pump's operating hours. The advantage of cycling through pumps is that they can keep their runtime around the same, resulting in even wear on the pumps.

Last, but not least, is redundancy (hurt friend). With a single pump installation, if you need to perform maintenance on a pump or it suddenly fails, you're without any means to create water pressure until the situation is resolved. With a VFD multiplex system, even if a single unit is taken out of the system, the other units can still provide a means to provide flow and create pressure in the system. Though it may not be able to create the full amount of pressure that one expects, it's still enough to satisfy the needs of those using the system.

Who knew that VFD pump multiplexing would be like moving from one home to another? And just like moving, the requirements and needs of the system are different from one to another. It's always good to evaluate what your needs are and what the optimal solution is for you. And yes, this does apply to both pumping and moving.

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