Technical Note

Application: Position Synchronization
Electronic Line Shaft

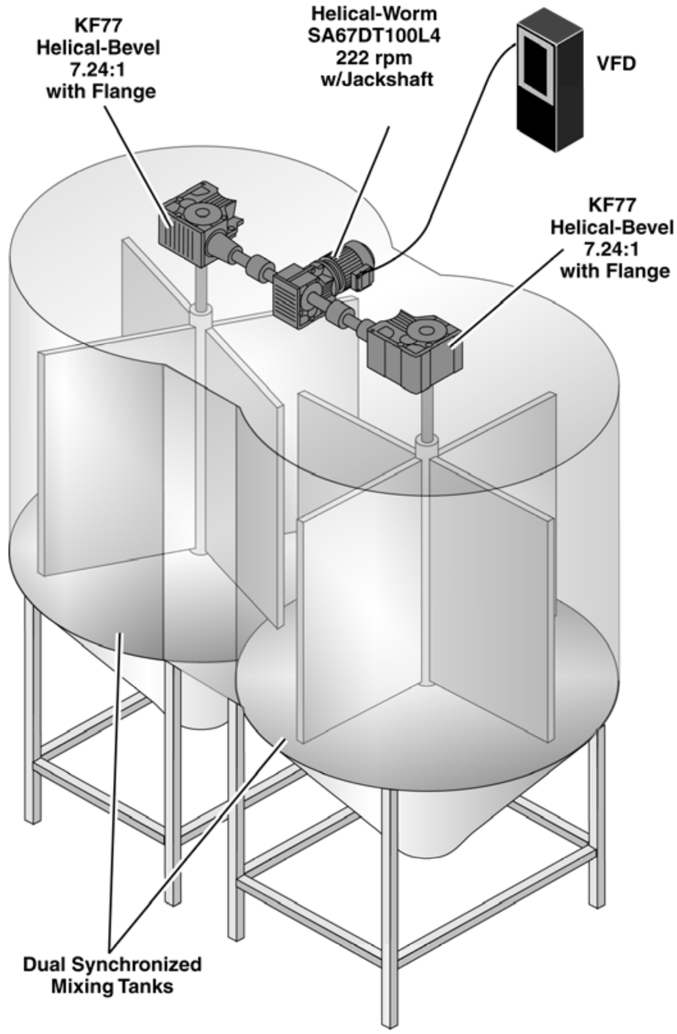
Application

Description:

This application is a single dairy tank with two agitator blades. Product is free to move between both sides of the tank. Since the agitator blades are long enough to touch each other, one blade is positioned 45 degrees from the other blade to prevent collision.

A 5 HP helical-worm gearmotor provides the input power to both tanks via a long shaft (jackshaft) that is inserted into the hollow shaft of the helical-worm gearmotor. A coupling attaches each end of the jackshaft to the input shaft of a helical-bevel gear reducer. Each bevel mounts to the top of the tank via a flange. Since the bevel reducers have identical ratios, the agitator shafts rotate exactly at the same speed. The common linkage provided by the jackshaft assures that their alignment is permanently fixed.

Variable speed is obtained from a single inverter attached to the helical-worm gearmotor.



Problems:

- Installation of jackshaft and alignment is time consuming

Requirements:

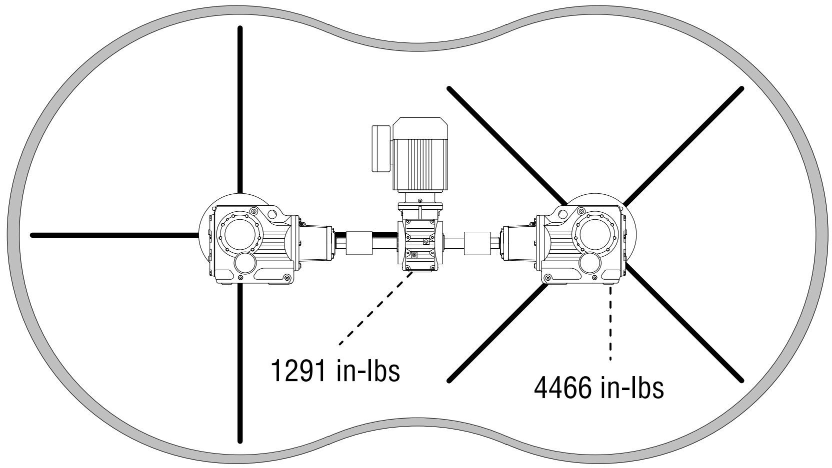
- Customer wants to reduce costs, if possible
- Blades cannot collide – potential damage is $15,000
- Variable speed

Discussion:

An explanation of the torque distribution helps the understanding of the components used on this application. The SA67DT100L4 helical-worm gear reducer is 91% efficient, has 5 HP input, and operates at 222 rpm. Thus, it produces 1291 in-lbs at its output shaft under full load.

$$T = \frac{63025 \times 5}{222} \times 0.91 = 1291$$

This torque is equally distributed to two bevel reducers, each receiving 646 in-lbs at the input shaft. Since each bevel is 95.5% efficient and has a ratio equal to 7.24:1, the torque produced at the output shaft is 4466 in-lbs.



$$T = 646 \times 7.24 \times 0.955 = 4466$$

Intuitively, it may appear that a KF77 bevel reducer is larger than required. However, in reviewing the SEW catalog values (shown at right), a KF67 has a torque capacity of 7260 in-lbs – but only at ratios above 27.28:1. At 7.28:1, its torque capacity is 3720 in-lbs, which is too low. Thus, a KF77, 7.24:1, with a capacity of 7260 in-lbs, is indeed the correct choice for the original application.

KF67		KF77	
Ratio	Max Torq	Ratio	Max Torq
57.28	7260	58.34	13700
44.32	7260	40.04	13700
27.28	7260	25.62	13700
17.54	6550	17.87	12800
10.63	4420	10.84	8760
7.28	3720	7.24	7260

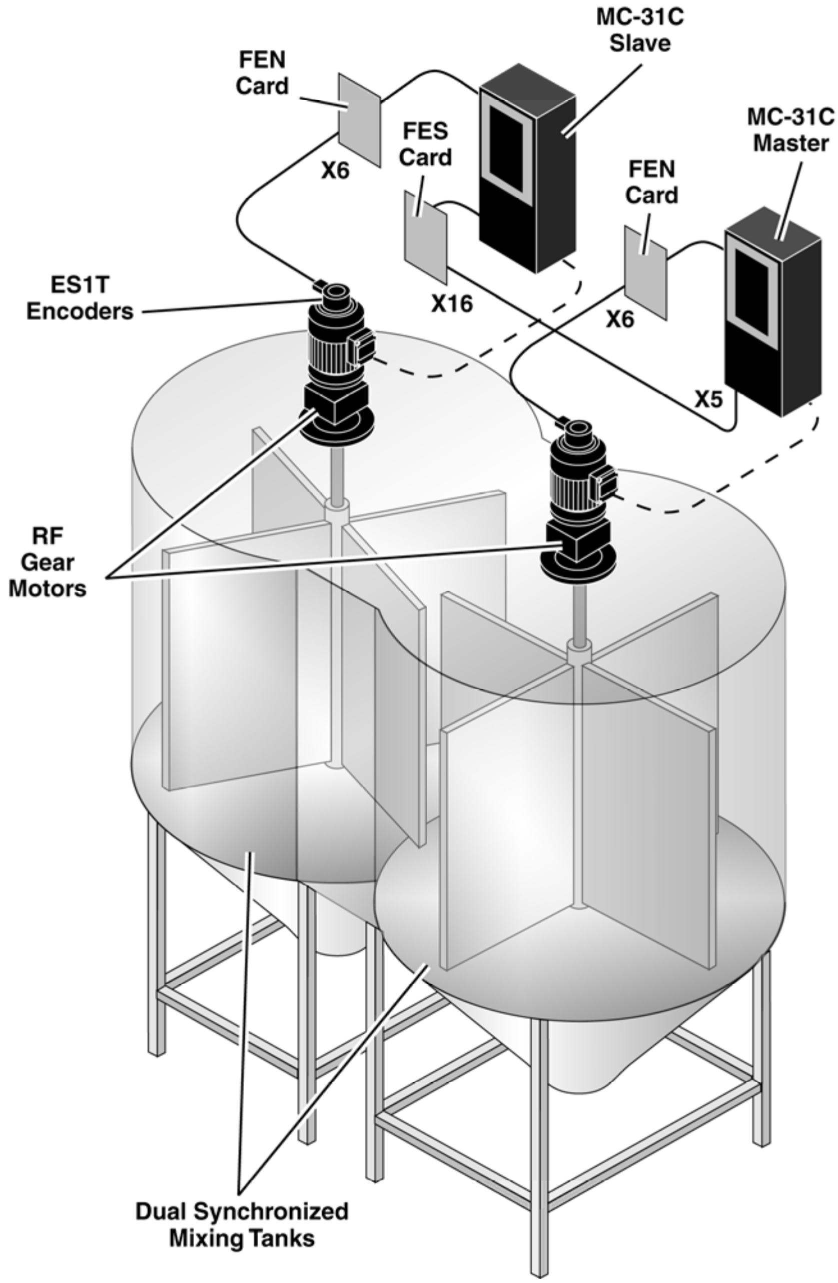
A drawback to the current design is that it requires two gear reducers to achieve 31 rpm, which can easily be accomplished with one reducer. Eliminating the helical-worm and placing a larger ratio inside a single bevel reducer serves two purposes: 1) It eliminates the cost of one reducer. 2) It increases the torque capacity of a single reducer, which may allow the use of a smaller reducer. Therefore, it is certainly worth consideration. Furthermore, a helical-bevel reducer (K-Series) is more expensive than a helical-inline (R-Series) reducer. Thus, switching to a flanged inline is also worth consideration, providing the customer has enough headroom to accept the taller profile of the R-Series.

The jackshaft assures blade alignment, but may be replaced with electronics that perform the same function. Both the Movitrac® and the Movidrive® have a synchronization option that acts as an electronic line shaft.

Technical Note

Solution 1: Movitracs®

This solution uses (2) Movitrac® inverters with FRS synchronization option.



Method:

Put the total reduction inside one gear reducer instead of splitting it between a helical-worm and a helical-bevel. The height of the inline-gear reducers (RF) is not a concern because there is ample headroom.

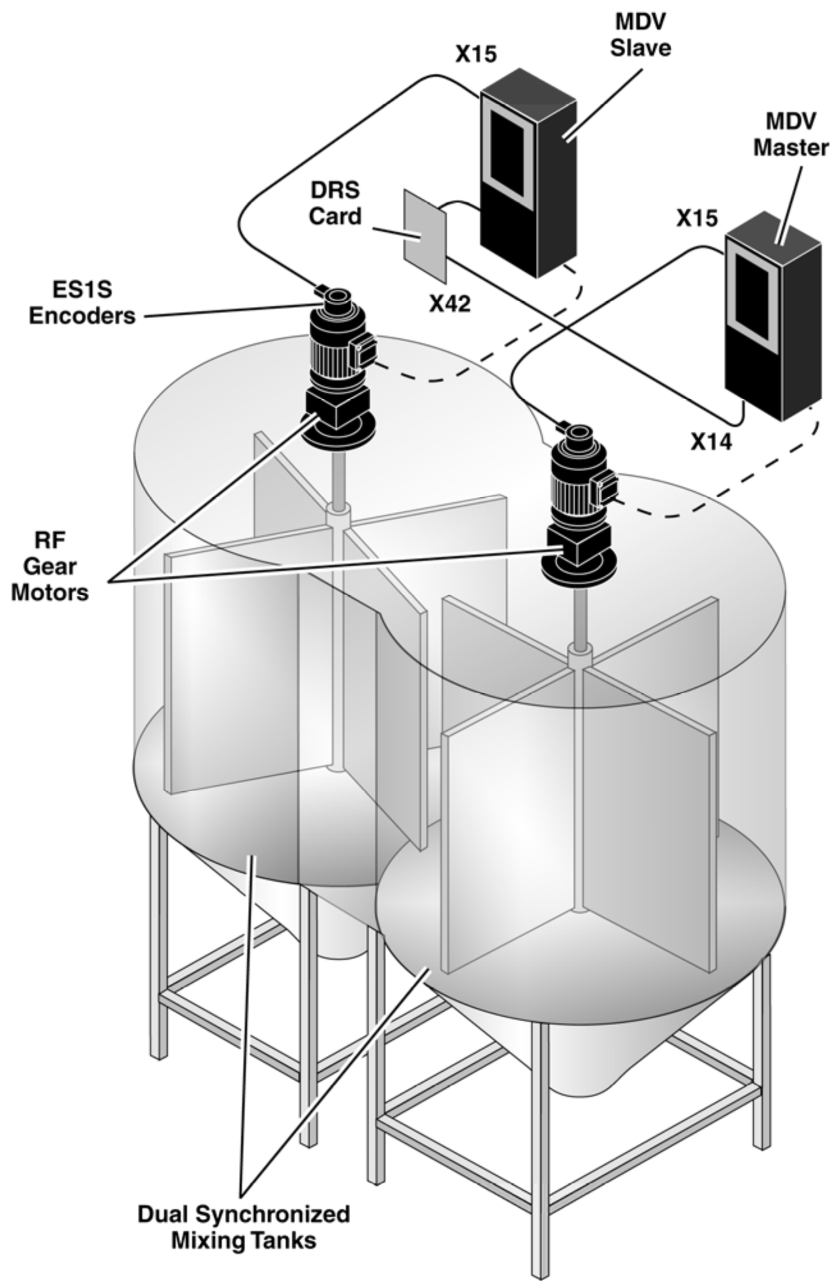
Notice that the FES option is only needed on the slave, not on both.

Features/Product:

- (2) RF77DT100LS4, 30 rpm or (2) RF67DT100LS4, 28 rpm (61.26:1)
- (2) ES1T incremental encoders – one for each motor
- (2) Movitrac® (MC-31C)
- FEN Speed Feedback Option – Master Drive
- FEN + FES (FRS31C) Synchronization Option – Slave Drive

Solution 2: MoviDrives®

This solution uses (2) Movidrive® inverters with DRS synchronization option.



Method:

The slave Movidrive® requires a DRS option card; the master requires no options.

The following is a list of parameters used for this solution. P220 and P512 are application-dependent and may differ from the values shown below.

Master:

P700	Mode	CFC

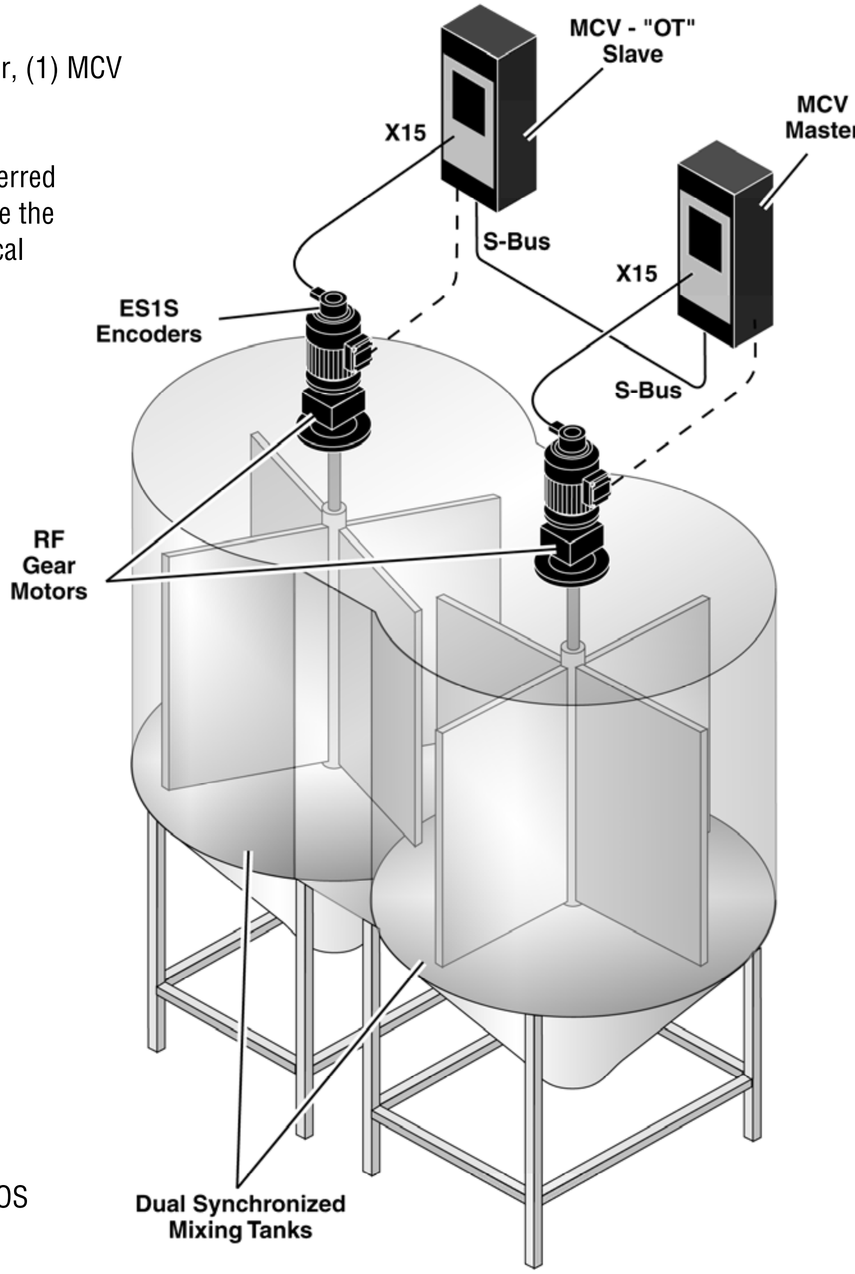
Slave:

P700	Mode	CFC & SYNC
P220	P Gain	2
P221	GRF- Mstr	1
P222	GRF-Slave	1
P512	Lag Error	4000

Features/Product:

- (2) RF77DT100LS4, 30 rpm or (2) RF67DT100LS4, 28 rpm (61.26:1)
- (2) ES1S incremental encoders – one for each motor
- (2) Movidrive® - MDV
- (1) DRS Synchronization Option Card – Slave Drive

Solution 3A: Movidrive® Compacts



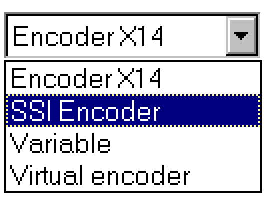
This solution uses (1) "MCV-0T" inverter, (1) MCV standard, and ***S-bus***.

The S-bus option in this solution is preferred over the X14 option in Solution 3B, since the S-bus is faster and less prone to electrical noise – especially over long distances.

Method:

The slave inverter is an MCV "-0T" Technology Version of the Movidrive® Compact, containing different firmware than the standard MCV.

Unlike the Movidrive® MDV, the DRS option is not needed with the MCV-"OT". Rather, the S-bus communication transports the encoder signal between drives. During commissioning, choose the *ISYNC* option. Then, select "*SSI Encoder*" as the Input Master Encoder.



The inverter automatically creates an IPOS program to perform synchronization.

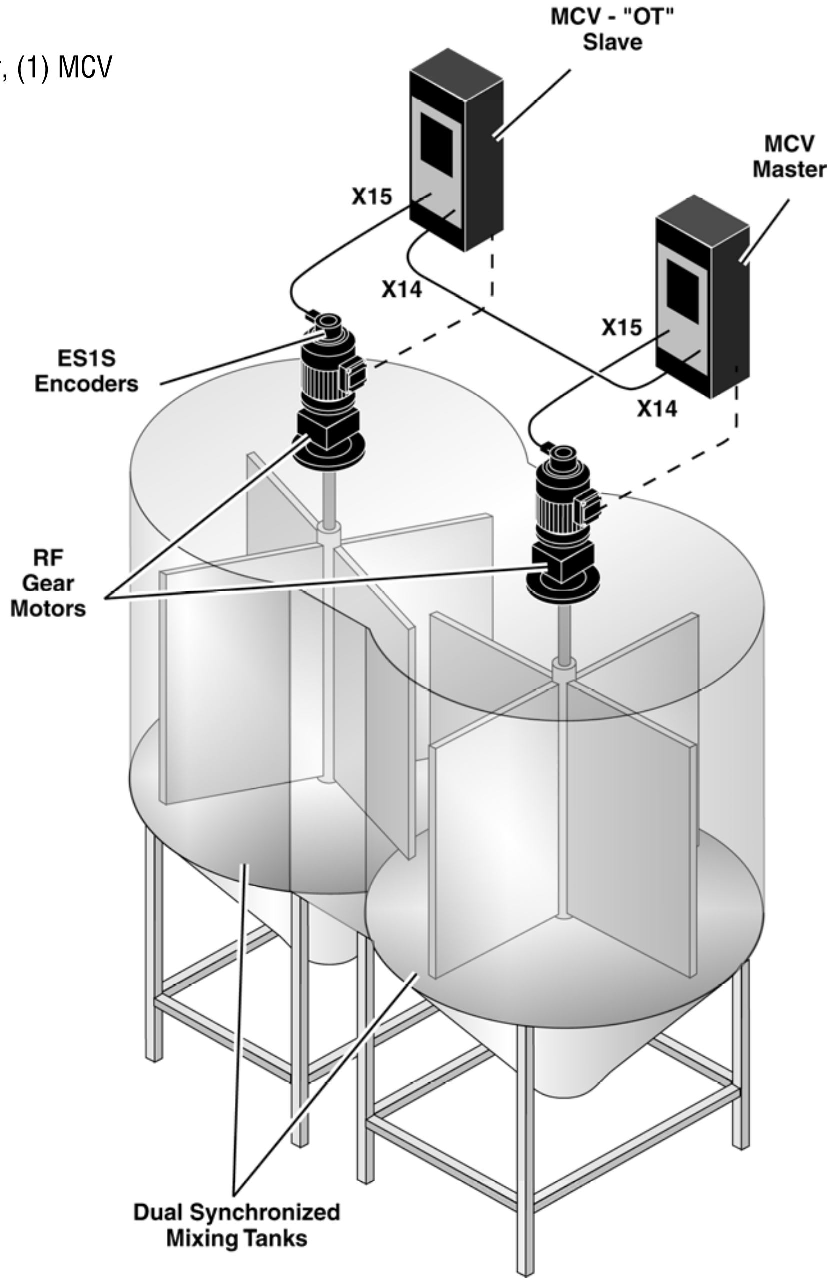
Features/Product:

- (2) RF77DT100LS4, 30 rpm or (2) RF67DT100LS4, 28 rpm (61.26:1)
- (2) ES1S incremental encoders – one for each motor
- (1) Movidrive® Compact – MCV ("-0T" Series)
- (1) Movidrive® Compact – MCV
- ISYNC commissioning

Solution 3B: Movidrive® Compacts

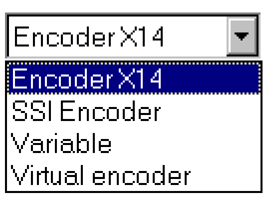
This solution uses (1) "MCV-0T" inverter, (1) MCV standard, and ***X14 inputs***.

Consider solution 3A when the length of X14 wires are long or when electrical noise is a problem.



Method:

The DRS option is not needed, unlike the standard Movidrive®. Instead, the master signal is sent across SEW's S-bus communication. During commissioning, choose the *ISYNC* option. Then, select "*Encoder X14*" as the Input Master Encoder.



The inverter automatically creates an IPOS program to perform synchronization.

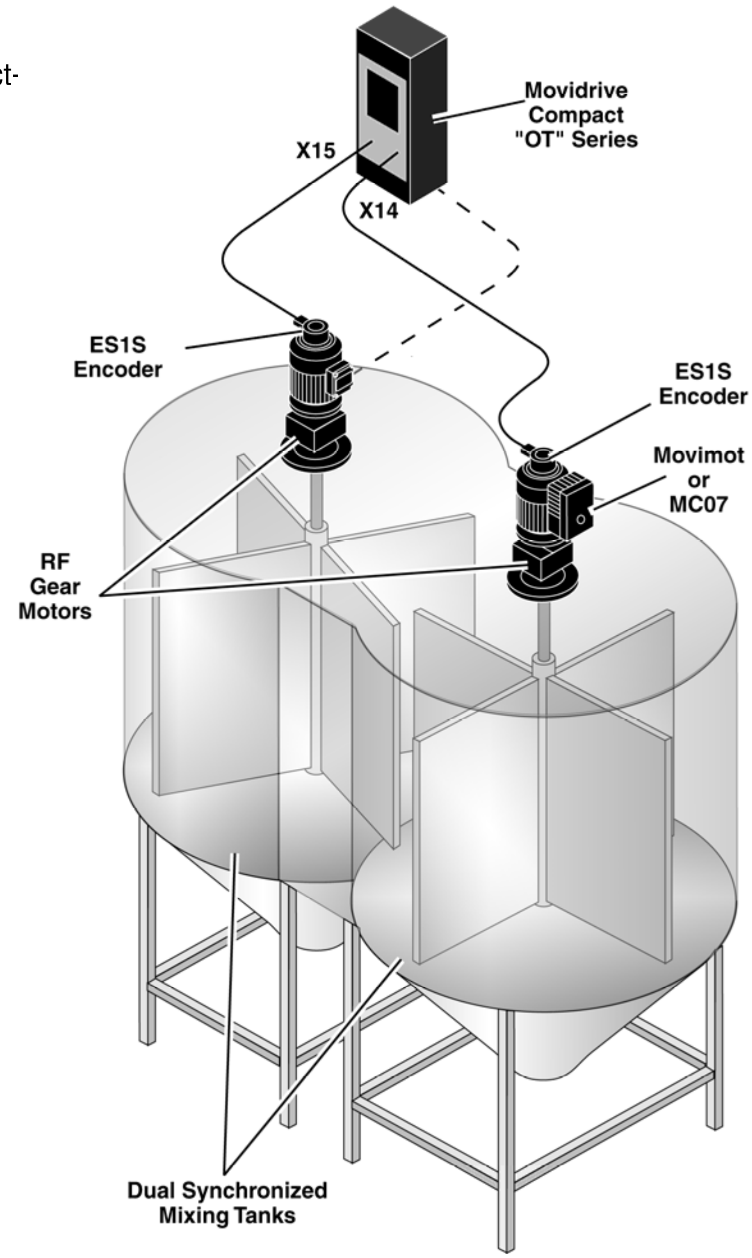
Features/Product:

- (2) RF77DT100LS4, 30 rpm or (2) RF67DT100LS4, 28 rpm (61.26:1)
- (2) ES1S incremental encoders – one for each motor
- (1) Movidrive® Compact – MCV ("-0T" Series)
- (1) Movidrive® Compact – MCV
- ISYNC commissioning

Solution 4: Movidrive® Compact + Movimot®

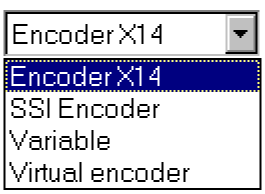
This solution uses (1) Movidrive® Compact- and either (1) Movimot® or (1) MC07.

It is the least expensive solution, due to the lower cost of the inverters. In addition, option cards are unnecessary since the Movidrive® Compact "-0T" Series utilizes the standard X14 and X15 encoder inputs.



Method:

During commissioning, choose the *ISYNC* option. Then, select "*Encoder X14*" as the Input Master Encoder.



The inverter automatically creates an IPOS program to perform synchronization.

Features/Product:

- (2) RF77DT100LS4, 30 rpm or (2) RF67DT100LS4, 28 rpm (61.26:1)
- (2) ES1S incremental encoders – one for each motor
- (1) Movimot® - MM22C (or MC07A022)
- (1) Movidrive® Compact - MCV40A0022-0T

Calculations:

RPM

The final rpm of each tank is determined simply by dividing the output rpm of the helical-worm gearmotor by the ratio of the helical-bevel reducer.

$$RPM = \frac{222}{7.24} = 31$$

HP

The HP formula calculates the HP for each of the two helical-inline gearmotors.

$$HP_{Load} = \frac{T \times RPM}{63025 \times Eff} \Rightarrow\Rightarrow HP_{Load} = \frac{4466 \times 31}{63025 \times .955} \Rightarrow\Rightarrow HP_{Load} = 2.3$$

Gearmotor - Method A:

Since 2.3 Load HP is larger than a nominal 2.0 HP, 3 HP input is necessary. From the SEW gearmotor catalog, an RF77DT100LS4 is available in either 33 rpm (52.07:1) or 30 rpm (57.68:1).

Gearmotor - Method B:

Since the nominal power (3 HP) is much larger than the load power (2.3 HP), the gearmotor combination listed in the SEW catalog (as described in Method A) will reflect a reducer with a much higher torque rating than the load torque. It may be possible that a smaller gear reducer is available, but it does not appear in the gearmotor catalog because the nameplate service factor is below 1.0.

Thus, an alternate method involves selecting a gear reducer based upon load torque. An RF67, 61.26:1 is available with a pinion gear for a 100LS4 motor and with a torque rating equal to 5310 in-lbs. Since this torque is larger than the load torque (4466 in-lb), the reducer is not overloaded and is acceptable for the application based upon load torque.

However, its maximum input power is only 2.53 HP. Therefore, the unit has a service factor below 1.0 when combined with a 3 HP motor. But, the inverter controls acceleration and limits the starting torque of the motor to 150%, which alleviates concern about a potentially high starting torque imposed to the RF67 from a 3 HP motor. Thus, an RF67DT100LS4, 61.26:1 is acceptable.

Benefits:

- Cost Savings – price for the total components on the new system is less than the total components of old system.
- Less Installation Time – jackshaft and critical alignment are eliminated.
- Simpler Design – Two gearmotors instead of three; no jackshaft.

Questions:

1. Could a single MC-31C be used to control both of the RF77DT100LS4 gearmotors, since they are identical in HP and ratio?

   No. One may think that since the motors are identical, they should rotate at exactly the same speed so that they blades never intersect. However, since the load on one side of the tank may occasionally differ from the load on the other side of the tank, over time the motors may rotate at slightly different speeds, causing the blades to intersect. Position synchronization is critical here.

2. Could an RF67DT100LS4, 56.89:1, 30 rpm, be used instead of the 61.26:1, 28 rpm in all of the solutions? After all, 30 rpm is closer to 31 rpm than is 28 rpm?

   No, because the 56.89:1 ratio does not have a pinion gear available to fit a 100LS4 motor. This information is found on page 44 of the 2002 Constant Speed Gearmotor Catalog.

3. Since the Movimot® in Solution 4 does not contain encoder inputs or outputs, how is the ES1S encoder on the right tank receiving power?

   The ES1S encoder receives 24V power from the Movidrive® Compact, since it is wired to the X14 encoder input. The Movidrive® Compact powers both encoders via the X14 input and X15 outputs.

4. Why does Solution 1 have ES1**T** encoders and Solution 2 have ES1**S** encoders?

   An ES1T is a TTL encoder that operates on 5V, while an ES1S is a sin/cos encoder that operates on 24V. The MC-31C supplies 5V; therefore it requires the ES1T. Similarly, the Movidrive® Compact supplies 24V; therefore, it requires the ES1S.

Comments:

This application uses position synchronization and is commonly referred to as ***electronic line shafting***.

The following are general guidelines. Exceptions may apply.

- Whenever a mechanical linkage is removed and replaced with separate electronic components, position synchronization should be considered.
- Whenever a mechanical linkage is still used with two or more electronics (such as a belt conveyor, chain conveyor, or jack shaft), position synchronization may be considered. However, load sharing and speed synchronization may also be viable solutions. Careful review of the application, especially the stress on the mechanical linkage, is necessary.

The tangible cost savings in this application is obtained by using helical-inline reducers instead of helical-bevels and by eliminating the helical-worm gearmotor.

Important Concepts:

- In an electronic line shafting application, a single inverter cannot power two gearmotors, even though they are identical in ratio and horsepower. Position synchronization must be used.
- Whenever a mechanical linkage is removed and replaced with separate electronic components, position synchronization should be considered.
- Helical-inline reducers usually provide the most cost-effective solution.
- The "-0T" version of the Movidrive® Compact enables position synchronization through ISYNC, which eliminates the DRS option.