Simpson S66x Counter Series Application Note

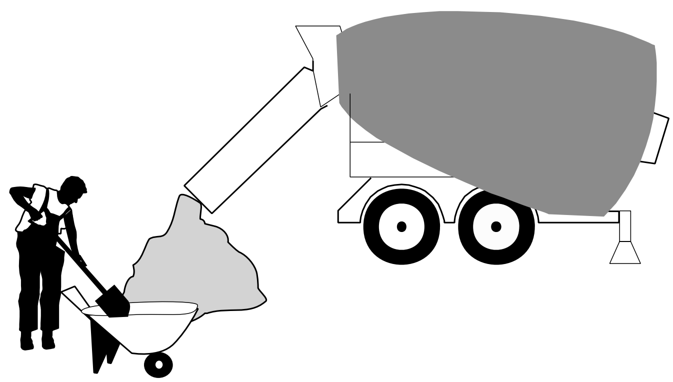
AN-6607

Machine Control

Technical Level: Advanced

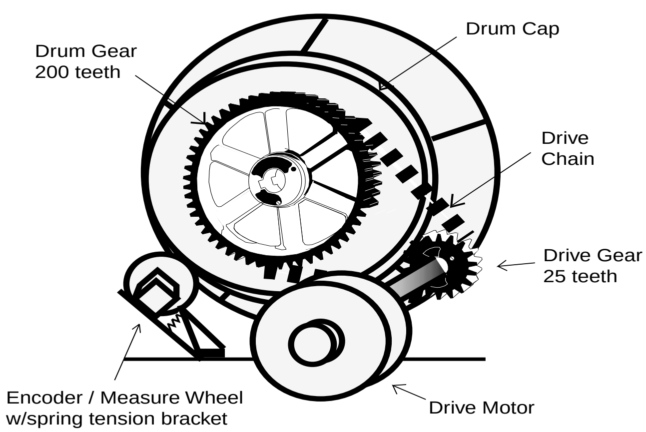
Application Description

A Simpson Encoder and Counter will be used to monitor the drum of a concrete mixer. The counter will control mix and pour cycles. Monitoring of drum speed and overspeed indication is also required.



In mixing mode, the drum turns counter-clockwise, in pouring mode, clockwise. The number of rotations for an automatic cycle will be different for each mode. Similarly, the overspeed limit is different for each mode.

The added capabilities are to be integrated with the existing controls package. In addition, the new 'retro-kit' will require minimal mechanical work, allowing field modification of the mixer.



Drum Detail

Control Panel

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Machine Specifications

Mixer Drum:	Counter Clockwise = Positive count direction = Mixing Mode Clockwise = Negative count direction = Pouring Mode Load range: 1 ton (empty) to 25 tons (full) Max operating speed = 50 RPM Operating above rated maximum speed for extended period will damage the drum.
Drive Train:	A hydraulic motor turns the drum via a drive chain. The motor's maximum speed is 600 RPM. The motor sprocket has 25 teeth, the drum has 200 teeth.
Encoder Pick-up:	The Drum Cap has a 2 inch wide steel rim that is 3 feet in diameter. A measuring wheel can roll on its smooth surface to directly measure the drum rotation. By using a bracket with spring tension, the encoder can be easily mounted to the chassis of the mixer. This method was chosen because it avoided complicated drive train modifications and shaft alignment procedures.
Speed Control:	The existing power unit adjusts the hydraulic flow (power) delivered to the motor. Operator adjustments are made via a control knob. Range is 0 to 100%. Since actual speed depends greatly on drum mass, overspeed conditions can result as the load decreases.
Start/Stop Buttons:	The Start button activates a latching relay. An isolated Normally Open contact on the Start button has been made available for our controls. The Stop button releases the latching relay. Maximum draw of the latching circuit is 1 Amp.
Mode Control:	Reverses the flow to the motor, controlling rotation direction. The two positions are labeled 'Mix' and 'Pour'.
Overspeed Alert:	An audible alarm will indicate overspeed conditions. A readily available vehicle 'backup up' alarm device drawing 2 amps max. will be used. A panel lamp will operate in parallel with the audible alarm. The lamp draws 1.25 Amps.
Power:	All controls must operate from 12VDC negative ground vehicle power.
Pouring Cycle:	The pouring cycle is a small (or partial) number of drum rotations at low speed. The automatic pouring cycle will limit the drum to ½ rotation after release of the Start button. Holding the Start button will override the auto cycle for continuous pouring. The overspeed alarm is to sound if the drum exceeds 10 RPM in pouring mode.
Mixing Process:	The mixing process generally runs many rotations at higher speeds. The automatic mixing cycle will limit the drum to 200 rotations after release of the Start button. This allows the mixer to prevent over airation of a batch if the operator has been distracted by other tasks and forgets to stop the mixer. The overspeed alarm is to sound if the drum exceeds its rated operating speed.
Display:	Display and entry of drum rotations is in turns with one decimal place (#####.#). Drum speed will be in RPM with two decimal places (####.##) and an update rate of once per second is desired.

Product Selection

A measuring wheel will be used on a smooth hard surface. Referring to the product bulletin reveals that the 46004 will provide the best traction. This is a 12 inch circumference wheel with 80A durometer tire.

When selecting an encoder and counter, initial computations are required to insure that maximum operation speeds will not be exceeded. To compute this, the Drum Cap circumference must be known.

$$\text{Drum Cap Circumference} = \text{Diameter} \times \pi = 3 \text{ feet} \times 3.1416 = 9.4248 \text{ feet} = 113.0976 \text{ inches}$$

$$\text{Max. Encoder speed} = \frac{\text{Max Drum Speed} \times \text{Drum Cap Circumference}}{\text{Encoder Wheel Circumference}} = \frac{50 \text{ RPM} \times 113.0976''}{12''}$$

$$= \mathbf{471.24\ RPM}$$

Selecting an encoder for maximum resolution, try a 60 pulse encoder (Simpson Model **SE-60**). Now computing encoder output frequency:

$$\text{Max Encoder Speed (RPS)} = \frac{\text{Max Encoder (RPM)}}{60 \text{ (seconds/min)}} = 7.854 \text{ RPS}$$

$$\text{Encoder Output Freq.} = \text{Encoder (RPS)} \times \text{Encoder (PPR)} = 7.854 \text{ (RPS)} \times 60 \text{ Pulses/Rev} = \mathbf{471.24\ Pulses/Sec}$$

The encoder output frequency is well below the encoder maximum frequency of 10 KHz and counter’s 20 KHz.

Now computing count resolution:

$$\text{Count Resolution (Quad X1)} = \frac{\text{Encoder Wheel Circumference}}{\text{Encoder (PPR)} \times \text{Drum Cap Circumference}} = \frac{12''}{60 \text{ (PPR)} \times 113.0976''}$$

$$= \mathbf{0.0017684\ Turn/Pulse}$$

The resolution is well below the minimum requirement of 0.1 inch.

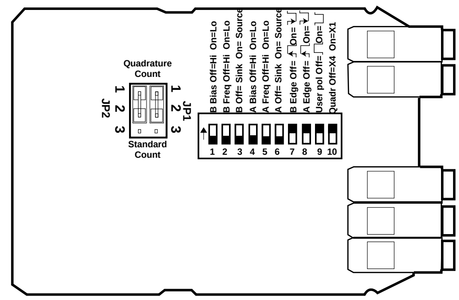
Preset Totalizer / Rate Counter (Simpson Model **S663**) operating from DC power supply option has the required capabilities. The Dual Relay option will be used for control. The 12V Excitation option will provide an isolated power source for the encoder. The excitation supply provides ‘clean’ power to the encoder vs using the vehicle power directly.

Product Ordering Information

Qty	Simpson Part #	Description
1	**46004**	12 inch measuring wheel with 80A durometer tire
1	**SE-60**	Quadrature Encoder, 60 pulses per revolution
1	**S663-3-2-2-1-0**	Model — Power — Input — Output — Excitation — Other Model: **S663**, **None=0** Power: 120VAC=1, 240VAC=2, **9-32 VDC=3** Input: Standard=1, **Quadrature=2** Output: None=0, 1 Relay=1, **2 Relay=2** Excitation: None=0, **12 VDC=1**

Hardware Setup :

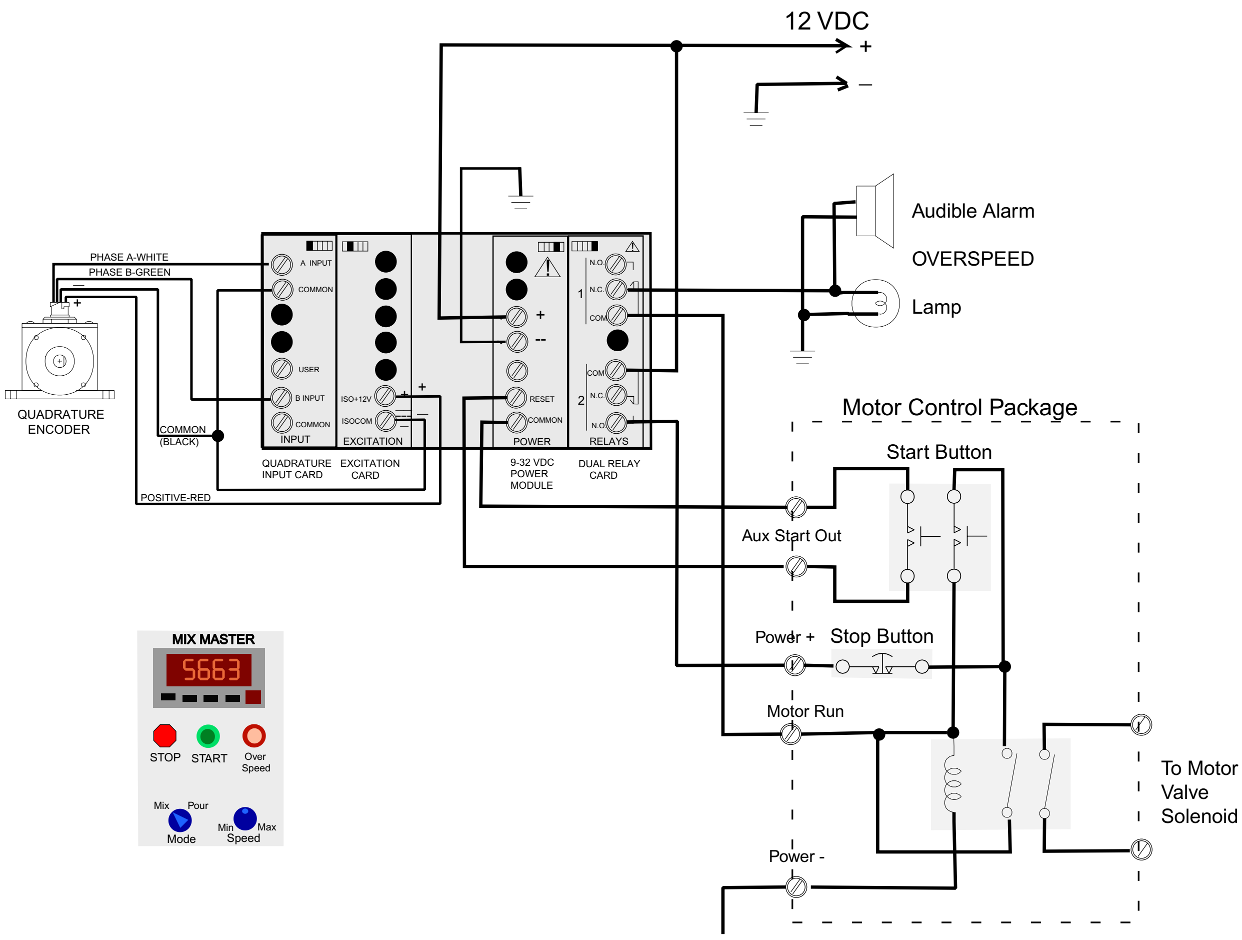
Since an SE Encoder is being used, the Quadrature input card will use the default settings. Note that X1 Quadrature mode will be used (switch 10 ON).



Output #1 Normally Closed contact will activate the OverSpeed Alarm devices. The NC circuit is used because the counter logic will activate the relay when the rate is within acceptable range. This circuit's power is provided by the Motor Run terminal. This is done so the alarm will not sound when the machine is stopped !

Output #2 Normally Open contact will arm/disarm motor operation. The contact is in series with the existing Stop Button and thus interrupts the power source to the control unit. The contact will be closed only when the count is within acceptable range.

The Start auxiliary contact is used to reset the counter.



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Counter Programming:

Input Setup:

After attaching the hardware, it was observed that the count decremented when the drum was turned Counterclockwise (Mixing Mode). This is the opposite behavior desired. Therefore, the **Reverse Quadrature mode** of operation will be used to effectively reverse the direction of rotation.

Position Scaling:

The relationship of the Drum Cap and encoder wheel acts as a multiplier of drum turns. As previously calculated, the encoder resolution is 0.0017684 Turns/pulse, which also serves as our initial Scaling Multiplier.

Since the display resolution is to be to the nearest 1/10 turn (multiply by 10) = 0.017684

Since this figure still has significant figures far to the right of the decimal place, we will use a prescaler of 0.1 (divide by 10). This allows a slightly higher degree of accuracy. We may now adjust the scaling factor by 10x again and round to the nearest 4 significant figures right of the decimal:

Final Position Scaling Multiplier = 00.1768 (Using 0.1 PreScale)

A Decimal Point must be placed 1 position from the right. Use DP format "**00000.0**".

Rate Scaling:

An update rate of one reading per second is desired for the application. We may use the **mSec** mode to achieve this. This overrides the normal method of selecting the rate mode based on units of measure. Using this range will result in a reading that is Hz x 1000. As computed earlier, the encoder will produce 471.24 Pulses/Sec (Hz) when the drum rotates at its maximum rated 50.00 RPM. Disregarding decimal places and considering the actual 'displayed values', the display will be 471240 vs. the desired 5000. This relationship can be used to determine the Rate Scaling Multiplier.

Rate Scaling Multiplier = $\frac{5000}{471240}$ = **00.0106 (Using Msec mode)**

A Decimal Point must be placed 2 positions from the right. Use DP format "**0000.00**".

Since 0 RPM = 0 on the display, no Rate Offset is required for this application.

Output & SetPoint Setup:

The following diagram illustrates the desired behavior of control outputs.

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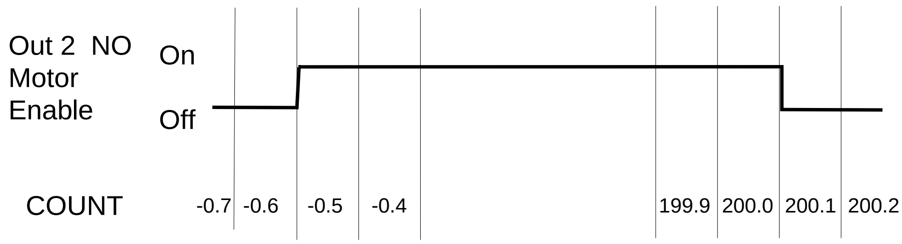

The behavior of Output 1 and Output 2 are both boundary operations.

Output1 uses SP1 and SP2 and the low and high boundary values respectively. Thus SP1 will be set to -10.00 and SP2 to 50.00. Output 1 activates when the RPM is between these points. The signal in the graph is effectively ‘inverted’ because we are using the Normally Closed contact as the alarm activation signal.

Output2 uses SP3 and SP4 and the low and high boundary values respectively. For pouring cycles (reverse count direction), a turns limit of -0.5 is desired. Setting SP3 to -0.5 sets this low limit. Setting SP4 to 200.0 establishes the mixing mode (forward count direction) turns limit.

Resets Setup:

Since the S663 is being used as a boundary controller, AutoReset is not used in this application.

The Reset button should be disabled to prevent in-advertant resets during operation. Reset functions will be performed using the ‘hardwaired’ Reset Input on the rear of the S663. This signal will be asserted by the machine’s Start button.

Using the Power On Reset feature is optional in this application.

S663 Programming

Category	Parameter	Selection	Comments
InPut SEtuP	A CHAn	rquAd	Chose the quadrature mode (Quad or Reverse Quad) that will result in forward counting when in mix mode. See *Input Setup* above.

Count SEtuP	PrESCL	0.1	A ÷10 is used in this application. *See Position Scaling* above.
Count SEtuP	CSCALE	00.1768	See *Position Scaling* above.
Count SEtuP	dP	00000.0	Displaying turns with 1 decimal place. *See Position Scaling* above.
rAtE SEtuP	ModE	MSEC	The mSec (Hz x 1000) mode is used in this application. *See Rate Scaling* above.
rAtE SEtuP	rSCALE	00.0106	See *Rate Scaling* above.
rAtE SEtuP	dP	0000.00	Displaying turns with 2 decimal places. *See Rate Scaling* above.
oPut 1 SEtuP	ModE 1	bound	Note: SP1 and SP2 serve as low / high boundary values.
oPut 1 SEtuP	SrC 1	rAtE	This output uses the Rate ‘channel’ as its source.
oPut 2 SEtuP	ModE2	bound	Note: SP3 and SP4 serve as low / high boundary values.
oPut 2 SEtuP	SrC 2	Count	This output uses the Count ‘channel’ as its source.
SEtPnt SEtuP	SP 1	-0010.00	Rate Alarm low boundary value (RPM).
SEtPnt SEtuP	SP2	0050.00	Rate Alarm high boundary value (RPM).
SEtPnt SEtuP	SP3	-0000.5	Motor Enable low boundary value (Turns).
SEtPnt SEtuP	SP4	00200.0	Motor Enable high boundary value (Turns).
SEtPnt SEtuP	rStPoS	00000.0	This sets the Turns count to 0 whenever the Motor Start Button is pressed or held.
rESEt SEtuP	ArESEt	AFtoP 1	Perform Auto-Reset after output 1 has timed out. See item 3.
rESEt SEtuP	ArESEt	di SAbL	The Auto Reset feature is not used in this application.
rESEt SEtuP	rStbtn	di SAbL	The counter’s reset button is disabled in this application.

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