

Solar Powered, Constant/Continuous Move Micro Center Pivot

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Abstract

The Solar Powered Pivot uses High Torque, 48 Volt, DC Motor(s) as prime means of moving the pivot in the field. The Pivot can be operated at any time with Deep Discharge batteries, charged by Photovoltaic Solar Panels. This allows pivots to run without the use of high-tension cables and electrical wires. The batteries & photovoltaic solar panels move with the pivot, eliminating the need for collector rings, thereby reducing electrical maintenance. This constant/continuous move pivot operates in a straight line, allows even distribution of water, and increases yield. Because all towers move continuously, multiple starts and stops are minimized, reducing stress on the structure, while increasing the life and reliability of the pivot. The constant/continuous move is facilitated by a Micro-controller unit, installed on each tower, is designed to calculate and control the synchronous speed of each tower. The micro-controller units are field-programmable. A slip timer design also senses the slippage of any pair of wheels, halting the pivot to reduce water waste and possible system damage. This control system is designed to sense the lag or lead of a particular tower and any deviation in the movement is corrected automatically. This concept is currently designed for a micro-pivot; however it can be adapted for use in larger diameter pivots.

Key Words: Center Pivot, Solar Power, Synchronous Speed, Slip Timer, Constant/Continuous move, Real Time Clock (RTC), Logic Controller, Standard Tower Controller, End Tower Controller, Yield.

Prologue:

Irrigation is the most important factor contributing to the process of harvesting any crop. Scientific progress has improved on the traditional means of irrigating croplands. Now, where abundant solar power is available, this renewable source of energy can be used to power irrigation systems.

Introduction:

Center pivot irrigation is popular and used extensively worldwide. The challenges encountered with most systems include:

1. The sprinkler spans move in a zigzag fashion and this motion prevents an even distribution of water. This adversely affects crop yield.
2. Power failure or cuts can also affect continuous operation of the pivot system.

Our Solar Powered Micro Pivot utilizes solar energy to power the pivot movement. This creates a substantial advantage to farms that have an abundance of hot, sunny weather.

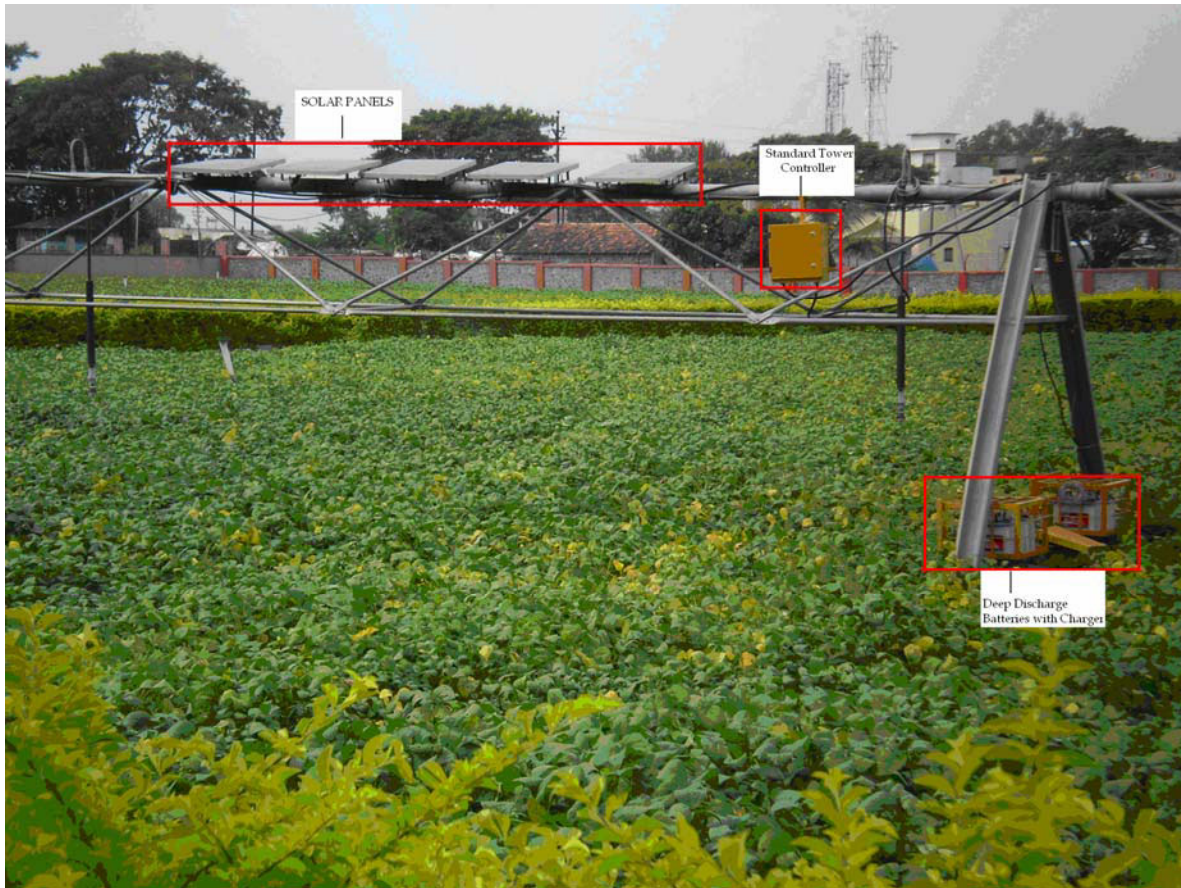
Our system has been designed as a constant / continuous move system, thus avoiding the jerky, stop / go span motion, providing even water distribution. It reduces maintenance costs, and increases the life cycle of the pivot. Continuous motion reduces the wear and tear on motors that need to start from zero to full speed and back to zero. The controller allows for a narrow band of deviation in lateral / linear movement thus reducing the probability of misalignment. Our software-driven stall timer detects wheel-churning, shuts down the pump and halts the machine, preventing water waste and tire wear.

The Pivot:

Our pivot system has a center pivot point with a number of spans or towers, which revolve around the pivot point. The system can have from 3 to 7 towers, each spanning a length between 90 to 130 feet, depending on the size and shape of the farm. Water is connected at the pivot point. When the structure is carrying water, and system is operating a coupler and rubber boot prevent water leakage. Each tower is built using a stable 'A' frame structure. It is operated with a 48 Volt-100 Watt, geared DC Motor, and driven by heavy duty gear boxes and tractor tires. The last tower, also called the end tower, moves at a maximum speed of 6 feet per minute, which can be reduced by 10% to increase the water discharge. Beyond the end tower is a cantilevered extension, which adds an additional 20 feet to the structure. A Logic Control box installed at the pivot point controls all machine operations.

Safety Features:

- Reverse Battery Connection
- Reverse PV Connection
- Over/Under Voltage cutoffs
- Overload protections
- Generally the machine works on a 60 Volt nominal DC supply, but can operate safely between 52 to 70 Volts
- LED indications for all above.



Logic Controller Features:

- Real Time Clock (RTC)
- Non Volatile (NV) RAM for 24X7X365 Real Time Operation,
- Battery backup saves data in the event of power failure.
- 20X4 Alphanumeric LCD Display indicates:
 - Machine status and diagnostic purposes.
- Operational parameters such as:
 - Starting Time
 - Run Hours or End Time
- Direction of Rotation (Clockwise, Counter Clockwise)
- End Limit Sensors detect boundary locations when pivot is not making 360 degree rotation and controls the Pivot operation.
- Real Time Clock tracks stop times.



Logic Controller Signal mode:

Power:	60 Volt DC Power being delivered to all towers
Pump:	Operates pump during Wet Mode
Speed:	Variable speed control from 10% to 100% by potentiometer Failsafe Current loop of 4-20 mA
Direction:	Signals all tower controllers to travel in pre-set direction
End Gun:	Pivot will water corners of square or rectangular fields. Can be programmed to remain in ON position for extra coverage if desired

The Logic Controller Receive mode:

Clockwise Start (CW):	Pivot starts in CW direction.
Counterclockwise Start (CCW):	Pivot starts in CCW direction.
Stop:	Stops pivot.
Misalignment:	Failsafe signal stops pivot if alignment off over 7.5 ⁰
CW Limit Switch:	Receives this signal when Pivot reaches CW end of the farm.
CCW Limit Switch:	Receives this signal when Pivot reaches CCW end of the farm
Pressure Switch:	Stops pivot when low pressure is detected. Used during Wet Mode Operation only.
End Gun On:	Instructs controller to water corners. Used mainly for square and rectangular-shaped croplands.
Temperature Indicator:	Shuts off pivot if air temperatures fall below zero.

Machine operation modes:

Auto Restart	ON	Stops the pivot under Low voltage condition (< 52 Volts). Once power is restored, pivot resumes operation.
	OFF	Once machine has stopped, pivot must be restarted manually.
Auto Reverse	ON	System oscillates between two end limits.
	OFF	System travels to one end and stops.
Wet/Dry	WET	Machine starts pump, checks water pressure and continues to work. This feature is critical when pump stops due to power failures or loss of water.
	DRY	Mainly used during diagnostic testing mode and parking.
Misalignment		If any tower alignment is off by 7.5 degrees; machine & pump are shut off. System must be manually aligned before restarting.
Normal operation		Each tower of the machine moves in synchronous speed, moving the entire system in a straight line. Any tower that lags by more than 3.5 degrees, it will move at a higher speed and catch up. Alternately, if a tower advances by 3.5 degrees, it stops and brings it back into alignment. A slip timer tracks churning of wheels.
All above conditions are indicated by bright LEDs on the Main Panel at the pivot point.		

Standard Tower Controller:

This controller is common to all the other towers, except the last one. It is a micro controller based unit and works on 52 to 72 Volts. The synchronous speed of the tower is adjusted by settings of the Dual in Package (DIP) switches & depends on total number of towers and its position from the pivot point. Normally, all the towers move at synchronous speed to run the machine in a straight line. A specially designed integrated sensor detects position of particular tower with respect to the next tower. The sensing angle is generally 3-3.5 degrees, for synchronizing purposes. If it finds that a tower is lagging, the controller increases the speed. A tower that advances ahead of others is stopped to bring it back to synchronous speed. The continuous feedback loop makes the system stable, reliable and keeps it in synchronization. Synchronous speed makes the pivot to run continuously in a straight line around the pivot point.

End Tower Controller:

This is a Micro controller base unit & operates on 52 to 72 DC Volts, which drives the End Tower Motor. The speed feedback is used in the system to regulate the speed of the motor, under Power Supply and Load fluctuations. Speed is maintained constant, regardless of voltage variations between 50-72 volts and uphill and downhill slopes up to 25 degrees (tested at local installation). The constant speed governs the total

movement and distributes water more evenly. The CW & CCW end limit switches and the End Gun are routed through this controller. The speed of the motor is governed by 4-20mA current loop set by Logic Controller.

Basic Features:

Power

1. System works on SOLAR energy, no external electrical power is required. Operation is not jeopardized due to power outages, power failures, or power maintenance and shortages.
2. Solar power charged storage batteries allow the machine to be operated any time, including nighttime.
3. No need to install underground or overhead high-tension wires or cables to the field.
4. If external electrical power is used, collector rings are required. Use of solar power, eliminates the need for collector rings.
5. Since irrigation must be used in sunny, hot and dry conditions, a solar power pivot provides an ideal application of this technology.

Conclusions:

Continuous Motion Pivot advantages:

- Avoids multiple starts and stops
- Reduces wear and tear and stress on all components
- Improved reliability and longer life-cycle
- Reduced wheel churn
- Improved water distribution, improves crop yield
- Stall Timer detects abnormal conditions and shuts down system
- DC motor improves stalling torque and increases the gradient of movement
- Spikes on power source are reduced

We have operated a three-tower system at the National Research Centre for Onion & Garlic, at Rajgurunagar, near Pune, Maharashtra, India, for last three (3) years. It is a 380-foot machine and was operated continuously for more than 20 hours with no solar charging required.

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