

# PROCESS

**LINCOLN**<sup>®</sup>  
**ELECTRIC**  
THE WELDING EXPERTS

WAVEFORM CONTROL TECHNOLOGY™

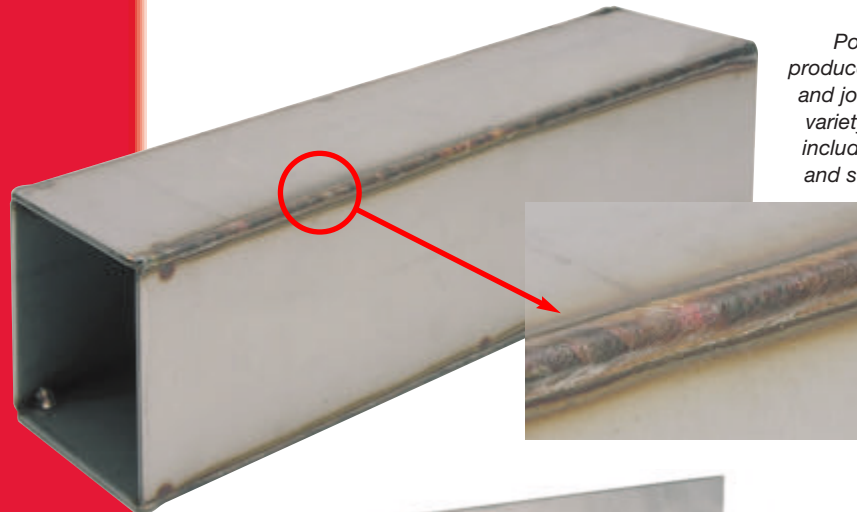
## Power Mode™

Do you need consistent arc stability and penetration profile? Are you joining materials thinner than 20 gage (0.7 mm)? If you answered yes to either of these questions, Power Mode™ may be just the answer you are looking for.

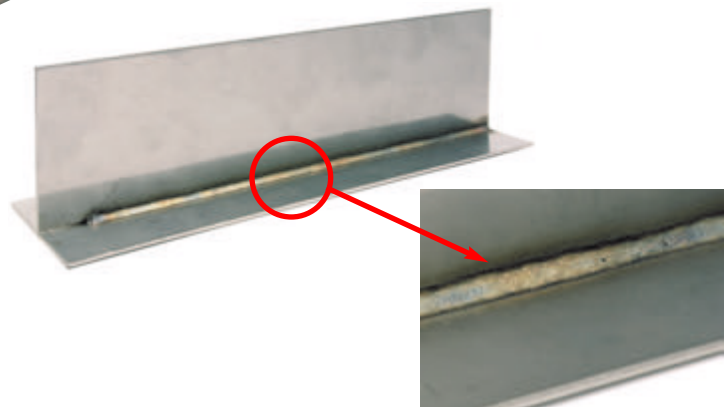
The controlled response of the Power Mode enables the power source to maintain a stable arc despite stickout fluctuation, even at very low current levels.

Power Mode is a new development in GMAW process technology that combines the benefits of today's Waveform Control Technology™ with the output characteristics of traditional constant current ("drooper") equipment.

The Power Mode is standard on Lincoln Electric equipment that supports Waveform Control Technology™. Simply select it in your Power Wave, Power MIG 300, or Invertec V350-PRO machine.



*Power Mode produces quality edge and joint welds on a variety of materials including aluminum and stainless steel.*



### a d v a n t a g e s

#### **PROVIDES STABLE ARC WELDING ON THIN MATERIALS**

Premier arc stability at very low current provides optimal conditions for short-circuit welding (GMAW-S). Additionally, it features a variable inductance control that reduces weld spatter and can improve wetting action at the toes of the weld.

#### **MAKES ALUMINUM WELDING MORE FORGIVING**

Because the output is characteristically constant current, the Power Mode tolerates large stickout fluctuations in semi-automatic applications to provide a consistent penetration profile.

The future of welding is here.®

NX-2.60 11/03

# Power Mode

## What

### Is Power Mode?

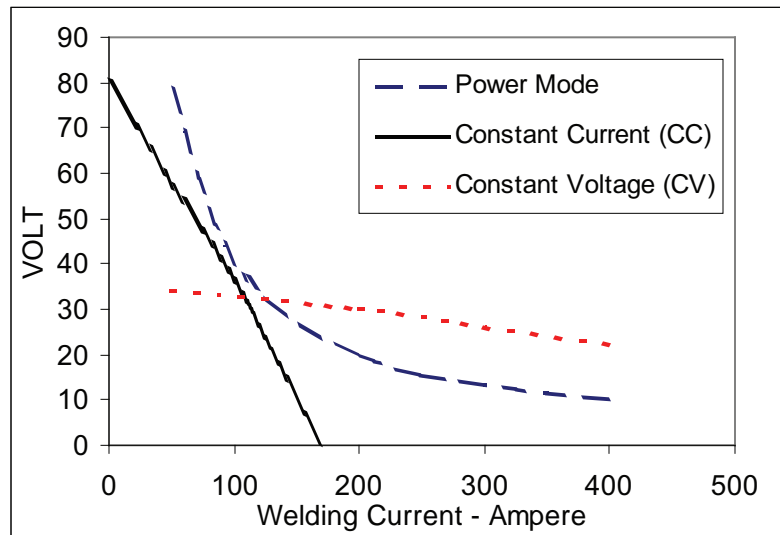
The Power Mode uses watt energy ( $V \times I = W$ ) to regulate the arc length.

The power supply responds to changes in voltage sensed at the welding arc. However, unlike a Constant Voltage weld process, the Power Mode will respond with less change in current than a Constant Voltage program.

Using watt energy to regulate the arc permits consistent response within the welding arc. The benefit of this type of control is best demonstrated in applications where energy and penetration must be closely monitored and consistent.

Power Mode aids in the control of the arc's response to variations in stickout. A change in stickout forces a current adjustment so that output power remains constant.

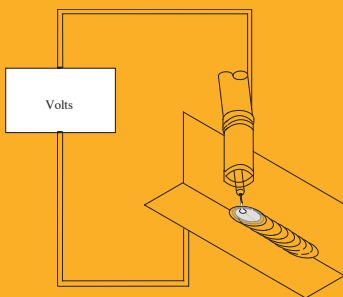
## The Power Mode



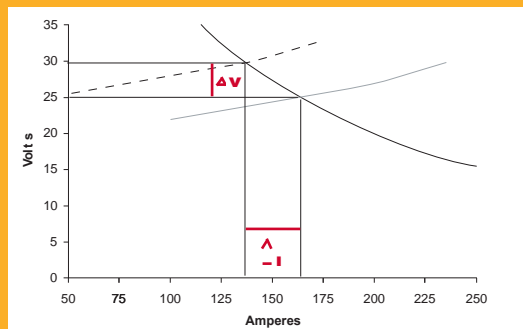
This graph compares the volt/amp relationships in the Constant Current, Constant Voltage, and Constant Power slope designs. As is illustrated, the Power Mode mimics the behavior of a constant current "drooper" while in its low range, and mimics the characteristics of a CV welder at higher amperage.

## How

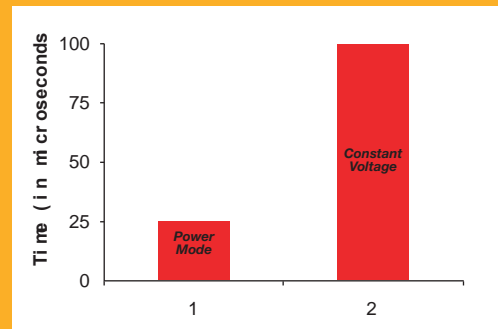
### Power Mode Works



The arc voltage sensing lead reports the voltage to the power source. The voltage sensed corresponds to the arc length.



This graph represents the voltage and amperage response to increases or decreases in arc length using constant power. Here, the arc sensing lead reports approximately a 5 volt change ( $\Delta V$ ) in arc length, forcing an imbalance in the power. The current compensates slightly (25 A,  $\Delta I$ ) to get the power relationship balanced to the setpoint. Note that the current response is much less than if a typical constant voltage procedure had been used.



The Power Mode compensates for arc length fluctuations four times faster than traditional Constant Voltage or Constant Current machines. Faster response times require less drastic compensation to maintain control.

# Power Mode

## Using

### Power Mode

#### Aluminum GMAW Spray Welding

In its operating range, the Power Mode behaves similarly to a constant current “drooper” machine, making it an ideal candidate for GMAW welding of aluminum. Additionally, the traditional drooper problems of arc starts are eliminated because the Power Mode takes on Constant Voltage characteristics at the start of a weld and during short circuit transfer mode.

The Power Mode is more adaptive than standard CV to arc length fluctuations in aluminum spray transfer welding because its waveform is programmed to react in reducing voltage by increasing current in smaller but more frequent increments, thus maintaining preset power output. As demonstrated in the experiment detailed at the right, the same arc fluctuation produces much smaller current compensation in the Power Mode than a Constant Voltage process.

The major advantage of Power Mode is the consistency of weld penetration and current while in axial spray transfer. The resulting weld is comparable to welds produced by drooper based welding output.



The Power MIG 300 provides a semi-automatic solution for aluminum welding.

## Comparing

### Power Mode

#### Power Mode vs. GMAW-CV on Aluminum

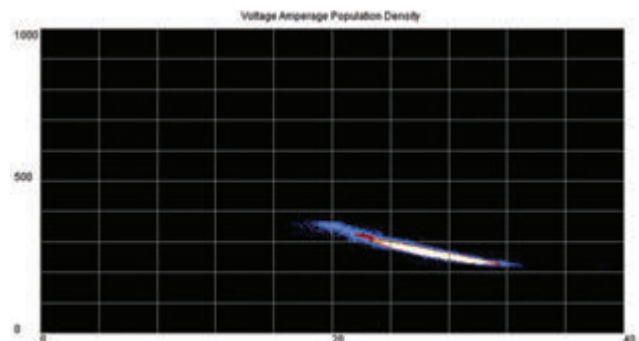
The images below represent voltage-current population density. They provide application evidence that compares an aluminum weld made with Power Mode to an aluminum weld made with a standard CV program. A Power MIG 300 power source with a push-pull torch is used for the experiment.

The specifications of the procedure are as follows:

- 1/4 in. T joint
- 3/64 in. 4043 electrode
- 450 ipm WFS
- 11.5 power preset for Power Mode
- 23.5 to 25.5 V for mode 5 (non synergic CV mode)
- 100% Argon gas

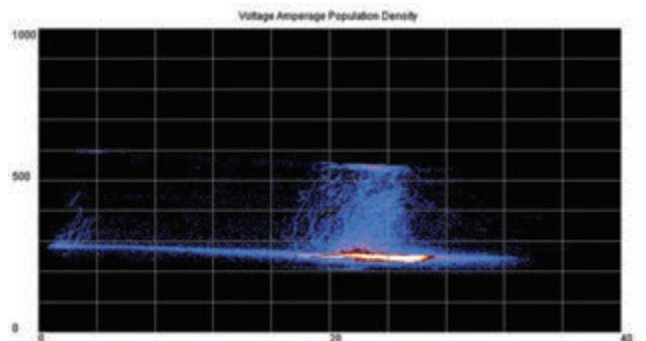
Aluminum welds are more sensitive to large current swings which could lead to penetration problems. This experiment proves Power Mode is suitable for use on aluminum in semi-automatic applications.

#### Power Mode™



The Power Mode holds a much tighter current range. The Total Voltage-Amperage signature area of mode 5 (CV) is 12.5 times larger than that of Power Mode.

#### Constant Voltage (CV)



Mode 5, a non-synergic CV waveform, exhibits large fluctuations of voltage and current under similar electrode stickout (ESO) disturbances

# Power Mode

## Short Arc GMAW (GMAW-S ) at Low Procedure Settings

Power Mode can be used on the same materials and with the same gas mixes as traditional Constant Voltage weld programs, but with more consistent arc starts and short circuits. The unique power regulation of the Power Mode is especially well-suited for semi-automatic and hard automation welding at low procedure settings.

The metal transfer mechanism of the Power Mode fluctuates according to the wire feed speed and power setpoints programmed. Whether it is spray, globular, or short arc transfer, the strength of the Power Mode lies in its regulation of power while in the arc. Controlling the power instead of the voltage gives the Power Mode an edge over Constant Voltage output — control during a short circuit.

During a short the voltage collapses, which makes it difficult to regulate with a voltage control. A sudden increase in voltage re-establishes the arc, but at too high a current, which induces spatter. Using Power Mode, the short circuit mechanism emulates the GMAW-S routine, except that at the short it regulates based on current instead of voltage. This lowers the pinch current, reducing the possibility of current overshoot. Power regulation picks up after the material has been pinched off.



Power Mode produces exceptional welds at low procedure settings, making it ideal for use on fine wire, thin gauge welds, such as foil or "wall-papering" welds.

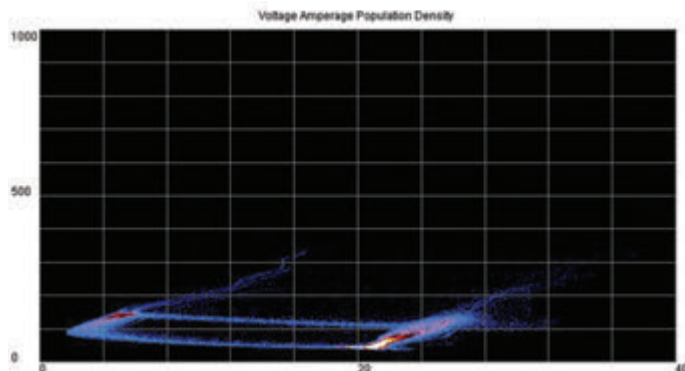
## Power Mode vs. Short Arc on Stainless Steel

The images below represent voltage-current population density. They provide application evidence that compares a short arc weld made with Power Mode to a short arc weld made with a standard CV program. A Power Wave 455 hard automated edge weld was performed using the following specifications:

- 1 mm – 1 mm edge joint
- 0.030 in. Bluemax 309 stainless steel electrode
- 190 ipm WFS
- 5.2 power preset for Power Mode, +7 arc control
- 17.8V for Constant Voltage (CV)
- 117 ipm travel speed
- 90% Helium, 7.5% Argon, 2.5% CO<sub>2</sub> gas

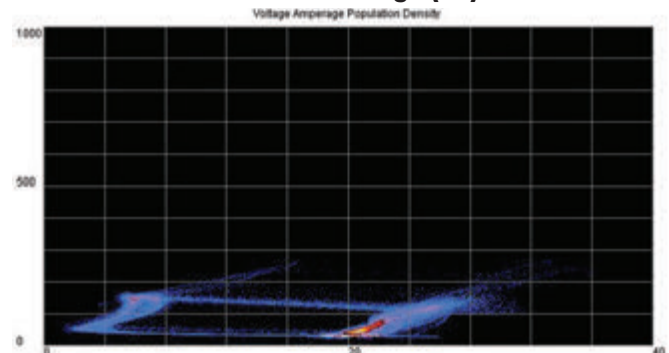
Both the Voltage-Amperage (VI) plots and arc statistics are very similar. Voltage stability and time stability calculations of Power Mode and Constant Voltage (CV) are very similar.

### Power Mode™



The VI plot of Power Mode indicates a tighter population in the arc region than that of Constant Voltage. This corresponds to a smaller standard deviation in arc voltage. Additionally, the average short circuit amperage of Power Mode occurs at a current 23A lower than Constant Voltage, which suggests that Power Mode may also produce lower spatter levels than standard GMAW-S procedures

### Constant Voltage (CV)



# Power Mode

## Lincoln Electric SuperGlaze™ Aluminum MIG Wire

### For superior welding performance,

turn to SuperGlaze aluminum MIG wire from Lincoln Electric. Lincoln Electric is the leader in MIG wire manufacturing technology. We carry that same technology and expertise to our aluminum MIG wire manufacturing. Our fully integrated aluminum MIG wire facility uses state-of-the-art equipment to produce a complete range of aluminum alloys including 1100, 4043, 4047, 5183, 5356, 5554 and 5556. SuperGlaze prevents the problems usually associated with aluminum wire feeding such as birdnesting, tangling and burnback to provide a stable arc, great feedability and exceptional control — every time you weld! The keys are SuperGlaze's smooth surface finish and consistent chemical composition. What all of this means to you is outstanding welding characteristics, spool to spool, time after time.

### What Makes Our SuperGlaze Stand Out From the Rest?

Three unique features:

- A proprietary process which gives SuperGlaze a superior surface finish for optimum surface integrity.
- A manufacturing process that precisely controls the alloy chemical composition to produce consistent physical characteristics.
- State-of-the-art testing equipment to evaluate the surface condition and feedability of the wire to ensure problem-free welding.

Lincoln's aluminum MIG wire coupled with our advanced MIG welding equipment makes aluminum as easy to weld as any other material and makes Lincoln the one source for all your aluminum welding needs.



## Lincoln Electric SuperArc™ Mild Steel and Blue Max™ MIG Wire

SuperArc and Blue Max are our premium MIG wires. This quality wire has a well-earned reputation for feedability, consistency, and exceptional arc characteristics.



We guard this reputation carefully by making sure every spool is of the very highest quality.

## Lincoln Welding Systems Featuring Power Mode

### Power MIG™ 300

The Power MIG 300 — a single phase, multi-process, synergic wire feeder welding package for the professional welder.

The Power MIG 300 offers:

- Superior multi-process welding.
- Synergic design for ultimate control over the arc, by automatically aligning wire feed speed and voltage.
- Top-quality aluminum welds with push-pull wire feed capability, not usually available in competitive models.
- True MIG pulsing and Pulse-on-Pulse™ capabilities, which ensure that superior feeding is matched by high quality arc performance.



### Invertec® V350-PRO

The Invertec V350-PRO is a versatile, multi-purpose, multi-process power source.

- Invertec V350 is lightweight, portable, and available in construction, factory, advanced process, and factory rack models.
- Capable of doing virtually any job, whether in the shop or on the construction site. Stick, DC TIG, MIG, Pulsed MIG, flux-cored and arc gouging abilities make the Invertec V350-PRO the most versatile inverter power source in its class.
- The Invertec V350-PRO was built tough to handle the rigors of harsh environments, and it is equipped with plug-and-play intelligence, allowing it to automatically adjust to your wire feeder.



# Power Mode

## Lincoln Welding Systems Featuring Power Mode

### Power Wave 455M, Power Wave 455M STT

These Power Waves are designed to be part of a modular, multi-process welding system.

- The Power Wave 455M and 455M/STT are high performance, digitally controlled inverter welding power sources capable of complex, high-speed waveform control.
- Digital communications enable the Power Wave to connect seamlessly to robot controllers and hard automation PLCs. Semi-automatic applications are also supported.
- The Ethernet/DeviceNet Gateway provides networking capabilities and allows process and production monitoring.
- Software-based controls can be upgraded as new features become available.



### Power Wave F355i

The Power Wave F355i is fully integrated with the FANUC ARC Mate™ R-J3iB controller and designed for the most demanding robotic applications.

- This compact unit delivers 350 amps at 60% duty cycle for MIG, Pulsed MIG or Flux-Cored welding applications.
- The Power Wave F355i/ARC Mate R-J3iB communicates via ArcLink™, allowing all welding procedures and process controls to be managed through the ARC Mate robot teach pendant — one central control for setup, process control and diagnostics.



### Customer Assistance Policy

The business of The Lincoln Electric Company is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customer and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for advice or information about their use of our products. We respond to our customers based on the best information in our possession at that time. Lincoln Electric is not in a position to warrant or guarantee such advice, and assumes no liability, with respect to such information or advice. We expressly disclaim any warranty of any kind, including any warranty of fitness for any customer's particular purpose, with respect to such information or advice. As a matter of practical consideration, we also cannot assume any responsibility for updating or correcting any such information or advice once it has been given, nor does the provision of information or advice create, expand or alter any warranty with respect to the sale of our products.

Lincoln Electric is a responsive manufacturer, but the selection and use of specific products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of the customer. Many variables beyond the control of Lincoln Electric affect the results obtained in applying these types of fabrication methods and service requirement.

*Subject to change* - This information is accurate to the best of our knowledge at the time of printing. Please refer to [www.lincolnelectric.com](http://www.lincolnelectric.com) for any updated information.

### WHAT IS NEXTWELD?

The challenges facing industrial fabricators today are increasingly difficult. Rising labor, material, and energy costs, intense domestic and global competition, a dwindling pool of skilled workers, more stringent and specific quality demands.

Through our commitment to extensive research and investments in product development, Lincoln Electric has established an industry benchmark for applying technology to improve the quality, lower the cost and enhance the performance of arc welding processes. Advancements in power electronics, digital communications and Waveform Control Technology™ are the foundation for many of the improvements.

NEXTWELD brings you a series of Process, Technology, Application and Success Story documents like this one. NEXTWELD explains how technologies, products, processes and applications are linked together to answer the important questions that all businesses face:

- How can we work faster, smarter, more efficiently?
- How can we get equipment and people to perform in ways they've never had to before?
- How do we stay competitive?

NEXTWELD is the future of welding but its benefits are available to you today. Ask your Lincoln Electric representative how to improve the flexibility, efficiency and quality of your welding operations to reduce your cost of fabrication.



**LINCOLN**®  
**ELECTRIC**  
THE WELDING EXPERTS

THE LINCOLN ELECTRIC COMPANY  
[www.lincolnelectric.com](http://www.lincolnelectric.com)  
1.216.481.8100