



# Power Amplifiers

*Power with Precision™*



## EXPERIENCE

- **Supplier Since 1984**
- **Leader in PWM Design Technology**
- **Thousands of Amplifier Installations**
- **Wide Range of Application**
- **Custom Engineering Support**

Copley Controls has led the industry as a supplier of full range high power, wide bandwidth, DC amplifiers since 1984 with designs that offer state of the art MOSFET and IGBT technology in a highly efficient Pulse Width Modulation (PWM) circuit design. Copley was the first to deliver high power 4-quadrant, filtered output units operating at up to 100 kHz effective switching frequency, enabling L-C filters to be built into the amplifier case. The result is a low-noise PWM power amplifier with characteristics much like a linear amplifier, but without the high dissipation and bulk. Copley amplifiers function as a current or voltage source and may be paralleled for high current loads. Configurations include single or multiple axis units, as individual components or fully integrated in rack assemblies including power supplies, breakers, and capacitor banks - delivered to customer specification.

Copley further pioneered the application of PWM amplifiers in MRI, magnetic resonance diagnostic imaging systems for energizing the gradient coil. The challenging high peak current demand in a precision pulsed environment is matched by the outstanding performance of Copley amplifiers. With thousands of systems installed, Copley's experience continues to overcome challenges of distortion and drift in a proven high power design - critical for high-resolution, neuro, angio and the latest diffusion scan imaging techniques.

The demand for power with precision is a hallmark of Copley amplifiers and systems.

## ADVANTAGE

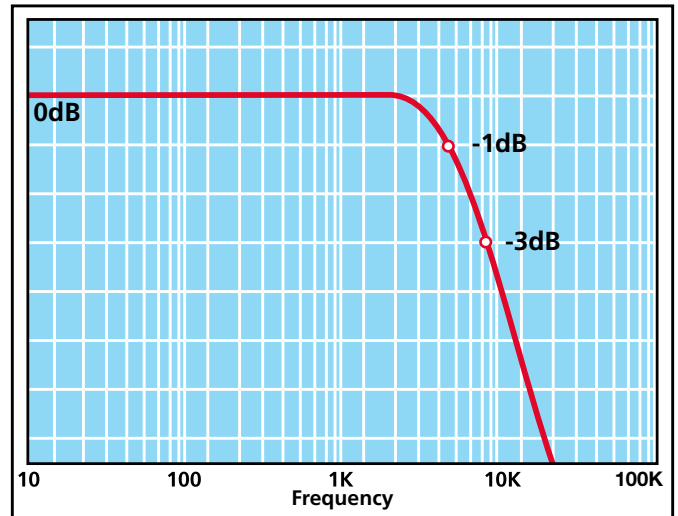
- **Compact physical size**
- **Outstanding reliability**
- **Unparalleled linearity**
- **Low cross-talk, low drift and distortion**
- **Voltage or current mode operation**
- **Optimized custom load tuning**

## TECHNOLOGY

- **Low ripple, advanced output filter design**
- **High efficiency PWM switching design**
- **State-of-the-art IGBT and MOSFET technology**
- **Active thermal management**
- **Digital signal processing**
- **Advanced current mode closed loop feedback control**

PWM design in a Copley power amplifier is maximized for output performance and minimal power dissipation. A Copley amplifier, operating in current mode, has a typical response within -3dB of 4-7kHz - and in voltage mode operation, performance is delivered over a wider range - up to 15kHz. In Copley amplifiers, the addition of a precision current sensor in the output leg improves the feedback for more accurate stability control - further controlling settling response with little or no overshoot. Drift and distortion are minimized by internal loop designs while ripple noise is reduced by selective output filtering.

Years of engineering experience and quality control, make Copley amplifiers, the standard of the industry.



Typical Bandwidth Response of Model 266

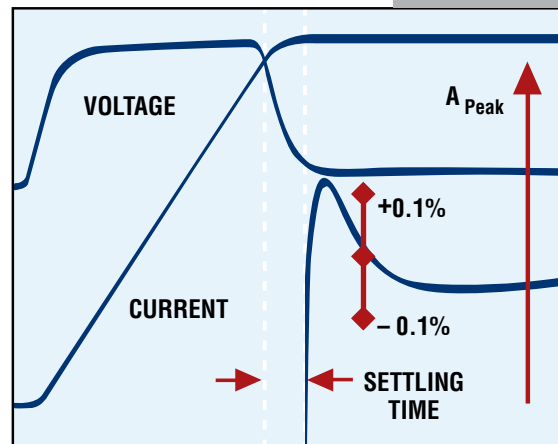
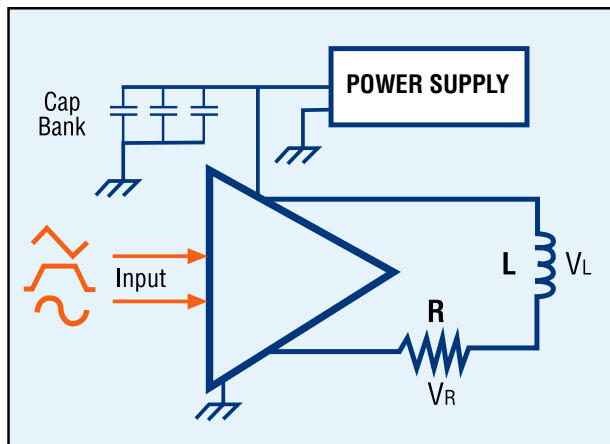
# POWER AMPLIFIER SELECTION CRITERIA

For the best choice of amplifier, good definition of the load and desired signal characteristics are critical. When matched to the correct amplifier, the output is predictable and reproducible. The Copley Power Amplifier is a modular high-performance current-controlled amplifier optimized to drive inductive loads or voltage-controlled for more resistive elements. The amplifier can be configured specifically for different applications such as gradient or shim control in magnetic resonance imaging, AC power conversion, vibration excitation, and beam steering.

In theory, the input and the overall system feedback configure the system for a specific application, optimizing the open loop gain and frequency response for a particular load. Connected to the input section are a precision gain potentiometer, zero-level adjustment, and an input limit potentiometer which sets the system current limit. A differential input eliminates unwanted signals due to ground voltage differ-

ences, while a slew limiter limits the rate of voltage change so currents in the output stage will always be within the capability of the power device - excessive voltage clipping or harmonic distortion in the output is an indication that the input should be modified or a more appropriate amplifier selected to match the desired output. A precision current sensor in series with the positive output terminal provides improved feedback performance - the addition of a precision DCCT further enhances performance.

In most applications, a single external regulated or unregulated DC power supply can energize an amplifier for single or multiple axis control circuits including low voltage internal circuits and matched power to meet losses in the amplifier and load circuit.



For pulse operation in an MRI application, amplifier stability into an inductive and resistive load is typically characterized by optimizing the tuning parameters. Depending on the rise time of the desired current waveform, the voltage functions as  $L \cdot di/dt + V_r$ . The slew rate of the current is therefore driven by the output voltage of the amplifier for a desired  $I_{max}$  and the physical characteristics of the coil -  $V_r$  drop in the output circuit reduces ideal performance. As the pulse reaches  $I_{max}$  less desirable effects related to improper feedback

settings and external factors such as eddy currents may cause unstable waveform and delayed settling of the current pulse.

Copley amplifiers are designed for optimal feedback to match loads over a wide range of impedance. Special configuration controls can be tuned for specific output results - thereby achieving stable, reproducible pulse sequences, critical for imaging performance.

## FEATURES AVAILABLE

- Master/Slave Configuration
- Internal or External Current Transducer
- Voltage or Current Mode Operation
- Optimized Tuning for Custom Loads
- External Clock Synchronization
- Noise Filtration
- Capacitor Banks
- Power Supply Selection
  - 2.5 - 40kW
- Rack Cabinet Accessories
  - 15 - 40U
  - Special enclosures
- Custom Wiring Solutions

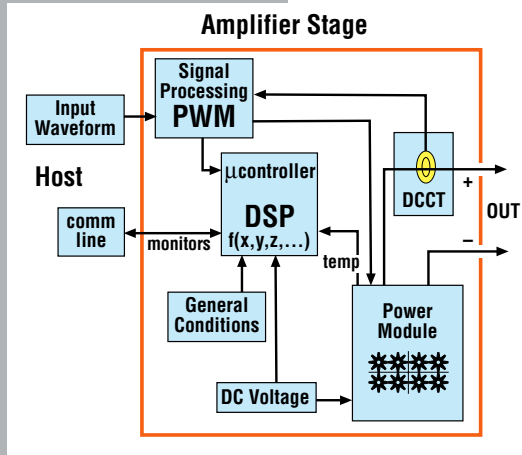
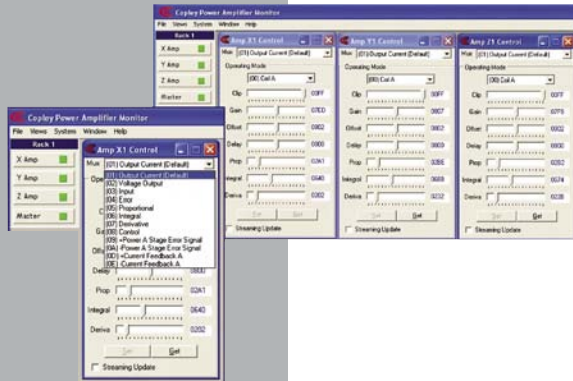
# 700V

- High Performance, Current Mode Amplifier
- Advanced Power Management
- Air or Liquid-Cooled Operation
- Single or Multiple Channel
- Low Drift, Low Distortion
- Digital Control Interface
- Master/Slave Configurations

The Copley range of high voltage amplifiers is designed for maximum power output and high current stability. Each amplifier is designed around a state-of-the-art PWM circuit utilizing the latest IGBT and MOSFET technology. The resident DSP provides a range of input signal processing and sophisticated internal and external monitoring for precision set-up and control - including complete system-wide management of thermal parameters - critical to reliable performance. Communication with the amplifier is available through a real-time ADCI controller, which directs information to/from the HOST device - quickly analyzing operational and fault status. Each amplifier may be configured in



multiple modes for specific load or test conditions, with adjustments for settling (i.e., proportion, integral and derivative) and other performance critical parameters through the digital bus.

The Model 281 and 282 are liquid-cooled systems, which deliver upwards of 575kVA<sub>peak</sub> or sustained 360 Arms in a compact, efficient configuration. The C700 is an air-cooled unit, capable of delivering 350kVA<sub>peak</sub> or 212Arms. All units may be configured with matching power supplies and additional capacitance for reliable power delivery.



Model 281/282 Liquid-cooled

Model C700 Air-cooled

Copley Controls Corp. Model	Output Current			Pulse Output (A)			
	+/-DC	Sine Wave	Triangle Wave	Duration On(ms)/Off(ms)			
	V <sub>max</sub> †	Adc/Arms	A <sub>peak</sub>	A <sub>peak</sub>	500/500	100/100	I <sub>max</sub>
C700	700	212	300	367	220	300	500
282 	675	250	354	433	325	350	500
281 	675	360	509	624	450	500	850*

# POWER AMPLIFIERS

A 350V power amplifier is available in two configurations, depending on the required peak and rms performance. The Model 271 is designed as a liquid-cooled system with the same internal DSP and control logic as described for the 700V amplifier range. The Model 266 is an air-cooled unit, ideal for a wide range of semiconductor, high power vibration drivers and precision controlled current applications. Both units employ a DCCT for

enhanced stability. Multiple load configurations may be remotely controlled for quick set-up and test of application specific outputs. The Block Diagram below for the Model 266 assures that maximal performance is derived from an efficient PWM design, with full bridge cancellation of common-mode components and tuned output filtration for reduced ripple output. Appropriate feedback circuitry provides gain stability across the full output range.

## 350V

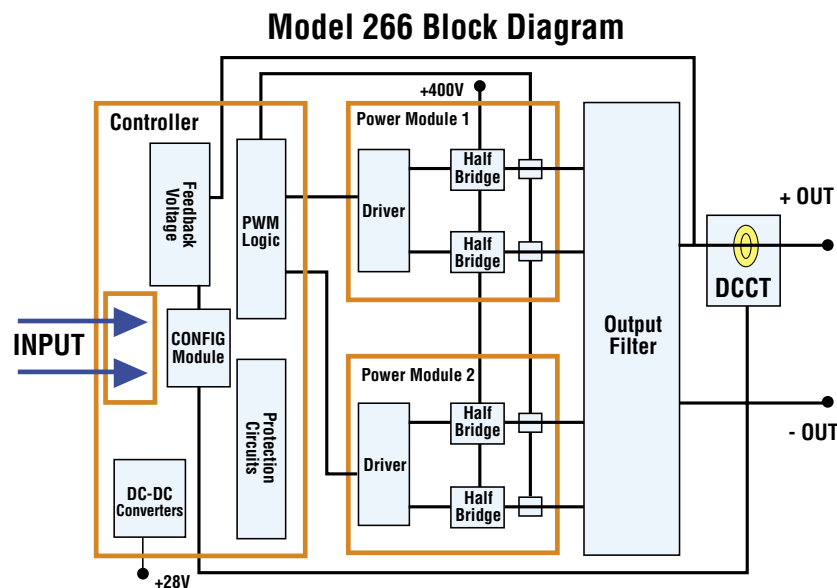
- High Performance Amplifier
- Customized Tuning for Range of Inductive Loads
- Air or Liquid-Cooled Operation
- Single or Multiple Channel
- Low Drift, Low Distortion
- Master/Slave Configurations
- Advanced Power Management



Model 266 System



Model 266



Model	Output Current				Pulse Output (A)		
	+/-DC		Sine Wave	Triangle Wave	Duration On(ms)/Off(ms)		
	Vmax †	Adc/Arms	Apeak	Apeak	500/500	100/100	Imax
266	350	250	354	433	312	350	475
271	350	400	566	693	525	600	950*

# 300V

- **Current or Voltage Mode**
- **Air-cooled Operation**
- **Customized Tuning**
- **Single or Multiple Channel**
- **Low Drift, Low Distortion**
- **Over current Protection**
- **Master/Slave Configurations**

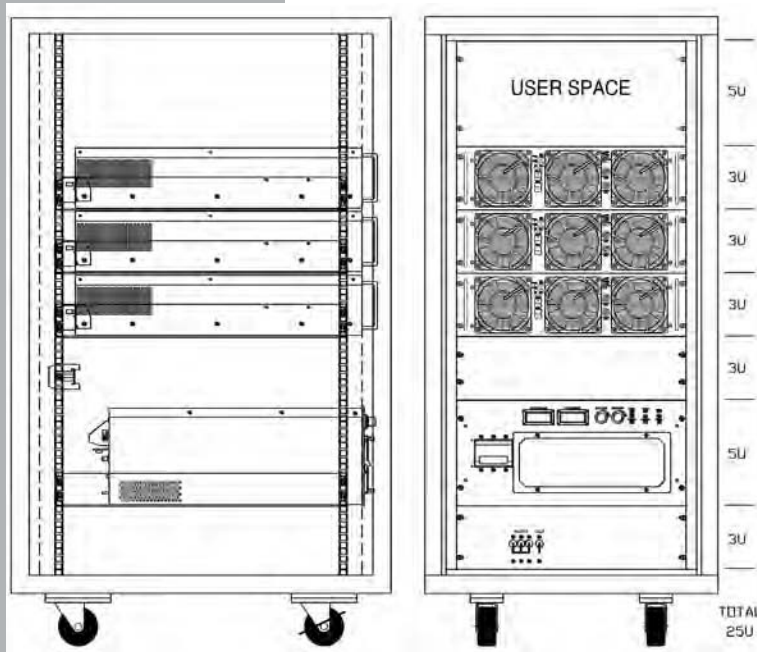
Copley has delivered thousands of Model 262PN and 265P amplifiers into a wide range of semiconductor, vibration and MRI applications. The track-record for this family of work-horse components continues to demonstrate the success that Copley delivers. The latest Model 261HC continues this line-up with an enhanced peak-current and limited duty-cycle operation, especially useful for pulsed operation. Slaved operation of any of the units in

this range, provide maximal current output for unique power requirements.


Selective tuning is possible over a wide range of output loads and programmable in a tuned configuration module. Internal protection and thermal monitoring circuits assure amplifier reliability.



Model 262PN



Model 265P  
High Current Master/Slave Application

	Output Current				Pulse Output (A)		
	+/-DC		Sine Wave	Triangle Wave	Duration On(ms)/Off(ms)		
	Model	V <sub>max</sub> †	A <sub>dc</sub> /Arms	A <sub>peak</sub>	A <sub>peak</sub>	500/500	100/100
261HC	300	45	64	78	65	65	180
262PN	300	85	120	147	106	120	190
265P	300	150	212	260	187	212	324

† Load Dependent

# POWER AMPLIFIERS

The Model 231HC and 232HC provide a flexible solution for modular configuration in single and multi-axis applications. These units may be paralleled for increased current output or Model 234 may be selected to deliver peak and sustained current in a single, efficient construction.

The range of amplifiers has found application in

MRI for driving gradient coils over a wide range of inductive loads, or as a power driver for large scale motor circuits.

The experience and reliability of these units has made them popular for accelerator projects that require stable performance, and vibration control applications that need a high power bandwidth.

## 150V

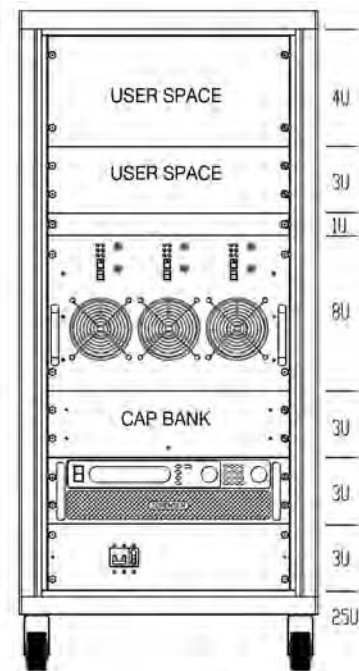
- Current or Voltage Mode
- Air-cooled Operation
- Customized Tuning
- Single or Multiple Channel
- Low Drift, Low Distortion
- Over current Protection
- Master/Slave Configurations




Model 234P



Model 231HC/232HC



Model 231HC/232HC

	Output Current				Pulse Output (A)		
	+/-DC		Sine Wave	Triangle Wave	Duration On(ms)/Off(ms)		
Model	Vmax †	Adc/Arms	Apeak	Apeak	500/500	100/100	Imax
231HC	150	70	98	120	75	85	130
232HC	150	120	170	208	150	170	260
234P02	150	225	318	390	300	340	520
234P04	150	300	424	520	375	440	675

† Load Dependent



# Power Amplifiers

*Power with Precision™*

## APPLICATIONS

- Electron Paramagnetic Resonance
- Magnetic Resonance Imaging
- Semiconductor Manufacturing
- Satellite Receiver Positioning
- Particle Beam Guidance
- Vibration & Shock Testing
- Beam Steering
- Magnetic Levitation

MODEL	V <sub>MAX</sub> †	OUTPUT CURRENT		
		A <sub>DC</sub> /A <sub>RMS</sub>	TRIANGLE WAVE A <sub>MAX</sub>	PULSE A <sub>MAX</sub>
231HC	150	70	120	130
232HC		120	208	260
234P02		225	390	520
234P04		300	520	675
261HC	300	45	78	180
262PN		85	147	190
265P		150	260	324
266	350	250	433	475
271		400	693	950*
C700	700	212	367	500
282	675	250	433	500
281		360	624	850*

Liquid Cooled

\*Special Mode † Load Dependent

*Power with Precision*

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