



# Accel Instruments

## TS250

# Waveform Amplifier

The TS250 waveform amplifier is a unique instrument ideal for amplifying function generators. It amplifies current or voltage or power for driving heavy loads. The TS250 offers eight voltage ranges to choose from  $\pm 10V$  to  $+65V$ . Refer to the ordering information on page 2 for the voltage ranges. The TS250 output peak current is up to 6A for the low-voltage model. Higher current is possible by connecting two or more TS250 in parallel as shown in the *Application Section*.

The TS250 is ideal for many test and measurement applications such as LDO and amplifier PSRR test, battery simulator, op-amp CMRR measurement, high current driver for electromagnetic coils, general function generator amplifier, transient response test, four-quadrant power supply, lab power amplifier and more.

### High-Current Amplifier

TS250 is ideal as a waveform generator amplifier for amplifying current. It can drive high current or high power or high voltage loads. It can output up to 6A for the low-voltage model and reduce current for the higher voltage models. As a current amplifier, it accepts AC or DC voltage input from a function generator to drive a heavy load that requires high current. The TS250 features a selectable gain of 0dB or 20dB.

### Battery Simulator

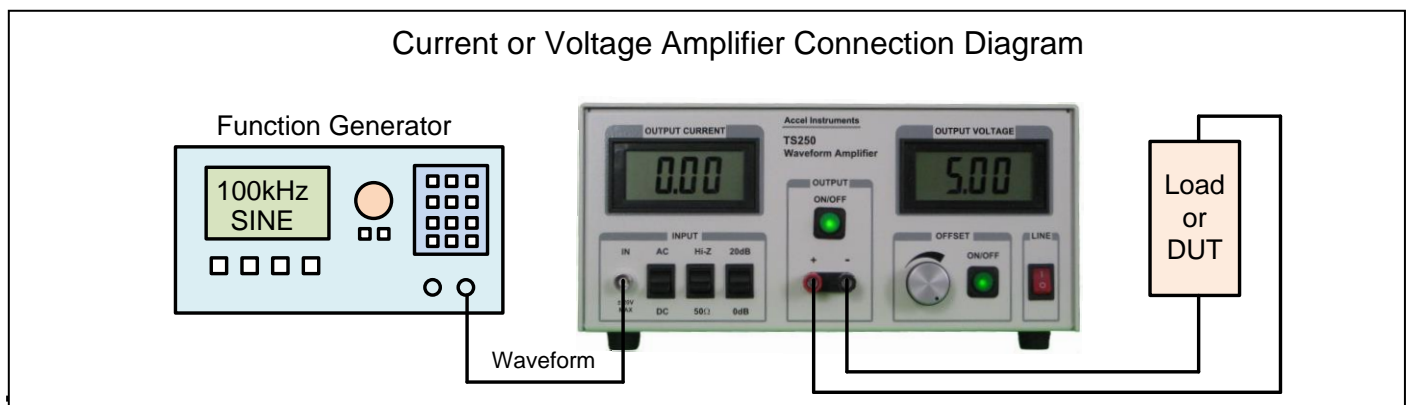
TS250 can source or sink current. It can be used as a battery simulator. It has a variable DC output that can easily simulate battery voltage changes. Thus it is great for battery charger testing such as those in battery operated portable electronic systems.

### Applications

- High Current Amplifier
- LDO PSRR Measurements
- Battery Simulator
- Amplifiers PSRR/CMRR Measurements
- Electromagnetic Coil Driver
- Transient Response Test
- Piezo Amplifier and Driver
- High Current LED Testing
- Four quadrant power supply
- Solar Cell Characterization

### Features

- Easy to use with a function generator
- Current monitor output to oscilloscope
- Flexible input AC/DC/Hi-Z/50 $\Omega$
- Selectable 0dB/20dB gain
- Offset (DC) voltage control
- Large voltage and current LCD
- Up to 6A peak (TS250-0)
- Up to +65V output (TS250-7)
- Thermal protection



## TS250 Order Information

Models	Output Voltage Range
TS250-0	-10V to +10V
TS250-1	-20V to +20V
TS250-2	-30V to +30V
TS250-3	-40V to +40V
TS250-4	-6V to +15V
TS250-5	-6V to +30V
TS250-6	-6V to +45V
TS250-7	-6V to +65V

## Accessory Order Information: (optional)

TS220 50Ω terminator for the TS250 current monitor output



## Electrical Specifications

Parameter	Condition/Note		MIN	TYP	MAX	UNIT
Output Voltage Range	TS250-0			-10 to +10		V
	TS250-1			-20 to +20		
	TS250-2			-30 to +30		
	TS250-3			-40 to +40		
	TS250-4			-6 to +15		
	TS250-5			-6 to +30		
	TS250-6			-6 to +45		
	TS250-7			-6 to +65		
Output Current	Greater than 10Hz, $V_{OUT} = 75\%$ of max voltage, resistive load. Current is derated with lower output voltage or driving reactive load (capacitor and inductor) or both	TS250-0		5.0		$A_{DC}$
				-6.0 to +6.0		$A_{peak}$
		TS250-1		3.1		$A_{DC}$
				-4.4 to +4.4		$A_{peak}$
		TS250-2		2.1		$A_{DC}$
				-3.0 to +3.0		$A_{peak}$
		TS250-3		1.7		$A_{DC}$
				-2.5 to +2.5		$A_{peak}$
		TS250-4		4.0		$A_{DC}$
				-5.0 to +5.0		$A_{peak}$
		TS250-5		2.1		$A_{DC}$
				-3.0 to +3.0		$A_{peak}$
		TS250-6		1.7		$A_{DC}$
				-2.5 to +2.5		$A_{peak}$
		TS250-7		2.1		$A_{DC}$
				-2.5 to +2.5		$A_{peak}$
Output Noise	Note 1			1		mVrms
				6		mVpp
Output Slew Rate				16		V/ $\mu$ s
Input Impedance	50 $\Omega$ setting			50		$\Omega$
	Hi-Z setting			1		k $\Omega$
Gain	Non-inverted	0dB setting		0		dB
		20dB setting		20		
Min Input Frequency	-3dB, Hi-Z setting	AC-Coupled		1		Hz
		DC-Coupled	DC			
	-3dB, 50 $\Omega$ setting	AC-Coupled		50		
		DC-Coupled	DC			

## Electrical Specifications - Continue

Max Output Frequency	-3dB, 3.5Vpp, (Note 2)		1000		kHz
	-3dB, 10Vpp		450		
	-3dB, 20Vpp		225		
	-3dB, 40Vpp		112		
	-3dB, 80Vpp		35		
Current Monitor Scale	50 terminated $\Omega$ , Note 3		100		mV/A
Current Monitor Accuracy	50 terminated $\Omega$ , max current		$\pm 1.0$		%
LCD Voltmeter Accuracy	Midrange, Note 4		$\pm 1.0$		%
LCD Ammeter Accuracy	Max current, Note 4		$\pm 1.0$		%
AC Power Supply Input Voltage Range	Universal Input, 50Hz/60Hz	100		240	VAC
Operating Temperature	0°C to 40°C		0 to 40		°C
Storage Temperature Range			-20 to +60		°C
Operating Humidity Range	(no condensation)		20 to 80		%
Weight			4.0		kg
Dimension (Inches)			11.25 x 10.5 x 5.5		Inches

1. 0dB gain, 50 $\Omega$  input setting, current monitor output is connected to an oscilloscope.
2. The maximum frequency is calculated by  $f_{MAX} = 4500/V_{pp}$ , in kHz. For example, the maximum frequency for a 20Vpp (-10V to +10V sinewave) is 225kHz.
3. 100mV is equal to 1A output current when terminated with 50 ohm. Output voltage is 200mV per ampere if unterminated.
4. LCD meter reading is the average voltage or current. For example, the average voltage of a sinewave is 0V.

## Basic theory of operation

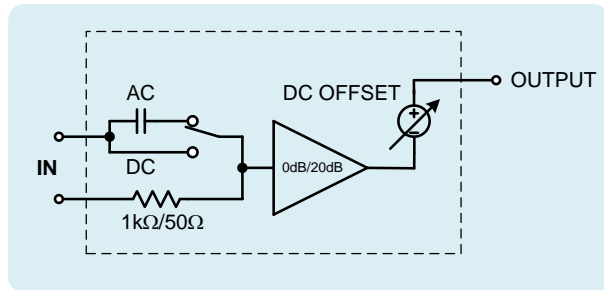


Figure 1. TS250 Functional equivalent diagram.

Figure 1 shows the TS250 waveform amplifier functional equivalent diagram. It consisted of an AC-coupled or DC-coupled input, a selectable input impedance (high-impedance or 50Ω), a selectable gain stage (0dB or 20dB), high current amplifier, and a DC output offset. The adjustable DC offset sets the output DC voltage. This DC offset feature is ideal for LDO or amplifier PSRR measurement, because they require a DC voltage.

### Input AC/DC Couple

The TS250 input signal is applied to the BNC connector on the front panel. The input is first conditioned by the selectable coupling. The TS250 input is either AC-coupled or DC-coupled. This allows added flexibility for the TS250 to work with a variety of instruments such network analyzers and function generators. Use the AC-coupled setting to block out any input DC voltage. Use the DC-couple setting to allow the source DC voltage to be amplified. In the case where you want the TS250 outputs the same voltage as the function generator for example, use DC-couple, 50Ω, 0dB gain, and adjust the DC offset to 0V.

### Input Impedance

The TS250 features a selectable input termination impedance. The input impedance is either high-impedance (1kΩ) or 50Ω. Most

signal generators expect 50Ω termination. The 50Ω setting also achieves the lowest noise. If AC-couple and 50Ω setting are used, the input lower cutoff frequency is about 50Hz.

Some signal source cannot drive 50Ω termination. In that case, use high impedance termination. If AC-couple and high impedance are used, the lower cutoff frequency is about 1Hz.

### Gain

The TS250 features selectable gains: 0dB or 20dB. Most function and arbitrary waveform generators output  $\pm 5V$  into 50Ω. For higher output voltage, gain is necessary. The 20dB gain setting will amplify the input by a factor of 10. The 0dB setting is unity gain (gain of 1).

### Output

The TS250 output is on a pair of banana binding posts. The output pair is labeled as “+” and “-”. The “+” terminal is the positive output while the “-” terminal is the negative output. The OUTPUT negative terminal shares a common connection with the Current-Monitor Output BNC (negative) connector in the back panel. However, the OUTPUT negative terminal does not directly connected to Input BNC ground. In normal usages, OUTPUT negative terminal is connected to the common “Ground”.

Upon power up, the OUTPUT is disabled. The ON/OFF button light is off. The OUTPUT is enabled by press-and-hold the ON/OFF button for about 200ms and released it. The LED light is on when the output is enabled. Press-and-hold the ON/OFF button for about 200ms and released it will turn off the output.

## Fault Conditions

The TS250 is protected by a number of fault protections. These fault protections are: output over-current, input over-voltage, over-heating (thermal), and under voltage. If a fault is occurred, the output is disabled and the ON/OFF LED light is flashing. After the fault condition is removed, press-and-hold the ON/OFF button for 200ms will exit the fault condition. Press-and-hold the ON/OFF button for 200ms again will re-enable the output. If the fault condition is still existed (e.g. not yet cool down), it will re-enter the fault condition and the LED light keep flashing.

## Input Over-Voltage

The TS250 features an input over-voltage protection. If the input peak voltage is over or under the threshold, both the input and output will be disconnected. The TS250 will enter a fault condition and the ON/OFF LED will be flashing. Once the over-voltage fault is removed, press-and-hold the ON/OFF button for 200ms will exit the fault condition. Press-and-hold the ON/OFF button for 200ms again will enable the output. The typical positive and negative over-voltage thresholds are shown in Table 1. If the input is set to AC-couple and the input is DC voltage, over-voltage will not be detected. The absolute maximum input voltage is  $\pm 20V$  for any input setting.

Table 1. Input over-voltage thresholds.

Model		Positive	Negative
TS250-0/1/2/3	Hi-Z	+10.5V	-10.5V
TS250-4/5/6/7		+10.5V	-9.3V
TS250-0/1/2/3	50 $\Omega$	+6.5V	-6.5V
TS250-4/5/6/7		+6.5V	-5.7V

## Output Over-Current

The TS250 features an output over-current protection. If the output current is over the threshold, the output will be disconnected. The TS250 will enter a fault condition and the

ON/OFF LED will be flashing. Once the over-current fault is removed, press-and-hold the ON/OFF button for 200ms will exit the fault condition. Press-and-hold the ON/OFF button for 200ms again will enable the output. The typical over-current thresholds are shown in Table 2.

Table 2. RMS Over-current threshold.

Model	Over-Current Threshold
TS250-0	6.0A RMS
TS250-1	3.3A RMS
TS250-2	2.3A RMS
TS250-3	1.9A RMS
TS250-4	4.1A RMS
TS250-5	2.3A RMS
TS250-6	1.9A RMS
TS250-7	2.3A RMS

## DC Offset

The TS250 features a DC OFFSET output. This feature is useful for waveforms that contained an AC waveform on top of a DC voltage such as PSRR, CMRR, and line transient tests. The OFFSET knob adjusts the DC voltage. In other applications where zero DC voltage is preferred, press and release the OFFSET ON/OFF button to disable the DC offset voltage. When DC offset is disabled, the LED light is off too.

## LCD Displays

The TS250 features two large LCD displays. The one on the left is the output current display. The one on the right is the output voltage display. A positive current indicates the current is sourced out of the TS250. A negative current indicates the current is sink into the TS250. Both LCD display read the average value. For example, a sine-wave with no DC offset will read 0V. A 30% duty cycle 0-to-10V square-wave will read 3.0V.

## Current Monitor Output

The TS250 include a current monitor output that can be connected to an oscilloscope to monitor the waveform current. The current monitor gain scale is 100mV per ampere when terminated into 50Ω. For example, a 2A output current will result in 200mV output voltage on the current monitor output. If the oscilloscope is set to high impedance (1MΩ), the output voltage will be 200mV/A. 50Ω termination is recommended especially for high frequency or square waveforms. If the oscilloscope does not have 50Ω termination build-in, you may purchase the TS220 external 50Ω terminator from us. Use Figure 2 for connecting the Current Monitor to an oscilloscope. If both current and voltage are monitored as in Figure 2, it is recommended to leave the voltage probe ground lead unconnected.

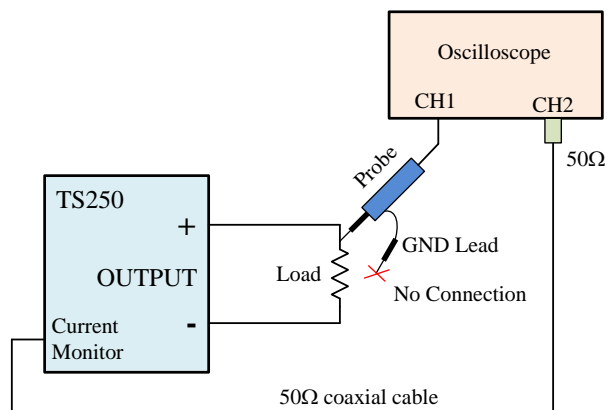


Figure 2. Leave the oscilloscope ground lead unconnected when using current monitor output.

## AC Power Input

The TS250 accepts universal AC power input from 100VAC to 240VAC 50/60Hz. It comes with an America-style power cord. Adapter is needed (not included) for any other country outlet.

## Applications

The TS250 waveform amplifier fulfills many laboratory applications and testing. Visit the *Application Information* section of our website for details.

## Higher Output Current

The TS250 output up to 6A peak. If higher current is needed, two or more TS250 can be connected in parallel as shown in Figure 3. The output current is increase in proportion to the number of TS250 connected in parallel. Series resistors are required to isolate the TS250 from each other. Typical series resistance value is 0.3Ω to 1.0Ω. Higher voltage should use higher resistance. Use power resistor to handle the rated power dissipation.

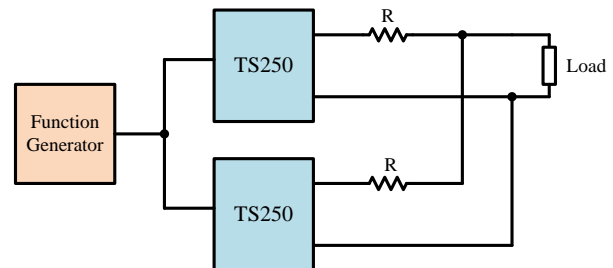


Figure 3. Parallel two TS250 doubles the output current.



## TS250

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