California Instruments Ls Series

3-18 kVA Programmable AC Power Source / Analyzer

- Backward Compatible with L Series
  Function and bus compatible with the California Instruments L Series

- Three phase and Single phase modes
  Ideally suited for avionics and defense applications

- 3 kVA to 18 kVA Power Levels
  Match power source and cost to application requirements

- Transient Programming
  Test products for susceptibility to AC line disturbances

- Built-in Measurements
  Performs voltage, current, and power measurements

- Advanced Features
  Arbitrary waveform generation, harmonic analysis, GPIB interface are some of the available options

- Interface
  Standard USB & RS232C interface. Optional GPIB & LAN available

- CE Marked (400V Input model ONLY)
  Safe, reliable, and consistent operation

Integrated System
The Ls Series is an improved version of the classic California Instruments L Series AC power sources. The Ls Series provides many basic AC source capabilities at an economical cost. Additional capabilities such as arbitrary waveform generation and harmonic analysis can be added as options.

The Ls Series can be ordered in either single phase (-1) or three phase (-3) configurations. Power levels range from 3 kVA to 6 kVA in a single chassis. Multiple chassis can be combined for power levels up to 18 kVA.

Easy-To-Use Controls
The Ls Series is completely microprocessor controlled and can be operated from simple front panel controls. A pair of analog controls located next to the backlit alphanumeric LCD display allows output voltage and frequency to be slewed up or down dynamically. For more advanced operations, a series of menus is provided using a dual line high contrast LCD display. An optional full keypad is available.

Applications
With precise output regulation and accuracy, high load drive current, multi or single phase mode and built-in measurement capabilities, Ls Series AC sources address many application areas of AC power testing. Additional features such as DO 160, MIL 704, Boeing, or Airbus test standards are available options that establishes the Ls Series as a solid choice for avionics or defense applications. All Ls Series AC sources are standard equipped with USB and RS232C remote control interfaces. GPIB and Ethernet (LAN) interfaces are optional.

Compatibility
Although the standard command language is SCPI, the Ls Series also offers functional and bus compatibility with the CI L Series AC power sources. Using the APE (Abbreviated Plain English) command syntax, the Ls Series can be used in existing test systems without having to modify program code. The APE language is part of the -GPIB option which includes a GPIB/IEEE-488 interface.

AMETEK Programmable Power
9250 Brown Deer Road
San Diego, CA 92121-2267
USA
Transient Programming
To simulate common line disturbance occurrences, the Ls Series offers a list of transient steps. These steps can be programmed from the front panel or downloaded over the interface using the Interface Instrument Control Software (GUI) program supplied. The GUI allows libraries of commonly used line disturbances to be created on disk for quick recall. Once downloaded, the transient program can be executed from the PC or from the front panel. AC transient generation allows the effect of rapid changes in voltage, frequency, phase angle and waveform shape on the unit under test to be analyzed. The Ls Series is available in either three or one phase output configurations and offers standard voltage ranges of 135 Vrms and 270 Vrms. A wide range of options can be added to customize the Ls Series to meet your specific application requirements.

Voltage Range Options
Output voltage range options are available to provide higher voltage outputs. In addition to the standard 135/270 V range pair, 156/312 Vrms (-HV option) or 200/400 Vrms (-EHV option) can be specified at the time of order. All voltage ranges are Line to Neutral. On three phase Ls Series models, maximum Line to Line voltages are 467 V (standard), 540 V (-HV option) and 692 V (-EHV option).

Phase Mode
The -MODE option provides automatic switching between three phase and single phase output modes. In single phase mode, all output current is routed to the Phase A output terminal. The -MODE option is available for 3 phase Ls configurations.

Waveform Generation
The standard Ls Series provides sine wave output capability. For more demanding test applications, the advanced option package (-ADV) adds the following waveform capabilities:

- Squarewave.
- Clipped Sinewave - Simulates THD levels to test for harmonic distortion susceptibility.
- Harmonic and Arbitrary (User defined) waveforms.

Using the provided Windows GUI, defining harmonic waveforms is as easy as specifying the relative amplitude and phase angle for each of up to the 50th harmonic. The waveform data points are generated and downloaded by the ICS to the AC source through the standard RS232C, USB or optional LAN or GPIB bus and are retained in non-volatile memory. Up to 50 waveforms can be stored and named for easy recall.

Ls Series - Measurement and Analysis
The Ls Series measurement system is based on real-time digitization of the voltage and current waveforms using a 4K sample buffer. The digitized waveform data is processed by a Digital Signal Processor to extract conventional load values such as rms voltage, rms current, real and apparent power. With the addition of the advanced features option. (-ADV option), the same data can also be used to perform Fast Fourier Transformation (FFT) to extract the harmonic amplitude and phase angle of 50 harmonics, or display acquired voltage and current waveforms.
Standard Measurements

The following standard measurements are available from the front panel or via the bus:

- Frequency and Phase
- Voltage (rms)
- Current (rms) and Peak Current
- Crest Factor
- Real Power and Apparent Power
- Power Factor

Advanced Measurement Functions

(-ADV option)

Power analysis of EUT load characteristics is available by adding the -ADV option. Harmonics up to the 50th harmonic (for fundamental frequencies up to 250 Hz) and total harmonic distortion of both voltage and current is provided as well.

Harmonic analysis data can be displayed on the front panel display or on the PC using the GUI program. The GUI can also be used to save and print harmonics data in tabular, bar graph or time domain formats.

The acquired voltage and current time-domain waveforms for each output phase can be displayed using the GUI program. Waveform displays on the PC. Available display modes include voltage and current combined, three phase voltage, three phase current and true power. The time-domain data is also available for transfer to a PC through the bus when using custom software.

Diagnostics Capability

The AC Source can perform a self test and report any errors. The self test will run until the first error is encountered and terminate. The response to the self test query command will either be the first error encountered or 0 if no error was found. (Self test passed).

Windows Graphical User Interface

A Windows compatible Instrument Control Software (GUI) offers a soft front panel interface for operation from a PC. The following functions are available through this GUI program:

- Steady state output control (all parameters).
- Create, run, save and print transient programs.
- Measure and log standard measurements.

With -ADV option:

- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Capture and display Voltage and Current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.
Ls Series: Specifications

### Output

<table>
<thead>
<tr>
<th>Maximum Power per phase</th>
<th>3000Ls: 1 phase: 3000 VA, 3 phase: 1000 VA; 4500Ls: 1 phase 4500 VA, 3 phase 1500 VA; 6000Ls: 1 phase 6000 VA, 3 phase: 2000 VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power factor</td>
<td>0 to unity at full output VA</td>
</tr>
</tbody>
</table>

### Voltage Ranges

<table>
<thead>
<tr>
<th>Range</th>
<th>V Low</th>
<th>V High</th>
<th>VA Programming Resolution</th>
<th>Load Regulation</th>
<th>Line Regulation</th>
<th>See -HV and EHV options for alternative voltage range pairs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>0-135V</td>
<td>0-270V</td>
<td>100 mV</td>
<td>&lt; 0.1 % FS</td>
<td>&lt; 0.02 % for 10 % line change</td>
<td></td>
</tr>
</tbody>
</table>

### Programming Accuracy (25°C ±5°C)

Voltage (rms): ± (0.05% + 0.25 V) from 5.0 V to FS; Frequency: ± 0.025 45 Hz - 819.1 Hz, ± 0.7 % > 819.1 Hz; Phase: ± 1° 45-100 Hz, ± (1° + 1°/kHz) 100 Hz-1kHz

### Frequency Range

45 Hz - 1000 Hz (see -HF option for higher output frequencies) 17 - 45 Hz operation available at reduced voltages

### Frequency Resolution

0.01 Hz at < 81.9 Hz, 0.1 Hz at 82.0 to 819.1 Hz, 1 Hz at > 819 Hz

### Max RMS Current

<table>
<thead>
<tr>
<th>V Range</th>
<th>V high</th>
<th>V low</th>
<th>&lt; At Full Power</th>
<th>Model</th>
<th>3000Ls-3 Ø</th>
<th>3000Ls-1 Ø</th>
<th>4500Ls-3 Ø</th>
<th>4500Ls-1 Ø</th>
<th>6000Ls-3 Ø</th>
<th>6000Ls-1 Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3 3 ø</td>
<td>7.4 A</td>
<td>14.8 A</td>
<td>22.2 A</td>
<td>V Low</td>
<td>7.4 A</td>
<td>11.1 A</td>
<td>33.3 A</td>
<td>14.8 A</td>
<td>44.4 A</td>
<td></td>
</tr>
<tr>
<td>-1 1 ø</td>
<td>22.2 A</td>
<td>44.4 A</td>
<td>7.4 A</td>
<td>V High</td>
<td>3.7 A</td>
<td>11.1 A</td>
<td>5.5 A</td>
<td>16.7 A</td>
<td>7.4 A</td>
<td></td>
</tr>
</tbody>
</table>

Note: Constant power mode on 3000Ls and 4500Ls provides increased current at reduced voltage; 6000Ls provides maximum voltage.

### Current Limit

Programmable from 0 Amps to maximum current for selected range

### Peak Current

3000Ls: 6 X (irms @ full scale voltage); 4500Ls: 4 X (irms @ full scale voltage); 6000Ls: 3 X (irms @ full scale voltage)

### Output Noise

100mV rms typ. (20 Hz to 1 MHz) Harmonic Distortion < 1% (at full scale voltage, full resistive load)

### Isolation Voltage

300 V rms output to chassis

### Input

#### Voltage Models

- Models 3000Ls, 4500Ls, 9000Ls, 13500Ls: Standard: 208-230 ± 10% VAC, (L-L, 3 Phase); Option -400: 400 ± 10% VAC (L-L, 3 Phase); Models 6000Ls, 12000Ls, 18000Ls: Standard 208-230 + 10% VAC (L-L, 3 Phase) 450V L-L: Consult factory

Notes: 1. Input must be specified when ordering. 2. -400 option not available on 6000Ls, 12000Ls, 18000Ls. 3. 3000Ls can be operated from 1 phase AC

### Line Current (rms per phase)

<table>
<thead>
<tr>
<th>Model</th>
<th>3000Ls</th>
<th>3000Ls (1Phase)</th>
<th>4500Ls</th>
<th>6000Ls (@ 208V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>187 VLL</td>
<td>19 A</td>
<td>32 A</td>
<td>31 A</td>
<td>38 A</td>
</tr>
<tr>
<td>360 VLL</td>
<td>10 A</td>
<td>n/a</td>
<td>16 A</td>
<td>n/a</td>
</tr>
</tbody>
</table>

#### Inrush Current

- @ 180-254 V: 50 A peak
- @ 360-440 V: 83 A peak

#### Line Frequency

47-440 Hz

### Efficiency

75% typical

### Power Factor

0.6 typical

### Hold-up Time

At least 10 ms

### System

#### Storage

Setup: 16 complete instrument setups / Transient List: 100 transient steps per list (SCPI mode) or 16 transient registers (APE mode)

#### Trigger Input/Output

Input: Triggers measurements or transient steps - SMA connector: 10K pull-up / Output: SMA Connector: HCTTL output

#### Protection

Overload/Temp/Voltage

Overload: Constant current or constant voltage mode; Over temperature: Automatic Shutdown; Over voltage: Automatic shutdown

Regulatory/RFI Suppresion

IEC1010, EN50081-2, EN50082-2, CE (for 400V input only), EMC, and safety mark requirements / RIF Suppression: CISPR 11, Group1, Class A

### Measurement

#### Measurements - Standard (AC Measurements)

| Parameter   | Frequency Phase Voltage (AC) Current (AC rms) Real Power Apparent Power Power Factor |
|-------------|-----------------------------------------------|---------------------------------|------------------|----------------------|-----------------|
| Range       | 45-81.91 Hz 82.0-819.1 Hz > 19 Hz 45-100 Hz 100-1000 Hz 0-400 V 0-50 A 0-6 kW 0-6 kVA 0-0.00-1.00 |
| Accuracy*   | ±(a) 1 ø mode (1-1) 0.1% + 1 digit 0.5° 0.5% + 250 mV 0.1% + 150 mA 0.15% + 9 W 0.15% + 9 VA 0.03 |
| Resolution* | ±(a) 2 ø mode (3-3) 0.1°/1° 10 mV 1 mA 1 W 1 VA 0.01 |

* Accurate specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25° ± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.
Ls Series : Specifications

Remote Control

IEEE-488 Interface (option)
IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax

USB Interface & Ethernet
Version: USB 1.1; Speed: 460 Kbps maximum / Ethernet Interface (Optional): specify -LAN option. 10BaseT, 100BaseT, RJ45

RS232C Interface

Physical Dimensions

Dimensions (per chassis)
Height: 10.5” (267 mm), Width: 19” (483 mm), Depth: 23.7” (602 mm) (depth includes rear panel connectors)

Weight
Chassis: Net: 193 lbs / 87.7 Kg, Shipping: 280 lbs / 127.3 Kg (for /2 or /3 model configurations multiply number of chassis)

Vibration and Shock
Designed to meet NISTA project 1A transportation levels

Air Intake/Exhaust
Forced air cooling, side air intake, rear exhaust

Temperature & Diagnostics
Temperature: Operating: 0 to 35° C, full power / Storage: -40 to +85° C; Diagnostics: Built-in self test available over bus (*TST)

Rear Panel Connectors

Option -AX Specifications

Option -AX
Provides separate isolated 26 VAC regulated and 5 Vac unregulated outputs. The 26 V is normally used for servo-syncro excitation, and the 5 V for lamp power. 26 Volt-Accuracy: ± 2%. Current capacity: 3 ARMS. Frequency: 360/440 Hz. Regulation ± 0.05%. 5 Volt-Accuracy: ± 5%. Current capacity: 5 ARMS

Option -ADV Specifications

Measurements - Harmonics
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
<th>Fundamental Harmonics</th>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>45-250 Hz</td>
<td>Fundamental Harmonics 2 - 50</td>
<td>Fundamental Harmonics 2 - 50</td>
<td></td>
</tr>
<tr>
<td>Accuracy* (a)</td>
<td>0.01% + 1 digit / 0.5% + 1 digit</td>
<td>750 mV 0.3% + 750 mV/0.3% /1 kHz</td>
<td>0.5 A / 0.3% + 150 mA +0.3% /1 kHz</td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01 Hz / 0.1 Hz</td>
<td>10 mV / 10 mV</td>
<td>10 mA / 10 mA</td>
<td></td>
</tr>
</tbody>
</table>

Waveforms
Pre defined: Sine, Square, Clipped User defined, 1024 addressable data points; Storage: 50 user waveforms, non-volatile memory

Data Acquisition
Parameters: Voltage, Current time domain, per phase; Resolution: 4096 data points, 10.4 usec (1ø) or 31.25 usec (3ø) sampling interval

Option -HV Specifications

Voltage/Frequency Ranges
Low: 0-156 Volt; High: 0-312 Volt / Frequency: With -HF option: 3000Ls, 4500Ls, 6000Ls: 45 Hz - 5000 Hz; 9000Ls, 12000Ls, 13500Ls, 18000Ls: 45 Hz - 5000 Hz

Max RMS Current at Full Power
3 Phase: High: 6.4 A, Low 12.8 A; 1 Phase: High: 19.2 A, Low: 38.4 A; Note: Constant power modes on 3000Ls and 4500Ls. Current available at reduced voltage for 3000Ls, 4500Ls, and max voltage for 6000Ls

Max RMS Current at FSVoltage

Option -EH Specifications

Voltage/Frequency Ranges
Voltage: Low: 0-200 Volt; High: 0-400 Volt / Frequency: With -HF option: 45 Hz - 5000 Hz

Max RMS Current at Full Power
3 Phase: High: 5.0 A, Low 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A; Note: Constant power modes on 3000Ls and 4500Ls. Current available at reduced voltage for 3000Ls, 4500Ls, and max voltage for 6000Ls

Max RMS Current at FSVoltage
3000Ls: 3 Phase: High: 2.5 A, Low: 5.0 A; 1 Phase: High: 7.5 A, Low: 15.0 A; 4500Ls: 3 Phase: High: 3.8, Low 7.5; 1 Phase: High: 11.3 A, Low: 22.5 A; 6000Ls: 3 Phase: High: 5.0 A, Low: 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A

Option -HF Specifications

Measurements:
F < 2000 Hz: See standard Ls Specifications;
F > 2000 Hz: See table >

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
<th>Phase</th>
<th>Voltage (AC)</th>
<th>Current (AC rms)</th>
<th>Real Power</th>
<th>Apparent Power</th>
<th>Power Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>45 - 5000 Hz</td>
<td>&lt; 2000 Hz</td>
<td>&gt; 2000 Hz</td>
<td>0-300 V</td>
<td>0-1000 Hz / &gt; 1000 Hz</td>
<td>0-50 A</td>
<td>0-5 kW</td>
</tr>
<tr>
<td>Accuracy* (a)</td>
<td>0.1% + 1 digit</td>
<td>0.5°</td>
<td>0.05% + 250 mV</td>
<td>0.5% + 150 mA</td>
<td>0.5% + 9 W</td>
<td>0.5% + 9 VA</td>
<td>0.03</td>
</tr>
<tr>
<td>Resolution*</td>
<td>0.01 Hz / 0.1 Hz / 1 Hz</td>
<td>0.1° / 1°</td>
<td>10 mV</td>
<td>1 mA</td>
<td>1 W</td>
<td>1 VA</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Accuracy specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

250 mVrms typical (20 kHz to 1 MHz)
3000Ls 34500Ls, 6000Ls: Standard: -HV 45 Hz- 5000 Hz; -EHV: 45 Hz - 5000 Hz

Output Noise
250 mVrms typical (20 kHz to 1 MHz)

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### Ls Series

<table>
<thead>
<tr>
<th>Model¹</th>
<th>Output Power</th>
<th>No of Output Phases</th>
<th>Nom. Input Voltage²</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000Ls</td>
<td>3 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>3000Ls-400</td>
<td>3 kVA</td>
<td>1</td>
<td>400 V</td>
</tr>
<tr>
<td>4500Ls</td>
<td>4.5 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>4500Ls-400</td>
<td>4.5 kVA</td>
<td>1</td>
<td>400 V</td>
</tr>
<tr>
<td>6000Ls</td>
<td>6 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>9000Ls/2</td>
<td>9 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>9000Ls/2-400</td>
<td>9 kVA</td>
<td>1</td>
<td>400 V</td>
</tr>
<tr>
<td>12000Ls/2</td>
<td>12 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>13500Ls/3</td>
<td>13.5 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
<tr>
<td>13500Ls/3-400</td>
<td>13.5 kVA</td>
<td>1</td>
<td>400 V</td>
</tr>
<tr>
<td>18000Ls/3</td>
<td>18 kVA</td>
<td>1</td>
<td>208-230 V</td>
</tr>
</tbody>
</table>

Note 1: The /2 or /3 designation indicates number of chassis.

Note 2: All input voltage specifications are for Line to Line three phase, delta or wye. Model 3000Ls (208 V input) can be operated on 230 V L-N single phase if needed.

### Ordering Information

**Model**
Refer to table shown for model numbers and configurations. Specify number of output phases (-1 or -3) as part of model number, eg 4500Ls-1 or 4500Ls-3.

**Supplied with**

**Options**

**Input Options**
- **-400** 400 ±10% Volt Line to Line AC input
  Includes CE Mark. (Not available on 6000Ls, 12000Ls and 18000Ls Models)
- **-480** 480 ±10% (3 phase output only)

**Output Options**
- **-AX** Auxiliary outputs, 26 VAC, 5 VAC.
  Limits upper frequency to 800 Hz.
- **-HV** 156/312 V output range.
- **-EHV** 200/400 V output range.
- **-HF** Extends upper frequency limit.
  See HF table.
- **-LF** Limits output frequency to 500 Hz.
- **-FC** Modifies output frequency control to ± 0.15%

### Keypad Options
**-KP** Upgraded keypad control panel.

### Cabinet Options
- **-RMS** Rackmount Slides. Recommended for rack mount applications.
- **C prefix** Cabinet System. Installed and pre-wired in 19” cabinet.

### Controller Options
- **-ABL** Emulates Elgar SL Series
- **-ADV** Advanced feature set. Adds arbitrary waveform generation and harmonic analysis of voltage and current.

### Avionics Test Routine Options
- **-ABD** Airbus Directive 0100.1.8 tests.
  (AC only). Requires -ADV and use of Windows PC and included LxGui software.
- **-AMD** Airbus AMD24 Test
- **-A350** Airbus Test Software
- **-AIRB** Airbus A380, A350 & AMD24 package
- **-704** Mil-Std 704 rev D and E test firmware.
  (AC only)
- **-704F** Mil-Std 704 rev A & F
- **-160** RTCA/DO-160, Change 2, EuroCAE-14D (Section 16, AC only)

*Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

### Option Matrix

<table>
<thead>
<tr>
<th>HF</th>
<th>LF</th>
<th>HV</th>
<th>EHV</th>
<th>LKM</th>
<th>LKS</th>
<th>EXS</th>
<th>AX</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>LKM X O O O O X O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LKS X O O X - O O O</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>EXS O O O O O O X -</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AX X O O O O O O -</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: See option matrix
Note 2: -LKS, -LNS and -EXS are mutually exclusive and with Ext Trig function.