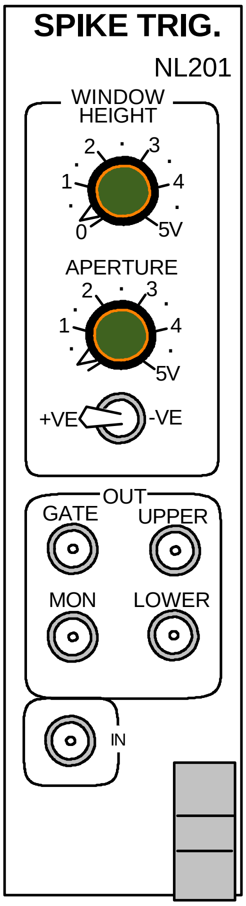
NL201 - Spike Trigger



Introduction

The **NL201 SPIKE TRIGGER** is a gated amplitude discriminator for nerve spikes and other events which produces separate output pulse trains for spikes which:-

(a) cross the Upper voltage threshold
(b) cross the Lower voltage threshold
(c) cross the Lower threshold but not the Upper threshold

The WINDOW HEIGHT potentiometer sets the DC level of the "window" and the APERTURE potentiometer sets the separation between the two voltage thresholds of this window. Thus, slight changes in signal amplitude require adjustments of only one setting, and it is impossible to set the Upper voltage threshold lower than the Lower voltage threshold.

A front panel switch selects either positive (+VE) or negative (-VE) slope and level triggering and there is an choice of two internally selected input voltage ranges.

The MONITOR output socket provides a display of the input signal with the Lower and Upper levels super-imposed on it to enable easy setting of the discrimination levels.

This module is essential for converting spike trains (which are analogue signals) into trains of digital pulses; these can be analysed using other modules (such as the **NL700 LOG DISPLAY**) or used to synchronise displays, trigger averaging, etc. An internal jumper allows the input to be DC coupled or have a time-constant which is appropriate for nerve spikes with rise times less than 200µs - modifications for longer rise times are available by special order.

To line up with the front panel markings the input signal should be externally amplified so that the required Lower threshold is in the range ±1 to ±5 Volts with the "window" 200mV to 5V wide. If this can not be accomplished the internal gain of x10 may be selected so that signals requiring a Lower threshold of 0 to ±500mV and a "window" of 20 to 500mV can be accommodated.

Although the **NL201 SPIKE TRIGGER** is specifically designed for spike amplitude discrimination, it can be used for events with much longer rise times if amplitude gating is not essential. For example, pulses can be triggered by QRS complexes in electrocardiograms, either at the upper or lower thresholds.

It is anticipated that the NL201 would be used with an standard, low specification Analogue oscilloscope not a Digital Storage Oscilloscope (DSO). Should a DSO be used, the user may wish to modify the speed of the multiplexer (see page 4) so that the discrimination levels are displayed more distinctly to the detriment of the display of the signal. Alternatively, the discrimination levels could be disabled completely (see page 6).

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Level detection:

Fig. NL201-1

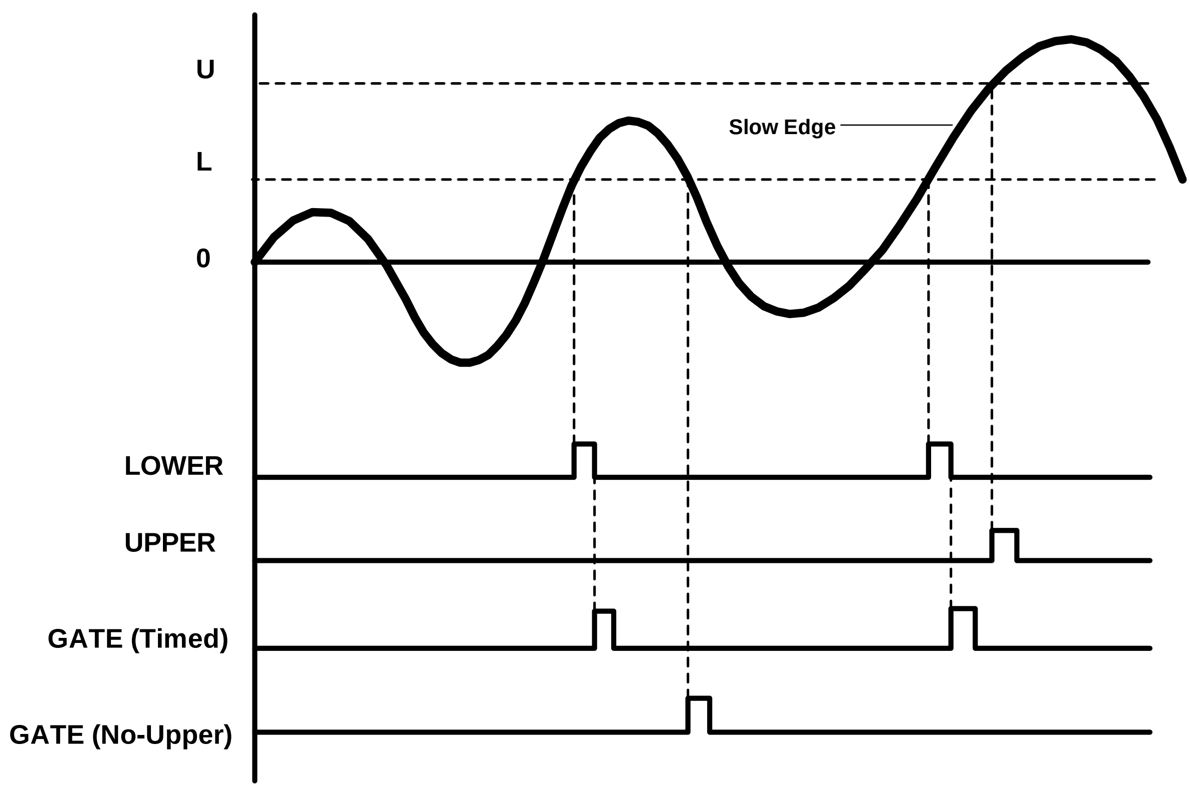

Fig. NL201-1 : Level detection

The thresholds are adjusted with the two potentiometers mounted on the front panel. The dial markings for the WINDOW HEIGHT potentiometer show the Lower threshold (see Fig. NL201-1) in volts; the Upper threshold, however, is equal to the WINDOW HEIGHT + APERTURE settings. The values of this arrangement are twofold:-

Firstly, the separation between the two thresholds (i.e. the APERTURE) can be kept constant and the position of this amplitude window can be shifted with respect to the baseline with a single potentiometer (WINDOW HEIGHT).

Secondly, it is impossible to incorrectly adjust the two thresholds, as would easily be possible if each was adjusted independently (e.g. the Upper threshold cannot be lower than the Lower threshold).

Input signals used to drive the **NL201** may have appreciable DC components (e.g. the vertical output signal of an oscilloscope will have a DC level which depends on the setting of the oscilloscope's vertical position knob), but the spike amplitudes are measured with respect to the baseline. The input of the NL201 is normally AC coupled for that reason (low frequency response approximately 0.8Hz) to simplify threshold adjustments. (An internal jumper allows the coupling capacitor to be shorted if DC discriminations are required). The WINDOW HEIGHT, APERTURE and INPUT RANGE labelling are therefore AC amplitudes.

The spike at the left in Fig. NL201-1 does not cross either threshold and therefore, no output pulses are produced. The middle spike crosses only the Lower threshold (i.e. its peak is within the "window" bounded by the two thresholds) and it triggers both LOWER and GATE pulses. The peak of the third spike is above the window and it triggers LOWER and UPPER pulses, but not a GATE pulse in 'No-Upper mode'. It does, however, produce a GATE in 'Timed' mode as the transition between the Lower and Upper level took longer than the 200µs (nom.) of the Lower-Output-Pulse, this is not typical of nerve spike activity. In this example, pulses are triggered by positive going slopes; if the POLARITY switch was towards the right (-ve) position, the threshold would have been arranged in a mirror-image position about the baseline.

Threshold setting

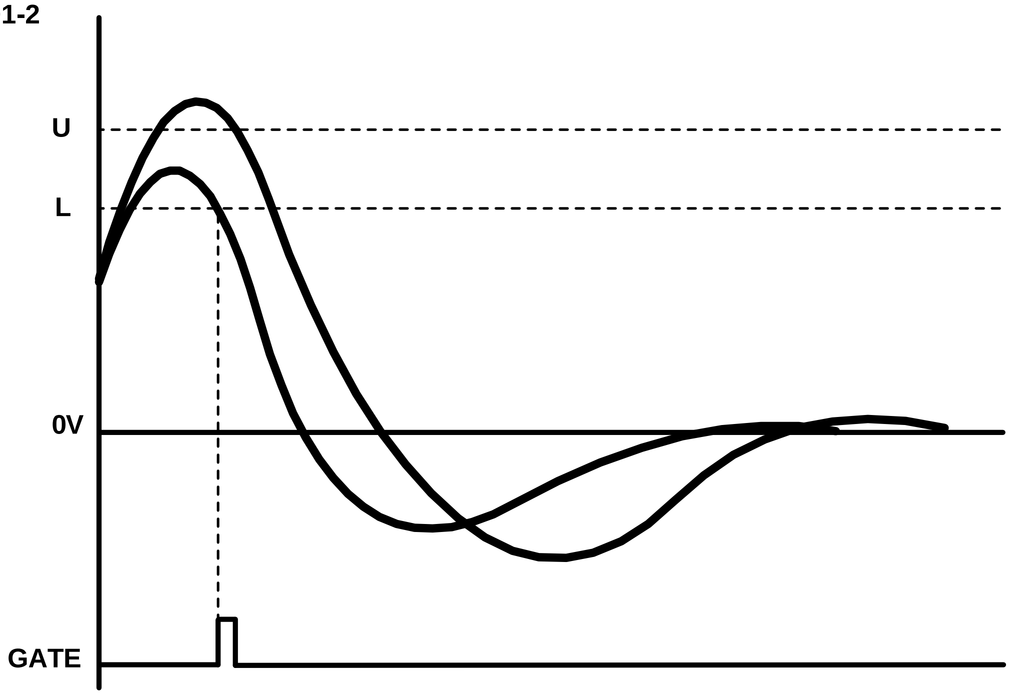

Fig. NL201-2 : Threshold setting

The NL201 thresholds can be set several ways; Fig. NL201-2 shows one method. The monitoring oscilloscope is triggered externally with the positive-going edges of the NL201 LOWER output pulses, with a moderately fast sweep speed (50 or 100 micro-second per division). All spikes which cross the lower threshold will appear on the 'scope face; the vertical origin at the left indicates precisely the actual threshold. Two super-imposed spikes are shown in Fig. NL201-2; one which crossed only the lower threshold and one larger spike which exceeded both thresholds.

The **first** method is to use the second channel of an oscilloscope to display GATE pulses (in 'No-Upper' mode) where there is no doubt about which spikes have peaks in the window. This method forces an awareness of each spike waveform and makes it less likely that different spikes with similar peak amplitude will be confused (spikes with the same amplitude produced by neighbouring cells, are simultaneously recorded more often than one might suppose).

The **second** method of setting the NL201's thresholds is simply to measure spike amplitudes at the NL201 input with a monitoring oscilloscope, and to set the thresholds from the dials. This may be the only method possible if the spike firing rate is low and somewhat unpredictable. The display shown in Fig. NL201-2 is useful when the spikes of interest occur more frequently than a few per second.

The **third** method is purely displaying the MONITOR signal on an oscilloscope and setting the levels appropriately

Perhaps the best method, however, for visualising the spike discrimination process is to use the **NL201 SPIKE TRIGGER** with the **NL741 ANALOG DELAY** or **NL202 AC DELAY** module. By delaying the spike signal, and triggering the oscilloscope time base with the GATE pulse, only those spikes which initiate GATE pulses will be displayed; these will be seen in their entirety, including portions of their waveform which precede the trigger thresholds.

The GATE output can be internally selected to occur under one of two conditions. In both cases it would occur after the input signal had passed through the Lower level and:-

a) 'Timed' mode - If it had not passed through the Upper level by the end of the LOWER output pulse (200 micro-second).
b) 'No-Upper' mode - Passes back through Lower without crossing the Upper level - this is without time constraint. [Normal position]

Rear Connections and Jumpers

The rear edge connector in the NL900 rack allows adjacent modules to be connected together without the need of front panel leads. Full details are giving the Jumpers section.

INPUT: The input signal can be disconnected from the output of the module on the immediate left if it is inappropriate.

OUTPUT: The user has the choice of one of three output signals that can be connected to the rear connector for automatic routing to the module on the immediate right.

Multiplexer Frequency

The internal multiplexer oscillator runs at a frequency of approximately 150kHz (a 6.67µs cycle) and can be measured at pin 2 of IC9. This oscillator is used to switch between the display of the Upper level, Signal, Lower level and Signal again in a 1:7:1:7 (6.67µs : 46.7µs : 6.67µs : 46.7µs) time-frame. If it is required to slow down this oscillator the value of C19 should be increased proportionally (see Fig, 201-3).

The standard value of C19 is 0.015µF (15nF) and a value of 0.1µF (100nF) would give an oscillation frequency of around one sixth the standard value, that is 25kHz (a 40µs cycle).

Output Pulse Widths

The duration (width) of the LOWER, GATE and UPPER pulses is set by the timing components fitted to three monostables. If the factory set values are not consistent with your needs, these may be changed. The position of these on the circuit board is shown in Fig. NL201-3.

Function	Capacitor / Value	Resistor / Value	Standard Width
LOWER	C26 / 0.01µF	R39 / 27k	200µs
GATE	C25 / 1000pF	R38 / 20k	15µs
UPPER	C20 / 0.01µF	R33 / 33k	230µs

The one point that must be considered is the fact that the GATE output, when set to the 'Timed' mode, uses the LOWER pulse width to determine the existence of a signal that lies within the GATE voltage window.

The calculation of the Resistor and Capacitor to be used come from the following, approximate, equation:-

Width = 0.7 x Capacitor x Resistor

Note that the values used in the equation are in Farads and ohms and the circuit has the limitation on values given below:-

Component	Minimum value	Maximum value
Capacitor	1000pF	10µF
Resistor for Lower and Upper	2k ohms	100k ohms
Resistor for Gate	1500 ohms	40k ohms

Example:-
Using the factory UPPER pulse width. UPPER = 0.7 x 0.01E-6 x 33E3 = 231E-6 or 231µs.

Specification Summary

Input:

Voltage range	±10V
Impedance	1MΩ
Protection	±100 Volts maximum
Time constant	0.2 second or DC (internal jumper)
Gain	x1 or x10 (internal jumper) -NB: after AC coupling

Thresholds:

Lower range (HEIGHT)	0 to 5 Volts (positive or negative)
Aperture range (WINDOW)	0.2 to 5 Volts (positive or negative)
Triggering (and levels)	positive or negative slope
Calibration	±10%

Outputs:

UPPER	TTL, 230 micro-second (±10%) pulse
LOWER	TTL, 200 micro-second (±10%) pulse
GATE	TTL, 15 micro-second (±10%) pulse
MONITOR	Input signal (x Gain) plus Upper and Lower levels

Internal Jumpers:

AC/DC Coupling	Input is DC coupled or a 0.2 second time-constant
GAIN	x1 or x10 on input signal
MONITOR OUT	Purely input signal or signal plus levels
GATE Pulse occurs:-	

a) LOWER pulse-width after signal goes through Lower if it has not crossed the Upper.
b) As signal re-passes Lower (towards zero) without having crossed the Upper.

We reserve the right to alter specifications and price without prior notification.

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Jumpers

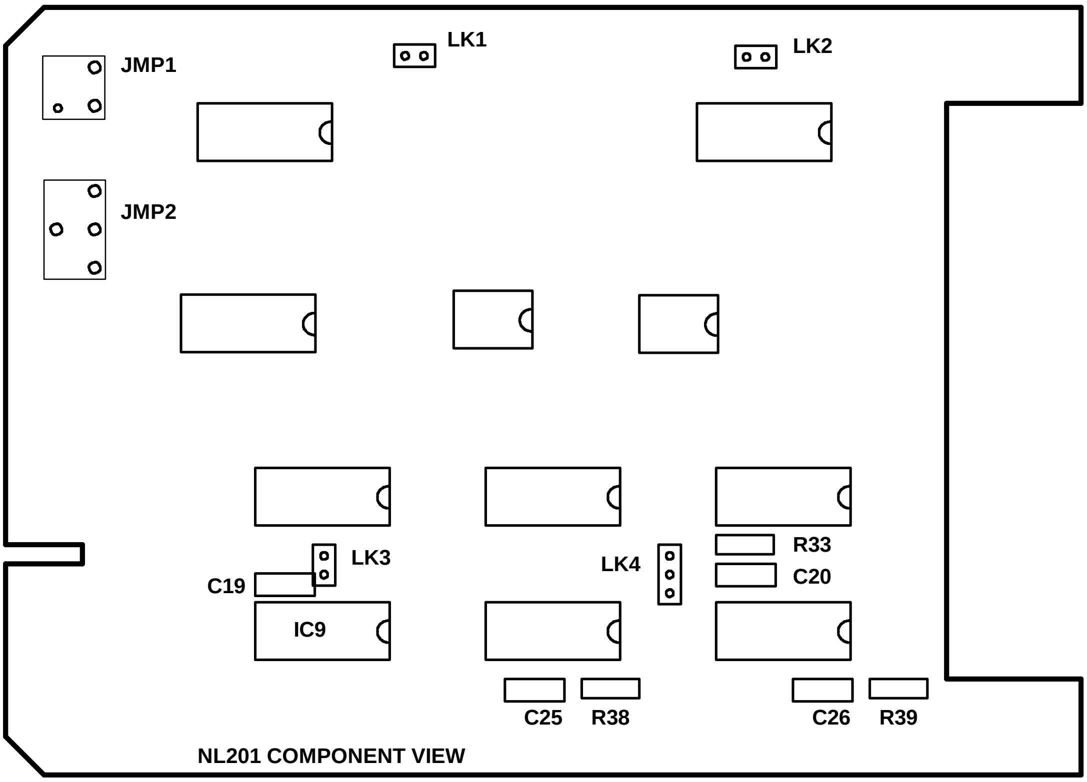

Fig. NL201-3 : On-board jumpers

LK1 - Input Coupling Jumper the pins together for DC coupling
LK2 - Signal Input Gain Jumper the pins together for an input gain of x10
LK3 - Multiplexer display Jumper the pins together for a display of the threshold levels with the signal at the 'MONITOR' socket.
LK4 - Gate pulse occurrence

The GATE pulse will occur after the input signal has passed through the Lower level (from 0V) and:-

'Timed' mode - (Jumper lower two pins of link LK4):- If it had not passed through the Upper level by the end of the LOWER output pulse (200 micro-second).

'No-Upper' mode - (Jumper upper two pins of link LK4):- Passes back through Lower without crossing the Upper level - this is without time constraint. [Normal position]

JMP1 - Rear Input Jumper the two gold sockets to source the INPUT signal from the output of the module on the immediate left.

JMP2 - Rear Output This selects the OUTPUT of this module for rear connection to the input of the module to the immediate right.

Jumper one of the following to the central socket as follows:-

Upper socket	for	LOWER signal
Middle socket	for	UPPER signal
Lower socket	for	GATE signal

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