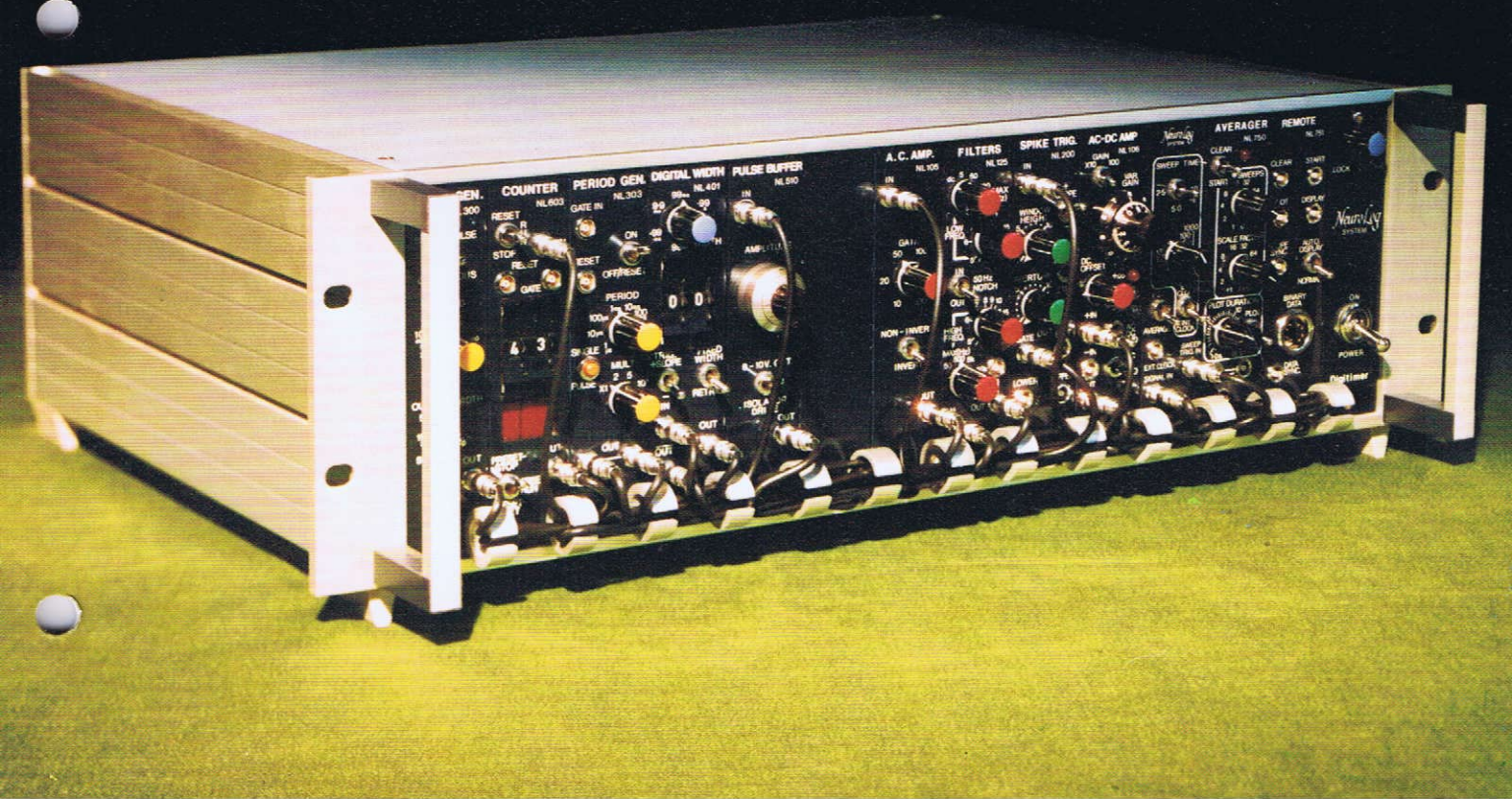
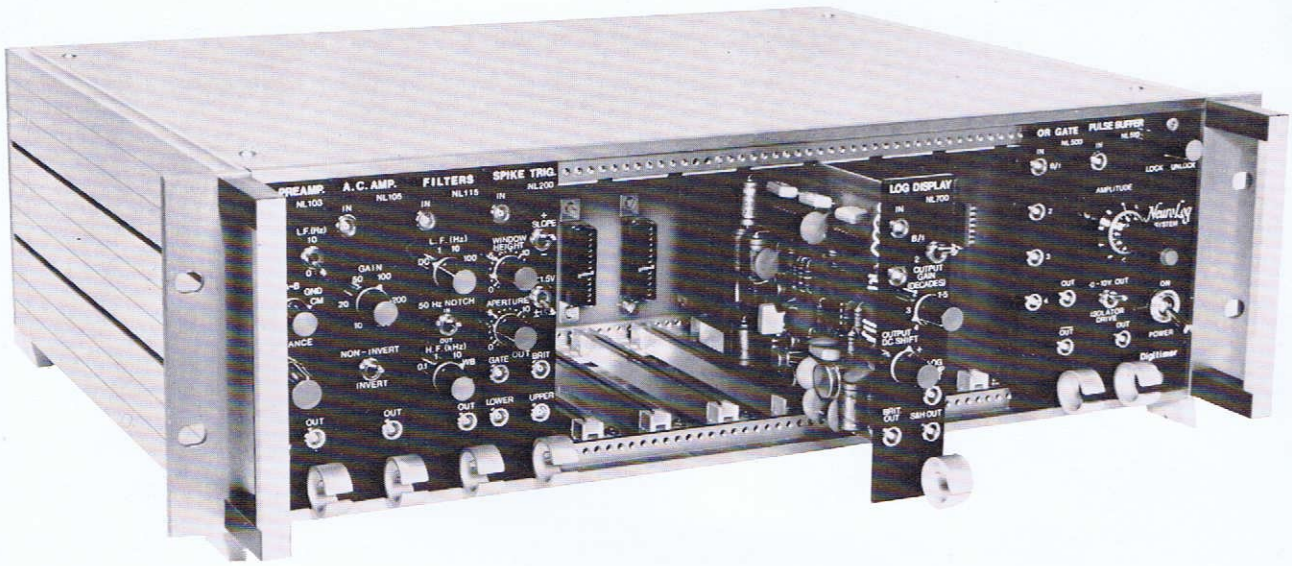
NeuroLog
SYSTEM

modular instrumentation for electrophysiology

ISSUE 2



System features



introduction

The NeuroLog System is now widely accepted throughout the world by scientists who demand high quality, dependability and innovation in their research instrumentation. NeuroLog System sales and service is available in over 30 countries, through Digitimer Ltd. and its network of agents.

Because the NeuroLog System is fully modular, it has the following well recognized advantages over non-modular "multi-purpose" instruments:

1. It is more flexible. Complex systems can be quickly assembled or modified.
2. It is more efficient. Modules can be shared among several set-ups, expanding capabilities without duplication. Only those modules required for a particular task are tied up and occupy rack space.
3. Fewer interface problems. Input and output levels, impedances, connectors, etc., of different modules in the system are compatible, minimizing the problems encountered in interconnecting pieces of equipment of diverse origin.
4. It is less costly. Only those modules actually required are purchased. You do not pay for all those functions added to an instrument to make it "general purpose". Individual modules can be added to the system at any time, as the scope and orientation of the application changes.

This brochure, like any other brochure or catalogue, is a presentation of a product line at one particular time. When the product line is in a state of continuous development, as is the case for the NeuroLog System, the brochure is out of date almost before it is printed. It is our practice to supplement this brochure with periodic product announcements to keep our customers (and potential customers) informed about new products as soon as they become available.

the modules

The front panel of each module measures 30 mm (1.2 inches) wide by 122 mm (4.8 inches) high. The attached printed circuit board is 152 mm (6.0 inches) long by 102 mm (4.0 inches) high. Each module has a split ring handle attached to its front panel; this serves as a cable run as well as a handle for withdrawing or inserting the module into the case. All module outputs are short circuit proof. The extensive use of standard transistor-transistor logic (TTL) and standard linear integrated circuits ensures the lowest possible cost and highest possible compatibility with other instruments (TTL is the standard logic in small computers, for example). The output levels and impedances of the linear inputs and outputs are appropriate for general purpose oscilloscopes and low gain chart recorders, etc. The NeuroLog System is also compatible with the components most frequently used in special circuitry built by individual investigators to meet their own particular needs (undrilled front panels and special printed circuit boards — assembled as the NL 50 Blank Module — are available to encourage the design and use of such special purpose modules with the NeuroLog System).

the case

The NeuroLog module frame and power supply are housed in a fully finished, enclosed case. The case has handles and integral rack mounting hardware so that it can be shifted directly between rack and bench top. The case measures 133 mm (5.25 inches) high (without feet) by 483 mm (19 inches) wide by 317 mm (12.5 inches) deep; it contains 13 module bays plus power supply panel. The case and power supply (without modules) weigh 5.5 kgm. (12.1 pounds).

The NeuroLog case has an integral module retention system, consisting of a simple, slide action lever on the power supply panel. Thus, fittings such as retained screws, D-locks, etc., on individual module front panels are unnecessary; this simplifies the modules' mechanical design, reduces their cost, and greatly improves the ease with which rapid changes in module arrangements can be made.

the power supply

The NeuroLog power supply produces three voltages (+15V., +5V., and −15V.), stabilized against line and load variations. The voltage outputs are rated at 650 mA., 4.0A., and 650 mA., respectively. All three supplies have internal "fold-over" current limiting; the 15V. supplies, in addition, are protected with series fuses. Each supply has less than 15 mV. line ripple at maximum load. The power supply transformer is electrostatically screened for additional safety and reduction of line frequency pick-up in modules with high impedance circuits. The power supply provides sufficient power for any mix of single width NeuroLog modules, plus up to 2 NL 750 Averagers.

A unique feature of the NeuroLog power supply is a built-in logic circuit which indicates (by extinguishing the power supply indicator on the front panel) excessive loading of one or more of the three supply outputs. While it is expected that a power supply failure will never occur using NeuroLog modules, the fault indication is invaluable when testing custom circuits built in the NL 50 Blank Module.

module interconnection

The general problem of module interconnection has been minimized in the NeuroLog System by a unique method of automatic connection of outputs and inputs of neighbouring modules through the case edge connectors. Thus, for many linear arrangements of modules, only the input and output cables connecting the system to the preparation and to output devices such as oscilloscopes, recorders, etc., are required. Front panel controls are therefore not obscured by cables which merely connect each module to the next. More complex module arrangements will, however, require some front panel cable interconnection; between 5 and 10 cables of various lengths will be required for a typical 13 module system. No cables are supplied with the case.

cables

Only microminiature coaxial connectors with a "snap-on" action are used in the NeuroLog System, eliminating the nuisances caused by connectors such as the BNC and UHF types which have a "twist-on" or "screw-on" action. All external connections between modules are made through miniature, screened coaxial cable, which reduce cross-talk and transient pick-up, as well as eliminating the "rat's nests" of fine, unscreened wires and 1 mm (or 2 mm or 4 mm) plugs frequently used for patching in other modular systems.

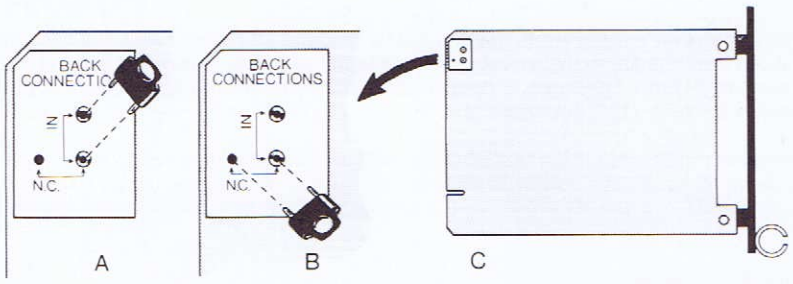
A variety of assembled cables, plugs, sockets, BNC to NeuroLog adaptors and "T" connectors are available from Digitimer Ltd., and its agents for the NeuroLog System (see **ACCESSORIES** list). Alternatively, cables can be assembled by the user with some savings in cost. The cable used is a miniature low noise coax such as that supplied by R. S. Components Ltd, (367-280). Alternative cable to RG 174 A/U specification can be used. RG 174 A/U is a military specification cable and is supplied by many companies. The connectors are manufactured by Lemo S.A. (CH-1110, MORGES, Switzerland; Lemo U.K. Ltd., 12 North Street, WORTHING, Sussex; Lemo U.S.A. Inc., 2015 Second Street, BERKELEY, California, 94710; John Barry Group of Companies, 105 Reserve Road, P.O. Box 199, Artarmon, SYDNEY, N.S.W.,2064, Australia. For agents in other countries, contact the MORGES, Switzerland office). The cable mounting plugs are type F00250 S2.7; the panel mounting sockets are type RA00250. The Lemo connectors were chosen for the NeuroLog System because they are the finest microminiature snap-action connectors available. (They are the standard connector in the new nuclear module specification — the CAMAC system — replacing the BNC connector. It is expected that the Lemo connector will become standard on other instrument ranges in the next few years). Without these particular plugs and sockets, the front panels in the NeuroLog System would necessarily have been substantially larger. This would have reduced the number of modules which would fit into a standard 483 mm (19 inch) case, and increased the total system cost.

warranty

All Digitimer products are guaranteed against defects in materials and workmanship for one year from the date of purchase. No other warranty is expressed or implied, Digitimer Ltd's obligations being limited to repair or replacement of apparatus found to be defective during the warranty period which is returned carriage paid to our Works.
Digitimer retains the right to discontinue any instrument or to change its specifications without notice, and without responsibility for incorporating changes in instruments already sold.

applications

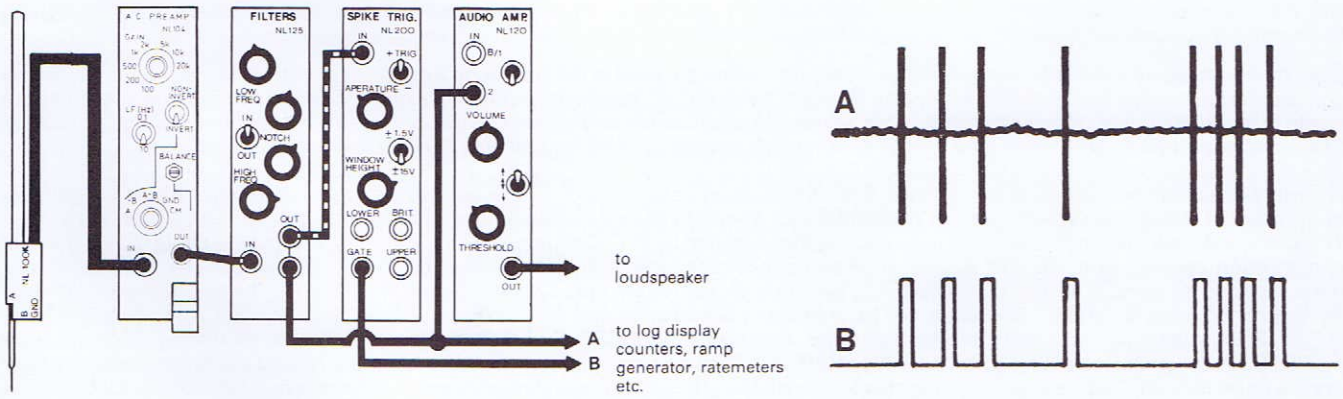
internal interconnections between modules



The inputs and outputs of neighbouring modules in the NeuroLog System can be connected together internally through the case and printed circuit board edge connectors — reducing the number of cables required. The diagram above shows how the shorting pin on a typical module printed circuit board is used to make the connection between the input of this module and the output of the module in the adjacent bay to its left. In **A**, the pin is placed for this connection; in **B**, the pin is placed in the "no connection" (N.C.) position, so that its input is **not** connected to the module at the left (this must be done if the output of another module is connected by a cable to the input socket on the front panel). **C** shows the location of the jumper pin in the upper left-hand corner of the p.c. board. Some modules with more than one output have a similar jumper pin arrangement for selecting the output to be relayed through its edge connector to the input of the module in the bay to its right.

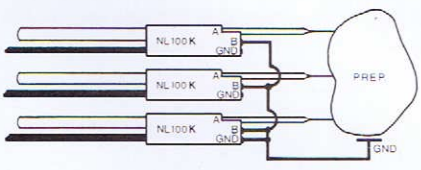
The following typical module arrangements illustrate the flexibility of the NeuroLog System. For clarity, some details have been omitted from the front panel drawings. Heavy dashed lines indicate internal interconnections between modules through the rack edge connectors; heavy solid lines indicate external cable connections.

an a.c. recording arrangement



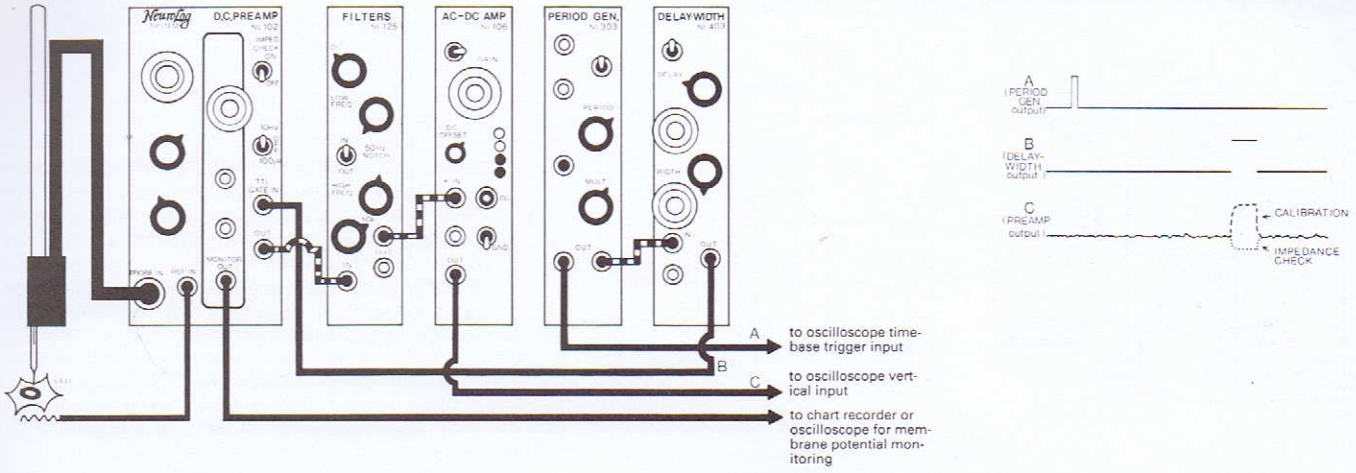
These modules provide impedance matching for microelectrode recording, low noise amplification (gain from 100 to 20,000) and continuously adjustable bandpass filtering from 0.1 Hz to >50kHz. The NL 200 SPIKE TRIGGER is used to convert spikes into uniform TTL pulses which can then be counted, converted to frequency or further analysed using other modules such as the AVERAGER (PST and Interval Histograms).

avoiding ground loops



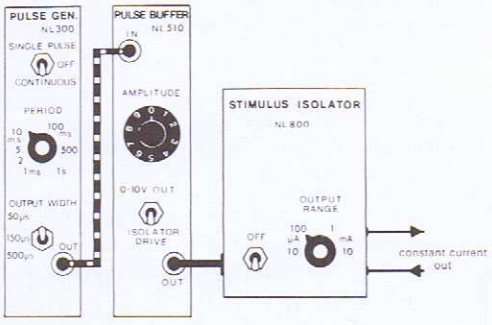
The only ground connection between the preparation and the NeuroLog System should be the single connection to the NL 100K **GND** pin. When more than one recording electrode is used, as shown at the left, each additional NL 100K should be "grounded" to the preparation **only** with its **B** (inverting) input; the NL 104 A.C. PREAMP modules should all be operated in their differential (**A** – **B**) modes. When differential recordings are made (eg. from nerves across pairs of hook electrodes), only one NL 100K **GND** connection should be made to the preparation, as at the left. Additional ground connections (including those through the animal frame or from other monitoring equipment) will produce ground loops and result in undesirable interference.

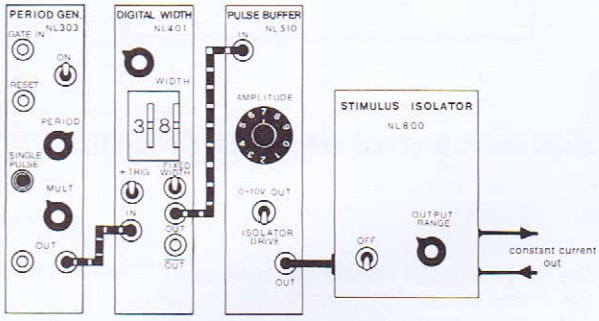
a typical d.c. recording arrangement



These modules constitute the usual arrangement for intracellular recording. (Note that the same arrangement can be used for extracellular microelectrode recordings as well as differential recordings from gross electrodes). Gains from 0 to +10,000 and continuously adjustable bandpass filtering (with a notch filter for interference rejection) from D.C. to >50kHz. are provided. The NL 303 PERIOD GENERATOR is used to initiate stimuli, trigger an oscilloscope monitor, etc. The NL 403 DELAY-WIDTH provides the gate signal for both the calibration and impedance checks on the NL 102 (toggle switches on the NL 102 select which is activated during the NL 403 pulse). The NL 403 pulse is thus positioned conveniently for observation on a scope trace, or to calibrate an averager sweep. The NL 102 has a similar TTL GATE input for initiating and terminating the injection of current. NL 200 and NL 120 modules could be added to this arrangement, as in the a.c. recording example above.

two simple stimulator circuits



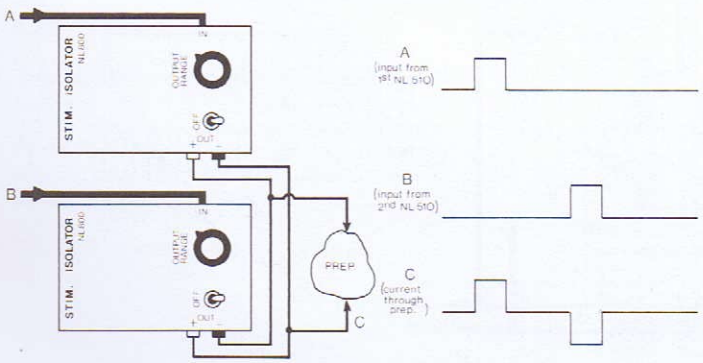


The arrangement above, at the left, provides single stimuli or continuous trains, with the pulse rate continuously variable from 1/sec. to 1000/sec., three output pulse widths (50, 150 or 500 μsec.) and continuously variable output amplitude in four ranges from 0 to 10 mA. The output is supplied by a light-coupled constant current source (NL 800 Stimulus Isolater). Alternatively, the NL 510 Pulse Buffer can be used alone for voltage stimulation (0 to 10V., output resistance less than 10 ohms, maximum output current 50 mA. — adequate for many nerve stimulation situations) or for driving relays, etc.

By substituting the NL 303 Period Generator for the NL 300 Pulse Generator, at the right, the pulse rate range has been extended (1 MHz. to .01 Hz. in 1-2-5 steps). Digital control of pulse width is provided by the NL 401 Digital Width module, which produces pulse widths from 1 μsec. to 9.9 sec. Amplitude is controlled in the same way as in the previous example. Additional NL 401's can be added to produce digital delays, etc.

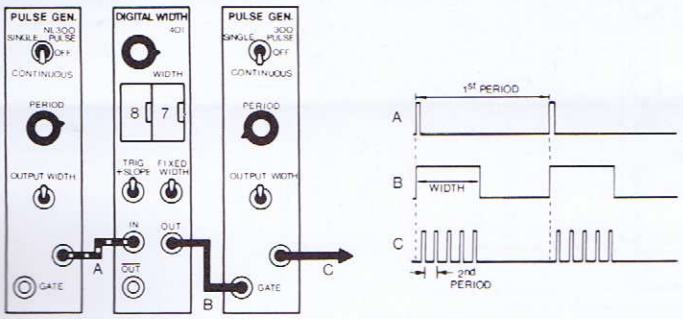
The two examples shown above illustrate two ways of generating very simple stimulus pulse trains. The NL 510 – NL 800 combination can be driven by many other NeuroLog modules, however. Other examples below show how more complex pulse trains can be generated. These pulse trains can be used in pulse train analysis, to control experiments, etc., in addition to providing the timing inputs for stimulators.

using two or more NL 800 STIMULUS ISOLATORS in parallel

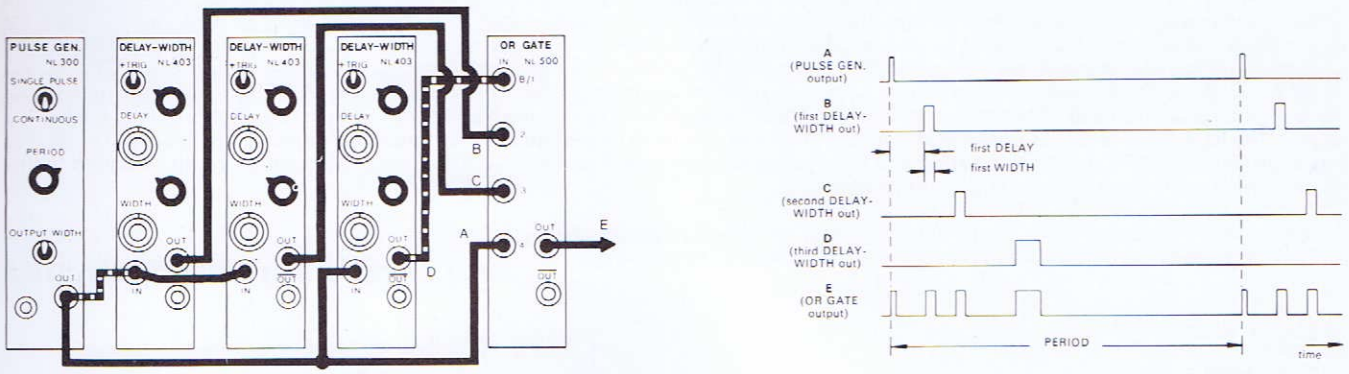


Because the output of the NL 800 behaves like a nearly perfect current source, two or more NL 800's can be connected in parallel (**never** in series). The scheme at the left can be used to produce a bipolar stimulus train. A similar arrangement, but with the outputs of the same polarity connected together, provides a useful stimulator for conditioning-test experiments in which the timing and amplitude of each pulse is independantly adjustable.

two simple ways of producing bursts of TTL pulses

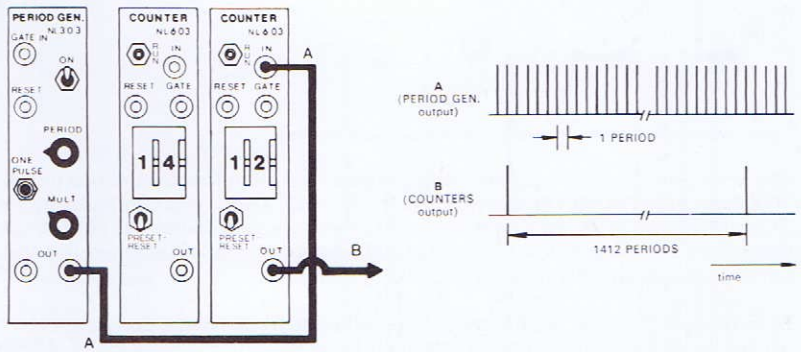


Note that the NL 303 PERIOD GENERATOR also has a GATE input, and can be used in much the same way (but with a much greater accuracy and frequency range) as the NL 300's in these examples. Since the NL 303's output pulse duration is only 0.5 μs., additional modules may be necessary to generate the desired pulse durations, however.



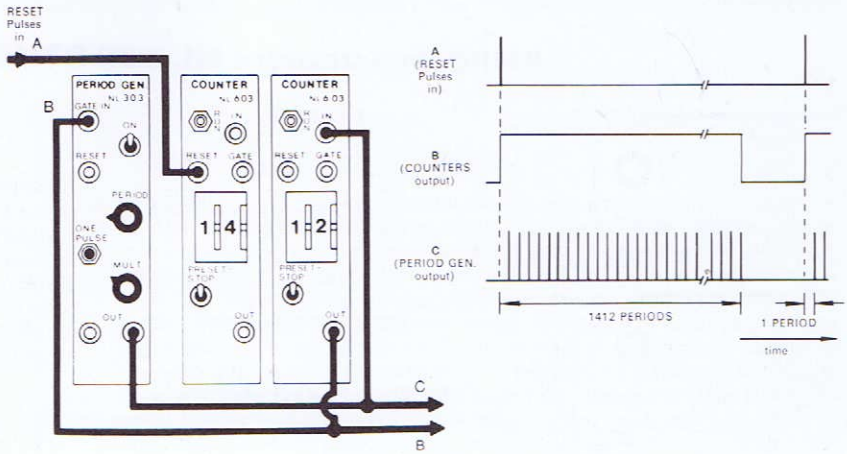
digital control of cycle duration

The two cascaded NL 603 Counters count the output pulses from the NL 303 Period Generator. When the count equals the number set in the four thumbwheel switches, the Counters (in the PRESET-RESET mode) generate an output pulse, are automatically reset to zero, and the cycle begins again. The time between the NL 603 output pulses is equal to the preset number times the NL 303 period settings.



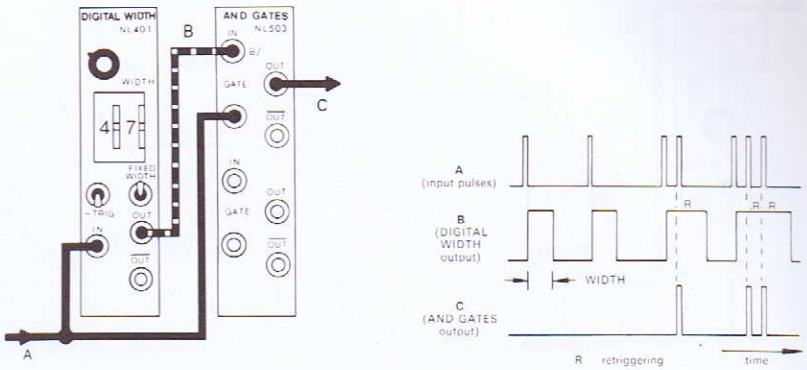
digital control of pulse width or number of pulses in a train

Two cascaded NL 603 Counters are used to count NL 303 output pulses, as above. When the count equals the preset number (1412 in this case), the output of the Counter goes low, and the Period Generator is gated off. Upon the arrival of a reset pulse, the Counters are reset to zero, their output goes high, the Period Generator is turned on and the cycle begins again. The reset pulses determine the total cycle duration. Asynchronous pulse trains (ie. having random phase with respect to the RESET pulse train) would be produced if the NL 603 output was not used to gate the NL 303; the NL 603 output duration would vary by $\pm$½ period as a result.



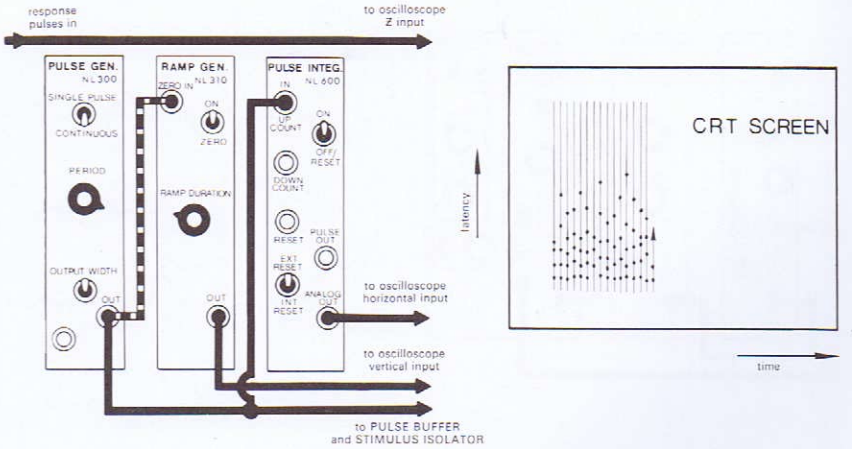
using the NL 401 WIDTH module to detect pulse intervals shorter or longer than a selected value

Because of its retriggering feature, the NL 401 Digital Width module is an extremely versatile element. Used alone, in the retriggering mode, the OUT output goes low only when the interval between input pulses is greater than the WIDTH settings; thus, by sensing a positive-going edge at the OUT output with another module (another NL 401, an NL 403, etc.), intervals **longer** than the set (WIDTH) value are detected. Combined with the NL 503 And Gates, as shown above, the NL 401 can be used to detect intervals which are **shorter** than the selected WIDTH. The NL 401 is triggered by the negative-going (−SLOPE) edges of the input pulses; only those pulses which occur before the Digital Width output pulse terminates pass through the NL 503. These pulses also result in retriggering.



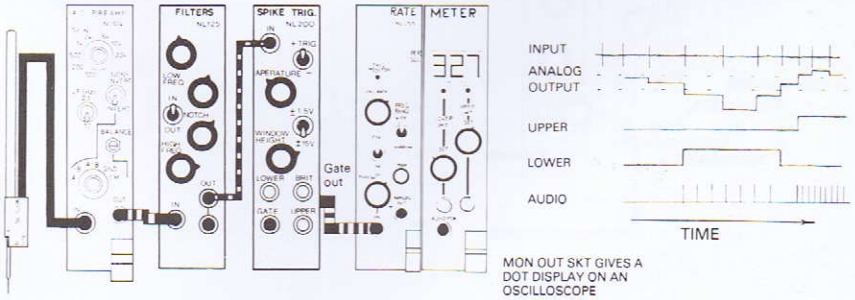
raster display of response latency

This example is only one of many possible raster displays which can be produced using NeuroLog modules. In this case, the NL 300 Pulse Generator produces the stimulus pulses, which also are used to zero the NL 310 Ramp Generator and "step" the NL 600 Pulse Integrator. The response pulses (derived, for example, from the BRIT output of the NL 200 Spike Trigger) transiently brighten the oscilloscope beam, which is driven vertically by the NL 310 output. Each stimulus pulse shifts the beam horizontally one increment. The responses will appear as dots spread out vertically from the baseline (which represents the instant of stimulation); their height from the baseline will be linearly proportional to latency. Many responses can be compressed on a single sweep in this way, each response remaining distinct. A similar display can be produced without the NL 600, with the oscilloscope time base set at a slow speed, but the lines of dots will not be exactly vertical. By zeroing the Ramp Generator with the falling edges of the response pulses themselves, a raster display of interpulse interval is obtained.



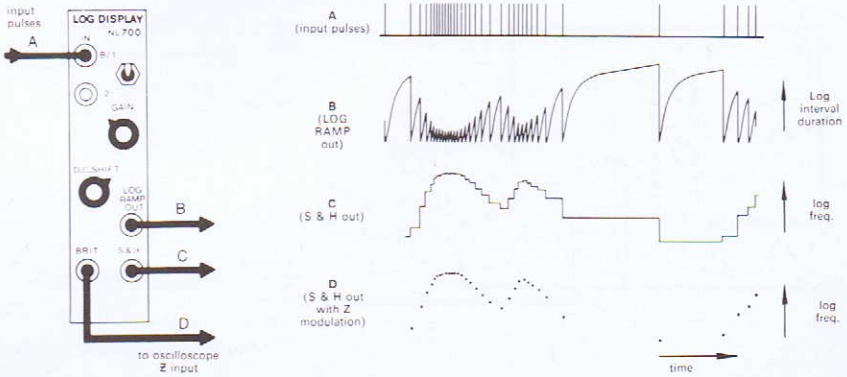
instantaneous frequency measurement

The Ratemeter input will accept either TTL logic pulses or an analog signal such as ECG's or spike trains. Simply adjust the THRESHOLD potentiometer until the TRIG MONITOR LED flashes at each event. (TTL pulses less than 5μsec in duration will not reliably trigger the input.) The nominal signal level required is about $\pm$0.5V. The rate of occurrence of the triggering events will be displayed on the digital display, right-hand module (over-range is indicated by a flashing display). Note that the display does not go completely to 00.0 events per min (NL 250) or 00.0 events per second (NL 255), since such frequencies would require infinitely long intervals between events.

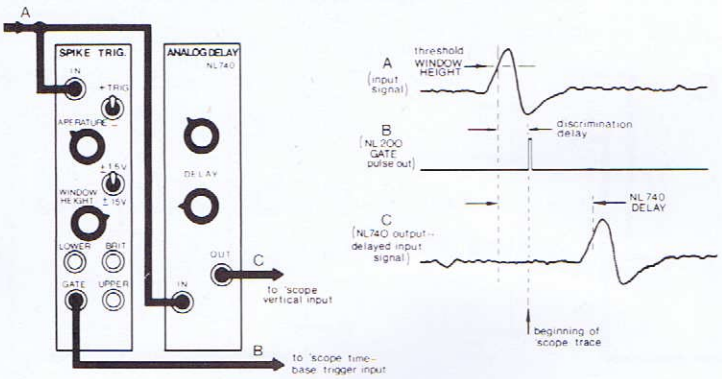


outputs of the NL 700 LOG DISPLAY

The NL 700 Log Display converts intervals between input pulses into output levels which are proportional to log frequency. The S & H output can be photographed or plotted on a chart recorder; combined with beam brightening (BRIT output), the S & H output can be photographed to give a "dot display" of instantaneous frequency.

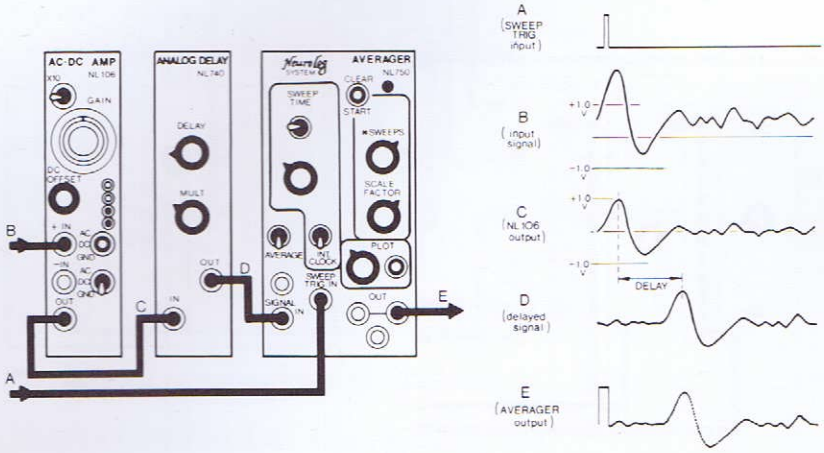


spike discriminator plus analog delay line



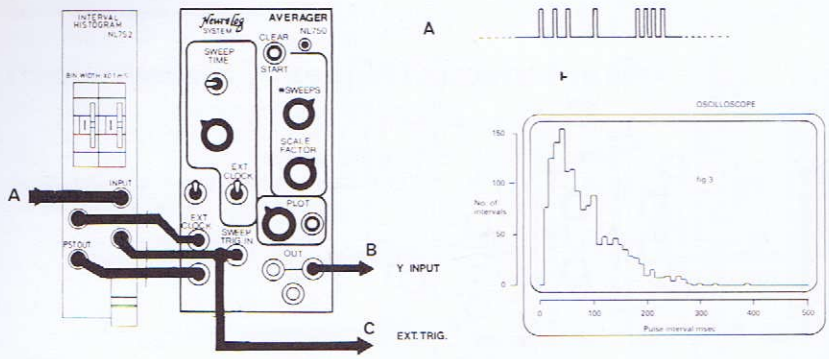
The ease with which spike amplitude discriminations are made is immeasurably enhanced with the NL 740 ANALOG DELAY module, as shown at the left. The NL 740 output provides the vertical input for the monitoring oscilloscope; this signal is suitably delayed so that the **entire** waveform of each discriminated spike can be examined (even portions occurring before the threshold crossing). The oscilloscope time base is triggered by the NL 200 GATE output so that only spikes selected by the gating circuit are shown on the oscilloscope screen. The NL 200 SPIKE TRIGGER thresholds are thus easily adjusted so that only the desired spikes initiate GATE pulses (in addition, NL 125-126 FILTER settings can be more carefully adjusted for the optimal signal-noise ratio).

pretriggered averages or PST's



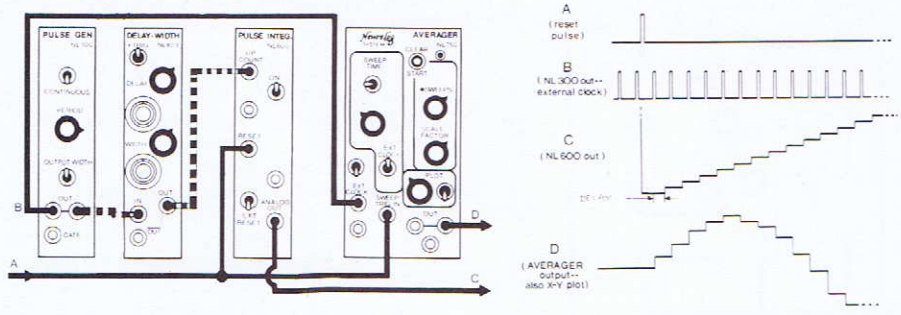
In the example at the left, the NL 106 AC/DC AMP is used to optimally adjust the amplitude (in this case requiring a slight attenuation) and shift the d.c. level of the input signal to match the ±1.0V input dynamic range of the NL 740 and NL 750. By delaying the input signal with the NL 740 ANALOG DELAY, parts of the waveform which occur **prior** to the SWEEP TRIG. signal are averaged. The same principle is employed in the computation of pretriggered PST histograms with the NL 750 AVERAGER, but the NL 730 PULSE SHIFT module is used to produce the delay.

interval histograms



The NL752 PULSE INTERVAL HISTOGRAM MODULE, used in conjunction with the NL750 AVERAGER, allows the operator to produce a pulse interval histogram from a spike train with extraordinary ease. T.T.L. pulses derived from the spike train – easily accomplished with DIGITIMER SPIKE PROCESSOR OR NL200 SPIKE TRIGGER provide the sole input while the only outputs are the histogram display to be fed to an oscilloscope Y input and an oscilloscope trigger signal.
The histogram consists of 256 bins each with a capacity of 4095 intervals. Bin width can be varied from 0.1 to 9.9 msec. in 0.1 msec. increments, allowing maximum interval of 2534.4 msec. Pulse intervals larger than this will be ignored. The contents of the bins are sampled every 2.56 msec. allowing the histogram to be viewed continuously as it progressively builds up.

generating an X-Y plot



The internal circuitry of the NL 750 AVERAGER allows for Y vs. T plots on ordinary chart recorders, but occasionally a more detailed record is required. The arrangement above shows how the NL 600 PULSE INTEGRATOR is used to provide the X input for an X-Y plotter. Once the average (or PST histogram) has been completed, the NL 750 is switched to its EXTERNAL CLOCK mode, and upon the arrival of a SWEEP TRIGGER pulse, its memory contents are read out one location at a time. (NL 603 or NL 606 COUNTERS, reset by the SWEEP TRIGGER pulse, could be used to indicate the memory location by counting the NL 300 EXTERNAL CLOCK pulses.)