



# INTRALAB MEMORANDUM

To: Distribution  
From: Joe Paradiso  
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Subject: **The Backgammon Timing/Gating Utility**  
Memo #: EJC 91-1101

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## **Abstract**

This memo describes the timing/gating utility unit that was developed under the Backgammon program to aid in sonar testing. It's essentially a users guide, with schematics, foil patterns, and technical detail appended. This unit has a wide range of application; it possesses a quad set of adjustable timers, clock generators, and comparators, which are an invaluable aid in designing and configuring a test setup.

## 1) Overview

In designing test setups for sonar systems, several "generic" devices (such as gate generators, clock generators, discriminators, coincidence units, and logic devices) are highly useful. In particular, it is extremely handy to have a bank of such circuits available in a programmable and/or patchable array, so that particular configurations can be quickly/easily realized and changed. I have often used such devices in nuclear and particle physics experiments. Here we have racks full of NIM crates, with each crate full of such utility modules, and interconnection accomplished via LEMO and BNC cabling. I've investigated applying such NIM modules to sonar application, and found a very significant price/performance mismatch. The nuclear world operates at much higher rates (i.e. 1 - 100 Mhz), and these modules have their own logic standard, which is far removed from conventional TTL and CMOS levels. These units are also highly expensive, which is somewhat prohibitive for our application (one pays for the extra performance and faster response, which we don't need in the sonar world).

Another area in which such devices were in common application has been in the area of electronic music. The old patchable music synthesizers used affordable technology and simple designs to realize the functions that we need to readily configure triggers for sonar systems. As a synthesizer musician/engineer, I've already designed, built, and fielded such systems for my own use. During the early 80's, I'd laid out PC board patterns for most of the units that are relevant to our sonar needs; fortunately I've been able to locate all of the circuit foils, thus we've been able to quickly and efficiently put the desired circuits together.

The collection of circuitry that we've deemed relevant to our sonar application are grouped into two rack-mount units. This memo describes the timing/gating unit, which has been already completed and tested. The other unit will focus on logic and gating functions; it is presently under construction. One activates the timing/gating circuitry by flipping the common power switch at the rear of the chassis. All other controls and connections operate independently for each submodule. The remainder of this memo presents a "users guide" for each type of circuit in the timing/gating package. The text of the next few pages often refer to the front panel layout (designed by Rick Ciliberto); a photograph of this panel is given in the first figure. All signals are input and output with BNC cables. Input impedances range beyond 10 K $\Omega$ . The logic outputs (and inputs) run 0  $\rightarrow$  5 Volts, have an output impedance of under 70  $\Omega$ , and are capable of driving TTL-level inputs.

## 2) The Pulser Units

At the left of the panel are four programmable gate generators. An output pulse (ranging in duration from several minutes down to a microsecond) will be created (at the "PULSE" output) in response to a rising edge applied at either the "TRIG" or "GATE" input. Pushing the "TRIG" button at the top of the unit also allows one to manually create an output pulse (this button is illuminated during the duration of an output pulse). An output pulse is immediately reset upon a rising edge applied to either "RESET" or "CLEAR" inputs. In addition, triggering is inhibited while the "CLEAR" input remains high.

In addition to the 5 Volt pulse available at the "PULSE" output, a linear ramp wave is available at the "RAMP" output. This ramp starts (from ground) as soon as a trigger is received, and normally grows in amplitude (up to 3 Volts or so) throughout the duration of the pulse, at which point it returns to ground. Things change, however, while the "GATE" input is held high. In this case, the ramp will continue to grow in amplitude (after the output pulse duration has elapsed) until either it reaches the +15 Volt saturation limit (where it will be held), or the "GATE" input is removed (at which point the ramp will be promptly be returned to ground).

The pulse width is set through the "WIDTH" adjustment, the "RANGE" switch, the "VC BIAS" trim, or an optional control voltage input. Initially, one adjusts the "VC BIAS" trim to the vicinity of its midpoint, then sets the "RANGE" switch to yield the proper magnitude of output duration. This switch has 6 positions. The pulse duration becomes wider as this switch is moved to the right (toward "HI"). The rightmost position (labeled "•") creates a latch. After being triggered, the pulse output will stay high until it is reset via the "RESET" or "CLEAR" inputs.

The width may be fine-tuned over a considerable range by the 10-turn "WIDTH" adjustment. Clockwise turning (toward larger number) will result in a wider pulse. The pulse width can also be changed by moving the "VC BIAS" trim. One must do this with caution, however, as setting this adjustment at an extreme range may inhibit the gate generator from properly functioning (i.e. triggering will be inhibited or the output will remain latched up), although this will not harm the unit. This adjustment works in an opposite sense to the "WIDTH" setting; clockwise turning will result in a narrower pulse.

The "VC BIAS" trim actually adjusts a DC bias summed into the pulse-width modulation control. The modulation input is also accessible through the "VC" input. This input amplitude should range within 5 Volts or so (depending on the "VC BIAS" setting, and at full "GAIN" adjustment); a larger voltage results in a narrower pulse. The "GAIN" adjustment sets the sensitivity of the "VC" input from zero (full left) through 100% (full right).

The schematics and print layout for this circuit are appended to this report. It is designed around the LM322 timer.

### 3) The Clock Units

These modules (located in the center of the panel) are essentially VCO's that can run from several minutes per cycle up through roughly 4 KHz. They produce either a TTL-compatible pulse wave (nominally square, although the duty cycle can fall off at extreme control voltage inputs) ranging 0 - 5 Volts, and a triangle wave (again nominally symmetrical, although becoming skewed with extreme control voltage inputs) centered near ground, with amplitude around  $\pm 2.5$  Volts. The outputs are at the bottom of each unit. The LED at the top of each unit monitors the pulse output.

The clock frequency is adjusted by the "RATE" setting, the "RANGE" switch, the "VC BIAS" trim, and an optional control voltage input. One first sets "VC BIAS" near its midpoint, sets the "RANGE" switch to yield the appropriate scale, and adjusts the "RATE" setting to select the desired clock rate. This is a 10-turn adjustment, with frequency increasing with clockwise turning (toward higher number). The "RANGE" switch is a 3-position toggle. The highest frequency range is obtained with this switch at its center position, the lowest range occurs with this switch down (at "SLO"), and a medium range is attained with this switch up (at "FAST"). The "VC BIAS" trim allows additional control over the clock rate. Again, one must watch the setting of "VC BIAS", as it can inhibit the clock functioning at its extreme range (the clock will latch into a high or low state; the pulse generally becomes highly asymmetric before this occurs).

Control voltages can be applied at the "VC" input to allow external modulation of clock frequency. The "GAIN" adjustment sets the control voltage sensitivity (fully counterclockwise is off, fully clockwise is 100%). This control voltage is summed with the DC voltage selected through the "VC BIAS" setting, thus the allowed input voltage ranges (before the clock stops functioning) will depend on its setting.

The schematic and foil patterns for this circuit are appended to this report. It is based on the LM566 voltage-controlled oscillator.

#### 4) The Comparator Units

These modules (located at the right end of the panel) compare two signals (or one signal to a DC bias), producing a 5 Volt TTL-compatible output that goes high when the "+" input (added to the "THREH" setting) surpasses the "-" input. They can be used as "discriminators" to fire a gate when an analog signal surpasses a preset level. The comparator state is monitored by the LED under the "TEST" button at the top of each module; this illuminates when the comparator state is high. The "TEST" button forces the comparator into a high state while it is pressed. The "THRESH" setting is a 10-turn adjustment that adds a DC bias into the "+" input (the "-" input is normally referenced at ground). When a signal is only applied to one of the inputs, the "THRESH" control will set the comparator threshold; in this case, it functions as a discriminator. When both inputs are driven, the "THRESH" control will determine a differential DC input offset. The "THRESH" adjustment produces no offset when it is set at its midpoint (5.0).

When the switch at the middle of the unit is turned on, hysteresis (positive) feedback is applied to prevent spurious comparator triggering on slow or noisy signals. The amount of hysteresis introduced is adjusted through the "HYST" control.

This circuit is based around an LM301 OP-AMP, which is a bit slow, but stable. Schematics and PC foil layouts are appended.



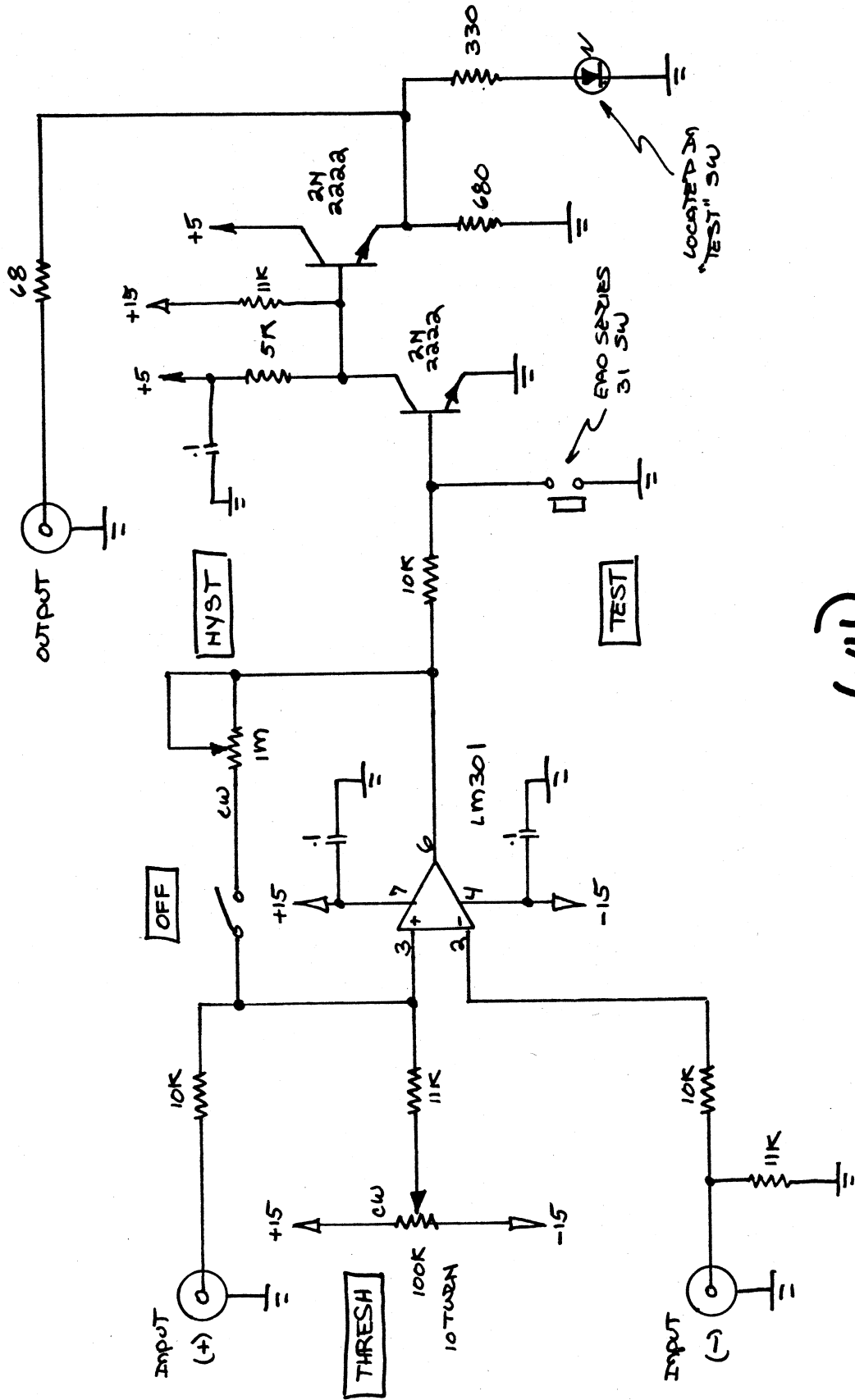












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UNITS

COMPARATOR

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