DIGITAL EQUIPMENT CORPORATION
Maynard, Massachusetts
9/64

30 MEGACYCLE MODULES

8000 SERIES CHARACTERISTICS

DEC 8000 Series Modules are a coordinated set of solid state digital circuits operating at frequencies up to 30 megacycles. They are mounted on protective aluminum frames measuring ½ by 4¼ by 14 inches overall. All logic and power connections are through 22-pin Amphenol plugs electrically connected to the circuit boards by flexible wires to minimize strain. Standard DEC system mounting panels may be used, but Type 1935 with rear support option is especially recommended.

It is possible to extend system capabilities or to achieve important savings in systems construction by incorporating units from the lower speed DEC module lines. The 8000 series units are electrically and mechanically compatible with 1000, 4000 and 6000 series system modules, and they are electrically compatible with 100, 3000 and 5000 series laboratory modules and FLIP CHIP modules.

The DEC 8000 series system modules use static flip-flops with level logic and pulse sampling. Flip-flop outputs that include built-in delay permit the flip-flop to be sampled while being changed. Additional direct outputs with a minimum of delay permit a maximum number of logical operations to be performed between pulses at very high frequencies. All pulse and level outputs are able to drive standard 50-ohm coaxial transmission line, so that interconnections may be made over large distances. Connections can be made with ordinary wire where the distances are small.

The 8000 series consists of two logic modules, a general purpose flip-flop, and a variable-frequency gateable clock. (See Application Note for a convenient method of obtaining 10 nanosecond clock pulses from ordinary sources of high frequency pulses, square waves, or sinusoids, if desired.)

DEC standard levels, used in all other Digital modules for performing logical gating functions, are 0 and -3 volts; these voltages are provided by any 8000 series logic module output loaded with 56 ohms (8202 flip-flops must drive lower frequency modules indirectly, by means of a logic module buffer). However, when operating at high speeds, 8000 series modules send and receive 0 and -1½ volt pulses and levels. These voltages are provided at any output loaded with approximately 25 ohms to ground. The standard pulse width in the 8000 series

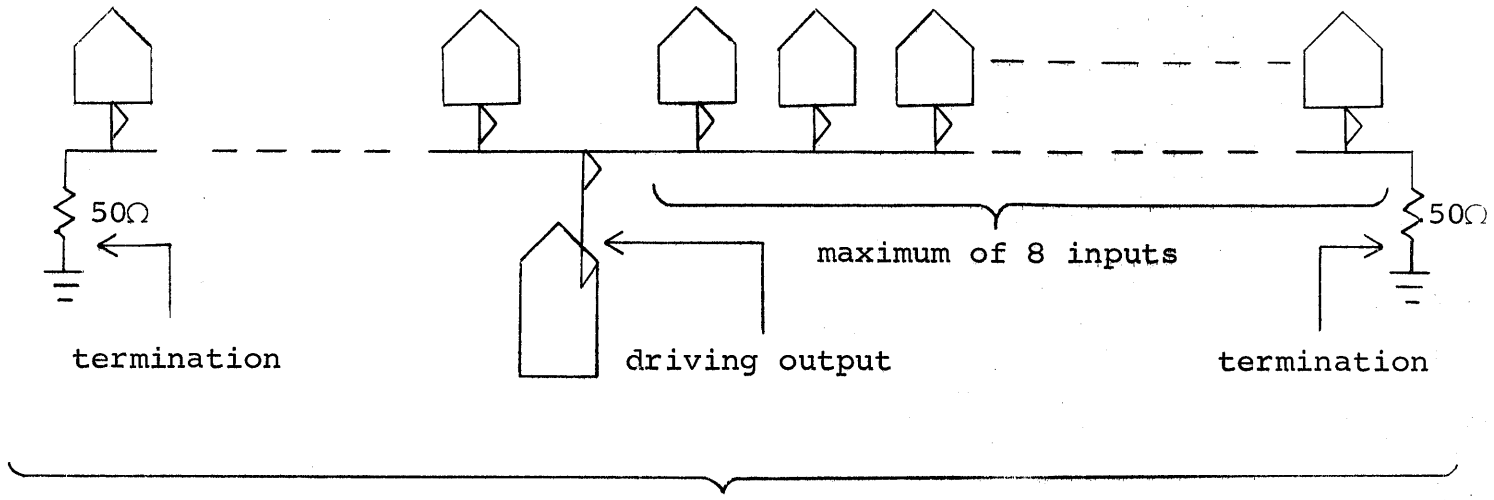
is 10 nanoseconds, which is also the time difference between delayed and direct outputs from flip-flops and gated clocks.

To assure convenient and short connections to ground, pins D, P, and Z of all modules are reserved for ground. Mounting panels should have these pins wired together in a mesh before the rest of the wiring is begun.

INTERCONNECTING 8000 SERIES MODULES

1. Fan-out

Each output of any 8000 series complementary output pair can drive up to twelve 8000 series inputs, not more than eight of which can be located along the line between the driving output and any one termination.



Each 8202 flip-flop direct output passes through a 50-ohm transmission line to become a delayed output. Consequently, the fan-out capability of each direct or delayed flip-flop output is eight, with no more than twelve total inputs driven from direct and delayed outputs of one side. The 8401 clock has multivibrator outputs with these same characteristics.

2. Driving Other Series

When the output of an 8000 series module has a 56-ohm load for driving modules from other speed lines giving 3 volt output, it can drive up to 6 bases from any one speed line. Do not mix base loads from more than one speed line. One-half DC emitter load may be driven, but no pulsed emitter may be driven. (The 8202 flip-flop is not designed to drive anything but other 8000 series modules; do not attempt to get 3 volt outputs from it.)

3. Loading

a. Load both complementary outputs of every output pair with the correct termination resistance, regardless of fan-out. Lack of such a load on any output, whether used logically or not, will prevent operation of the associated complementary output.

b. Load each 60 milliampere output with about 25 ohms to obtain 1.5 volt outputs, the normal signal amplitude for communication between 8000 series modules. In the case of 8202 and 8401 modules with built-in delay, divide the load so as to load each end of each 50-ohm delay line with about 50 ohms.

c. Every signal line should be treated as a 50-ohm transmission line terminated in its characteristic impedance at each end. Buswire (within the limitations of 5a below) can be combined with 50-ohm co-ax (and built-in 50-ohm 8202 or 8401 delay lines), but the result must be equivalent to a single line without branches from one terminating resistor to the other. Failure to observe this restriction will result in reflections (noise).

d. When 8000 series modules other than flip-flops must drive modules in another series, provide standard outputs by increasing the load from 25 ohms to 56 ohms. Flip-flop outputs cannot reliably provide 3 volt outputs; use part of a logic module as a buffer amplifier if necessary.

4. Grounding

a. All 8000 series modules have three grounded pins: D, P and Z. A ground mesh consisting of the vertical connections between these pins within the modules together with horizontal buswire connections between mounting panel connectors will provide excellent high frequency grounding for modules, terminations, and (where necessary) co-ax cable shields.

b. Use uninsulated buswire for the ground connections. All three ground busses must be fully exposed for grounding co-ax shields and numerous load resistors.

c. Run a separate wire directly from pin Z of each socket in the upper mounting panel to pin D of the corresponding socket in the lower mounting panel if two mounting panels (or more) with 8000 series modules are used.

5. Wiring

a. An ordinary wire may connect the same input pin on up to ten side-by-side modules (e.g. the shift-pulse line in a shift register or the reset line in a counter), because the input capacitance at each module combines with the wire's inductance to approximate a transmission line. The longest buswire between connector pins must not exceed 3 inches.

b. For longer runs, use miniature 50-ohm co-axial cable. It is easiest to strip and prepare cable with solid inner and outer conductors and teflon dielectric such as Uniform Tubes, Inc. type UT-85, Precision Tube Co. type 0653ST0853, or similar products made by HiTemp and Superior Tube Co. The 0.085" outside diameter of these types is large enough for center-conductor strength but small enough to be bent by hand if care is taken to avoid buckling. Use teflon spaghetti to insulate portions that pass over connector pins. If a stranded center-conductor can be tolerated, Precision Tube's RG 196/U equivalent with 0.056" O.D. will reduce bulk, which may be important if optimum module location fails to avoid extensive use of co-ax. Cables with O.D. smaller than about 0.05" have weak center-conductors (even with "copperweld" steel core wire) and should be avoided if possible.

c. Ground all co-ax shields at each end, using not more than 1" of wire. Make the distance from the shield to the signal connection (along the center conductor) about 0.5". Wiring will be easier if all hookup-wire connections go in before any co-ax. For short lengths of co-ax, bend to shape before stripping, so center conductor won't slide within dielectric.

d. Use an Acme multi-hole wire stripper (or equivalent) for co-ax, both shield and dielectric (select the optimum hole size for cutting shield by experiment).

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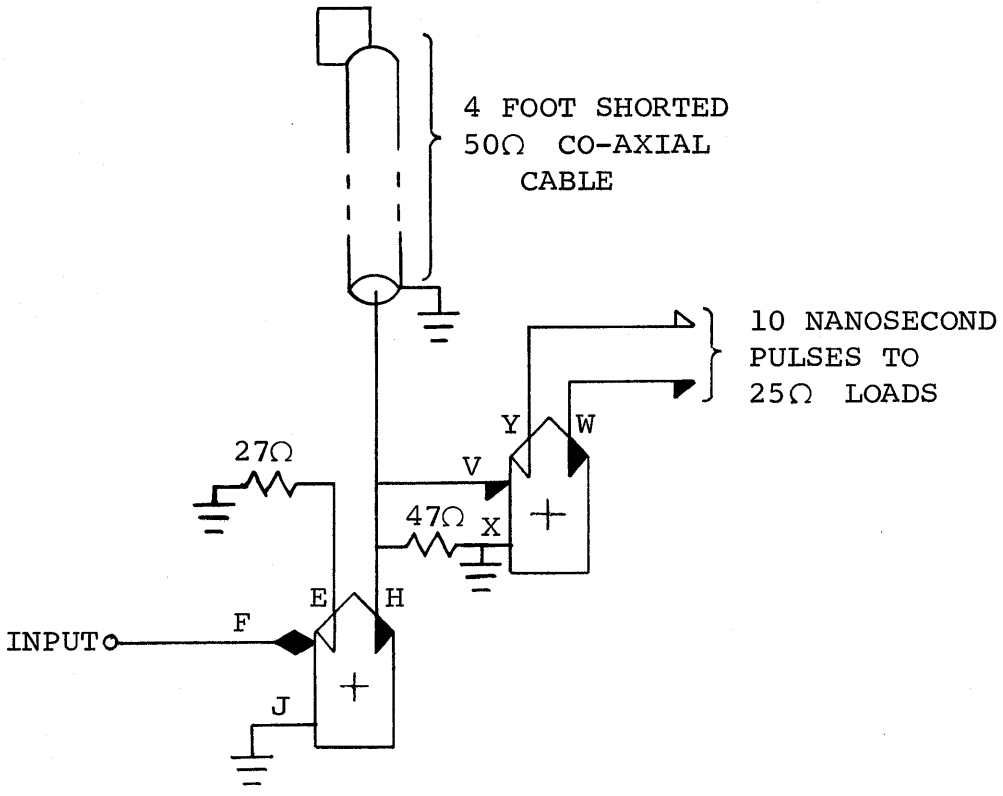
8000 SERIES

APPLICATION NOTE

This application note shows how to produce 10 nanosecond pulses from miscellaneous signals such as sinusoids, square waves, or DEC Standard pulses or levels. The method may be used with any input whose maximum positive or negative excursions are no greater than 4.0 volts from ground, and which make a smooth negative-going transition from -1/4 volt to -1 1/4 volt in 20 nanoseconds or less, and whose positive-going transition from -1 1/4 volt to -1/4 volt is smooth and free from kinks. These requirements can be met by 6 volt (peak-to-peak) sinusoids frequencies down to 5 megacycles, by high quality square waves at any frequency, and by DEC Standard 2.5 volt 40 nanosecond or 70 nanosecond pulses. Level transitions from DEC 1000 Series and 6000 Series modules will also meet the requirements if short leads are used and if no more than two 5 mc inverter bases or three 10 mc inverter bases are being driven from the same source. Source impedance can be quite high, since an 8000 Series input loads the source less than a 6000 Series inverter base would.

The block diagram shows pin connections appropriate to an 8104 or 8120 module. If an 8104 is used, the center section is free for some other use. If an 8120 is used, the outputs may be gated by signals at Pins R, S, T, or U, but Pins K, L, M, N, and any other unused inputs should be grounded.



8104

$227.00

LOGIC MODULE

This module performs the logical operations AND, OR, NOT, and XOR at rates up to 30 megacycles. Two of its three circuits operate as 2-input AND, OR, NAND, or NOR gates. The third circuit can be regarded as a gateable Exclusive-OR circuit, but its logical capabilities are better defined by the complete logical block diagram shown below.

All three circuits have complementary-pair outputs, so it is never necessary to add circuitry to obtain inversion.

Typical delay for ground and -1½ volt signals at 50% points:
5 nanoseconds for either 2-input gate;
7 nanoseconds for the 6-input gate.

INPUT levels are normally 0 volts and -1½ volts. The two 2-input gates are also fast enough to be used with pulses nominally 10 nanoseconds wide at their 50% points. Pulses going to -1½ volts from ground and pulses going to ground from -1½ volts are equally acceptable. These 2-input gates can also be used with 3 volt levels from slower speed lines, each input constituting one standard base load.

The slower 6-input gate should be used for ground and -1½ volt levels with at least 15 nanoseconds separating successive output transitions. Overshoots as small as 1/2 volt on 3 volt levels from other speed lines could cause false outputs from this gate. (These effects can be avoided by the use of a 2:1 voltage divider made from two 830-ohm resistors to convert 3 volt inputs to 1½ volts. The divider input will then be equivalent to two standard base loads.)

All unused inputs should be grounded to prevent crosstalk.

OUTPUTS: Each of the three gates has a 60 milliampere negative current source switched to either of two complementary output connections. Each of these six outputs must be loaded with about 25 ohms to ground to provide ground and -1½ volt outputs. Both outputs of a pair must be loaded in order for either side to operate properly. Each load may be separated into two 50-ohm loads, which allows two terminated 50-ohm transmission lines to be driven from each output connection. Each such line can drive up to eight 8000 series inputs, as long as the total number of such inputs driven from any one output connection does not exceed 12.

For driving lower frequency modules, any output connection can be loaded with 56 ohms, giving ground and -3 volts output levels. Up to six bases all from the same speed line can be driven in this fashion. The speed of the complementary output may be slightly reduced, but will be adequate for driving 8000 series modules. An output driving bases from other speed lines may be too slow to give satisfactory results if used as the input of an 8000 series module that accepts 3 volt inputs. No emitters may be driven, but up to 1/2 DC emitter load may be driven, in addition to base loads mentioned above.

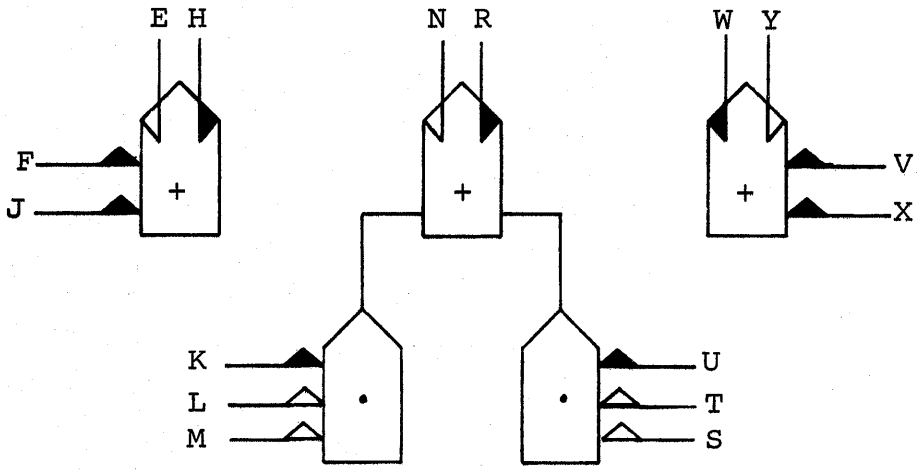
All 8000 series outputs are immune to being accidentally shorted to ground for limited periods, but normally 25-ohm loads should be used even for output connections that are not driving anything.

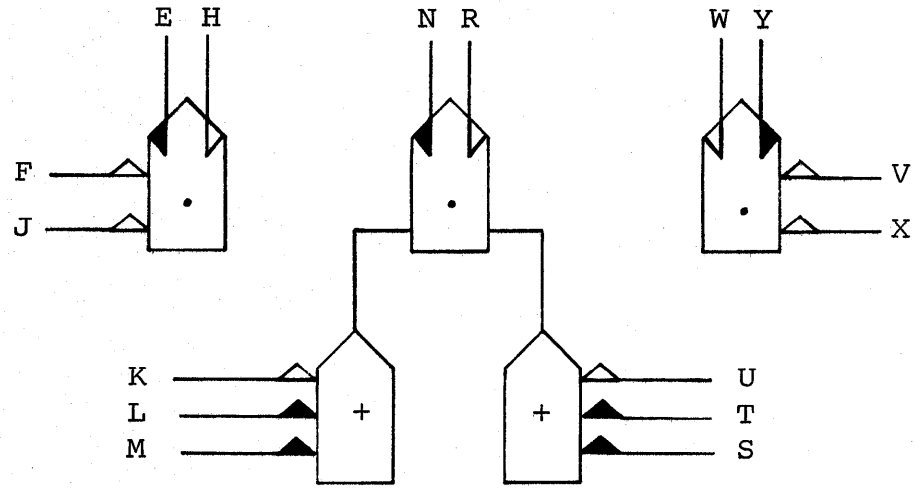
POWER: -15 V/350 ma.; +10 V(A)/55 ma.; +10 V(B)/55 ma.

8104

LOGIC MODULE

The diagrams below show two alternate ways of representing the 8104 logically, for the two possible definitions of assertion. Any of the three gates may have assertions defined either way, independent of how the others are defined.





8120

$182.00

TWO 6-INPUT NOR

Each of the two circuits in this module can perform the logical operation OR, AND, NOR, NAND, or NOT at rates from DC to 30 mc. A typical application is in detecting the state of a flip-flop counter or shift register. Ten nanosecond pulses can be used with this module.

Typical delay at 50% points: 5 nanoseconds.

INPUTS: Normal input levels are ground and -1½ volts. Up to eight such inputs can be driven by any one 50-ohm transmission line from an 8000 series output connection, and up to a total of 12 such inputs can be driven by two 50-ohm transmission lines from an 8000 series output.

Three volt levels from modules in lower speed lines can also be used. Each 8120 input is equivalent to one base load or less.

All unused inputs should be grounded to prevent crosstalk.

OUTPUTS: Each gate has a 60 milliampere current source that is switched to one or the other of its complementary output connections. Each of the four output connections on the module should be loaded with about 25 ohms to ground to provide standard ground and -1½ voltages. Each such load can consist of two 50-ohm transmission lines terminated at their far ends and driving inputs to 8000 series modules according to the rules under "Inputs", above.

Each output can withstand accidental shorts to ground without damage, but normally even unused output connections should be loaded with about 25 ohms to ground. Neither output of a gate will operate properly if one is left open-circuited.

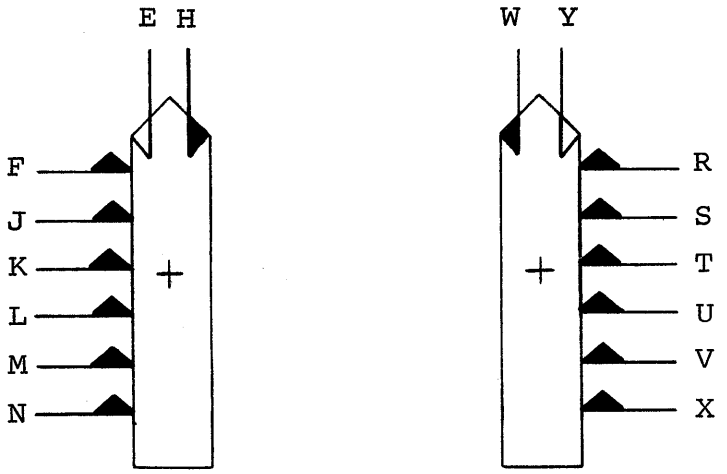
For driving modules from lower frequency lines, a 56-ohm load may be used. Such an output can drive up to six grounded emitter bases from any one speed line, and up to 1/2 DC emitter load simultaneously. Outputs loaded by lower speed circuits may not be fast enough to provide satisfactory drive to 8000 series inputs that tolerate 3 volt signals.

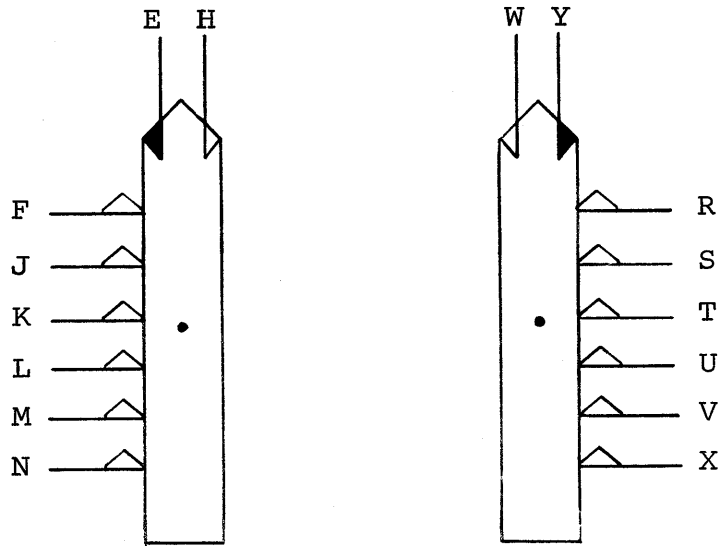
POWER REQUIREMENTS: -15 volts/200 ma.; +10 volts(A)/22 ma.; +10 volts(B)/22 ma.

8120

TWO 6-INPUT NOR

The logic diagram below shows the 8120 gates with two different definitions of assertion. Either gate can be used with either definition independent of the definition used with the other gate.





8202

FLIP-FLOP

At frequencies up to 30 megacycles this module can serve as one bit of a counter, serial-parallel converter, shift register, etc., without additional gating.

The 8202 contains one flip-flop with both direct and delayed output connections (time difference: 10 nanoseconds), and input gating suitable for counting, shifting, etc.

Typical delay at 50% points: 7 nanoseconds at direct outputs.

INPUTS: Input voltages are normally 0 and -1 1/2 volts.

Direct set and clear inputs may be driven to -2 1/2 volts (pulses) or -3 volts (levels), for the purpose of reading in from DEC modules of other speed lines. Each is then one base load.

Up to 12 inputs may be driven from one 8000 series module output. Up to 8 may be located along one 50-ohm transmission line from the output doing the driving. (If a 30 mc flip-flop provides the drive, this means that up to 8 inputs can be driven from the direct or delayed output connections at one side of the flip-flop, and that the maximum total number of inputs on both the direct and delayed output connections from the same side of the flip-flop is 12.)

All unused inputs must be grounded to prevent crosstalk.

OUTPUTS: The flip-flop output consists of a 60 ma. current source switched to one of the two direct output connections. Two 50-ohm, 10 nanosecond delay lines connect the direct output connections to the delayed output connections. Each of the four output connections must be loaded with approximately 50 ohms to ground, so that the output voltages swing between 0 and -1 1/2 volts.

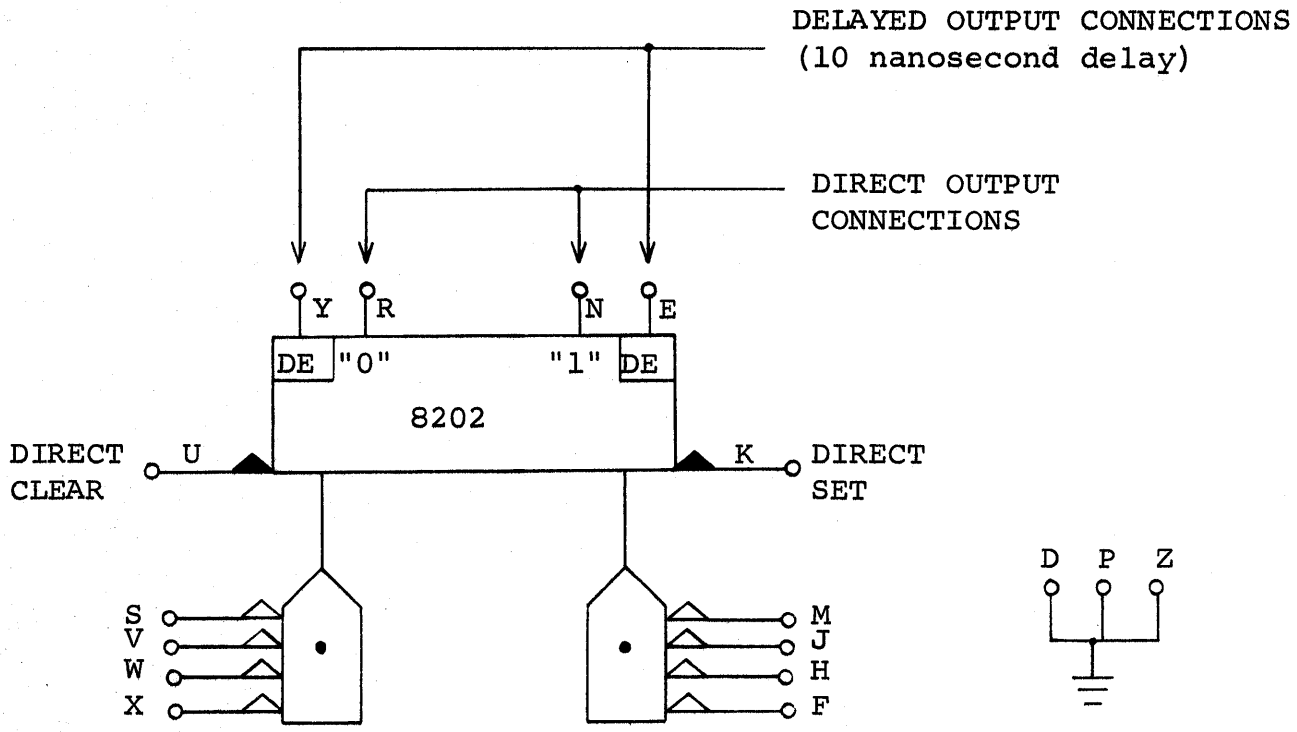
The four 50-ohm terminating resistors may be separated from their respective output connections by any length of 50-ohm transmission line. 8000 series inputs may be located along these lines according to the rules under "Inputs", above. Modules belonging to lower speed lines may be driven with the aid of an 8000 series logic module.

POWER REQUIREMENTS: -15 volts/225 ma.; +10 volts(A)/60 ma.; +10 volts (B)/60 ma.

Price: $206.00

8202

FLIP-FLOP



8401

GATEABLE CLOCK

This module provides a controllable source of high frequency signals from below 5 Mc to 30 Mc in two overlapping ranges. Both range and vernier frequency are controlled by DC biases to facilitate remote control. Multivibrator action can be started and stopped by a logic level at the gate input.

The module includes two 2-input logic gates for producing 10 nanosecond pulses from the direct and delayed multivibrator outputs. They can also be used for other logical operations.

INPUTS:

Multivibrator Gate Input: Enables multivibrator at 0 volts, inhibits it at -1 1/2 or -3 volts. When inhibited, multivibrator is in "0" state. Time from gate enable to first output transition is approximately equal to time between transitions for continuously enabled condition. Loading characteristics are the same as all other 30 Mc inputs.

Logic Gate Inputs: Same characteristics as 8104 2-input gates. All unused inputs must be grounded.

OUTPUTS:

Multivibrator Outputs: Same characteristics as 8202 outputs, both direct and delayed. Output squareness ratio is within 2:3 from 10 Mc to 30 Mc, so that the outputs of an 8401 set to a given frequency resemble the outputs of a flip-flop complementing from an input of twice that frequency. All four outputs must be terminated in approximately 50 ohms, whether logically used or not.

Logic Gate Outputs: Same characteristics as 8104 2-input gates. All outputs must be terminated, whether logically used or not.

CONTROLS:

Return pin L to -15 volts (draws an additional 75 ma. from -15 volt supply) if low frequency range is desired. Otherwise, may be left open or returned to +10 volts (draws no current).

To use the internal pot for frequency control, jumper pins S and T together.

To obtain remote control of vernier frequency, connect a 500 ohm variable resistance from pin S to +10B. Lead lengths are of no importance, since both range and vernier frequency connections are isolated from high frequencies within the module.

POWER: -15 volts/420 ma.; +10 volts(A)/ 31 ma.; +10 volts(B)/130 ma.

8401

GATEABLE CLOCK