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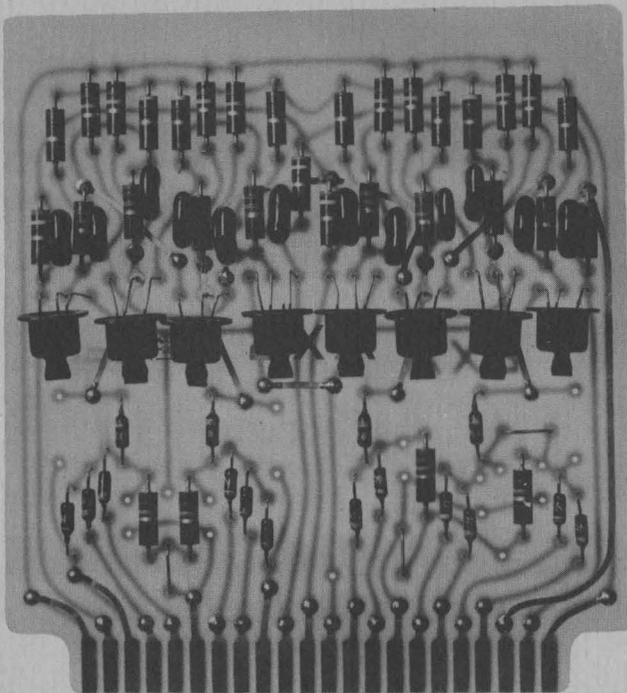
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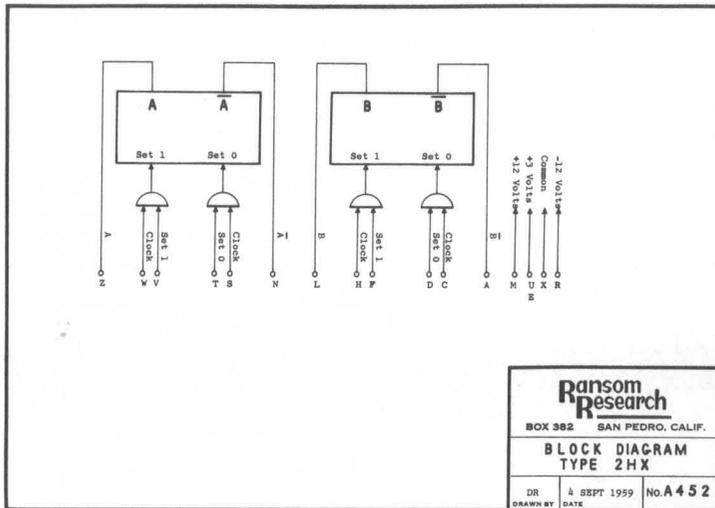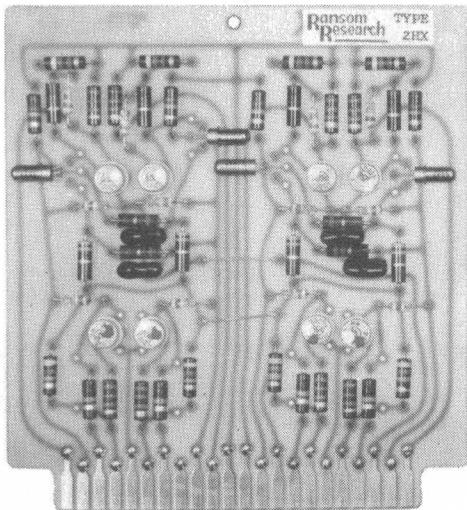
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TECHNICAL BULLETIN C-46

TErminal 2-1128

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

Type 2HX Dual 1MC Flip Flops

Ransom Research
BOX 382   SAN PEDRO, CALIF.

BLOCK DIAGRAM TYPE 2HX		
DR DRAWN BY	4 SEPT 1959 DATE	No. A452

GENERAL DESCRIPTION

The implementation of computer and control logic generally requires that information be stored at some point for a period of time and then released to the system again. Such units as switches, magnetic delay lines and flip flops have been used to advantage for this purpose in various applications. The flip flop has the added advantage of being directly compatible with high speed diode logic circuits.

The Ransom Research Type 2HX Dual Megacycle Flip Flop consists of two independent one megacycle flip flops; these flip flops have been designed for operation in high speed computer systems such as adders, shift registers and the like. To maintain the correct timing in such systems, a 1MC clock pulse is required. This clock pulse may be generated either from an external signal or from a crystal controlled oscillator contained in the equipment. All diode gating for the Type 2HX unit is implemented on separate diode gating cards for maximum flexibility.

Each flip flop used on the Type 2HX unit is composed of two transistors cross-coupled in a conventional Eccles-Jordan circuit. An amplifier transistor is connected to each side of the flip flop to provide the required output power. Two additional transistors are provided on the input to each side of the flip flop to properly gate the input signals; due to the method of coupling used, three volts of noise discrimination is provided at the input gates. Use of this type of unit provides considerable output power from the flip flop for use in gates elsewhere in the system, and additional power amplifiers are seldom required.

The Ransom Research Type 2HX Dual Megacycle Flip Flop is one of a new series of RR one MC Computer Elements now available to provide reliable digital equipment for high speed operation. Additional units include 1 MC diode AND and OR gates, and the Type MBD Megacycle Binary Decade for high speed divide by ten operation.

SPECIFICATIONS -- TYPE 2HX

DC Inputs: Set 0 and Set 1 provided for each flip flop. All diode gating for the Type 2HX is external and should be implemented with the Megacycle Diode Gates such as the Type A2-6M unit.
Normal Level = Common
Set Level = +5 volts to +12 volts
Impedance (Normal) = 1K ohms to +3 volts.
Impedance (Set) = 22K ohms to -12 volts.

CLOCK Inputs: Separate CLOCK inputs associated with each DC input for maximum flexibility of clock logic.
Amplitude: -10 volts to -15 volts
Rise and Fall Times: 0.05 microseconds nominal maximum.
Pulse Width: 0.2 microseconds nominal maximum.
Frequency: 1 MC nominal max.

Outputs: F and $\overline{F}$ provided for each flip flop
0 Levels: F = Common
$\overline{F}$ = +12 volts unloaded
1 Levels: F = +12 volts unloaded
$\overline{F}$ = Common
Rise Time: 0.5 usec. maximum
Fall Time: 0.2 usec. maximum
Loading: 25 ma. to +12 volts
5 ma. to Common

Power: +12 volts @ +50 milliamperes
+3 volts @ +6 milliamperes
Common
-12 volts @ -22 milliamperes
±2% voltage regulation required

Physical: Standard 4 1/2" x 5" circuit card
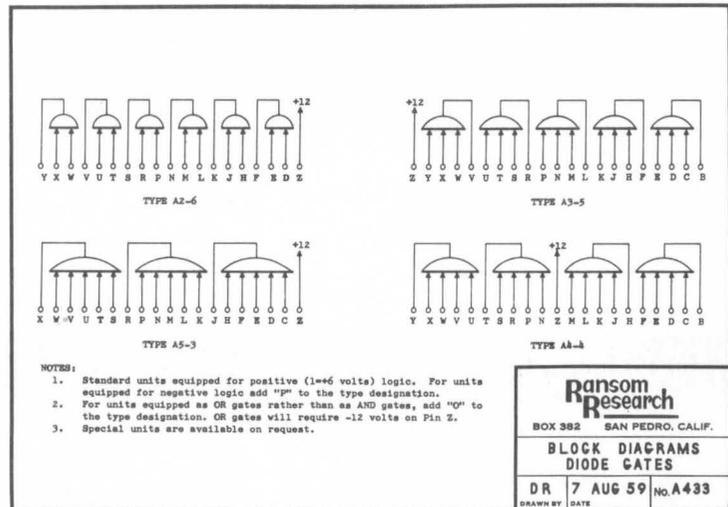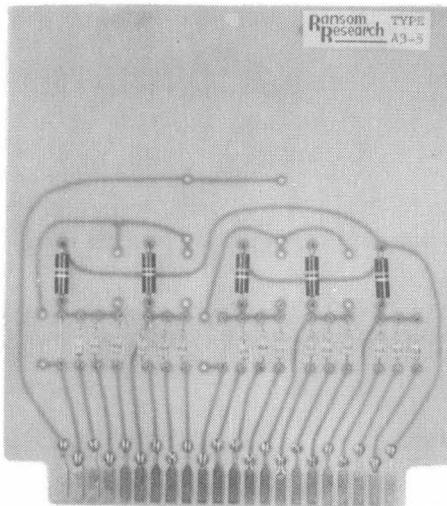Connector: 22 pin PC connector
Operating Temperature: 0° - 50°C

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

Counters ● Timers ● Transistorized Instruments ● Logical Control Systems ● Computer Logic Systems ● Digital Systems

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TECHNICAL BULLETIN C-44

TErminal 2-1128

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

Diode AND & OR Gates

TYPE A2-6   TYPE A3-5

TYPE A5-3   TYPE A4-4

NOTES:
1. Standard units equipped for positive (1=+6 volts) logic. For units equipped for negative logic add "P" to the type designation.
2. For units equipped as OR gates rather than as AND gates, add "O" to the type designation. OR gates will require -12 volts on Pin Z.
3. Special units are available on request.

Ransom Research

BOX 382   SAN PEDRO, CALIF.

BLOCK DIAGRAMS
DIODE GATES

DR | 7 AUG 59 | No. A433
DRAWN BY | DATE |

GENERAL DESCRIPTION

The diode gate is the means whereby various commands and control functions are introduced to a system. Thus, diode gates in conjunction with flip flops and inverters may be used to synchronize the operation of data processing equipment, special purpose computers, or even counters. The diode gate may also be used, however, to make an actual calculation. The result of such a calculation is then fed to memory circuits, such as a flip flop, where the results are stored. Calculation and control makes use of two types of the diode gate: the OR gate and the AND gate. An OR gate will provide an output signal if any one of its input signals is in the 1 condition; the AND gate will provide a true output signal only when all of its inputs are in the 1 (true) condition.

To simplify the application of diode gates, two symbols are used to represent the OR and the AND operations. The symbol "+" will be used to mean OR; for example, the equation

$$D = A + B + C$$

will give the input and output connections for a three diode OR gate. Similarly, the symbol "." will be used as AND, as in the equation

$$X = R \cdot S \cdot T$$

describing a three diode AND gate. Use of these equations, while not required, will often aid in the design of systems using many diode gates and will provide a ready means of checking.

RANSOM RESEARCH Diode Gates are designed to be used in conjunction with RR Computer Elements for the solution of digital problems. They are supplied with two, three, four or five inputs to provide maximum flexibility. Special units are also available for particular applications.

SPECIFICATIONS -- RR AND GATES

Inputs:	5 inputs maximum as specified for the particular unit.
	Normal Level = Common to +2 volts
	Set Level = +4 volts to +12 volts
	Impedance (diode isolated) = 22K ohms to +12 volts per gate.
Outputs:	Output level essentially equal to input level (unloaded).
Loading:	Determined by the requirements of the circuit to be driven.
Frequency:	DC to 500KC nominal maximum
Power:	+12 volts @ 0.5 milliamperes/gate
PNP Logic:	Where necessary, RR AND Gates may be supplied for negative logic.
Physical:	Standard RR $4\frac{1}{2}$" x 5" circuit card Connector = 22-pin PC connector Operating Temperature: 0°C - 50°C

SPECIFICATIONS -- RR OR GATES

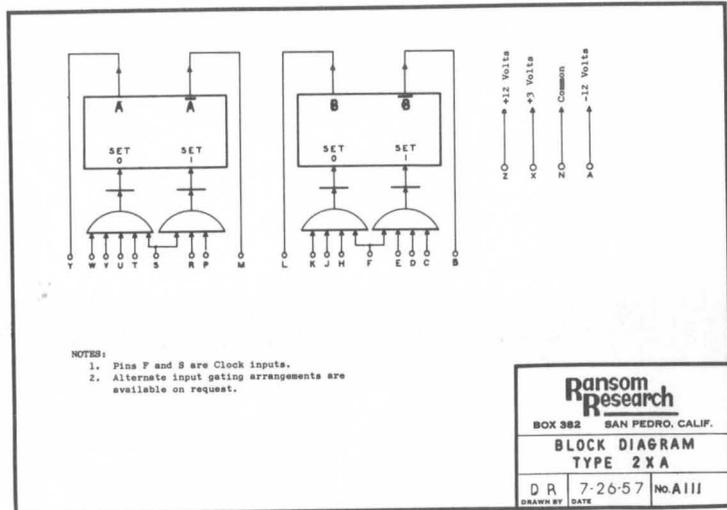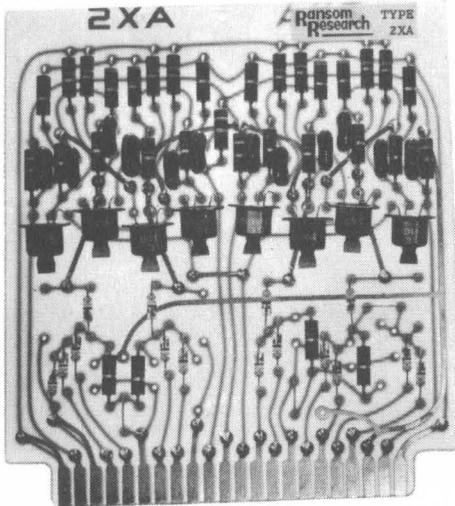|	
Inputs:	5 inputs maximum as specified for the particular unit.
	Normal Level = Common to +2 volts
	Set Level = +4 volts to +12 volts
	Impedance (diode isolated) = 47K ohms to -12 volts per gate.
Outputs:	Output level essentially equal to input level (unloaded).
Loading:	Determined by the requirements of the circuit to be driven.
Frequency:	DC to 500KC nominal maximum
Power:	-12 volts @ .25 milliamperes/gate
PNP Logic:	Where necessary, RR OR Gates may be supplied for negative logic.
Physical:	Standard RR $4\frac{1}{2}$" x 5" circuit card Connector = 22-pin PC connector Operating Temperature: 0°C - 50°C

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

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TECHNICAL BULLETIN C-37A

TErminal 2-1128

BOX 269 • 323 WEST SEVENTH STREET • SAN PEDRO, CALIFORNIA

Type 2XA Dual Flip Flop

NOTES:
1. Pins F and S are Clock inputs.
2. Alternate input gating arrangements are available on request.

Ransom Research

BOX 382   SAN PEDRO, CALIF.

BLOCK DIAGRAM
TYPE 2XA

| D R | 7-26-57 | NO. A111 |
| DRAWN BY | DATE | |

GENERAL DESCRIPTION

The design of logical control circuitry always requires that information be stored at some point for a period of time, and then released to the system. Such controls as switches, magnetic cores, delay lines and flip flops have been used to advantage for this function in various applications. The flip flop, capable of information storage for long periods of time, has the added advantage of being directly compatible with high speed diode logic circuits.

The Ransom Research Type 2XA Dual Flip Flop has been designed for maximum flexibility in all types of control and logical applications. Consisting of two RR Basic Flip Flops complete with input logic on one printed circuit card, a block diagram of the unit is illustrated above.

Each flip flop used on the Type 2XA unit is composed of two transistors cross coupled in the conventional Eccles-Jordan circuit. An amplifier transistor is connected to each side of the flip flop to provide power output and to give a short time delay between the input and the output. The delay is provided to permit use of the flip flop in circuits such as counters, shift registers or other configurations which may require simultaneous logic. The common emitters of the flip flop are biased to +3 volts, thereby providing noise discrimination of approximately 3 volts on input signals. In cases where the output of the standard Type 2XA does not supply enough gating power, use of the Type 2XA-H is recommended.

The Ransom Research Type 2XA Dual Flip Flop is one of a series of RR dual flip flop Computer Elements available. Other units such as the Type 2XC Dual Shift Register Flip Flops represent the same pair of flip flops but with different input gating arrangements.
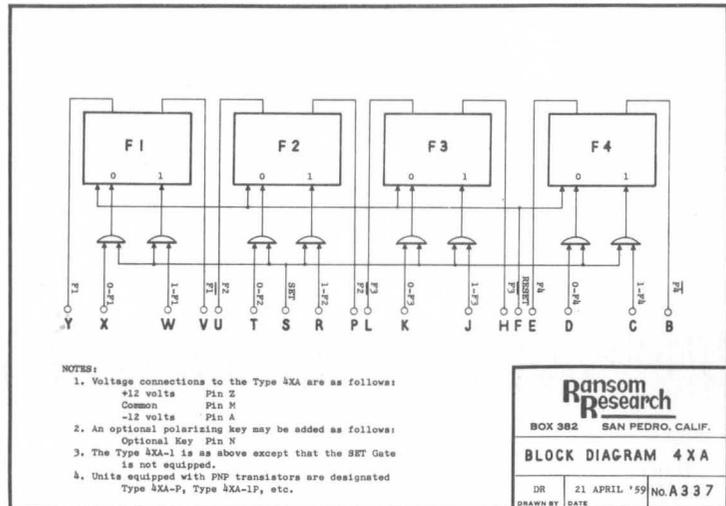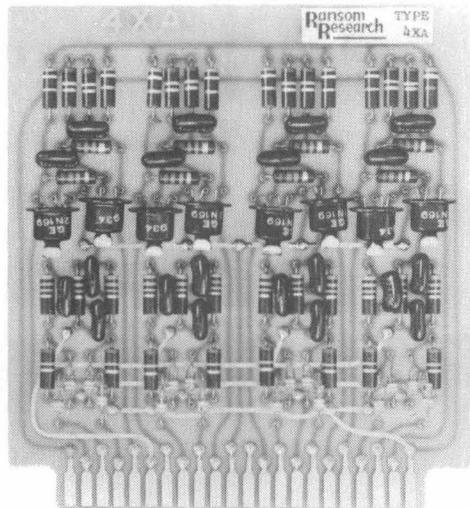
SPECIFICATIONS -- TYPE 2XA

DC Inputs: Set 0 and Set 1 provided for each flip flop as shown on the block diagram above, RR #A111.
Normal Level = Common to +2 volts
Set Level = +4 volts to +12 volts
Impedance (diode isolated) = 18K ohms to +15 volt clock pulse

CLOCK Inputs: Amplitude: +15 volts to +20 volts
Rise and Fall Times = 0.1 usec.
Pulse Width = 0.5 usec. nominal
Negative Overshoot = -6 volt nom.
Overshoot Return Time = 1 usec.
Frequency = 500KC nominal maximum

Outputs: F and $\overline{F}$ provided
0 Levels: F = Common
$\overline{F}$ = +6 volts
1 Levels: F = +6 volts
$\overline{F}$ = Common
Rise Time = 0.5 usec. nominal
Fall Time = 0.1 usec. nominal
Loading: 2.0 ma. to +12 volts
0.2 ma. to Common
50 uuf. maximum

Power: +12 volts @ 9.5 milliamperes
+3 volts @ -3.5 milliamperes
Common
-12 volts @ -0.4 milliamperes
±2% voltage regulation required

Options: The Type 2XA is also available as the Type 2XA-H for maximum load limits of 20 ma. & 2 ma. above.

PNP Units: Where necessary, the Type 2XA may be supplied with 8 PNP transistors for circuit compatibility.

Physical: Standard RR 4½" x 5" circuit card
Connector = 22-pin PC connector
Operating Temperature: 0°C - 50°C

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TECHNICAL BULLETIN C-42

TERMINAL 2-1128

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

Type 4XA Storage Flip Flops

NOTES:
1. Voltage connections to the Type 4XA are as follows:
   +12 volts   Pin Z
   Common   Pin M
   -12 volts   Pin A
2. An optional polarizing key may be added as follows:
   Optional Key Pin N
3. The Type 4XA-1 is as above except that the SET Gate is not equipped.
4. Units equipped with PNP transistors are designated Type 4XA-P, Type 4XA-1P, etc.

Ransom Research
BOX 382   SAN PEDRO, CALIF.
BLOCK DIAGRAM 4XA

| DR | 21 APRIL '59 | No. A337 |
| DRAWN BY | DATE | |

GENERAL DESCRIPTION

The Ransom Research Type 4XA Storage consists of four independent flip flops with Set 0 and Set 1 inputs for each flip flop. A SET Gate is provided to enable all diode gate inputs to the unit, as well as a RESET Line to reset all flip flops to the 0 condition. The principal applications of this unit are as an Output Storage, where the information is set in parallel and held for long periods of time without changing, and as a Buffer Storage to hold information for parallel or serial shift from one part of a system to another. In both cases, the input gating required on each flip flop is generally at a minimum, and the Type 4XA Storage unit, shown on the Block Diagram above, is adequate for the majority of these applications.

In addition to the general purpose applications above, the Type 4XA Storage has been designed for operation with RR NOR logic. It is true that two NOR elements may be combined to form a flip flop, but considerable area is wasted on the printed circuit board with this method. The Type 4XA, besides providing economical flip flops for use with NOR logic, is also equipped with diode isolated input gates to permit setting of the flip flop in five or less microseconds.

The Ransom Research Type 4XA Storage unit is one of a new series of quadruple flip flop Computer Elements now available to provide an inexpensive digital storage that is also compatible with high speed RR Computer Elements.

SPECIFICATIONS -- TYPE 4XA

Inputs: Set 0 and Set 1 provided for each flip flop.
           Normal Level = 0 volts (Common)
           Set Level = +8 volts to +16 volts
           Impedance (diode isolated) = 15K ohms minimum to +12 volts.

SET Gate: One provided to enable all inputs to all four flip flops.
           Normal Level = 0 volts (Common)
           Set Level = +8 volts to +16 volts
           Impedance (diode isolated) = 4K ohms minimum to +12 volts.

RESET Line: One is provided to reset all four flip flops to the 0 condition.
           Normal Level = 0 volts (Common)
           Set Level = +8 volts to +16 volts
           Impedance = 8K ohms in parallel with 150 uuf. max. to Common.

Outputs: "F" and "F̄" outputs provided from each flip flop.
           True Level = +12 volts (unloaded)
           False Level = 0 volts (Common)
           Impedance (True) = 3.9K ohms to +12 volts.
           Maximum Loading to Common = 8.2K ohms or equivalent.
           Maximum Loading to +12 v. = 4.7K ohms or equivalent.

Power: +12 volts @ 22 milliamperes
           Common
           -12 volts @ 40 microamperes

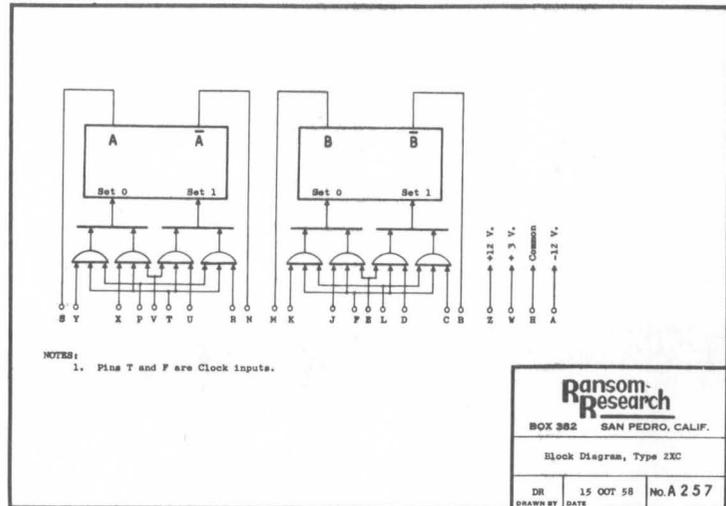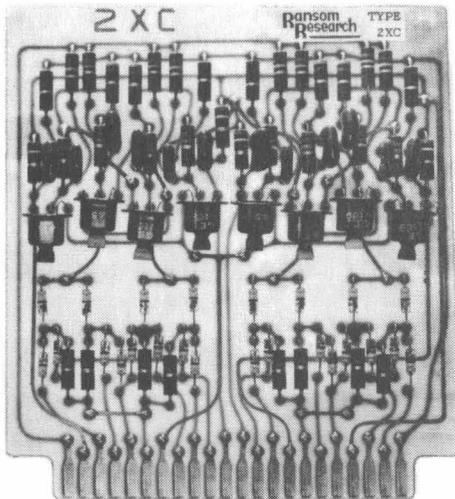Options: The Type 4XA is also available as the Type 4XA-1, and is supplied less the SET Gate.

PNP Units: Where necessary, the Type 4XA may be supplied with 8 PNP transistors for circuit compatibility.

Physical: Standard RR 4½" x 5" circuit card
           Connector = 22-pin PC connector
           Operating Temperature: 0°C - 50°C

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TECHNICAL BULLETIN C-43

TERMINAL 2-1128

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

Type 2XC Dual Shift Register

NOTES:
1. Pins T and F are Clock inputs.

Ransom Research
BOX 382   SAN PEDRO, CALIF.

Block Diagram, Type 2XC

DR	15 OCT 58	No. A257
DRAWN BY	DATE	

GENERAL DESCRIPTION

The design of logical control circuitry always requires that information be stored at some point for a period of time, and then released to the system. Such controls as switches, magnetic cores, delay lines and flip flops have been used to advantage for this function in various applications. The flip flop, capable of information storage for long periods of time, has the added advantage of being directly compatible with high speed diode logic circuits.

The Ransom Research Type 2XC Dual Shift Register Flip Flops has been designed for use as a bi-directional shift register or as a uni-directional, parallel entry register. Consisting of two RR Basic Flip Flops with gating logic on one PC card, a block diagram is illustrated above.

Each flip flop used on the Type 2XC unit is composed of two transistors cross coupled in the conventional Eccles-Jordan circuit. An amplifier transistor is connected to each side of the flip flop to provide power output and to give a short time delay between the input and the output. The delay is provided to permit use of the flip flop in circuits such as counters, shift registers or other configurations which may require simultaneous logic. The common emitters of the flip flop are biased to +3 volts, thereby providing noise discrimination of approximately 3 volts on input signals. In cases where the output of the standard Type 2XC does not supply enough gating power, use of the Type 2XC-H is recommended.

The Ransom Research Type 2XC Dual Shift Register Flip Flops is one of a series of RR dual flip flop Computer Elements available. The Type 2XA, for example, contains the same pair of flip flops, but is equipped with different input gating arrangements.

SPECIFICATIONS -- TYPE 2XC

DC Inputs: Set 0 and Set 1 provided for each flip flop as shown on the block diagram above, RR #A257.
Normal Level = Common to +2 volts
Set Level = +4 volts to +12 volts
Impedance (diode isolated) = 18K ohms to +15 volt clock pulse

CLOCK Inputs: Amplitude: +15 volts to +20 volts
Rise and Fall Times = 0.1 usec.
Pulse Width = 0.5 usec. nominal
Negative Overshoot = -6 volt nom.
Overshoot Return Time = 1 usec.
Frequency = 500KC nominal maximum

Outputs: F and $\overline{F}$ provided
0 Levels: F = Common
$\overline{F}$ = +6 volts
1 Levels: F = +6 volts
$\overline{F}$ = Common
Rise Time = 0.5 usec. nominal
Fall Time = 0.1 usec. nominal
Loading: 2.0 ma. to +12 volts
0.2 ma. to Common
50 uuf. maximum

Power: +12 volts @ 9.5 milliamperes
+3 volts @ -3.5 milliamperes
Common
-12 volts @ -0.4 milliamperes
±2% voltage regulation required

Options: The Type 2XC is also available as the Type 2XC-H for maximum load limits of 20 ma. & 2 ma. above

PNP Units: Where necessary, the Type 2XC may be supplied with 8 PNP transistors for circuit compatibility.

Physical: Standard RR 4½" x 5" circuit card
Connector = 22-pin PC connector
Operating Temperature: 0°C - 50°C

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TECHNICAL BULLETIN C-40
TErminal 2-6848

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

NOR LOGIC

RANSOM RESEARCH NOR LOGIC

In addition to our standard line of diode logic and associated flip flops, etc., Ransom Research also produces the "Series N3" Logical Elements using resistors instead of diodes for the basic logic element. This is the so called NOR logic. The principal advantage of this logic is its low cost and simplicity, while the main disadvantage is the relatively slow operating frequency compared to diode AND-OR logic and DCTL. Standard Ransom Research NOR logic is conservatively rated for operation at 50KC; special transistors may be used to appreciably increase this maximum operating speed.

The NOR logic element is, in itself, sufficient to solve all logical problems. It has the added advantage of automatically including power gain, and hence a pair of NOR logic elements may be connected to form the conventional RS type flip flop. Since NOR logic does not include time delays, the triggered, or binary, flip flop requires the addition of these delay times to the NOR elements.
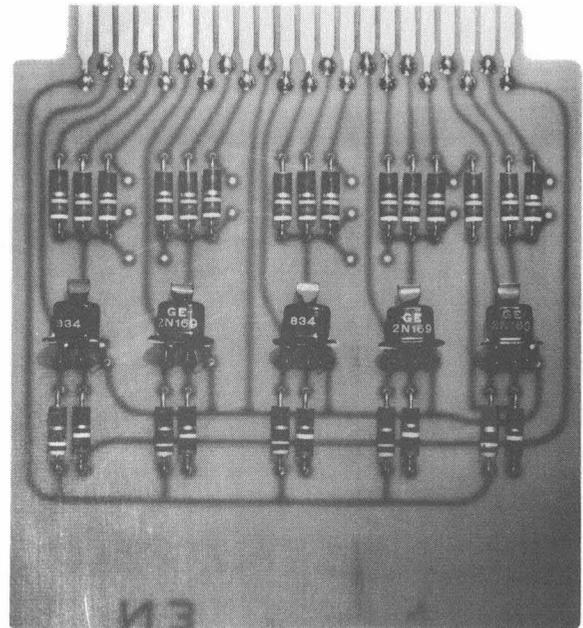
GENERAL DESCRIPTION

Transistor NOR circuits are specially designed to take advantage of the low power requirements and relatively low cost of the transistor. This logic employs a reliable and stable transistor circuit, resulting in a single logical element able to solve all logical equations. The basic circuit, shown in Figure 1, employs an NPN junction transistor in the common emitter configuration. This transistor is operated as a switch: when the input voltage exceeds a certain minimum, for NPN transistors a positive voltage, the transistor switches from the cutoff state to saturation. While the transistor is in the cutoff state, the collector to emitter impedance is very high, and therefore the output level (unloaded) is essentially the supply voltage. The output impedance in this condition is therefore the collector load resistance. When the transistor is in the saturated condition, on the other hand, the collector to emitter impedance becomes quite low, and the output is clamped at the emitter voltage. The output impedance of the transistor in this condition is a function of the beta and maximum collector current; for some transistors this may be as low as several ohms, or even tenths of ohms. The NOR circuit may be designed for either NPN or PNP transistors, depending on the system requirements.

As mentioned above, combinations of NOR logic elements are able to express all logic equations with the exception of time delays. Thus equations written in the conventional AND, OR and NOT form may be implemented entirely with NOR elements. Further, the solution of some logical equation does not necessarily require more NOR elements than the conventional English, or diode AND-OR, logic. The NOR element has the advantage of signal regeneration without the addition of emitter followers and the like; when used properly, the NOR element will provide a simple, very reliable tool for the solution of logical problems.

Ransom Research NOR logic elements are available with either NPN or PNP transistors, and a variety of standard RR Computer Element printed circuit cards provide NOR logic elements with a choice of 2, 3 or 6 inputs to each element; in addition special units are available for special applications. Where the use of our standard printed circuit cards is contemplated, we are happy to offer advice as to the most effective combination of RR Computer Elements to meet a specific requirement. There is no charge for this service.

The following are the specifications for the Ransom Research basic NPN NOR logic element:

Operating Frequency: 50KC nominal maximum

Input Signals: 0 = Common to +2 volts
1 = +7 volts to +16 volts

Input Impedance: 33K ohms to Common

Number of Inputs: 6 maximum per NOR element

Output Signals: 0 = Common
1 = +12 volts to +7 volts

Output Impedance: 3.9K ohms to +12 volts

Output Loading: The unit may be loaded by as many as 6 NPN NOR element inputs or an equivalent of 5.6K ohms to Common. This will maintain required output levels.

Supply Voltages: +12 volts @ 3 ma.
Common
-12 volts @ 80 ua.

Circuit Diagram: Figure 1

The following are the specifications for the Ransom Research basic PNP NOR logic element:

Operating Frequency: 50KC nominal maximum

Input Signals: 0 = Common to -2 volts
1 = -7 volts to -16 volts

Input Impedance: 33K ohms to Common

Number of Inputs: 6 maximum per NOR element

Output Signals: 0 = Common
1 = -12 volts to -7 volts
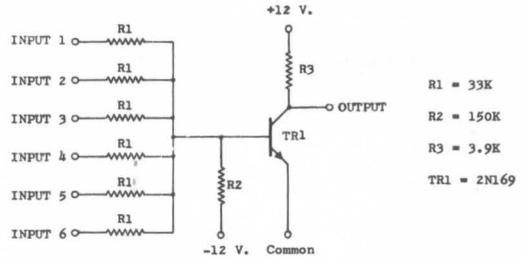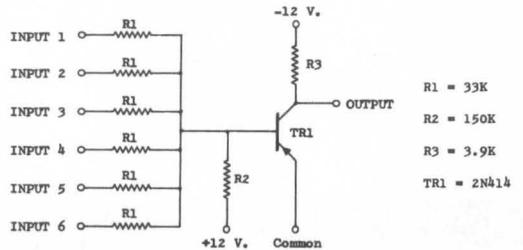
Output Impedance: 3.9K ohms to -12 volts

Output Loading: The unit may be loaded by as many as 6 PNP NOR element inputs or an equivalent of 5.6K ohms to Common. This will maintain required output levels.

Supply Voltages: -12 volts @ 3 ma.
Common
+12 volts @ 80 ua.

Circuit Diagram: Figure 2

APPLICATION OF THE NOR LOGIC ELEMENT

Logically, the NOR logic element may be considered as the conventional OR gate and an inverter in series. Thus, an output signal is present only if NO input signals are present; similarly, no output signal is present when ANY input signal is present. If we let "n" represent the NOR operation and "+" represent the AND operation, and if A, B, C, etc. are inputs, then $\overline{X}$, the output from the NOR element, may be expressed as:

$$\overline{X} = A \, n \, B \, n \, C \, n \ldots = \overline{A} + \overline{B} + \overline{C} + \ldots$$

where $\overline{A}$, for example, is the inverse of A.

Two NOR logic elements may also be connected to form a conventional RS type flip flop as shown in Figure 3. Any of the leads S_1, S_2 may be used to set the flip flop, and any of the leads R_1, R_2 may be used to reset the flip flop.

Figure 4 illustrates, in block diagram form, the circuits of the Type N3 and Type N3-P Logical Elements. This unit consists of five NOR elements with three inputs to four elements and two inputs to one element. A third optional input is shown dotted to the fifth NOR element.

Figure 5 illustrates, in block diagram form, the circuits of the Type N3A and Type N3A-P Logical Elements. This unit consists of three NOR logic elements with six inputs to two elements, and two inputs to one element. A third optional input is shown dotted to the third NOR element.
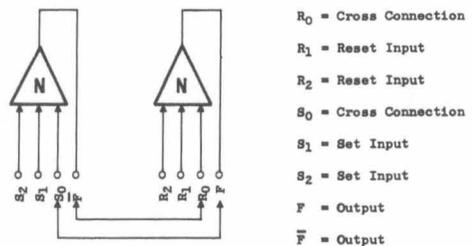
Figure 1

Figure 2

R_0 = Cross Connection
R_1 = Reset Input
R_2 = Reset Input
S_0 = Cross Connection
S_1 = Set Input
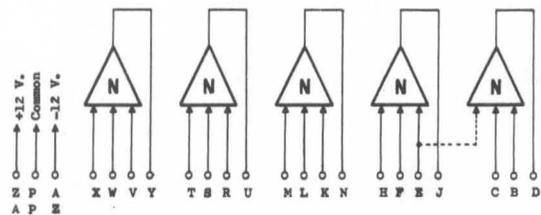S_2 = Set Input
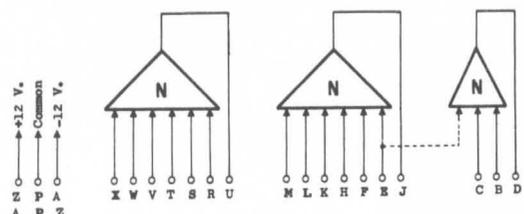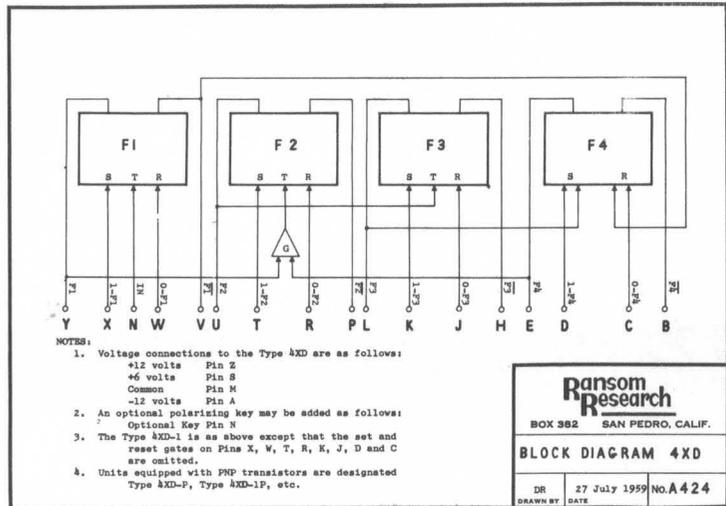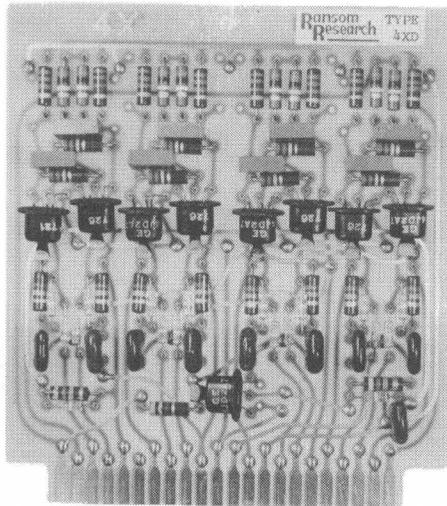F = Output
$\overline{F}$ = Output

Figure 3

Figure 4

Figure 5

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R R

TECHNICAL BULLETIN C-45

TErminal 2-1128

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Type 4XD Decade Counter

NOTES:
1. Voltage connections to the Type 4XD are as follows:
   +12 volts   Pin Z
   +6 volts   Pin S
   Common   Pin M
   -12 volts   Pin A
2. An optional polarizing key may be added as follows:
   Optional Key Pin N
3. The Type 4XD-1 is as above except that the set and reset gates on Pins X, W, T, R, K, J, D and C are omitted.
4. Units equipped with PNP transistors are designated Type 4XD-P, Type 4XD-1P, etc.

Ransom Research
BOX 382   SAN PEDRO, CALIF.
BLOCK DIAGRAM 4XD
DR | 27 July 1959 | No. A424
DRAWN BY | DATE

GENERAL DESCRIPTION

The Ransom Research Type 4XD Decade Counter consists of four binary flip flops arranged as a counter. In order to provide operation as a divide by ten circuit or decade, a transistor gate is provided to reset the unit as the tenth count is received. In this manner the outputs from the Type 4XD are provided in standard 1-2-4-8 binary code for use with RR Projection Displays, etc.

The RR Type 4XD Decade Counter is also provided with Set 0 and Set 1 inputs to each of the four flip flops. These inputs allow the counter to be preset to any given number before or after actual counting; the preset operation may either be done manually or electronically.

The following table will show the operation of the RR Type 4XD Decade Counter:

#	F1	F2	F3	F4
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
0	0	0	0	0

where a 0 indicates that the flip flop is in the 0 condition and a 1 indicates that the flip flop is in the 1 condition. Both outputs from each of the flip flops is available for external use.

The Ransom Research Type 4XD Decade Counter is one of a new series of RR quadruple flip flop Computer Elements now available to provide inexpensive digital storage and counters also compatible with high speed Computer Elements.
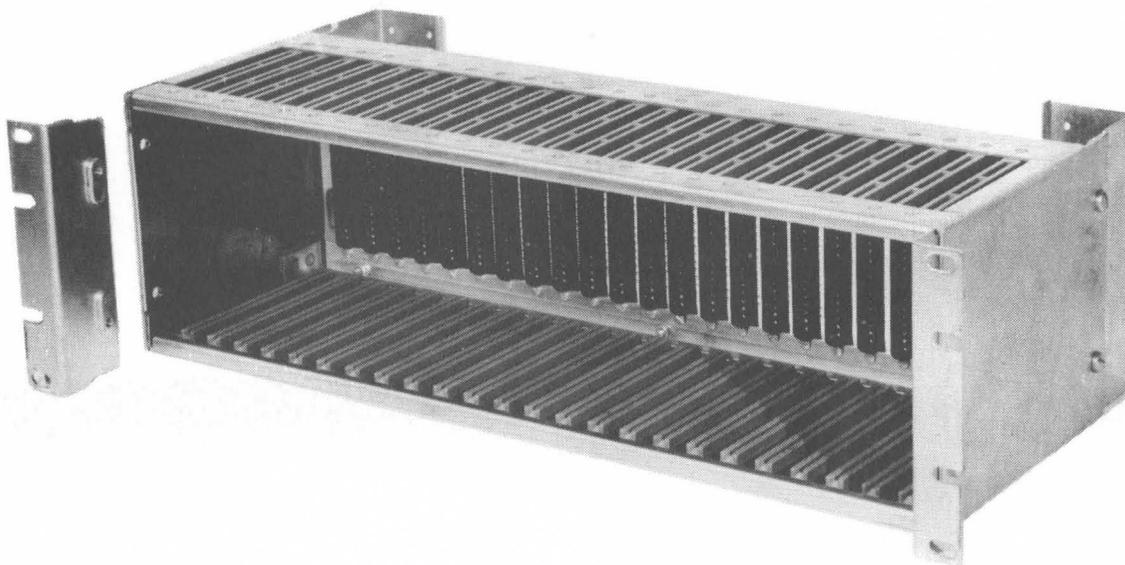
SPECIFICATIONS -- TYPE 4XD

Input:
Negative pulse or square wave
Frequency = 100KC nominal maximum
6 volt minimum amplitude
1.0 microsecond fall time maximum
Impedance = 390 uuf. to Common

R & S Inputs:
Eight provided: 0-F1, 1-F1, etc.
Normal Level = +2 to +6 volts
Set Level = -2 to -4 volts
Impedance (diode isolated) = 12K ohms to Common.
R Inputs reset to 0 condition
S Inputs set to 1 condition

Outputs:
F & F̄ provided for each flip flop
0 Levels: F = Common
            F̄ = +12 volts
1 Levels: F = +12 volts
            F̄ = Common
Output levels above are unloaded.
Rise Time = 0.5 usec. nominal
Fall Time = 1.0 usec. nominal
Loading: 2.5 ma. to +12 volts
           0.5 ma. to Common
           600 uuf. max. to Common
F4 drives succeeding decade

Power:
+12 volts @ 24.0 milliamperes
+6 volts @ -0.12 milliamperes
Common
-12 volts @ -3.8 milliamperes

Options:
The Type 4XD is also available as the Type 4XD-1, and is supplied less the R and S Input diodes.

PNP Units:
Where necessary, the Type 4XD may be supplied with 9 PNP transistors for circuit compatibility.

Physical:
Standard RR 4½" x 5" circuit card
Connector = 22-pin PC connector
Operating Temperature: 0°C - 50°C

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

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TECHNICAL BULLETIN C-39A

TErminal 2-6848

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Ransom Research Card Files

The Ransom Research Card Files are specifically designed to mount standard RR $4\frac{1}{2}$" x 5" Computer Elements printed circuit cards. Two types of Card File are available: the Type R-1 Card File will mount up to 24 printed circuit cards on 11/16" centers; and the Type R-2 Card File will mount up to 29 printed circuit cards on 9/16" centers. These Card Files may also be used to mount any $4\frac{1}{2}$" wide printed circuit card having a length of no more than $5\frac{1}{2}$"; in addition special arrangements may be made to accept cards having a length between $5\frac{1}{2}$" and 7". Each printed circuit card is guided to its connector by a high impact styrene slider that also provides lateral support against high vibration and shock. Connections to the printed circuit cards are by means of standard 22 pin printed circuit connectors; two types of these connectors are available as standard equipment: soldered contacts for units with permanent wiring, and AMP Taper Pin contacts for prototype units or breadboards.

RR Card Files are supplied with two Type A236 Mounting Flanges, and two Type A278 Connector Brackets as standard equipment. Special brackets are available for the Winchester "Series MRE" connectors, as described below. Standard units allow for the removal of the cards from the panel side of the unit. Where it is required to remove the cards from the rear, add the letter "R" to the type designation. Standard units plated steel; for aluminum add "L".

<u>Type R-1 Card File</u>: less printed circuit connectors.

<u>Type R-1A Card File</u>: with 22 pin printed circuit connectors for soldered connections.

<u>Type R-1K Card File</u>: with 22 pin printed circuit connectors for Taper Pin connections.

<u>Type R-2 Card File</u>: less printed circuit connectors.

<u>Type R-2A Card File</u>: with 22 pin printed circuit connectors for soldered connections.

<u>Type R-2K Card File</u>: with 22 pin printed circuit connectors for Taper Pin connections.

PHYSICAL SPECIFICATIONS

Panel Space:	$5\frac{1}{4}$"
Width:	$17\frac{1}{2}$" less all brackets
Mounting:	19" Relay Rack
Depth:	$6\frac{1}{4}$" less all brackets
	7" with 2 Type A236
	$8\frac{1}{2}$" with 2 Type A236 and 2 Connector Brackets.

MOUNTING FLANGES FOR RR CARD FILES

Type A236 — 2 required per Card File for mounting to standard 19" relay rack.
Special types available on request.

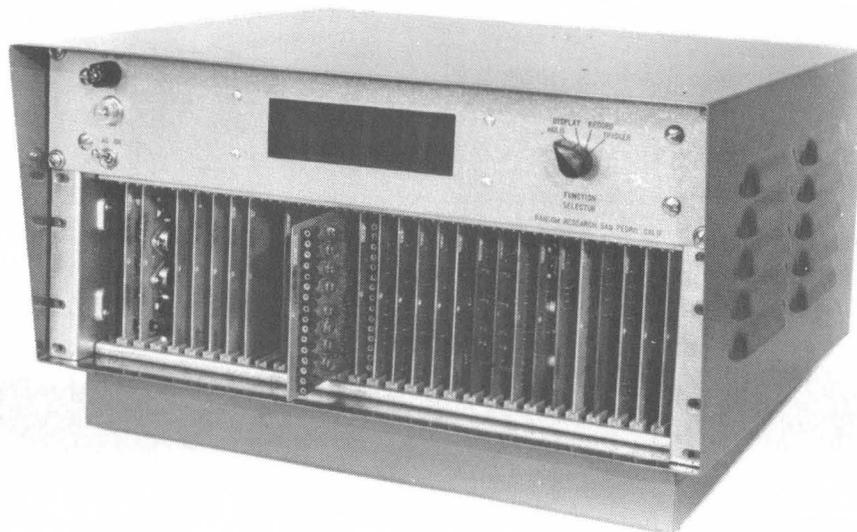CONNECTOR BRACKETS FOR RR CARD FILES

Type A278	1 1/8" x 3 23/32" cutout
Type A279	1 – MRE 26S-G cutout
	2 – MRE 9S-G cutouts
Type A311	1 – MRE 50S-G cutout
	1 – MRE 9S-G cutout

Special types available on request.

Series 300 A/D Converters

TypicalSeries 300 A/D Converter
shown with front panel removed.

GENERAL DESCRIPTION

The Ransom Research Model 301 Analog to Digital Converter is a precision instrument designed primarily for data processing and instrumentation applications. The Model 301 will convert any input voltage with a full scale input of -0.999 volts to three decimal digits with an overall accuracy of plus or minus two digits, or an equivalent of plus or minus two millivolts. The conversion time of the instrument is a constant value of 1.0 milliseconds, and is controlled by an internal multivibrator and associated timing and control circuitry. Various optional features are available for the Model 301 to provide the maximum in flexibility and compatibility for all types of digital and control applications.

The Model 301 is a basic Analog to Digital Converter designed to operate as the heart of some Analog to Digital System; this instrument, along with the optional equipment also available, is capable of operation in many modes and in conjunction with other digital equipment ranging from high speed magnetic tape systems to simple printers, from general purpose computers to a simple visual display. The use of amplifiers and/or attenuators at the input to the Model 301 Analog to Digital Converter will permit its use over a wide range of input amplitudes. Operation of the instrument may also be synchronized with some external clocking signal where required.

The Model 301 Analog to Digital Converter is composed of a number of all transistorized Ransom Research Computer Elements mounted on our standard printed circuit cards and supported in our Card Files. This modular construction permits the addition of many optional features without the usual "custom instrument" costs, and provides high reliability and ease of maintenance. The basic instrument, the Model 301 Analog to Digital Converter, consists of 3 principal sections, the Digital to Analog Converter, the Error Amplifier, and the Control Logic and Storage; these various sections are described below. The instrument is arranged so that at the end of a given

conversion the digital information retained in the Storage represents the input analog voltage. The outputs from this storage then provide a 1-2-4-8 binary coded decimal parallel output from the instrument which is then fed to the read equipment. The Model 301 also contains all required power supplies and reference voltages and is designed for mounting in a standard 19" relay rack.

The specifications of the Model 301 Analog to Digital Converter are as follows:

Input Voltage:	-0.999 volts for full scale reading (999).
Input Impedance:	5,500 ohms to ground.
Conversion Time:	1.0 ms. for any input.
Conversion Accuracy:	± 2 digits = $\pm 0.2\%$ of f.s.
Resolution:	1 part in 1000
Parallel Output:	3 decimal digits with 1-2-4-8 code on 12 output lines.
Output Levels:	0 = 0 volts; 1 = +6 volts
Output Loading:	22K ohms maximum

OPERATION -- MODEL 301

Figure 1 illustrates the block diagram of the Ransom Research Model 301 Analog to Digital Converter. Twelve conventional flip flops mounted on 3 RR printed circuit cards provide three decimal digits of storage for the instrument. These flip flops control the Hundreds, Tens and Units Digital to Analog (D/A) Converters; these converters generate analog voltages that correspond to the digital information in the Storage section. The outputs from the D/A converters are fed to the Error Amplifier where they are combined and then compared to the Analog Input. If the output from the D/A Converters is greater than the Analog Input, then a RESET signal is generated and fed to the Control Logic. It is the function of the Control Logic to sort out these signals and to direct them to the proper flip flop. The result is a closed

```
                    ┌─────────────────────┐
                    │  ERROR AMPLIFIER    │◄──────────────○ Analog Input
                    └─────────────────────┘

┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│ HUNDREDS CONVERT.│  │  TENS CONVERTER  │  │  UNITS CONVERTER │
└──────────────────┘  └──────────────────┘  └──────────────────┘
                                                        ○
                                                        ○  Outputs

┌──────────────────┐  ┌──────────────────┐  ┌──────────────────┐
│ HUNDREDS STORAGE │  │  TENS STORAGE    │  │  UNITS STORAGE   │
│    TYPE 4XA      │  │    TYPE 4XA      │  │    TYPE 4XA      │
└──────────────────┘  └──────────────────┘  └──────────────────┘

            ┌───────────────────┐
            │   CONTROL LOGIC   │────○ GATE
            └───────────────────┘
```

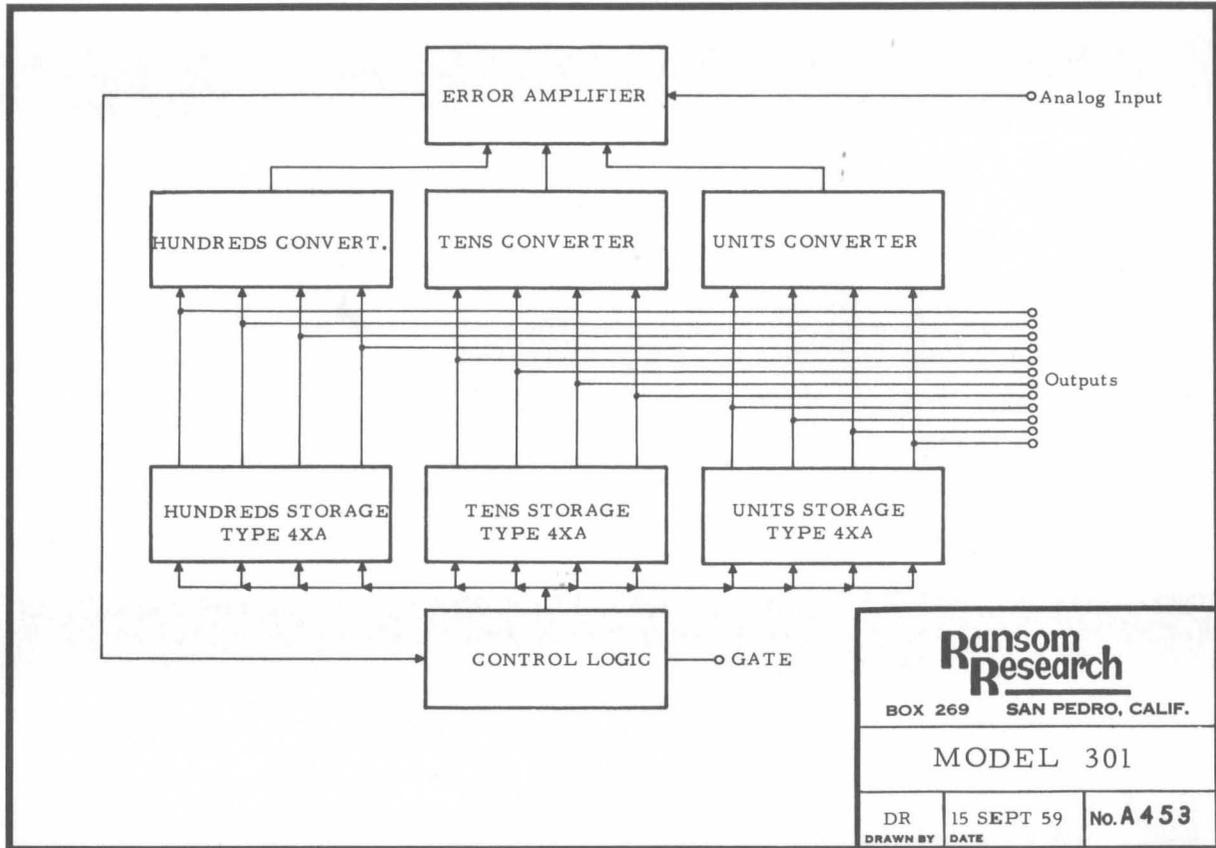|	
Ransom Research	
BOX 269 SAN PEDRO, CALIF.	
MODEL 301	
DR / DRAWN BY	15 SEPT 59 / DATE No. A453

Figure 1. Block Diagram, Model 301 A/D Converter

loop digital/analog system that will correctly select the digital information to represent the Analog Input.

The operation of the instrument is according to a fixed logic program or pattern wired into the Control Logic section. At the start of a given measurement, the Control Logic causes the most significant bit (8) of the hundreds storage to be set to the "1" condition. This will cause a signal to be generated in the D/A Converters that is the equivalent of an Analog Input of -0.500 volts. If the Analog Input is greater or equal to this amount, then the Error Amplifier will not generate an output signal. If, on the other hand, the Analog Input is less than -0.500 volts, then the Error Amplifier will generate a RESET signal which, after being directed by the Control Logic, will cause the 8 bit of the hundreds storage to be reset to the "0" condition. Following this, the 4 bit of the hundreds storage will be set to the "1" condition and the same procedure followed until the 1 bit of the units storage has been checked.

This type of measurement, commonly known as successive approximation, is particularly useful with other digital equipment because the time of measurement is constant, regardless of the Analog Input. This means that the Model 301 may easily be synchronized with its associated digital equipment.

During each conversion, a period of approximately 65 microseconds is allotted to each of the 12 bits that are sampled; thus, the actual conversion is made in approximately 780 microseconds. Following the conversion, a pause of 65 microseconds is generated, and then a gate of 65 microseconds, a second

pause of 65 microseconds, and then a final period of 65 microseconds for the instrument reset. The GATE signal indicates to the external read equipment that the information retained in the Storage section is complete and represents the Analog Input. In cases where this gate time must be of longer duration, measure and hold optional equipment is available, as well as buffer storage units for intermediate storage of the information from a conversion. Additional information on optional features available with the Model 301 Analog to Digital Converter is given below.

SERIES 300 D/A CONVERTERS

Model 301 A/D Converter, as described above.

Model 301A A/D Converter:

The Ransom Research Model 301A Analog to Digital Converter has identical specifications to the Model 301 above, except that provision for overcount readout has been included. Thus the Model 301A will read and encode any analog input voltage up to -1.599 volts directly. This instrument has, in addition to the standard 12 output lines, an additional output line for the "0" or "1" in the fourth digit. All other features are the same as for the Model 301.

Model 301B A/D Converter:

The Model 301B Analog to Digital Converter is essentially the same as the Model 301 except

SERIES 300 CONVERTERS (continued)

that instead of providing binary coded decimal outputs from the converter, ten bits of straight binary information is presented at the output. Accuracy of this binary instrument is plus or minus two digits (approximately $\pm 0.2\%$) with a resolution of one part in 1024. The analog input, with an impedance of 7040 ohms, is arranged so that readings are encoded in increments of one millivolt, and full scale input is -1.023 volts. Operation of the instrument is the same as the Model 301.

Model 302 A/D Converter:

The Model 302 A/D Converter is a high speed converter designed to encode in a total time of 400 microseconds, permitting measurements at the rate of 2500 per second. The input impedance for this instrument is 2750 ohms for -0.999 volts full scale. All other specifications are identical to the Model 301 above.

Model 302A A/D Converter:

The Model 302A A/D Converter is a high speed converter designed to encode in a total time of 400 microseconds, permitting measurements at the rate of 2500 per second. The input impedance for this instrument is 2750 ohms for -1.599 volts full scale. All other specifications are identical to the Model 301A above.

Model 302B A/D Converter:

The Model 302B A/D Converter is a high speed binary converter designed to encode in a total time of 400 microseconds, permitting measurements at the rate of 2500 per second. The input impedance for this instrument is 3520 ohms for -1.023 volts full scale. All other specifications are identical to the Model 301B above.

OPTIONAL EQUIPMENT

Measure and Hold Logic:

The addition of "Measure and Hold" logic to the Series 300 Analog to Digital Converters will permit the operation of the instrument in four modes controlled by two external logic lines: Hold, Display, Record, and Trigger. In the Hold mode, the information from the last measurement will be held in the storage section of the converter indefinitely. In the Display mode, the instrument will perform conversions every 100 milliseconds, allowing the information to be displayed on a visual display (such as the RR Series 320 Projection Displays); in this mode, the instrument is performing a conversion for 1 millisecond or less, and provides steady outputs for the display for 100 milliseconds. In the Record mode, the instrument is operated at maximum rate, with no pause between conversions. In the Trigger mode, the instrument will perform a conversion on receipt of a TRIGGER command (normal = 0 volts, Trigger = +6 to +12 volts). In order to have a converter equipped with the "Measure and Hold" logic, add the letter "H" to the model number of the converter desired.

Parallel Readout Amplifiers:

The addition of Parallel Readout Amplifiers to the Series 300 Analog to Digital Converters will permit considerably greater loading of the parallel output lines, and prevents inadvertent excessive loading of the output lines from affecting the operation of the converter. With the Parallel Readout Amplifiers equipped, the output lines may be loaded by as much as 1K

ohms to ground. Output levels and polarities are the same as for the standard converter. In order to have a converter equipped with the Parallel Readout Amplifiers, add the letter "P" to the model number of the converter desired.

Serial Readout Logic:

The addition of "Serial Readout" logic to the Series 300 Analog to Digital Converters will permit the instrument to feed serial information directly to computers and other high speed data processing equipment as the measurement is made. The Serial Readout logic provides that immediately after each bit of the result is determined during the conversion, that bit is fed to the serializing logic and presented at the serial output. Therefore, no additional time is required for the parallel to serial conversion. Information is presented in standard 8-4-2-1 format, with the most significant bit of the most significant digit appearing first. Coincident with the serial output of the instrument, a timing output is generated which contains a train of pulses with each pulse used to locate each of the bits of the serial output. Thus, in the case of the Model 301 A/D Converter, 12 pulses would appear on the timing output locating in time each of the 12 bits in the serial output. In the case of straight binary instruments such as the Model 302B, only 10 pulses would appear. In order to have a converter supplied with the "Serial Readout" logic, add the letter "R" to the model number of the converter desired.

Projection Display and Printer Options:

Ransom Research Series 320 Projection Displays are available for use with the Series 300 A/D Converters. The Model 323 Projection Display is for use with the Model 301 and 302 Converters, and provides for the display of three decimal digits. The Model 324 Projection Display is for use with the Model 301A and 302A Converters, and provides for the display of four decimal digits. In order to provide for sufficient time for the display to light properly, it is necessary to also provide the Measure and Hold logic on converters designed to be used with displays. In order to have a converter equipped for a projection display, add the letters "DH" to the model number of the converter desired.

Ransom Research Series 310 Digital Printers are also available in three and four digit models that may be used with the Series 300 A/D Converters. Any converter which may be used with a digital printer will require the addition of the Measure and Hold logic.

OTHER RANSOM RESEARCH DIGITAL EQUIPMENT

In addition to the Analog to Digital Converters described in this Technical Bulletin, Ransom Research manufactures a complete series of all transistorized Computer Elements ranging from slow speed NOR logic and storage flip flops to the one megacycle series of flip flops and counters. These Computer Elements may be used to solve all types of digital problems and data processing requirements. Alternately, Ransom Research will design and construct such systems to customer specifications.

Ransom Research invites your inquiries concerning possible applications for our digital equipment and Computer Elements to solve your problems.

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CONSULTING ENGINEERS
TRANSISTOR CIRCUIT SPECIALISTS

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EFFECTIVE DEC. 15, 1959

TERMINAL 2-1128

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RANSOM RESEARCH LOGICAL GATING CIRCUITS, PRICE LIST

Type	Description	1 - 9 Price
	Diode Gating Circuits for 250KC Operation:	
A2-6	Six 2-input AND Gates	19.00
A2-06	Six 2-input OR Gates	19.00
A3-5	Five 3-input AND Gates	21.00
A3-05	Five 3-input OR Gates	21.00
A4-4	Four 4-input AND Gates	22.00
A4-04	Four 4-input OR Gates	22.00
A5-3	Three 5-input AND Gates	21.00
A5-03	Three 5-input OR Gates	21.00
	Diode Gating Circuits for 1 Megacycle Operation:	
A2-6M	Six 2-input AND Gates	24.00
A2-06M	Six 2-input OR Gates	24.00
A3-5M	Five 3-input AND Gates	26.00
A3-05M	Five 3-input OR Gates	26.00
A4-4M	Four 4-input AND Gates	27.00
A4-04M	Four 4-input OR Gates	27.00
A5-3M	Three 5-input AND Gates	26.00
A5-03M	Three 5-input OR Gates	26.00
	NOR Logic Circuits for 50KC Operation:	
N3-5	Four 3-input NPN NOR Gates, one 2-input NPN NOR Gate	27.00
N3-5P	Four 3-input PNP NOR Gates, one 2-input PNP NOR Gate	27.00
N4-4	Three 4-input NPN NOR Gates, one 3-input NPN NOR Gate	23.50
N4-4P	Three 4-input PNP NOR Gates, one 3-input PNP NOR Gate	23.50
N5-3	Three 5-input NPN NOR Gates	20.00
N5-3P	Three 5-input PNP NOR Gates	20.00
N6-3	Two 6-input NPN NOR Gates, one 4-input NPN NOR Gate	20.00
N6-3P	Two 6-input PNP NOR Gates, one 4-input PNP NOR Gate	20.00

ORDERING INFORMATION

All Diode Gating Circuits are normally supplied for positive logic levels, where 0 = 0 volts and 1 = +6 to +12 volts. In cases where negative logic levels (0 = 0 volts, 1 = -6 to -12 volts) are to be used, add the letter "P" to the appropriate type designation above. All units are supplied on standard Ransom Research $4\frac{1}{2}$" x 5" printed circuit cards for use with 22-pin printed circuit connectors.

Quantity Discounts: 10-24, less 5%; 25-99, less 10%; 100 and up, less 15%.

All prices f.o.b. San Pedro, California. Prices and specifications subject to change without notice.

PRICE LIST PL-29

Ransom Research

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TErminal 2-6848

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RANSOM RESEARCH COMPUTER ELEMENTS PRICE LIST

Type	Description	1-9 Price
2ST	2 Schmidtt Triggers, 500KC operation	$ 57.50
2XA	Logical Control Circuit, 2 Flip Flops with std. gates	62.50
2XB	Dual Flip Flops with input gating	67.50
2XC	Dual Bi-Directional Shift Register Flip Flops	71.50
4XA	4 Flip Flops with SET line, 100KC operation	55.00
4XA-1	4 Flip Flops, 100KC operation	47.50
5A	5 Shaper Amplifiers	46.50
5AI	5 Amplifiers-Inverters, positive input signals	55.50
5NA	5 Amplifiers-Inverters, negative input signals	55.50
5PB-301	5 Power Amplifiers, low frequency	98.50
5PB-553	5 Power Amplifiers, medium frequency	144.50
5SS	5 Single Shot Multivibrators	62.00
8AG	8 Shift Gates	35.50
A3	Series A3 Logical Gating Circuits	Request PL-23
A4	Series A4 Logical Gating Circuits	Request PL-23
BDC	Binary Decimal Counters	Request PL-24
BT	Buffer Transistors, 10 sections	36.50
BT-1	Buffer Transistors, 8 sections	31.50
EL	Input Amplifiers and Shapers	73.00
FTO	Transistorized Tuning Fork & Driver	92.50
I	Decimal Indicator Unit	69.00
I2	Binary Indicator Unit	21.00
KE-100	Crystal Controlled Oscillator, 100KC	85.00
KE-200	Crystal Controlled Oscillator, 200KC	80.00
MPR	Master Power Regulator	87.00
N3	50KC NPN NOR Logical Element	24.00
N3-P	50KC PNP NOR Logical Element	24.00
N3A	50KC NPN NOR Logical Element	17.00
N3A-P	50KC PNP NOR Logical Element	17.00
PRF-TD	Flip Flop with reset, preset and time delay circuits	52.50
RM-1	Readout Matrix, for use with Type PD Display, etc.	74.00
RPS	Regulated Power Supply	112.00
RPS-1	Regulated Power Supply, less -6 volt output	98.50
TCG-1	Transistorized Clock Generator, w/ 1 ampl; 250KC operation	81.50
TCG-2	Transistorized Clock Generator, w/ 2 ampl; 250KC operation	98.50
TCG-3	Transistorized Clock Generator, w/ 3 ampl; 250KC operation	118.50
TEF	Ten NPN Emitter Followers	53.50
TEF-P	Ten PNP Emitter Followers	53.50
UPS	Unregulated power supply (+16, Com, -16; 0.5 amp. max.)	47.50
CR	Extension Plug	7.50
SP	Blank printed circuit card with etched connector	5.00

Quantity Discounts: 10-24, less 5%; 25-99, less 10%; 100 and up, less 15%.

All prices f.o.b. San Pedro, California. Prices and specifications subject to change without notice.

PRICE LIST PL-25A

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TERMINAL 2-1128

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

RANSOM RESEARCH CARD FILE PRICE LIST

Type	Description	1 - 9 Price
R-1	24 Slot Card File supplied less connectors. Construction: plated steel.	$ 40.00
R-1A	24 Slot Card File supplied with connectors for soldered wiring. Construction: plated steel.	85.00
R-1K	24 Slot Card File supplied with connectors for taper pin wiring. Construction: plated steel.	160.00
R-2	29 Slot Card File supplied less connectors. Construction: plated steel.	45.00
R-2A	29 Slot Card File supplied with connectors for soldered wiring. Construction: plated steel.	90.00
R-2K	29 Slot Card File supplied with connectors for taper pin wiring. Construction: plated steel.	180.00
R-1L	24 Slot Card File supplied less connectors. Construction: anodized aluminum.	45.00
R-1AL	24 Slot Card File supplied with connectors for soldered wiring. Construction: anodized aluminum.	90.00
R-1KL	24 Slot Card File supplied with connectors for taper pin wiring. Construction: anodized aluminum.	165.00
R-2L	29 Slot Card File supplied less connectors. Construction: anodized aluminum.	50.00
R-2AL	29 Slot Card File supplied with connectors for soldered wiring. Construction: anodized aluminum.	100.00
R-2KL	29 Slot Card File supplied with connectors for taper pin wiring. Construction: anodized aluminum.	185.00

Ransom Research Card Files are normally supplied with cards removed from the panel side. Where it is desired to remove cards from the rear, add the letter "R" to the appropriate type designation above.

NOTE: All Ransom Research Card Files are normally supplied equipped with two Type A236 Mounting Flanges for relay rack mounting. Connector Brackets are also available for mounting connectors for external wiring; these items are available separately:

A236	Single Mounting Flange, price per pair:	5.00
A247	Dual Mounting Flange, for mounting two standard Card Files as an integral unit, price per pair:	10.00
A278	Connector Bracket with 1 1/8" x 3 23/32" cutout.	2.50
A279	Connector Bracket for 1 MRE 26 and 2 MRE 9 connectors.	4.00
A311	Connector Bracket for 1 MRE 50 and 1 MRE 9 connectors.	4.00

Quantity Discounts: 10-24, less 5%; 25-99, less 10%; 100 and up, less 15%.

All prices f.o.b. San Pedro, California. Prices and specifications subject to change without notice.

Ransom Research

CONSULTING ENGINEERS
TRANSISTOR CIRCUIT SPECIALISTS

R R

EFFECTIVE DEC 1, 1959

TErminal 2-6848

BOX 269 ● 323 WEST SEVENTH STREET ● SAN PEDRO, CALIFORNIA

RANSOM RESEARCH SERIES 300 ANALOG TO DIGITAL CONVERTERS PRICE LIST

Model	Description	Price
301	Converter, Basic Unit, Binary Coded Decimal, Input Voltage 0 to 0.999 volts 1,000 conversions per second 12 line parallel output without amplifiers	$1,550.00
301A	Converter, Basic Unit, Binary Coded Decimal, Input Voltage 0 to 1.599 volts 1,000 conversions per second 13 line parallel output without amplifiers	1,600.00
301B	Converter, Basic Unit, Binary Input Voltage 0 to 1.023 volts 1,000 conversions per second 10 line parallel output without amplifiers	1,500.00
302	Converter, Basic Unit, Binary Coded Decimal, Input Voltage 0 to 0.999 volts 2,500 conversions per second 12 line parallel output without amplifiers	1,950.00
302A	Converter, Basic Unit, Binary Coded Decimal, Input Voltage 0 to 1.599 volts 2,500 conversions per second 13 line parallel output without amplifiers	2,000.00
302B	Converter, Basic Unit, Binary Input Voltage 0 to 1.023 volts 2,500 conversions per second 10 line parallel output without amplifiers	1,900.00

Optional Equipment

Measure and Hold Logic	50.00
Serial Read Out	165.00
Buffer Amplifiers for parallel read out	100.00
Series 320 Projection Displays Model 323 - 3 digits for Models 301 & 302	350.00
Model 324 - 4 digits for Models 301A & 302A	490.00

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