

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO ELECTRICAL SIGNALLING APPARATUS

(71) We, HEWLETT-PACKARD COMPANY, a corporation organised and existing under the laws of the State of California, United States of America, of 1501 Page Mill Road, Palo Alto, California 94304, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with improvements in or relating to signalling apparatus.

When designing and servicing equipment with integrated circuit logic modules, it is necessary for an engineer to know the logic states at various points in the equipment. Since these logic states are represented by discrete voltage levels which are present on the input and output leads of the integrated circuits the usual method of determining the states has been to use an oscilloscope or a voltmeter to measure the voltage on each lead. This method is slow and cumbersome, since only one or two leads at a time can be tested, and the engineer or operator must divert his attention away from the circuit under test to read the instrument. Also, since most logic circuits are binary in nature, the precise voltage is not important to the operator, because he desires to know only whether the voltage is above or below some given threshold value. Recently a probe has been made available which comprises a light source which is illuminated when the voltage is above the threshold and is not illuminated when the voltage is below. The probe overcomes some of the limitations of a voltmeter or oscilloscope, but one must still measure the voltage on the integrated circuit leads one by one, which is a slow process when there are many leads. In addition, each of the aforementioned instruments requires power from some external source.

It is an object of the present invention to

[Price 25p]

provide an improved electrical signalling apparatus.

The invention provides a signalling apparatus comprising a plurality of inputs, a reference signal line, a plurality of gates, one for each input and each gate being connected to its associated input and to the reference signal line to support current flow between the reference signal line and an input having a potential extremum applied thereto for connecting the input to which the potential extremum is applied to the reference signal line, and indicating means connected to each input and to the reference signal line for indicating the signal level on each input with respect to a predetermined threshold level.

In an apparatus according to the invention each gate may comprise a diode having a cathode electrode connected to its associated input and an anode electrode connected to the reference signal line, and the indicating means comprises a plurality of light-emitting diodes, one for each input, each light-emitting diode being connected to the reference signal line through means including a resistor and to its associated input through conducting means for conducting current through the light-emitting diode whereby emitting light in response to a potential on the input attaining a value greater than the threshold level.

In an apparatus according to the invention wherein the potential extremum is a lower extremum, the apparatus further comprising a supply line, each gate is preferably connected to the supply line to support current flow between the supply line and an input having a higher potential extremum applied thereto for connecting the input to which the higher potential is applied to the supply line. The indicating means is also preferably connected to the supply line. Each gate preferably comprises two diodes, a first one of which is connected between the input and the reference signal line and

has a cathode electrode connected to the input and the second of which is connected between the input and the supply line and has a cathode electrode connected to the supply line. The indicating means preferably comprises a plurality of threshold detectors, one for each input, each detector comprising an amplifier having an input connected to the associated one of the plurality of inputs, and having an output which acts as a current source when its input is above a predetermined potential and acts as a current sink when its input is below a predetermined potential, a plurality of driver amplifiers, one for each one of said plurality of inputs and each driver amplifier comprising an amplifier having an input connected to the output of the associated threshold detector and having an output which acts as a current sink when current flows into its input and acts as an open circuit when no current flows into its input, and a light emitting device for each one of said plurality of inputs, each device being connected to the supply line and the output of its associated driver amplifier for emitting light only when the driver amplifier output acts as a current sink. Preferably said plurality of inputs is physically arranged to allow electrical and mechanical connection to corresponding conductors of an integrated circuit package, and the light emitting devices are physically arranged in a pattern which bears a direct relationship to the physical arrangement of the conductors of the integrated circuit.

The output of each threshold detector of an apparatus according to the invention acts as a current source when its input is open circuited. Each light emitting device preferably comprises a light-emitting diode.

An apparatus according to the present invention is arranged to indicate the logic state on each lead or pin of an integrated circuit package simultaneously. The apparatus, in the form of a clip, can be fastened to an integrated circuit, and the light emitting diodes are connected to logic gates in the clip; there are preferably sixteen light emitting diodes, each of which is illuminated when the logic state on the lead or pin it represents is high or is on open circuit and is off otherwise. The light-emitting diodes are arranged in a pattern which bears a one-to-one correspondence with the physical arrangement of the leads on the integrated circuit package. An apparatus according to the present invention does not require an external power supply or external power leads to connect to a power source and does not require a battery. Accordingly, an apparatus according to the present invention incorporates a circuit which determines the power and ground leads on the integrated

circuit under test and uses some of the power on those leads to power itself.

There now follows a detailed description to be read with reference to the accompanying drawings of an apparatus, in the form of a logic clip, according to the invention which has been selected for description to illustrate the invention; it is to be clearly understood that the illustrative apparatus has been selected for description to illustrate the invention by way of example and not by way of limitation.

In the accompanying drawings:—

Figure 1 is a simplified schematic block circuit diagram of the illustrative apparatus according to the invention;

Figure 2 is a schematic circuit diagram of a logic state detectors used in the illustrative apparatus;

Figure 3 is a perspective view of the illustrative apparatus and of a dual in-line integrated circuit package.

Referring to Figure 1, there are sixteen inputs 10, each of which is connected to a decision gate network 12 and a threshold detector/amplifier 14. The detector/amplifier 14 drives a light-emitting device in the form of a light-emitting diode (LED) 16. Elements 10, 12, 14 and 16 comprise one logic state detector 22. The logic clip comprises sixteen logic state detectors 22 which share a common positive supply voltage line provided by a bus 18 and an earth line provided by an earthed bus 20. The decision gate network 12 decides whether its associated input 10 is connected to a ground, a supply or a logic lead on the integrated circuit. If this input 10 is connected to a supply lead, the decision gate network connects the input 10 to the supply bus 18, and all other logic state detectors 22 receive supply voltage from the supply bus 18 through that input 10. If the input 10 is connected to earth, the decision gate network connects the input 10 to the earthed bus 20, and all other logic state detectors 22 are connected to ground through the earthed bus 20 to that input 10. If that input 10 is connected to a logic lead the detector/amplifier 14 determines whether the input voltage is above or below a threshold level of 1.4 volts, and turns on the diode 16 if the input is on open circuit or is above 1.4 volts. Each logic clip also includes a reference voltage circuit 23 which is connected to the supply bus 18 and the earthed bus 20. The reference voltage circuit 23 supplies 2.1 volts to each detector/amplifier 14 through a reference bus 31.

Figure 2 shows a schematic diagram of one logic state detector 22. A diode 36 connected between its input 10 and the supply bus 18 and a diode 38 connected between the input 10 and the earthed bus 20 comprise the decision gate network 12. Which-

ever input 10 is highest in voltage will forward bias the diode 36 and will therefore be connected to the supply bus 18. Which-
ever input 10 is lowest in voltage will forward bias the diode 38 and will therefore
5 be connected to the earthed bus 20. Any input 10 with a logic level on its will be a few tenths of a volt higher than earth and lower than the supply voltage due to the way
10 integrated circuit logic circuits are designed, and therefore both diodes 36 and 38 will not be biased to conduction. Each logic state detector 22 is connected to each other detector and to the reference voltage circuit
15 at point 30 for supply voltage, at point 32 for the reference voltage, and at point 34 for earth. A transistor 40 operates as the threshold detector, with its emitter connected to input 10, its base connected to the supply bus 18 through a bias resistor 41, and its collector connected to the base of transistor 44. Transistors 42 and 44 provide the driver
20 amplifier of the diode 16. The diode 16 is connected between the supply bus 18 and the collector of the transistor 42 so that the diode 16 turns on when the transistor 42 is on or conducting. The base of the transistor 42 is connected to the reference bus 31 and therefore is always at the reference
25 voltage, i.e. 2.1 volts. The emitter of the transistor 42 is connected to the collector of the transistor 44 through a bias resistor 43 and the emitter of the transistor 44 is connected to the earthed bus 20.
30 If the input 10 is an open circuit, current will flow from the supply bus 18 through the base-collector junction of the transistor 40 and into the base of transistor 44, which will allow the transistor 44 to conduct. When
35 transistor 44 conducts, the transistor 42 conducts and the diode 16 turns on. This effect is consistent with the operation of many types of integrated circuits in which an open circuited lead is considered to be in the high
40 logic state. If the voltage on the input 10 is higher than the threshold value of 1.4 volts current will still flow through the base-collector junction of the transistor 40 since its collector is at 1.4 volts. The active elements in the logic clip are all silicon semiconductor devices, and there is a voltage
45 drop across each diode junction of 0.7 volts when the diode is forward biased. Therefore, the earthed bus 20 will be 0.7 volts higher than the earth lead on the integrated circuit under test and the base of the transistor 44 will be at 1.4 volts with respect to earth. If the voltage on the input is lower than 1.4 volts, current will flow through the base-emitter junction of the transistor 40 and
50 turn it on, thus removing the base bias current from the transistor 44, which will turn it off and turn off the diode 16. This effect corresponds to a low logic state. The reference voltage applied to the base of the

transistor 42 stabilizes the current through the diode 16.

Figure 3 shows the physical configuration of the logic clip 11, with its inputs 10 and its light emitting diodes 16. The circuitry
70 shown in Figure 1 is contained within the casing 54 together with the light emitting diodes 16. A dual in-line integrated circuit package 50 is shown having leads 52 emerging in a regularly spaced linear array from
75 opposite sides 51. The logic clip 11 fits over the integrated circuit package 50 so that each input 10 contacts one lead 52. Squeezing side walls 56 of the casing 54 together near the top thereof causes the two rows of
80 input leads 10 to spread apart so that the logic clip 11 can be attached or removed from the integrated circuit package 50; a spring mechanism in the logic clip 11 keeps the input leads 10 in contact with the integrated circuit leads 52 when no pressure is applied to the side walls 56.

WHAT WE CLAIM IS:—

1. A signalling apparatus comprising a plurality of inputs, a reference signal line, a plurality of gates, one for each input and each gate being connected to its associated input and to the reference signal line to support current flow between the reference signal line and an input having a potential
90 extremum applied thereto for connecting the input to which the potential extremum is applied to the reference signal line, and indicating means connected to each input and to the reference signal line for indicating
95 signal level on each input with respect to a predetermined threshold level.

2. A signalling apparatus according to Claim 1, wherein each gate comprises a diode having a cathode electrode connected
105 to its associated input and an anode electrode connected to the reference signal line, and the indicating means comprises a plurality of light emitting diodes, one for each input, each light-emitting diode being connected to the reference signal line through means including a resistor and to its associated input through conducting means for conducting current through the light emitting diode whereby emitting light in response
110 to a potential on the input attaining a value greater than the threshold level.

3. A signalling apparatus according to Claim 1 wherein the potential extremum is a lower extremum and the apparatus further
120 comprising a supply line, each gate being connected to the supply line to support current flow between the supply line and an input having a higher potential extremum applied thereto for connecting the input to
125 which the higher potential is applied to the supply line.

4. A signalling apparatus according to Claim 3, wherein the indicating means is connected to the supply line.

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ever input 10 is lowest in voltage will forward bias the diode 38 and will therefore
5 be connected to the earthed bus 20. Any input 10 with a logic level on its will be a few tenths of a volt higher than earth and lower than the supply voltage due to the way
10 integrated circuit logic circuits are designed, and therefore both diodes 36 and 38 will not be biased to conduction. Each logic state detector 22 is connected to each other detector and to the reference voltage circuit
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20 bus 18 through a bias resistor 41, and its collector connected to the base of transistor 44. Transistors 42 and 44 provide the driver amplifier of the diode 16. The diode 16 is connected between the supply bus 18 and
25 the collector of the transistor 42 so that the diode 16 turns on when the transistor 42 is on or conducting. The base of the transistor 42 is connected to the reference bus 31 and therefore is always at the reference
30 voltage, i.e. 2.1 volts. The emitter of the transistor 42 is connected to the collector of the transistor 44 through a bias resistor 43 and the emitter of the transistor 44 is connected to the earthed bus 20.
35 If the input 10 is an open circuit, current will flow from the supply bus 18 through the base-collector junction of the transistor 40 and into the base of transistor 44, which will allow the transistor 44 to conduct. When
40 transistor 44 conducts, the transistor 42 conducts and the diode 16 turns on. This effect is consistent with the operation of many types of integrated circuits in which an open
45 circuited lead is considered to be in the high logic state. If the voltage on the input 10 is higher than the threshold value of 1.4 volts current will still flow through the base-collector junction of the transistor 40 since
50 its collector is at 1.4 volts. The active elements in the logic clip are all silicon semiconductor devices, and there is a voltage drop across each diode junction of 0.7 volts when the diode is forward biased. There-
55 fore, the earthed bus 20 will be 0.7 volts higher than the earth lead on the integrated circuit under test and the base of the transistor 44 will be at 1.4 volts with respect to earth. If the voltage on the input is lower
60 than 1.4 volts, current will flow through the base-emitter junction of the transistor 40 and turn it on, thus removing the base bias current from the transistor 44, which will turn
65 it off and turn off the diode 16. This effect corresponds to a low logic state. The reference voltage applied to the base of the

transistor 42 stabilizes the current through the diode 16.

Figure 3 shows the physical configuration of the logic clip 11, with its inputs 10 and its light emitting diodes 16. The circuitry
70 shown in Figure 1 is contained within the casing 54 together with the light emitting diodes 16. A dual in-line integrated circuit package 50 is shown having leads 52 emerging
75 in a regularly spaced linear array from opposite sides 51. The logic clip 11 fits over the integrated circuit package 50 so that each input 10 contacts one lead 52. Squeez-
80 ing side walls 56 of the casing 54 together near the top thereof causes the two rows of input leads 10 to spread apart so that the logic clip 11 can be attached or removed
85 from the integrated circuit package 50; a spring mechanism in the logic clip 11 keeps the input leads 10 in contact with the integrated circuit leads 52 when no pressure is applied to the side walls 56.

WHAT WE CLAIM IS:—

1. A signalling apparatus comprising a plurality of inputs, a reference signal line, a
90 plurality of gates, one for each input and each gate being connected to its associated input and to the reference signal line to support current flow between the reference
95 signal line and an input having a potential extremum applied thereto for connecting the input to which the potential extremum is applied to the reference signal line, and indicating means connected to each input and
100 to the reference signal line for indicating signal level on each input with respect to a predetermined threshold level.

2. A signalling apparatus according to Claim 1, wherein each gate comprises a
105 diode having a cathode electrode connected to its associated input and an anode electrode connected to the reference signal line, and the indicating means comprises a plurality of light emitting diodes, one for each
110 input, each light-emitting diode being connected to the reference signal line through means including a resistor and to its associated input through conducting means for
115 conducting current through the light emitting diode whereby emitting light in response to a potential on the input attaining a value greater than the threshold level.

3. A signalling apparatus according to Claim 1 wherein the potential extremum is a
120 lower extremum and the apparatus further comprising a supply line, each gate being connected to the supply line to support
125 current flow between the supply line and an input having a higher potential extremum applied thereto for connecting the input to which the higher potential is applied to the supply line.

4. A signalling apparatus according to Claim 3, wherein the indicating means is
130 connected to the supply line.



5. A signalling apparatus according to either one of Claims 3 and 4, wherein each gate comprises two diodes, a first one of which is connected between the input and the reference signal line and has a cathode electrode connected to the input and the second of which is connected between the input and the supply line and has a cathode electrode connected to the supply line.
6. A signalling apparatus according to Claim 5, wherein the indicating means comprises a plurality of threshold detectors, one for each input, each detector comprising an amplifier having an input connected to the associated one of the plurality of inputs, and having an output which acts as a current source when its input is above a predetermined potential and acts as a current sink when its input is below a predetermined potential, a plurality of driver amplifiers, one for each one of said plurality of inputs and each driver amplifier comprising an amplifier having an input connected to the output of the associated threshold detector and having an output which acts as a current sink when current flows into its input and acts as an open circuit when no current flows into its input, and a light emitting device for each one of said plurality of inputs, each device being connected to the supply line and the output of its associated

driver amplifier for emitting light only when the driver amplifier output acts as a current sink.

7. A signalling apparatus according to Claim 6, wherein said plurality of inputs is physically arranged to allow electrical and mechanical connection to correspond conductors of an integrated circuit package, and the light emitting devices are physically arranged in a pattern which bears a direct relationship to the physical arrangement of the conductors of the integrated circuit.

8. A signalling apparatus according to Claim 7, wherein the output of each threshold detector acts as a current source when its input is open circuited.

9. A signalling apparatus according to any one of Claims 6, 7 and 8, wherein each light emitting device comprises a light emitting diode.

10. A signalling apparatus according to Claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

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