E/\COMMS BUGTRAP INSTRUMENTATION

LOGIC COMPARATOR
MODEL 2000C

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E-COMMS BUGTRAP MODEL 2000C LOGIC COMPARATOR

THEORY OF OPERATION

The Model 2000C incorporates a new comparison technique not used in other logic comparators. Conventional logic comparators require some sort of preprogramming prior to testing any specific I.C. Generally, this pre-programming involves the separation of inputs from outputs on an I.C. The inputs are usually tied directly together while the outputs are separated for routing through the comparison circuits. The technique used in the Model 2000C requires all nodes, with the exception of power and ground, be indirectly tied together. Since all nodes are indirectly tied, the circuitry in the Model 2000C has the unique ability to treat each node as an input, an output or a "don't care" as each application may require. The switches are used only for directly tying VDD and ground from the reference I.C. to the I.C. under test (UUT) since the current requirements are such that indirect connections are not suitable.

IT TAKES ONE TO KNOW ONE!

The 2000C is designed to let you know when a reference I.C. and an I.C. under test are in disagreement. There are three positions that a digital integrated circuit node may take at any one time. These are a logic "1", (high or on), a logic 0 (low or off), and a "don't care", or floating status. To determine if a suspect I.C.

is performing the way that it should, the first thing that is required is to bring in an expert. What could be more of an expert on the proper operation of a particular I.C. than one of its own kind? By comparing the operation of a "known good" I.C. to that of the suspect I.C. you have allowed the comparator to tell you if there are any disagreements between the two. These disagreements may take place between the two I.C.s on any of the three positions (high, low, or "don't care") discussed above. The behavior of these little devices has been designed and programmed by people that have spent years making them perform just right. Learning their proper operation is fine, however, for rapid in-circuit troubleshooting we suggest that you cash in on the headaches of others and use the "experts".

TO CARE OR NOT TO CARE

An I.C. that has outputs connected to a bus has its own set of problems. Looking at an output that is on the same trace as ten other I.C.s can be confusing at best. What you really want to know is what is going on when the I.C. that you're testing has something to say or when it is "enabled". The 2000C also has the ability to determine when the output activity is relevant or not. This is done internally so that the user need not be concerned with the connection of external enable connections. This feature is also useful if a device being tested has given up all together. This type of failure often includes floating nodes or nodes that simulate a tri-state "don't care" condition.

BACK AND FORTH . . . REAL FAST

The feature of the 2000C that ties together nodes and treats them as required is the key to its versatility. In the case of bi-directional I.C.s, a node that at one moment was an input may instantly become an output. Since this change can take place thousands or even millions of times per second, you can see that nimble fingers would be a necessity to keep up with these changes if you needed to flip switches accordingly.

DIGITAL FAITH HEALER?

There are few things in this universe that can get a technician as frazzled as a good intermittent failure. If you have been working on digital troubleshooting for any length of time, the experience of receiving a "faulty" board only to find out that the problem goes away as soon as you lay your healing hands on it is probably a familiar experience. If you have spent hours on end watching a scope screen looking for that failure to occur where you think it will occur, then you probably don't need this comparator since you're either in another line of work by now or in a straight jacket. However, for those of you that are stuck returning those intermittent boards while knowing deep inside that it will probably come back, good news! The 2000C has the patience to "watch" these boring signals for you. If a failure should occur at any time the 2000C will latch its error indicator LED for the corresponding node. This feature frees you to work on something else, or eat, or sleep, as the case may be, and still catch those failures that may span minutes or even hours between an occurrence.

SHOTGUNNING WITHOUT A TRACE

This common troubleshooting technique is used by the best of technicians. After all, if you had the ability to glance at an unfamiliar board and pinpoint a problem you would most likely be making a bunch more bucks than you are now. Anyone who has done much troubleshooting using the shotgunning method knows that the result of removing and replacing I.C.s that were good to begin with can be an expensive and time consuming exercise. This method quite often results in a technician "chasing his tail" because of damaged traces or heat damaged components that occurred while trying to locate the original problem. While not even the 2000C will eliminate the need for some "educated guesswork", at least your shotgunning can be done without leaving its traditional telltale signs. Since I.C. removal and replacement is no longer necessary, your savings in replacement parts is dwarfed only by the savings in time and frustration.

USING THE 2000C

We've spent a lot of time here trying to figure out how to turn something so simple into pages of instructions, so we have had to resort to a few "what ifs" and a bunch of details. Don't worry, once you've read these instructions and have used the 2000C there's a good chance that you will never have to read this section again.

CONNECTING POWER AND GROUND

The 2000C is powered by the unit under test (UUT) via the two E-Z hook cables provided. You will notice that one cable is red (POWER or VDD (+5 to +15 VDC)) and the other one is black (VSS or GROUND or GND). To connect power and ground, first make sure that the power to the UUT is off and that the I.C. test clip of the logic comparator is not connected to the UUT. Next, as CMOS can be powered by a wide range of voltages, typically +5VDC to +15VDC, you must determine what voltage powers the I.C. you want to test. THIS IS IMPORTANT SINCE THE 2000C MUST BE POWERED, THROUGH THE EZ HOOK CABLES, BY THE SAME VOLTAGE AS THE I.C. YOU ARE TESTING. Locate appropriate hook-up points on the UUT for both POWER (VDD) and GROUND (VSS). It is not recommended that the power and the ground pins of an I.C. be used since the EZ hooks may short to adjacent pins. If the UUT has test points for VDD and VSS, then use these as they should be ideal. If not, some good connection points may be capacitor leads, large resistors, or diodes that may be connected to the power or ground bus.

IMPORTANT NOTE: It is important that the voltage to the 2000C not exceed +15VDC. Never attach the power lead or the test clip of the comparator to voltages greater than +15 VDC or less than 0 VDC. It is highly recommended that you verify the voltages at your hook-up points prior to connecting the 2000C. Also be sure that the voltage levels present on the pins of the I.C. you want to test are bracketed within the voltage range established by the voltages on your red and black EZ hook leads of the logic comparator. NEVER attach the test clip to an I.C. before power and ground are supplied to the 2000C and NEVER attach it to anything with greater voltages present than the voltages that power your 2000C. A little care taken here will protect your 2000C from damage and save you needless troubleshooting headaches.

Quiescent current draw of the comparator at +5VDC is 10 mA and with all 20 LEDs lit the current draw is 60 mA. At +15VDC, the quiescent current draw is 30 mA and with all 20 LEDs lit it is 200 mA maximum. If it is more convenient, you may use a separate power supply for powering your 2000C. If another power supply is used, you must connect the ground from your alternate power supply to the ground on the UUT so that the ground to the 2000C is continuous to the ground supplied to the I.C.s being tested. Once everything is hooked up, power up the unit under test. Check to see that the "POWER" LED on the 2000C is lit. If the power LED appears dim, check the security of the E-Z hook connectors and, if necessary, verify the voltage present at the hook-up points. If there is no power indication on the 2000C, check for the cor-

rect polarity of the connectors. Remember, red is POWER (VDD) and black is GROUND (VSS).

SELECTING A KNOWN GOOD I.C.

As mentioned before, the key to the operation of the 2000C is that the "known good" I.C. will be compared to your suspect I.C. on the UUT. It is important that the known good I.C. be a match to the I.C. under test. For example, if the I.C. under test is a 74C86 don't use a CD4030 for the known good reference I.C., even though the pin-out and function are the same. Their speed and driving capabilities are not the same. Although the CD4030 may be fine for use in many instances, "may" just doesn't cut it when you are testing an I.C. For now, just take our word for it, the reference I.C. must match the "suspect" I.C. Generally, the part number is sufficient, but on rare occasions we have seen the performance of I.C.s vary significantly between manufacturers. You may not see it in your lifetime, but still try to have as close a match as possible. We realize that on many occasions the best you could hope to find is a "thought to be O.K." I.C., so we suggest that when you find a good one, label it and keep it for testing.

SETTING POWER AND GROUND SWITCHES

At this point it is a good idea to refer to the "I.C. REFERENCE SECTION" of this manual (Appendix E), for the proper power and ground switch settings. You will notice that one of the columns is labeled "VCC (VDD) PIN" and one of the columns is labeled "GND (VSS) PIN". Once you have selected the I.C. that you want to test by the number in the left hand column, move over to the VCC (VDD) PIN column. There will be two numbers listed. The top number is the actual pin number of the I.C. that is used for VDD (for our purposed consider VDD, VCC, and POWER as equivalent terms and VSS, GND, and GROUND as equivalent terms). The number underneath in parentheses is the channel number of the 2000C that will correspond to the VDD pin of the I.C. once it is placed into the ZIP socket on the 2000C. For example, if you wanted to test a 74C04, you would first locate the 74C04 in the I.C. REFERENCE SECTION. In the VCC (VDD) PIN column there will be two numbers, 14 and (20). The number 14 refers to the actual I.C. pin number and the number (20) refers to the channel number of the 2000C once the I.C. is placed into the ZIP socket. Notice that while the GND (VSS) PIN assignments are also shown with two numbers, both numbers are the same in most cases (example: 7 and (7)) on the 74C04. This is because the VSS or GROUND pins of I.C.s are usually located on the left side of the I.C. Any pin numbers on the left side of an I.C. will match their corresponding channel numbers exactly. So, in the example of the 74C04, you've seen that comparator channel 7 corresponds to the VSS (GROUND) pin of the I.C. and the comparator channel 20 corresponds to the VDD (VCC or POWER) pin. These two switches (7 and 20) must be switched inward toward the ZIP socket. All the other switches remain in the outward position.

PLUGGING IN YOUR "KNOWN GOOD"

Insert a "known good" I.C. of the type that you want to test into the ZIP socket on the top of the comparator with the #1 pin of the I.C. in the left uppermost position of the ZIP socket, closest to the locking handle. The locking lever should be in the "up" position before inserting I.C. and then locked to the "down" position to securely hold the I.C. in place as well as to assure good contact. If the I.C. has fewer than 20 pins, you will notice that some of the spaces in the ZIP socket are not used. This is no problem. If you are using a 20-pin test clip on a smaller I.C., the same channels will not be used either.

SELECTING A TEST CLIP

Your 2000C Logic Comparator comes with two test clips, a 20 pin size and a 16 pin size. For most purposes the 20 pin test clip should be fine as it's perfectly OK to use the 20 pin clip on smaller I.C.s (14, 16, and 18 pin). As with the "known good" I.C. in the ZIP socket, some of the pins will not be used. The 16 pin test clip has been provided for the testing of 14 and 16 pin I.C.s that may be in areas on a board where a 20 pin test clip simply won't fit without contacting something that it shouldn't. It is important that the test clip make contact only with pins of the I.C. being tested. After you have pondered all of the pros and cons of your test clip selection simply insert the IDC connector of the test clip cable into the IDC recepticle on the logic comparator and lock the locking arms into position. To remove a test clip, push the locking arms toward the outside of the comparator to eject the IDC connector.

CLIPPING ONTO THE UUT

There are only a few things to keep in mind here. First, make sure that the #1 pin position of the I.C. test clip (marked by a red dot) is on the #1 pin of the I.C. Second, never, ever, ever connect to an I.C. that has a voltage present on any pin that's greater than the voltage present on the red (VCC) EZ hook lead of the 2000C (maximum of +15VDC) or less than OVDC. If the pins of the I.C. appear to be dirty or oxidized try gently rocking the test clip back and forth on the I.C. to achieve a better contact. This technique is worth a try if you should receive an error indication. Sometimes this will cause the error to clear and prevent an unnecessary I.C. replacement.

READY TO GO

OK, now that you have the test clip connected, a "known good" I.C. chosen and locked into the ZIP socket (that hopefully matches the I.C. you clipped onto), the power and ground leads connected to the proper voltages, the wind to your back, and smile on your face, apply power to the UUT. Make sure that the power light comes on. If any of the other LEDs should light on power up, press the "RESET" button on the comparator. If all of the red LEDs remain unlit then you're done with the test (unless the problem is intermittent, in which case let the comparator monitor the suspect I.C. as long as necessary). If one or more of the LEDs persist in relighting, note the channel numbers and refer to the OPERATIONAL BLOCK DIAGRAM, Appendix A. The OPERATIONAL BLOCK DIAGRAM will assist you in verifying that you have correctly connected your 2000C and determine if you have to "clear" the I.C. prior to pronouncing it dead. Clearing an I.C. is explained in Appendix C. Noting the channel number of a miscompare will be helpful in identifying the exact node of any failure or problem.

IMPORTANT NOTE: Do not test a suspected bad I.C. by placing it in the ZIP socket of the comparator and testing it against a known good I.C. in circuit on a

circuit board. For reliable testing, the "bad" I.C. must be attached to the test clip of the logic comparator. The design of the 2000C precludes having these I.C.s reversed. Also, with the comparator powered up and the test clip attached to the suspect I.C., the user should not expect to see error indications if no reference I.C. is placed in the ZIP socket. The reference socket "floats" along with the logic levels of the I.C. being tested unless a known good reference I.C. "tells" it differently. By the same token, if the reference I.C. is a tri-state type and is mismatched to the I.C. being tested, the comparator may not show an error indication. This happens when the logic conditions keep the reference I.C. from being enabled, in which case, its outputs will be floating along with whatever logic is occurring on the unit under test, as if you had an empty reference socket. As long as you are using the correct reference I.C. there will be complete and accurate testing.

2000C INSTRUCTION SUMMARY

1. Connect the 2000C to POWER and GND by using the E-Z hooks provided. Red is VDD (POWER or VCC) and black is GND (VSS). Do not exceed +15VDC and always supply power and ground to the 2000C before attaching the est clip to your suspect I.C.

2. Set toggle switches on the 2000C to correspond to the VDD and VSS pins of the I.C. to be tested. With an I.C. of less than 20 pins you must convert the I.C. pin numbers to match the channel numbers of the comparator. For example, on a 14 pin I.C., pin #14 would correspond to channel number 20 on the comparator since it is in the upper right corner of the ZIP socket. I.C. pins on the left side of the ZIP socket need not be converted. On the VDD (VCC) and VSS (GND) channels, the switches must be inward toward the ZIP socket as directed by the VCC and GND arrows on the top of the comparator. All other switches remain in the outward position. If in doubt, double check the VDD and VSS pins by referring to I.C. documentation.

3. Insert your "known good" reference I.C. into the ZIP socket of the comparator with the #1 pin of the I.C. in the top left corner of the socket (handle position). Push down the ZIP lever to lock in the I.C.

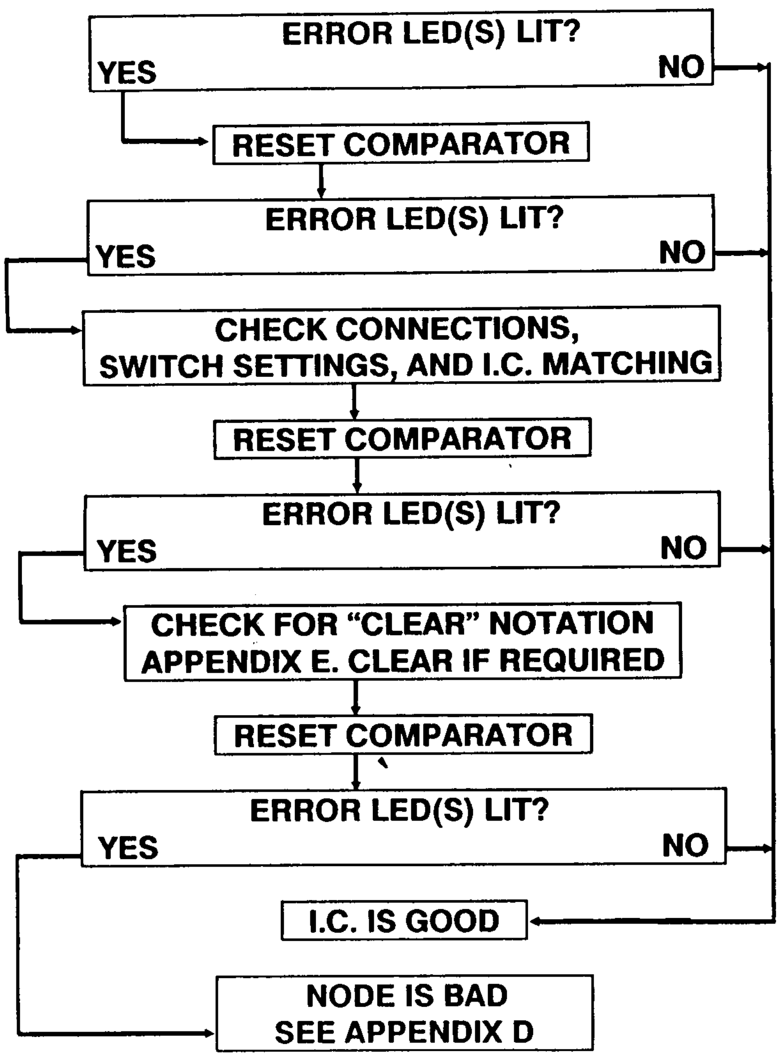
4. Clip the test clip over the I.C. to be tested with the red dot on the test clip in the #1 pin position. The 20 pin clip may be used for any size I.C. of 20 pins or less (some of the pins will not be used on I.C.s smaller than 20 pins). However, a 16 pin cable has been provided for tight fit areas.

5. Power-up the unit under test. Make sure that the power light comes on. Press the reset button on the comparator. If any of the red LEDs light, make sure you have good connections on the test clip and ZIP socket and also verify #1 pin orientation on the test clip and ZIP socket. Also check to see if the I.C. is the type that needs to be "cleared". On some occasions this must be done manually, either by using a logic pulser or a hard wire to the appropriate pin (see Appendix C). If any LEDs continue to remain lit they may be treated as an error indication for the corresponding nodes. Make sure that the reference I.C. is a match for the I.C. under test.

6. NOTE: If a known good I.C. is mismatched to the I.C. under test, the result will not always be an error indication as you might expect. An example might be if a tri-state I.C. is inadvertently placed in the ZIP socket to compare to a non-matching I.C. on your board. In order to get an error indication, it would be essential for the known good tri-state I.C. to receive the proper signal on its enable pin. It needs to be enabled in order to produce a different output than the UUT.

7. CAUTION! Do not attempt to connect the 2000C to any I.C. that has more than +15VDC on any pin.

APPENDIX A
OPERATIONAL FLOW CHART



APPENDIX B

I.C. PIN TO LOGIC COMPARATOR CHANNEL CONVERSION TABLE

COMPARATOR CHANNEL No.	20 PIN	18 PIN	16 PIN	14 PIN
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	N/C
9	9	9	N/C	N/C
10	10	N/C	N/C	N/C
11	11	N/C	N/C	N/C
12	12	10	N/C	N/C
13	13	11	9	N/C
14	14	12	10	8
15	15	13	11	9
16	16	14	12	10
17	17	15	13	11
18	18	16	14	12
19	19	17	15	13
20	20	18	16	14

APPENDIX C

"CLEARING" AN I.C.

Provided in the I.C. REFERENCE SECTION is information on which I.C.s may have to be "cleared" or reset, which pins would have to be pulsed to clear the I.C., and what polarity the pulse would have to be. Clearing an I.C. will reset the reference I.C. and the unit under test I.C. to "square one" together or will load the two I.C.s with the same information at the same time and thus "sync them up". Generally this will not be necessary if the board has an operating clock and the damage to the board is not extensive. However, it is recommended that an I.C. with a "clear" be cleared, if a miscompare should occur.

Generally, the easiest way to reset or clear an I.C. is to either temporarily interrupt power to the board under test, thereby causing a "power-on" reset, or by resetting the MPU, usually done with a reset button on the board. In cases where this doesn't accomplish the reset, you must manually clear the I.C. The I.C.s are cleared by a pulse of a logic 1 (high) or a logic 0 (low) to a designated input pin or pins on the UUT. When the UUT is pulsed, the signal will reach the reference I.C. and clear both I.C.s at the same time. It is strongly recommended that a logic pulser be used for this purpose. The clear instructions are written for simple interpretation. They are a combination of a number (I.C. pin number) and a pulse state. For example, if you need to clear a 74C161, you will see the instruction "1/L". This means you should pulse pin #1 low or

to logic 0. Some of the clear instructions will show more than one I.C. pin that should be pulsed (Example: 74C76). Multiple clear instructions usually indicate a dual pack I.C. that has two separate clears, one for each half of a dual function. They may be cleared separately. If the clear instructions are accompanied by "SEE NOTE 2", these clear commands must be performed at the same time, together.

Although it is not recommended, these clear pulses can be executed by a brief contact of a wire jumper from a logic high source (VDD) or a logic low source (GND). These VDD and GND pin locations are noted in the I.C. REFERENCE SECTION, Appendix E. If you should choose to use this method, please use extreme caution. The jumper wire has a great potential for shorting adjacent pins if not handled carefully. The length of time that is required to clear the I.C. is very, very short. Momentarily touching or striking the GND or VDD source to the clear pin is all that is required. If a logic pulser is used, as recommended, it will automatically source and sink a signal required for a "clear".

Please keep in mind that the pulsing must be done on the appropriate pin of the I.C. being tested, not on the same pin of the reference I.C. Pulsing the pin of the I.C. under test will simultaneously reset it and the reference I.C. but not vice-versa. In cases of difficult access to the pins of the I.C. being tested, you can pulse the pin of the reference I.C., but only if you first throw the corresponding switch on the logic comparator inward, towards the ZIP socket. This ties the pin of the reference I.C. and the pin of the I.C. being tested directly together allowing a simultaneous reset pulse. For example, on a 74C161 that isn't getting a reset pulse on the board you're testing (and you don't have access to pin #1 under the test clip), simply throw switch #1 of the 2000C inward and pulse pin #1 of the reference I.C. to a logic 0 (GND). The two I.C.s are now reset together and accurate testing can now be done.

APPENDIX D

REASONS FOR ERROR INDICATIONS

In the vast majority of cases, failure of the I.C. under test will be the direct cause of an error LED lighting. However, there are other possible reasons for an error indication. While these error indications may not be a direct result of an I.C. under test failure, they do point out a valid problem on the indicated node. Node failure indications may be caused by any of the following:

1. PHYSICAL SHORT OF TRACE ON ASSOCIATED NODE. This type of short may be caused by a solder splash, liquids, stray lead clippings, etc.

2. SHORTED INPUT NODE DRIVEN BY THE ERROR INDICATING OUTPUT NODE. As with the physical short, the 2000C will sense the fault caused by this shorted input.

3. ANOTHER SHORTED OUTPUT SHARING THE COMMON TRACE. Be alert for this in wire-ored and bus-oriented circuits.

APPENDIX E

I.C. REFERENCE SECTION

This section is meant to be a handy reference guide for quickly checking the function of an I.C., the pin numbers of its outputs, and the pin numbers for the I.C.s VCC and VSS (GND). Please note that this table lists the I.C. pin numbers on the top line of the I.C. listing. The numbers on the second line of the I.C. listing appear in parenthesis and represent the LED and switch number of the corresponding comparator channel. This conversion is necessary when testing chips less than 20 pins since some comparator channels will not be used. Appendix B contains an "I.C. PIN TO LOGIC COMPARATOR CHANNEL CONVERSION TABLE", but for your convenience, we have done all the necessary conversions in this reference section.

As you have already read, the only switch settings required on the 2000C are for VDD and GND. In most cases you can determine the VDD and GND pins of an I.C. by simply looking at which pins of the I.C. are connected to the VDD and GND bus of the circuit board being tested. However, if it isn't obvious simply look up the I.C. number in this section. In the "VDD PIN" and "VSS PIN" columns of the table are the appropriate I.C. pin numbers and more importantly, in parenthesis, are the corresponding numbers of the logic comparator switches that must be set. For example, the listing for a 74C04 I.C. shows pin #14 is VDD and pin #7 is VSS. The numbers in parenthesis

below these tell you that switch 20 must be switched inward (toward the ZIP socket) for VDD and switch 7 must be switched inward for VSS (GND).

As discussed earlier, certain I.C.s may have to be "cleared". The "CLEAR PIN(S) OF I.C." column in this table tells you which pins of the I.C. may have to be pulsed to clear the I.C. and what polarity pulse is required (L=logic low pulse and H=logic high pulse).

The "NOTES" column is for pointing out tips or cautions when testing a particular I.C. The notes are summarized at the end of the reference section.

Any abbreviations used in this I.C. REFERENCE SECTION are explained at the end of the section.

I.C.	FUNCTION	1.C. OUTPUT PINS (LED #(S))	VDD(VCC) PIN (SWITCH #)	VSS(6MD) PIN (SWITCH #)	CLEAR PIN(S) OF I.C.
4000	NOR-INV	6 9 10 (6 15 16)	14 (20)	7 (7)	
4001	NOR	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)	
4002	NOR	1 13 (1 19)	14 (20)	7 (7)	
4006	SHIFT REG	8 9 10 11 12 13 (14 15 16 17 18 19)	14 (20)	7 (7)	
4008	ADDER	10 11 12 13 14 (14 15 16 17 18)	16 (20)	8 (8)	
4009	BUFFER INV	2 4 6 10 12 15 (2 4 6 14 16 19)	16 (20)	8 (8)	SEE NOTE 3
4010	BUFFER	2 4 6 10 12 15 (2 4 6 14 16 19)	16 (20)	8 (8)	SEE NOTE 3
4011	NAND	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)	
4012	NAND	1 13 (1 19)	14 (20)	7 (7)	

4013	D FLIP FLOP	1 2 12 13 (1 2 18 19)	14 (20)	7 (7)	4-6-8-10/H
4014	SHIFT REG	2 3 12 (2 3 16)	16 (20)	8 (8)	9/H
4015	STATIC REG	2 3 4 5 10 11 12 13 (2 3 4 5 14 15 16 17)	16 (20)	8 (8)	6-14/H
4016	SWITCH BI	1 3 8 10 (1 3 14 16)	14 (20)	7 (7)	SEE NOTES 1 AND 4
4016	SWITCH BI	2 4 9 11 (2 4 15 17)	14 (20)	7 (7)	SEE NOTES 1 AND 4
4017	COUNTER	1 2 3 4 5 6 7 9 10 11 12 (1 2 3 4 5 6 7 13 14 15 16)	16 (20)	8 (8)	
4018	COUNTER	4 5 6 11 13 (4 5 6 15 17)	16 (20)	8 (8)	15/H
4019	AND-DR	10 11 12 13 (14 15 16 17)	16 (20)	8 (8)	
4020	COUNTER	1 2 3 4 5 6 7 9 12 13 14 15 (1 2 3 4 5 6 7 13 16 17 18 19)	16 (20)	8 (8)	9/H

4021	SHIFT REG	2 3 12 (2 3 16)	16 (20)	8 (8)	9/H	
4022	COUNTER	1 2 3 4 5 7 10 11 12 (1 2 3 4 5 7 14 15 16)	16 (20)	8 (8)	15/H	
4023	NAND	6 9 10 (6 15 16)	14 (20)	7 (7)		
4024	COUNTER	3 4 5 6 9 11 12 (3 4 5 6 15 17 18)	14 (20)	7 (7)	2/H	
4025	NOR	6 9 10 (6 15 16)	14 (20)	7 (7)		
4027	JK FLIP FLOP	1 2 14 15 (1 2 18 19)	16 (20)	8 (8)	4-7-9-12/H	
4028	DECODER	1 2 3 4 5 6 7 9 14 15 (1 2 3 4 5 6 7 13 18 19)	16 (20)	8 (8)		
4029	COUNTER	2 6 7 11 14 (2 6 7 15 18)	16 (20)	8 (8)	1/H	
4030	XOR	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)		
4031	SHIFT REG	6 7 (6 7)	16 (20)	8 (8)	1-10/H	SEE NOTE 2

4035	SHIFT REG	1 13 14 15 (1 17 18 19)	16 (20)	8 (8)	5/H
4040	COUNTER	1 2 3 4 5 6 7 9 12 13 14 15 (1 2 3 4 5 6 7 13 16 17 18 19)	16 (20)	8 (8)	11/H
4041	BUFFER	1 2 4 5 8 9 11 12 (1 2 4 5 14 15 17 18)	14 (20)	7 (7)	
4042	D LATCH	1 2 3 9 10 11 12 13 15 (1 2 3 13 14 15 16 17 19)	16 (20)	8 (8)	
4043	NOR LATCH TRI	1 2 9 10 (1 2 13 14)	16 (20)	8 (8)	4-6-12-14/H
4044	NAND LATCH TRI	1 9 10 13 (1 13 14 17)	16 (20)	8 (8)	3-7-11-15/L
4048	GATE	1 (1)	16 (20)	8 (8)	
4049	BUFFER INV	2 4 6 10 12 15 (2 4 6 14 16 19)	1 (1)	8 (8)	
4050	BUFFER	2 4 6 10 12 15 (2 4 6 14 16 19)	1 (1)	8 (8)	

4060	COUNTER	1 2 3 4 5 6 7 13 14 15 (1 2 3 4 5 6 7 17 18 19)	16 (20)	8 (8	12/H	
4066	SWITCH BI	1 3 8 10 (1 3 14 16)	14 (20)	7 (7)		SEE NOTES 1 AND 4
4066	SWITCH BI	2 4 9 11 (2 4 15 17)	14 (20)	7 (7)		SEE NOTES 1 AND 4
4069	INVERTER	2 4 6 8 10 12 (2 4 6 14 16 18)	14 (20)	7 (7)		
4070	XOR	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)		
4071	OR	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)		
4073	AND	6 9 10 (6 15 16)	14 (20)	7 (7)		
4075	OR	6 9 10 (6 15 16)	14 (20)	7 (7)		
4076	D FLIP FLOP	3 4 5 6 (3 4 5 6)	16 (20)	8 (8)	15/H	
4081	AND	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)		

4089	MULTIPLIER	5 6 (5 6)	16 (20)	8 (8)	13/H
4093	NAND SCHMITT	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)	
4099	LATCH	1 9 10 11 12 13 14 15 (1 13 14 15 16 17 18 19)	16 (20)	8 (8)	2/H
40106	INVERTER SCHMITT	2 4 6 8 10 12 (2 4 6 14 16 18)	14 (20)	7 (7)	
40160	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/l
40161	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L
40162	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L
40163	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L
40174	D FLIP FLOP	2 5 7 10 12 14 (2 5 7 14 16 18)	16 (20)	8 (8)	1/L

40175	D FLIP FLOP	2 3 6 7 10 11 14 15 (2 3 6 7 14 15 18 19)	16 (20)	8 (8)	1/L
40192	COUNTER	2 3 6 7 12 13 (2 3 6 7 16 17)	16 (20)	8 (8)	14/H
40193	COUNTER	2 3 6 7 12 13 (2 3 6 7 16 17)	16 (20)	8 (8)	14/H
4510	COUNTER	2 6 7 11 14 (2 6 7 15 18)	16 (20)	8 (8)	9/H
4511	DRIVER	9 10 11 12 13 14 15 (13 14 15 16 17 18 19)	16 (20)	8 (8)	
4516	COUNTER	2 6 7 11 14 (2 6 7 15 18)	16 (20)	8 (8)	9/H
4518	COUNTER	3 4 5 6 11 12 13 14 (3 4 5 6 15 16 17 18)	16 (20)	8 (8)	7-15/H
4519	AND-OR	10 11 12 13 (14 15 16 17)	16 (20)	8 (8)	
4520	COUNTER	3 4 5 6 11 12 13 14 (3 4 5 6 15 16 17 18)	16 (20)	8 (8)	7-15/H
4527	MULTIPLIER	5 6 (5 6)	16 (20)	8 (8)	13/H

4723	LATCH	4 5 6 7 9 10 11 12 (4 5 6 7 13 14 15 16	16 (20)	8 (8)	15/H
4724	LATCH	4 5 6 7 9 10 11 12 (4 5 6 7 13 14 15 16)	16 (20)	8 (8)	15/H
74C00	NAND	3 6 8 11 (3 6 14 17)	14 (20)	7 (7)	
74C02	NOR	1 4 10 13 (1 4 16 19)	14 (20)	7 (7)	
74C04	INVERTER	2 4 6 8 10 12 (2 4 6 14 16 18)	14 (20)	7 (7)	
74C08	AND	3 6 8 11 (3 6 14 17)	14 (20)	7 (7)	
74C10	NAND	6 8 12 (6 14 18)	14 (20)	7 (7)	
74C14	INVERTER	2 4 6 8 10 12 (2 4 6 14 16 18)	14 (20)	7 (7)	
74C20	NAND	6 8 (6 14)	14 (20)	7 (7)	
74C30	NAND	8 (14)	14 (20)	7 (7)	

74C32	OR	3 6 8 11 (3 6 14 17)	14 (20)	7 (7)		
74C42	DECODER	1 2 3 4 5 6 7 9 10 11 (1 2 3 4 5 6 7 13 14 15)	16 (20)	8 (8)		
74C48	DECODER	9 10 11 12 13 14 15 (13 14 15 16 17 18 19)	16 (20)	8 (8)		
74C73	JK FLIP FLOP	8 9 12 13 (14 15 18 19)	4 (4)	11 (17)	2-6/L	
74C74	D FLIP FLOP	5 6 8 9 (5 6 14 15)	14 (20)	7 (7)	1-13/L	
74C76	JK FLIP FLOP	10 11 14 15 (14 15 18 19)	5 (5)	13 (17)	3-8/L	
74C83	ADDER	2 6 9 15 (2 6 13 19)	5 (5)	12 (16)		
74C85	COMPAR- ATOR	3 12 13 (3 16 17)	16 (20)	8 (8)		
74C86	XOR	3 4 10 11 (3 4 16 17)	14 (20)	7 (7)		
74C90	COUNTER	8 9 11 12 (14 15 17 18)	5 (5)	10 (16)	2-3/H	SEE NOTE 2

74C93	COUNTER	9 10 12 13 (15 16 18 19)	4 (4)	11 (17)	1-2/H	SEE NOTE 2
74C95	SHIFT REG	9 10 12 13 (15 16 18 19)	4 (4)	11 (17)	6/H	
74C107	JK FLIP FLOP	2 3 5 6 (2 3 5 6)	14 (20)	7 (7)	10-13/L	
74C151	MULTIPLEXER	5 6 (5 6)	16 (20)	8 (8)		
74C157	MULTIPLEXER	4 7 9 12 (4 7 13 16)	16 (20)	8 (8)		
47C160	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L	
74C161	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L	
74C162	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L	
74C163	COUNTER	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L	
74C164	SHIFT REG	3 4 5 6 10 11 12 13 (3 4 5 6 16 17 18 19)	14 (20)	7 (7)	9/L	

74C165	SHIFT REG	7 9 (7 13)	16 (20)	8 (8)	1/L
74C173	D FLIP FLOP TRI	3 4 5 6 (3 4 5 6)	16 (20)	8 (8)	15/L
74C174	D FLIP FLOP	2 5 7 10 12 15 (2 5 7 14 16 19)	16 (20)	8 (8)	1/L
74C175	D FLIP FLOP	2 3 6 7 10 11 14 15 (2 3 6 7 14 15 18 19)	16 (20)	8 (8)	1/L
74C192	COUNTER	32 3 6 7 12 13 (2 3 6 7 16 17)	16 (20)	8 (8)	14/H
74C193	COUNTER	2 3 6 7 17 13 (2 3 6 7 16 17)	16 (20)	8 (8)	14/H
74C195	SHIFT REG	11 12 13 14 15 (15 16 17 18 19)	16 (20)	8 (8)	1/L
74C240	INV BUFFER TRI	3 5 7 9 12 14 16 18 (3 5 7 9 12 14 16 18)	20 (20)	10 (10)	
74C244	BUFFER TRI	3 5 7 9 12 14 16 18 (3 5 7 9 12 14 16 18)	20 (20)	10 (10)	
74C373	LATCH TRI	2 5 6 9 12 15 16 19 (2 5 6 9 12 15 16 19)	20 (20)	10 (10)	11/H

74C374	D FLIP FLOP TRI	2 5 6 9 12 15 16 19 (2 5 6 9 12 15 16 19)	20 (20)	10 (10)
74C901	INV BUFFER	1 3 5 9 11 13 (1 3 5 15 17 19)	14 (20)	7 (7)
74C902	BUFFER	1 3 5 9 11 13 (1 3 5 15 17 19)	14 (20)	7 (7)
74C903	INV BUFFER	1 3 5 9 11 13 (1 3 5 15 17 19)	14 (20)	7 (7)
74C904	BUFFER	1 3 5 9 11 13 (1 3 5 15 17 19)	14 (20)	7 (7)
74C915	CONVERTER TRI	5 7 8 10 11 13 (5 7 8 12 13 15)	18 (20)	9 (9)
70C95	BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
70C96	INV BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
70C97	BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
70C98	INV BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)

80C95	BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
80C96	INV BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
80C97	BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)
80C98	INV BUFFER TRI	3 5 7 9 11 13 (3 5 7 13 15 17)	16 (20)	8 (8)

I.C. REFERENCE NOTES

1. The input/output status of the I.C. pin depends on which direction in enabled on the I.C. (bidirectional).

2. The clear pins noted must be pulsed simultaneously.

3. Switch #1 must also be thrown inward (towards the ZIP socket). this is a VCC reference input pin.

4. This I.C. can switch both digital and analog signals. The logic comparator will accurately test only digital signals. Be aware of this when testing any I.C. that may have linear (analog) inputs or outputs.

ABBREVIATIONS

BI	Bidirectional
CMOS	Complimentary Metal-Oxide Semi-conductor
GND	Ground
I.C.	Integrated Circuit
INV	Inverter
LED	Light Emitting Diode
TRI	Tri-state
UUT	Unit Under Test
VCC	Supply voltage (typically +5 VDC)
VDD	CMOS supply voltage (typically +5 to +15 VDC). For the purposes of this manual, consider VDD and VCC as one and the same.
VSS	Ground
ZIP	Zero-Insertion-Pressure socket

MODEL 2000C SPECIFICATIONS

I.C. CAPACITY:	8, 14, 16, 18, 20 pin dual-in-line packages, digital CMOS, +5VDC to +15 VDC.
TEST RATE:	Continuous, 8 MHz. maximum.
INPUT LOGIC LEVELS:	CMOS logic levels, 0 VDC to +15 VDC (no less than -.3 VDC or more than +15.5 VDC)
SUPPLY VOLTAGE:	+5V DC to +15 VDC
SUPPLY CURRENT:	10 mA at +5 VDC (60mA maximum with all 20 LEDs on) 30 mA at +15 VDC (200 mA maximum with all 20 LEDs on)
SUPPLY PROTECTION:	Reverse polarity protected; over voltage protected to +18 VDC at 500 mA maximum.

ERROR SENSITIVITY (at +5 VDC):

Error detection sensitivity increases as error frequency increases:

DETECTABLE ERROR	ERROR RATE FREQUENCY
300 nanoseconds	Single error
150 nanoseconds	1.5 MHz.
100 nanoseconds	3.0 MHz.
50 nanoseconds	6.0 MHz.

Errors smaller than those listed are considered to be within reasonable tolerance at the corresponding frequency and are ignored.

Subject to change without notice.

LIMITED WARRANTY

E-COMMS warrants to the original purchaser that its Bugtrap Logic Comparator, and the component parts thereof, will be free from defects in workmanship and materials for a period of two years from the date of purchase.

In this period, E-COMMS Inc. will, without charge, repair or replace, at its option, defective Bugtrap Logic Comparators or component parts.

Return the entire unit, shipping prepaid and insured, to:

E-COMMS, INC.
5720 144st NW
Gig Harbor, WA 98335

Exclusions: This warranty does not apply in the event of improper use, abuse of the product or as a result of unauthorized alterations or repairs.