DIGI-COMP II
FIRST EDITION

Quick Start Guide

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Evil Mad Scientist

DIGI-COMP II
FIRST EDITION

INTRODUCTION

The Digi-Comp II: First Edition ("DCIIFE") is a modern, fully-operational recreation of the Digi-Comp II, the classic 1960's educational computer kit. The Digi-Comp II was invented by John T. Godfrey, and is described in US Patent No. 3,390,471, which was filed on April 30 1965. The kits were produced by ESR ("Education Science Research") Incorporated, and sold for an original price of $16.00, roughly $112 in inflation-adjusted 2012 dollars.

The Digi-Comp II is automatic binary digital mechanical computer, capable of conducting basic operations like adding, multiplying, subtracting, dividing, counting, and so forth. These operations are conducted by the action of balls rolling down a slope, directed by mechanical switches and flip flops, all powered by gravity.

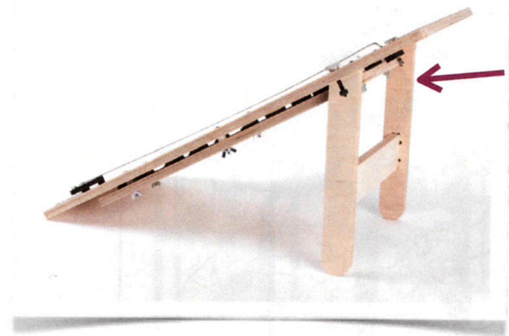
Original advertisement for Digi-Comp II: "You can literally PROCESS DATA!"

This *Quick Start Guide* is meant to get you up and running with the Digi-Comp II: First Edition.

Your next steps should probably be as follows:

- Attach the stand to your Digi-Comp II
- Perform the Operational Tests to test the machine and familiarize yourself with its anatomy.
- Read through the Digi-Comp II Operations section of this guide to learn what your Digi-Comp II can do.
- Download the full, original Digi-Comp II Instruction Manual (PDF) from digi-compii.com

Attaching the Stand



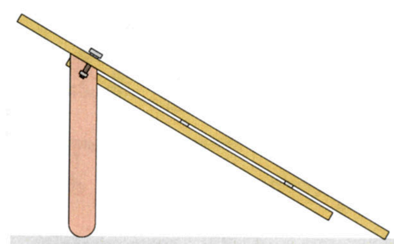
The stand is an "H" shaped wooden frame that holds the Digi-Comp II upright. Attach it, or detach it for storage with the two large thumbscrews.

The thumbscrews index into square nuts set into the legs of the base.

The stand is also reversible:

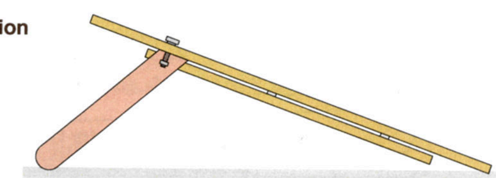
Normal configuration
Angle: 30°

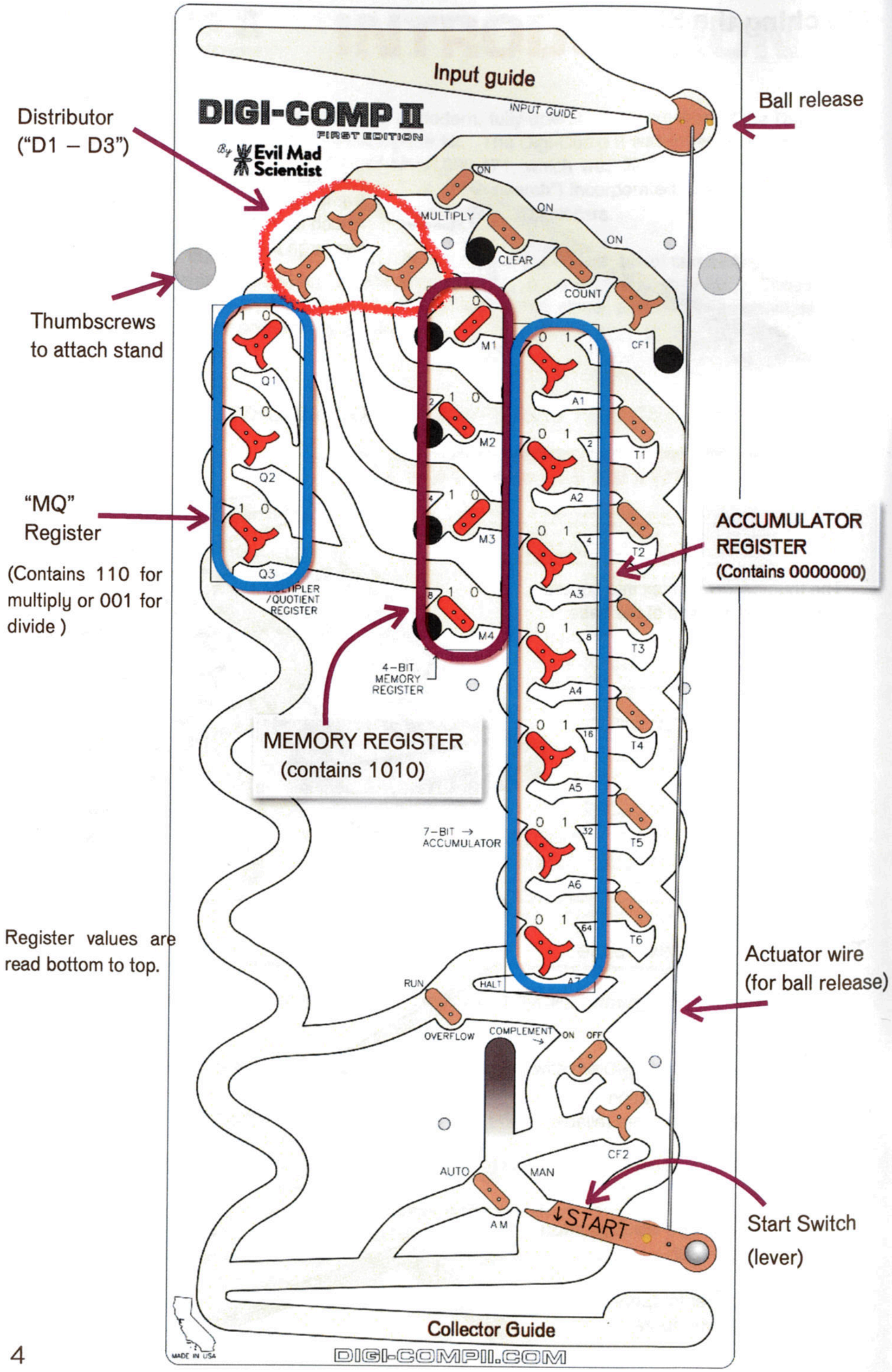
- More compact.
- Faster operation.
- Generally more reliable.

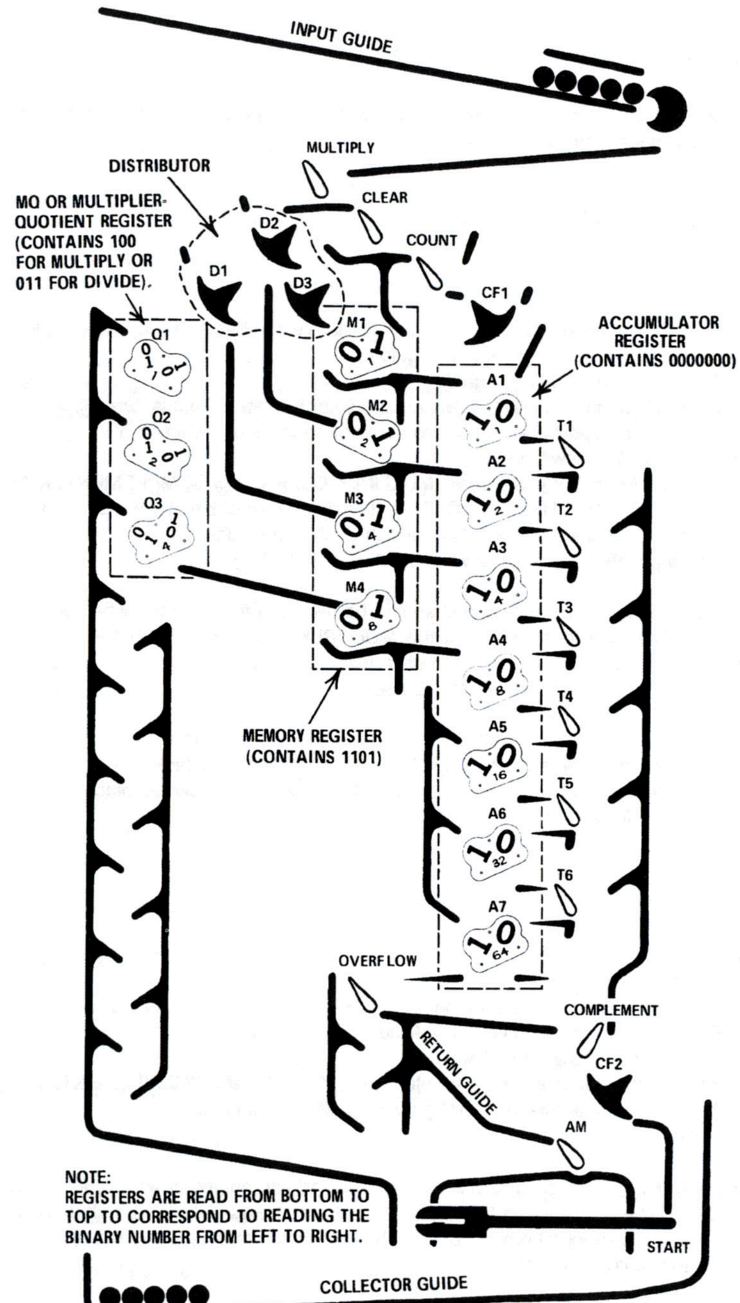


Low-angle configuration
Angle: 20°

- Larger footprint.
- Slower operation.







↑ Anatomy of the original Digi-Comp II

← Anatomy of the Digi-Comp II, First Edition

Operational Tests

Here are some simple yet comprehensive tests that you can perform to verify that every part of your Digi-Comp II is functioning correctly.

TEST #1: COUNT, START switch

Procedure:

- INITIALIZE: Follow the INITIALIZE procedure in the "New Operations Check List," on the back cover of this guide
- Place one ball in the input guide
- Enter 127 (binary 1111111) in the Accumulator Register. That is, turn all flip-flops A1-A7 to point to the right, towards the number "1"
- Set the COUNT switch to ON
- Set the other function switches (MULTIPLY, CLEAR, and COMPLEMENT) to OFF. (For MULTIPLY and CLEAR, that means not pointing towards ON.)
- Set the Automatic-Manual ("AM") switch to MAN (manual)
- Gently pull the start lever down and release ("START")

If everything is working correctly: The ball should be released from the top when you pull down the start lever. That ball then rolls past the MULTIPLY and CLEAR switches to the COUNT switch, where it enters the Accumulator and changes each "1" to a "0." The ball should come out the bottom and come to rest in the Collector Guide.

If it didn't work, check the switch settings– particularly the initialization –and try again. If only some of the flip-flops changed to zero, wiggle the ones that didn't flip back and forth until they are nice and free before trying again. If the ball came to rest in an unexpected place, check that the DIGI-COMP II is on a level table.

TEST #2: CLEAR circuit

Procedure:

- INITIALIZE
- Place one ball in the input guide.
- Enter 127 (binary 1111111) in the Accumulator Register
- Set the CLEAR switch to ON
- Set the other function switches (MULTIPLY, COUNT, and COMPLEMENT) to OFF
- Set the Automatic-Manual ("AM") switch to MAN (manual).
- START

If everything is working correctly: The ball then is released and guided down the hole to the left of the word CLEAR, where it drops to the lower deck of the DIGI-COMP II, and changes all of the Accumulator Register flip-flops from "1" to "0." The ball should then return to the upper deck, and come to rest in the Collector Guide.

If it didn't work, check the switch settings and try again. If only some of the flip-flops changed to zero, wiggle the ones that didn't flip to loosen them up. If the ball did not exit the lower level, also check that the wing nuts holding the two decks together are present and finger-tight.

TEST #3: AUTO-START

Procedure:

- INITIALIZE
- Place exactly two balls in the input guide
- Set the Accumulator Register to 0000000
- Set the CLEAR switch to ON, and the other function switches (MULTIPLY, COUNT, and COMPLEMENT) to OFF
- Set the Automatic-Manual ("AM") switch to AUTO (automatic)
- Gently pull the start lever down and release ("START")

If everything is working correctly: The first ball will roll down beneath the Accumulator Register, leaving all of the Accumulator flip-flops pointing towards zero. When it reaches the bottom, it will pull the start lever, triggering the second ball to be released. When the second ball reaches the bottom, it will pull the start lever (not releasing any balls this time), and roll down into the collector guide.

If it didn't work, check to be sure that the start lever and ball release move smoothly, without excess friction.

TEST #4: ACCUMULATOR MODE SWITCHES

Procedure:

- INITIALIZE
- Make sure that there is are at least five balls in the input guide
- Set the Accumulator Register to 0000000
- Set the function switches (MULTIPLY, CLEAR, COUNT, and COMPLEMENT) to OFF
- Set OVERFLOW to RUN
- Set the AM switch to MAN
- START

If everything is working correctly: The ball turns Flip-flop CF1 to the right, and goes to the lower deck, where it turns *Accumulator Mode Switches* T1 – T6 to point to the right. Again, wiggle any of the parts that did not turn correctly.

- Pull the Start lever again

If everything is working correctly: The ball turns Flip-flop CF2 to the left, and goes through the accumulator, switching each to the right so that it reads 127 (binary 1111111).

- Pull the Start lever again

If everything is working correctly: The ball turns Flip-flop CF1 to the right, and goes to the lower deck, where it turns *Accumulator Mode Switches* T1 – T6 back to the left.

- Pull the Start lever again

If everything is working correctly: CF1 flips back to the left, and the ball rolls through the accumulator, switching each to the left so that it reads 0 (binary 0000000).

TEST #5: FULL COMPLEMENT CIRCUIT

Procedure:

Use the exact same setup as for *TEST #3*, except

- Set COMPLEMENT to ON, and
- Set the AM switch to AUTO

If everything is working correctly: The same steps that happened in *TEST #3* will happen again but in higher speed: T1 – T6 will flip to the right and back, the Accumulator Register flip-flops will flip to the right and back, and both CF1 and CF2 will each flip twice as well. The test will run for exactly four balls, and then halt automatically. If it didn't work, check your settings, verify that flip-flop CF2 moves freely, and try *TEST #3* again as well.

TEST #6: MULTIPLICATION AND ADDITION CIRCUITS

Procedure:

- INITIALIZE, and load the input guide with balls (at least 17)
- Set the Accumulator Register to 0000000
- Set the MQ Register to the value 4 (binary 100, reading up from the bottom)
- Set the Memory Register to the value 5 (binary 0101, reading up from the bottom)
- Set the MULTIPLY switch to ON
- Set the other function switches (CLEAR, COUNT and COMPLEMENT) to OFF
- Set the AM switch to AUTO
- START

If everything is working correctly: The Digi-Comp II will stop automatically after drawing 17 balls. The final state will have 111 in the MQ Register, 0101 in the Memory Register, and 20 (binary 0010100) in the Accumulator Register.

- Repeat the last test, instead beginning with the value 10 (binary 1010) in the Memory Register

If everything is working correctly: The Digi-Comp II will stop automatically after drawing 17 balls. The final state will have 111 in the MQ Register, 0101 in the Memory Register, and 40 (binary 0101000) in the Accumulator Register.

If you did not get the correct result in either part, check to make sure that the Distributor flip-flops (those three above and between the MQ and Memory Registers) and the MQ Register flip-flops turn freely. If any of them are sticking, wiggle them back and forth to free them.

Differences versus the original Digi-Comp II

There are a number of differences between our kit, the Digi-Comp II First Edition ("DCIIFE") and the original 1960's Digi-Comp II. We have taken care to use the same basic layout as the original, so that the vast majority of the original Digi-Comp II Instruction Manual is still applicable. However, there are certain differences that you should be aware of, including some important changes to how things on the computer are labeled.

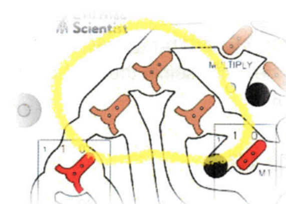
- Construction: The DCIIFE is made out of hardwood plywood, and is considerably more compact and sturdy than the original, which was made of masonite and thin vacuum formed plastic. The DCIIFE uses steel pachinko balls, rather than half-inch marbles. Those balls are guided through carved channels, rather than directed by protruding plastic features.

- In the registers where binary values are represented (MQ, Memory, Accumulator), each flip flop or switch points to either a "1" or "0" engraved into the wood, which indicates its state. This is in contrast to the original, which had plastic cards mounted to the flip flops and switches where either a printed "1" or "0" turned vertically would indicate the state.

- The MQ register labels on the original had *two* sets of numbers on each card. For all operations except division, you would read the upper set of numbers, and for division you would read the lower set. The lower set had the 1's and 0's swapped.

On the DCIIFE, there is only one set of numbers to read. When doing a division problem, it is up to you (the human) to mentally swap the 1's and 0's. For example, if doing a division problem you would read a value of "011" in the MQ register as "100", and you would read a value of "101" as "010." Our method has a precedent: Preproduction versions of the original Digi-Comp II had only a single set of MQ register labels, read this same way.

- The three flip flops that together form the "distributor," D1, D2, and D3, are not labeled on the DCIIFE. These are the three flip flops above and between the MQ and Memory registers. These three should point to the right– the direction indicated by the "default position" marks on the board – before each operation as part of the "initialize" operation.



- The design of the Start Lever is slightly different than that of the original. The pivot position is on the right side of the board, rather than the left. To start an operation, gently pull the start lever in the direction indicated by the arrow on the Start Lever, and then release.

(Incidentally, the start lever actually used in the original version bears absolutely no resemblance to the start lever shown on the box and advertisements for the original Digi-Comp II. Those showed an older– presumably less reliable –design without a visible start lever!)

- The "New Operations Check List" which was affixed as a sticker on the front face of the original, is instead printed on the back cover of this guide.

Digi-Comp II Operations

The original Digi-Comp II was advertised and sold as a "computer" in the 1960's, and we have kept the moniker for historical reasons. But today, we might more commonly refer to a device with its same functions (adding, multiplying, subtracting, dividing, counting, complementing, etc.) as a calculator or arithmetic and logic unit (ALU). The Digi-Comp II Instruction Manual describes each of these functions in detail, and tells you how you how to map operations onto (e.g.) Fortran, assuming that you allow a human to do some of the setup operations on the Digi-Comp. So, while it is not Turing-complete on its own, the term "computer" is not an entirely unfair description.

Here we describe the actual operations that the Digi-Comp II is capable of (from a modern perspective), and how to carry them out. The "New Operations Check List" on the back page of this guide is another reference on how to perform these operations.

INITIALIZE

Strictly speaking, the Digi-Comp II does not have an "INITIALIZE" function– it is a task that the human operator must perform, before most computations, to prepare the wooden "circuitry" for use.

The INITIALIZE procedure consists of three steps:

1. Be sure that T1, T2, T3, T4, T5, and T6 are to the left
2. Be sure that CF1 is to the left and that CF2 is to the right
3. Set Flip-Flops D1, D2, and D3 in the Distributor to the right

The default, "initialized" position of each of these flip-flops and switches is marked on the deck of the DCIIFE with a heavy dark line. So in practice, initializing just consists of making sure that each of these components is pointing in the direction indicated by the line. You will find that the distributor will need to be reset after most operations, but that the other parts (CF1, CF2, T1-T6) tend to need setup only at the beginning of a computation session.

Again, the INITIALIZE procedure only prepares the wooden circuitry for use. It does not clear the registers nor select the next operation that will be performed.

CLEAR

The CLEAR operation clears the Accumulator Register; i.e., it sets each bit in the register to zero.

Procedure:

- Make sure that there is at least one ball in the input guide.
- Set the CLEAR switch to ON
- Set the other function switches* (MULTIPLY, COUNT, and COMPLEMENT) to OFF
- Set the Automatic-Manual ("AM") switch to MAN (manual)
- START

The CLEAR switch directs the ball into a special channel on the lower deck, where it rolls *beneath* the Accumulator Register. There is a "half flip-flop" below each flip-flop in the Accumulator that switches each 1 to a 0, and leaves each 0 alone. Since the entire operation is completed with a single ball, the "manual" mode is used, so that it does not trigger any additional balls when the operation completes.

*Technically, only the MULTIPLY switch needs to be off. The state of the others is immaterial.

COUNT

At the heart of the Digi-Comp II is a binary counter. You can use this fact, with the COUNT operation, to count the number of balls in the input guide.

- INITIALIZE
- Set the Accumulator Register to 0000000 (e.g., with a CLEAR operation)
- Put the desired number of balls into the input guide
- Set the COUNT switch to ON
- Set the other function switches (MULTIPLY, CLEAR, and COMPLEMENT) to OFF
- Set the AM switch to AUTO
- START

Each ball enters the Accumulator at the top, effectively adding one to the 1's place of the register. If the flip-flop contains a 0, it flips to 1. If it contains a 1, it flips to 0 and carries: the ball rolls down to the next flip-flop and adds a 1 at the 2's place (i.e., binary 10's), and the process continues– each ball triggering the next after it finishes –until the supply of balls is exhausted. The final count is displayed as the number in the Accumulator. Binary numbers in the registers are always read bottom to top, so a count of "1" would read 0000001, bottom to top.

Note 1: This is an example of an asynchronous (ripple) counter, much as you find in many electronic circuits. By analogy, the process of one ball passing through the Digi-Comp II is very much like a single clock cycle in an electronic circuit.

Note 2: The Accumulator can only hold numbers as large as 127 (binary 1111111). If your count should exceed this– i.e., overflow to have a 1 in the 128's place (binary 1xxxxxxx) – the OVERFLOW switch setting will determine the behavior. If it is set to "HALT," the operation will end upon overflow. If it is set to "RUN," the operation will continue after overflow.

Addition and/or Multiplication

In modern terms, the Digi-Comp II has a single-process "multiply-accumulate" operation, that can add, multiply, or both. The Multiply and Addition operations described in the Digi-Comp II Instruction Manual are special cases of this operation.

The operation could be described as

$C' = (A \times B) + C$, *where*
A is the initial value of the MQ Register,
B is the value of the Memory Register,
C is the initial value of the Accumulator Register, and
C' is the final value of the Accumulator Register

If the initial value of C is zero, then we just have $C' = (A \times B)$; a pure multiplication. Or, if the initial value of A is 1, then we just have $C' = (1 \times B) + C$, or simply $C' = B + C$; a pure addition.

Procedure:

- INITIALIZE, and load the input guide with balls
- Set the MQ Register to the value A
- Set the Memory Register to the value B
- Set the Accumulator Register to the value C
- Set the MULTIPLY switch to ON
- Set the other function switches (CLEAR, COUNT and COMPLEMENT) to OFF
- Set the AM switch to AUTO
- START

The result will appear in the Accumulator Register when the Digi-Comp II halts.

(Multiply-Accumulate, continued.)

Aside: How many balls do you need in the input guide for the full computation? It turns out that you need $4A + 1$ balls, where A is the initial value in the MQ Register.

Multiplication is performed by looped addition. That is to say, the value in the Memory Register is added to the value in the Accumulator A times, where A is the initial value of the MQ register. Each addition cycle takes 4 balls to complete. On the first ball, and every four balls after that, the Digi-Comp II checks the value in the MQ Register. If the value is nonzero, the value in the MQ register is decremented and a four-ball addition cycle begins, where that first ball (that checked the MQ value and decremented its value) is the first of the four balls used in that addition cycle. On the other hand, if the value of the MQ register is zero, the computation halts: The ball goes down the left-hand side of the Digi-Comp II and does not trigger the start lever.

So, for a simple addition (where the initial MQ value– "*A*" in our terminology – is 1), only one addition cycle (using four balls) executes. The next ball checks and finds the value of the MQ register to be zero, and halts the computation, so exactly five balls are needed.

As the MQ register can hold a value as large as 7 (binary 111), the largest number of balls that will ever be required for a Multiply-Accumulate operation is $4 \times 7 + 1 = 29$.

Example: Multiply 3 × 5

For multiplication, we begin with a value of zero in the Accumulator. The two operands (3 and 5) go in the MQ Register and the Memory Register. (Either operand can go in either register. Commutative property of multiplication– w00t!)

Procedure:

- INITIALIZE, and load the input guide with balls
- Set the Accumulator Register to 0000000 (e.g., with a CLEAR operation)
- Set the MQ Register to the value 3 (binary 011)
- Set the Memory Register to the value 5 (binary 0101)
- Set the MULTIPLY switch to ON
- Set the other function switches (CLEAR, COUNT and COMPLEMENT) to OFF
- Set the AM switch to AUTO
- START

When the Digi-Comp II halts (after 13 balls), the result will appear in the Accumulator Register:
15 (binary 0001111).

Example: Add 10 + 23

For addition, we begin with a value of 1 in the MQ register, and the other two operands go into the Memory Register and Accumulator Register. Since the Memory Register only stores values up to 15 (binary 1111), 10 goes in the Memory and 23 goes in the Accumulator.

(Multiply-Accumulate, continued.)

Procedure:

- INITIALIZE, and load the input guide with balls
- Set the MQ Register to the value 1 (binary 001)
- Set the Accumulator Register to 23 (binary 0010111)
- Set the Memory Register to the value 10 (binary 1010)
- Set the MULTIPLY switch to ON
- Set the other function switches (CLEAR, COUNT and COMPLEMENT) to OFF
- Set the AM switch to AUTO
- START

When the Digi-Comp II halts (after 5 balls), the result will appear in the Accumulator Register:
33 (binary 0100001)

Complements, Negative Numbers, and Subtraction

The other major operation of the Digi-Comp II is the COMPLEMENT function, which calculates the *two's complement* of a number in the Accumulator. The two's complement is a binary-number representation of a negative number, for working with "signed" integers in binary. For example, the two's complement of the number 3 represents "-3" in binary. This binary "-3" is the correct number such that if you should add 3 to it, you will get zero (with an overflow). Together with the addition function, this ability to calculate the two's complement allows us to perform subtraction.

The two's complement of a binary number is calculated by first inverting every bit in the number (swapping each 0 for a 1 and each 1 for a 0) and then adding 1 to the result. (The intermediate result with each bit inverted is called the *one's complement.*) The Digi-Comp II automates this process:

Procedure: Calculate the two's complement of a number *C*

- INITIALIZE, and load the input guide with at least four balls
- Set the Accumulator Register to the value *C*
- Set the COMPLEMENT switch to ON
- Set the other function switches (CLEAR, COUNT and MULTIPLY) to OFF
- Set the AM switch to AUTO
- START

The result will appear in the Accumulator Register when the Digi-Comp II halts, which will be after four balls.

Aside: How does the COMPLEMENT operation work?

The COMPLEMENT operation is managed by a simple four-stage state machine comprised of flip-flops CF1 and CF2, which takes four balls to complete.

The first ball is directed by CF1 into a special channel on the lower deck of the Digi-Comp II, where it travels beneath T1 – T6, the *accumulator mode switches*. On the lower deck, there are six flip-flops located beneath and connected to T1 – T6. As the ball rolls from one flip-flop to the next, it switches each to the opposite side, which also switches T1 – T6 to the opposite side. When it finishes, the accumulator mode switches T1 – T6 will point to the right.

When T1 – T6 are pointing to the left (their default, initialized state), the Accumulator Register is a *counter*. A single ball added to the top will increase the value of the register by one. But when they point to the right, the Accumulator Register is an *inverter*. A single ball added to the top will flip every bit from 1 to 0 or vice versa. The second ball does just this: It is directed by flip-flop CF1 into the top of the Accumulator, and flips every bit, thereby calculating the one's complement. As this ball exits, it is directed by the COMPLEMENT switch to Flip-Flop CF2 before pulling the start switch and triggering the next ball.

We have already flipped every bit in the Accumulator. To complete the COMPLEMENT operation (which calculates the two's complement), we still need to add one to the value in the Accumulator. To do that, we first need to change it back from being an inverter to being a counter.

The third ball is directed by CF1 into the channel on the lower deck, and changes each of the accumulator mode switches (T1 – T6) back from right to left, thereby changing the Accumulator back from being an inverter to being a counter. Finally, the fourth ball is directed by CF1 into the top of the accumulator, and adds one to the value shown there. As this ball exits, it is directed by the COMPLEMENT switch to Flip-Flop CF2. The last time that a ball went through CF2 (the second ball), it was directed to the left. This time, it is directed to the right, where it does not trigger the start lever, and the operation halts.

***Example**: Find the Two's Complement of 3*

Procedure:

- INITIALIZE, and load the input guide at least four balls
- Set the Accumulator Register to the value 3 (binary 0000011)
- Set the COMPLEMENT switch to ON
- Set the other function switches (CLEAR, COUNT and MULTIPLY) to OFF
- Set the AM switch to AUTO
- START

When the Digi-Comp II halts (after 4 balls), the result will appear in the Accumulator Register:
-3 (binary 1111101).

***Example**: Subtraction: calculate 15 - 10*

Subtraction is a two-step process, which we formulate as adding a negative number to a positive one. In other words, we calculate 15 + (-10). First, calculate the two's complement of 10, and then add 15 to it.

Procedure:

- INITIALIZE, and load the input guide at least nine balls
- Set the Accumulator Register to the value 10 (binary 0001010)
- Set the COMPLEMENT switch to ON
- Set the other function switches (CLEAR, COUNT and MULTIPLY) to OFF
- Set the AM switch to AUTO
- START

When the Digi-Comp II halts (after 4 balls), the intermediate result will appear in the Accumulator Register:
-10 (binary 1110110)

Next, we need to add 15 to that result. For addition, we use the multiply/accumulate function:

- Set the MQ Register to the value 1 (binary 001)
- Set the Memory Register to the value 15 (binary 1111)
- Set the MULTIPLY switch to ON
- Set the COMPLEMENT to OFF
- Set the OVERFLOW switch to RUN
- START

When the Digi-Comp II halts (after 5 balls), the result will appear in the Accumulator Register:
5 (binary 0000101).

Division

Division on the Digi-Comp II is another composite operation. Place the dividend in the Accumulator Register, and the divisor in the Memory Register. Run the Complement operation to find the two's complement (negative) of the dividend. Then, repeatedly add the divisor to the Accumulator, until it overflows (i.e., reaches zero). The number of addition operations required is the quotient. The repeated additions are performed like a multiplication operation; the number of addition cycles is counted on the MQ register.

As we mentioned in the section titled *Differences versus the original Digi-Comp II*, it is necessary to invert each digit as we read it from the MQ register when doing division. This is because we are using the MQ register as an up-counter, rather than its usual role as a down-counter. For example, when dividing, if the flip flops point to the "111" engraved into the wood, that is understood to mean a value of "000."

Example*: Calculate 30 / 5*

Procedure:

- INITIALIZE, and load the input guide
- Set the Accumulator Register to the value 30 (binary 0011110)
- Set the COMPLEMENT switch to ON
- Set the other function switches (CLEAR, COUNT and MULTIPLY) to OFF.
- Set the AM switch to AUTO
- START
- Wait for the COMPLEMENT operation to halt

When the Digi-Comp II halts (after 4 balls), the intermediate result will appear in the Accumulator Register:
-30 (binary 1100010).

- Set the COMPLEMENT switch to OFF
- Set the MULTIPLY switch to ON
- Set the Memory Register to the value 5 (binary 0101)
- Set the MQ Register to the value 0 (binary 000; *All to the left*)*
- Set the OVERFLOW switch to HALT
- START

When the Digi-Comp II halts, the result will appear in the MQ Register:
6 (binary 110)*.

For a more extensive reference, including details about how to deal with remainders, please see the full Digi-Comp II Instruction Manual.

*Again, remember that MQ register values are inverted when doing division. Binary 000 will read "111" before inversion, and binary 110 will read "001" before inversion.

Removing and re-attaching the lower deck

The lower deck of the DCIIFE is held in place by six sets of screws and wing nuts. Each screw goes through the top deck, through one or more spacers and/or shims, through the lower deck, and is finally held in place by the wing nut. The spacers and/or shims are trimmed to give the correct spacing between the two decks.

If it becomes necessary for any reason to remove the lower deck, begin with the DCIIFE with its stand attached, resting on its side such that (1) you have access to both the top and bottom sides and (2) the screws are pointing horizontally. (This orientation makes it much easier to not lose the spacers when you remove the lower deck.) Press firmly on the head of one screw to hold it in place while you loosen the wing nut on the back side. When all six wing nuts are loosened, thread them off, leaving the lower deck temporarily held in place by the six screws. Gently work the lower deck off, taking care to not lose the spacers/shims.

When reassembling the unit, work in reverse, again with the DCIIFE resting on it side. Insert the screws, slide the spacers/shims onto the screws, slide on the lower deck, and finally add the wing nuts. Take care not to tighten them so much that you will have trouble removing them later if necessary.

Troubleshooting

If balls should come to rest in an unexpected place, or the balls do not roll down the input guide to the ball release, check that the DIGI-COMP II is on a level table.

The length and shape of the actuator wire for the ball release is rather critical; take care to treat it nicely. It should go in a straight line from the Start Lever to the Ball Release, and both parts should turn together freely, with little friction.

In general, flip-flops should turn freely, while switches do not need to. The exception is the set of Accumulator mode switches, which have flip-flops on the lower deck: those need to turn freely.

If multiple balls should enter the lower deck, it is possible to create a traffic jam down there. If you find that balls are regularly getting stuck down there, you may have an extra ball "trapped" there that is causing repeated jams. If so, wiggle the flip-flops and switches in the vicinity of the jam to free it.

Sharp edges, small parts

The flip-flops and switches are laser-cut wooden parts, held together with brass pins that may have sharp edges. If necessary, these edges can be gently sanded. Similarly, the wooden upper and lower deck may have sharp points, particularly in the interior. Pointy edges can be sanded with 400-grit sandpaper. The wood surface is finely sanded, but otherwise unfinished. If you choose to, it can potentially be finished with any standard wood finish, but take care to avoid clogging the holes or otherwise preventing parts from moving.

The DCIIFE contains many small parts (notably, the steel balls) and should be kept out of reach of young children.

Technical assistance and spare parts

Evil Mad Scientist offers comprehensive technical support for the lifetime of its products, and stocks or can fabricate any replacement parts that are necessary. If you should need any assistance with your Digi-Comp II, please do not hesitate to contact us by e-mail (contact@evilmadscientist.com) or by using the contact form on our web site, www.evilmadscientist.com

Special thanks

To George Hart and Seth Golub for finding errors and making helpful suggestions to improve this quick-start guide.

DIGI-COMP II®
Programmer's Card

MACHINE LANGUAGE COMMANDS

Command	Definition
MULTIPLY=ON	Turn MULTIPLY SWITCH to the RIGHT
MULTIPLY=OFF	Turn MULTIPLY SWITCH to the LEFT
CLEAR=ON	Turn CLEAR SWITCH to the RIGHT
CLEAR=OFF	Turn CLEAR SWITCH to the LEFT
COUNT=ON	Turn COUNT SWITCH to the RIGHT
COUNT=OFF	Turn COUNT SWITCH to the LEFT
COMPLEMENT=ON	Turn COMPLEMENT SWITCH to the LEFT
COMPLEMENT=OFF	Turn COMPLEMENT SWITCH to the RIGHT
OVERFLOW=RUN	Turn OVERFLOW SWITCH to the LEFT
OVERFLOW=HALT	Turn OVERFLOW SWITCH to the RIGHT
A-M=AUTO	Turn A-M SWITCH to the LEFT
A-M=MANUAL	Turn A-M SWITCH to the RIGHT
START	Pull the START SWITCH
PAUSE	Pause until the computer has completed its automatic cycle before continuing with program.
A=XXX.XXXX	Means that there is an imaginary Binary Point between the bits in A4 and A5. It must be remembered by the programmer.
M=A	Put the contents of the MEMORY REGISTER into the ACCUMULATOR REGISTER.
A↔M	Interchange the contents of the ACCUMULATOR and MEMORY REGISTERS.
PRINT X	Write down the value of X.
If (A > X); 8, 3	If A is greater than X go to Step 8, if A is less than or equal to X go back to Step 3.
SHIFT LEFT	Manually shift the ACCUMULATOR left by one place by moving each bit down one place.
ROUND (XX.XX)	Round the number to the form shown in the parentheses. (Remember that if the highest order bit which is truncated is A 1, that 1 should be added to the lowest order bit which is preserved.)

DIGI-TRAN COMPILER LANGUAGE COMMANDS

Digi-Tran Command	Machine Language Program	Digi-Tran Command	Machine Language Program
COUNT	1. INITIALIZE 2. A =0000000 3. COUNT=ON 4. START	SUBTRACT	5. PAUSE 6. MULTIPLY=ON 7. COMPLEMENT=OFF 8. START
CLEAR	1. INITIALIZE 2. CLEAR=ON 3. AM=MANUAL 4. START	DIVIDE	1. INITIALIZE 2. MQ=111 3. COMPLEMENT=ON 4. START 5. PAUSE 6. COMPLEMENT=OFF 7. MULTIPLY=ON 8. OVERFLOW=HALT 9. START
ADD	1. INITIALIZE 2. MULTIPLY=ON 3. MQ=001 4. START		
MULTIPLY	1. INITIALIZE 2. MULTIPLY=ON 3. A=0000000 4. START	COMPLEMENT	1. INITIALIZE 2. COMPLEMENT=ON 3. START
SUBTRACT	1. INITIALIZE 2. COMPLEMENT=ON 3. MQ=001 4. START	MULTIPLY-ADD (A×B+C)	1. INITIALIZE 2. MULTIPLY 3. A=C 4. START

These reference cards were included with the original Digi-Comp II kit; we've scanned them here for your reference.

BINARY-DECIMAL CONVERSION TABLE

Decimal No.	Binary No.	Decimal No.	Binary No.	Decimal No.	Binary No.
0	0000000	43	0101011	86	1010110
1	0000001	44	0101100	87	1010111
2	0000010	45	0101101	88	1011000
3	0000011	46	0101110	89	1011001
4	0000100	47	0101111	90	1011010
5	0000101	48	0110000	91	1011011
6	0000110	49	0110001	92	1011100
7	0000111	50	0110010	93	1011101
8	0001000	51	0110011	94	1011110
9	0001001	52	0110100	95	1011111
10	0001010	53	0110101	96	1100000
11	0001011	54	0110110	97	1100001
12	0001100	55	0110111	98	1100010
13	0001101	56	0111000	99	1100011
14	0001110	57	0111001	100	1100100
15	0001111	58	0111010	101	1100101
16	0010000	59	0111011	102	1100110
17	0010001	60	0111100	103	1100111
18	0010010	61	0111101	104	1101000
19	0010011	62	0111110	105	1101001
20	0010100	63	0111111	106	1101010
21	0010101	64	1000000	107	1101011
22	0010110	65	1000001	108	1101100
23	0010111	66	1000010	109	1101101
24	0011000	67	1000011	110	1101110
25	0011001	68	1000100	111	1101111
26	0011010	69	1000101	112	1110000
27	0011011	70	1000110	113	1110001
28	0011100	71	1000111	114	1110010
29	0011101	72	1001000	115	1110011
30	0011110	73	1001001	116	1110100
31	0011111	74	1001010	117	1110101
32	0100000	75	1001011	118	1110110
33	0100001	76	1001100	119	1110111
34	0100010	77	1001101	120	1111000
35	0100011	78	1001110	121	1111001
36	0100100	79	1001111	122	1111010
37	0100101	80	1010000	123	1111011
38	0100110	81	1010001	124	1111100
39	0100111	82	1010010	125	1111101
40	0101000	83	1010011	126	1111110
41	0101001	84	1010100	127	1111111
42	0101010	85	1010101	128	10000000

etc.

NEW OPERATIONS CHECK LIST

INITIALIZE

1. Be sure that T1, T2, T3, T4, T5, and T6 are to the left.
2. Be sure that CF1 is to the left and that CF2 is to the right.
3. Set Flip-Flops D1, D2, and D3 in the Distributor to the right.

OPERATION	MQ REGISTER SETTING	MEMORY REGISTER SETTING	ACCUMULATOR REGISTER SETTING	SWITCH SETTINGS					
				MULTIPLY	CLEAR	COUNT	COMPLE-MENT	OVER-FLOW	AM
COUNT			0000000	OFF	OFF	ON	OFF	RUN	AUTO
CLEAR				OFF	ON	OFF	OFF	RUN	MAN.
ADD (A + B)	001	A	B	ON	OFF	OFF	OFF	RUN	AUTO
MULTIPLY (A × B)	A	B	0000000	ON	OFF	OFF	OFF	RUN	AUTO
SUBTRACT (A − B)	001	A	B	OFF	OFF	OFF	ON	RUN	AUTO
				ON	OFF	OFF	OFF	RUN	AUTO
DIVIDE (A / B)	000* (111, before inverting)	B	A	OFF	OFF	OFF	ON	RUN	AUTO
				ON	OFF	OFF	OFF	HALT	AUTO