

*TI-83+ Z80 ASM
for the Absolute
Beginner*

LESSON NINE:

- *Math Applied to Constants*
- *The Special Purpose of HL*
 - *Displaying Text*

MATH APPLIED TO CONSTANTS

If you remember, `.db` is used to enter raw data into the calculator, data which you access by the ram addresses in which the data is contained. Data entered via `.db` is unaltered, untranslated.

Let's say, hypothetically, that you want to program a four-color grayscale game with black, white, light grey and dark grey colors. This game—we can pretend, can't we—will be a four-player, split-screen multiplayer game, that allows each player to build a car. There are five values of data in particular: Color of car, color of wheels, type of car, size of car, and speed of car. (Don't compile this)

```
#include "ti83plus.inc"
.org 40339
.db  t2ByteTok, tAsmCmp

Truck .equ 0      ; A whole bunch of constants
Car .equ 1
Motorcycle .equ 2
Slow_Speed .equ 0
Medium_Speed .equ 1
Fast_Speed .equ 2
Small_Size .equ 0
Medium_Size .equ 1
Big_Size .equ 2
White .equ 0
Light_Grey .equ 1
Dark_Grey .equ 2
Black .equ 3
```

; Continued on next page

```

Player1:
    .db White, Light_Grey, Truck, Small_Size, Slow_Speed
Player2:
    .db Black, Dark_Grey, Car, Medium_Size, Fast_Speed
Player3:
    .db Light_Grey, Dark_Grey, Motorcycle, Large_Size, Slow_Speed
Player4:
    .db Black, White, Motorcycle, Small_Size, Medium_Speed

```

So then, you remember how to access data in a variable, right? For example, `ld a, (Player1)`. However, register A will only contain the color White, meaning the number zero! Want to know why? Here's a program with its translation:

ASM	RAM ADDRESS ON CALCULATOR	TRANSLATION, IN DECIMAL NUMBERS
<code>#include "ti83plus.inc"</code>		
<code>.org 40339</code>		
<code>ld a, (Player1)</code>	40339	58, 40342
<code>Player1:</code>		
<code>.db White,</code>	40342	0,
<code>Light_Grey,</code>	40343	1,
<code>Truck, Small_Size, Slow_Speed</code>	40344	0, 0, 0

As you can see, register A accesses only what is inside RAM address 40342; that is, Player1 pertains to RAM address 40342, which holds the first value of data, and that is all that is stored inside register A. So if you want to get the other four values and store them in registers B, C, D and E? These four values are stored in addresses 40343, 40344, 40345 and 40346, so how do you get them? You could create a label for each value, but that can get quite tedious and messy.

However, if you think of the label as just a constant, you can do some math with the constant. In this case, Player1 is equal to 40342, which means that SPASM puts in the number 40342 whenever it comes across Player1. So what if you do a little math, and add 1 to the constant? For instance, Player1 + 1? Then SPASM will put in 40343, which is $40342 + 1$!

So, you can access the first value in Player1 by `ld a, (Player1)`, the second value using `ld a, (Player1 + 1)`, the third value by using `ld a, (Player1 + 2)`, etc.

You can also apply a minus sign to a constant. And even multiplication! For instance, `Player1 - 5` and `Player1 * 15`.

So why can you do this and not use multiplication, addition or subtraction directly on registers? Why can't you say "`ld a, e + 5`?" This is because the processor, directly, can't handle this. Whenever there is a value that has to change, the processor can only do so much at a time to change it.

But the value for constants is set. When you apply addition, subtraction, and multiplication to a constant before compiling it, the value is fixed, it will never change...a constant added, subtracted, or multiplied by a constant is still a constant. In other words, if you tell your program to `ld a, (Player1 + 7)`, the program doesn't translate into

“find out what `Player1 + 7` is equal to, and then put into register A whatever is inside of `Player1 + 7`.” Instead, the program translates into “put into register A whatever is inside of RAM at address 40350.”

For this reason, you can use addition, subtraction and multiplication on definite numbers. For instance, `ld a, 3+ 3` will translate into `ld a, 6`. Similarly, `ld a, 4 * 23` will translate into `ld a, 92`. Finally, `ld a, NumberSeven + NumberFour` is the same as `ld a, 11`.

THE SPECIAL PURPOSE OF HL

Now that you understand how you can access subsequent areas of ram, let's look at an example of how to do this. We will use our previous data, and store the color of the car in register b, the color of the wheels in register c, the type of car in register d, and the size of the car in register e. Register A will contain the speed of the car. The values we load will depend on the player.

```
; Register A will contain the player, whether 1, 2, 3 or 4. We use the value
; in register A to decide what data to load.
```

```
cp 1
jr z, Load_Player1_Data
cp 2
jr z, Load_Player2_Data
cp 3
jr z, Load_Player3_Data
cp 4
jr z, Load_Player4_Data
```

```
Load_Player1_Data:
```

```
ld a, (Player1)
ld b, a
ld a, (Player1+1)
ld c, a
ld a, (Player1+2)
ld d, a
ld a, (Player1+3)
ld e, a
ld a, (Player1+4)
ret
```

Load_Player2_Data:

```
ld a, (Player2)
ld b, a
ld a, (Player2+1)
ld c, a
ld a, (Player2+2)
ld d, a
ld a, (Player2+3)
ld e, a
ld a, (Player2+4)
ret
```

Load_Player3_Data:

```
ld a, (Player3)
ld b, a
ld a, (Player3+1)
ld c, a
ld a, (Player3+2)
ld d, a
ld a, (Player3+3)
ld e, a
ld a, (Player3+4)
ret
```

```
Load_Player4_Data:
```

```
    ld a, (Player4)
```

```
    ld b, a
```

```
    ld a, (Player4+1)
```

```
    ld c, a
```

```
    ld a, (Player4+2)
```

```
    ld d, a
```

```
    ld a, (Player4+3)
```

```
    ld e, a
```

```
    ld a, (Player4+4)
```

```
    ret
```

```
Player1:
```

```
    .db White, Light_Grey, Truck, Small_Size, Slow_Speed
```

```
Player2:
```

```
    .db Black, Dark_Grey, Car, Medium_Size, Fast_Speed
```

```
Player3:
```

```
    .db Light_Grey, Dark_Grey, Motorcycle, Large_Size, Slow_Speed
```

```
Player4:
```

```
    .db Black, White, Motorcycle, Small_Size, Medium_Speed
```

Okay, so this works, but did you notice how much space this takes? You also notice that if you were to write a program to do the same thing in Ti-Basic, you wouldn't have to make a 4x copy of your simple code. The problem is, in ASM, you have to pick a different constant, a different ram address, each time. This is because of the function `ld a, (Value)`, which calls for a strict value, a strict ram address. What we need is to load register A with an address that can change. We

can't change the value of constants, but we can sure change the value of registers!



In a perfect world, we could load a ram address into a register depending on what player we want to load. In a perfect world, we could use this value to access the car color for the player, and then increase the value in the register to access the next value of data for the car, aka the color of the wheels. On the next page is our perfect world program, using the register H to hold the ram address.

; Register A will contain the player, whether 1, 2, 3 or 4. We use the value
; in register A to decide what data to load.

```
cp 1  
call z, Load_Player1_Data  
cp 2  
call z, Load_Player2_Data  
cp 3  
call z, Load_Player3_Data  
cp 4  
call z, Load_Player4_Data  
call Load_Data_Into_Registers
```

Load_Player1_Data:

```
ld h, Player1  
ret
```

Load_Player2_Data:

```
ld h, Player2  
ret
```

Load_Player3_Data:

```
ld h, Player3  
ret
```

Load_Player4_Data:

```
ld h, Player4  
ret
```

; Continued on next page

Load_Player_Data:

```
ld a, (h) ; In a perfect world, h contains the ram address to load from
ld b, a
inc h
ld a, (h)
ld c, a
inc h
ld a, (h)
ld d, a
inc h
ld a, (h)
ld e, a
inc h
ld a, (h)
ret
```

Player1:

```
.db White, Light_Grey, Truck, Small_Size, Slow_Speed
```

Player2:

```
.db Black, Dark_Grey, Car, Medium_Size, Fast_Speed
```

Player3:

```
.db Light_Grey, Dark_Grey, Motorcycle, Large_Size, Slow_Speed
```

Player4:

```
.db Black, White, Motorcycle, Small_Size, Medium_Speed
```

But let's face the facts: it's not a perfect world. Remember that H cannot be bigger than 255? Most RAM addresses are much bigger than 255!

Oh, but this was so much smaller (and would be faster) than using constants! Oh, if only we could do something like this in a Z80 ASM program.

Oh, but we can! It's just we can't use a one-byte register, as it only goes up to 255. H and L are both one-byte registers. But, what happens when you put one byte and one byte together? You get TWO bytes! Simple math! ☺ Oh, and 2 bytes can go up to 65535, which, as you can tell, is high enough to store RAM addresses!

So you use HL (H and L put together) to store RAM addresses. Then, as you might expect, you use (HL) to access whatever is inside of the RAM pointed to by HL.

By the way, if you use a fixed number/constant to store a RAM address and retrieve whatever is inside of it, you can only use register A to do so. BUT when you use HL, you can immediately store it to any one-byte register! **Whenever you see a function that has a parameter of a one-byte value, you can also use (HL) inside that parameter.**

For example, instead of

ld a, (Player1)

ld e, a

You can use

ld hl, Player 1

ld e, (hl).

This will give us VAST improvements to our data-accessing program. You can use INC and DEC functions on HL by the way.

```
; Register A will contain the player, whether 1, 2, 3 or 4. We use the value  
; in register A to decide what data to load.
```

```
    cp 1  
    call z, Load_Player1_Data  
    cp 2  
    call z, Load_Player2_Data  
    cp 3  
    call z, Load_Player3_Data  
    cp 4  
    call z, Load_Player4_Data  
    call Load_Data_Into_Registers
```

```
Load_Player1_Data:
```

```
    ld hl, Player1  
    ret
```

```
Load_Player2_Data:
```

```
    ld hl, Player2  
    ret
```

```
Load_Player3_Data:
```

```
    ld hl, Player3  
    ret
```

```
Load_Player4_Data:
```

```
    ld hl, Player4  
    ret
```

```
; Continued on next page
```

```
Load_Player_Data:
```

```
    ld b, (hl) ; In a perfect world, h contains the ram address to load from
    inc h
    ld c, (hl)
    inc hl
    ld d, (hl)
    inc hl
    ld e, (hl)
    inc hl
    ld a, (hl)
    ret
```

```
Player1:
```

```
    .db White, Light_Grey, Truck, Small_Size, Slow_Speed
```

```
Player2:
```

```
    .db Black, Dark_Grey, Car, Medium_Size, Fast_Speed
```

```
Player3:
```

```
    .db Light_Grey, Dark_Grey, Motorcycle, Large_Size, Slow_Speed
```

```
Player4:
```

```
    .db Black, White, Motorcycle, Small_Size, Medium_Speed
```

You can also use (hl) to store values into variables.

For example, instead of

```
ld a,1
```

```
ld (Player1), a
```

You can use

```
ld hl, Player 1
```

```
ld (hl), 1
```

DISPLAYING TEXT

Now that you understand on how HL is used to store **changing, non-constant** RAM addresses for data access, we can start playing with functions that require HL as a parameter. After reading the title, you might wonder, “why do we need HL to display text?” Because text is stored as pure, unaltered data with .db, meaning *you need a label!* And HL is used to access this label.

Since .db is used to enter raw data, you can use it to store strings. However, there is a catch, nothing that you need to be concerned about, and actually something that gives you an advantage.

Remember that a translated ASM program, in the end, consists of a whole bunch of numbers. When your calculator stores a string, it’s stored as a bunch of numbers. When your calculator needs to display the string, these numbers are, when the program is running, translated into their respective characters so you see them on the screen as letters.

For example, the letter “A” is the number 65, and the letter “C” is the number 67. So if you need your calculator to display “ACA,” your program should contain the numbers 65 67 65, in other words .db 65, 67, 65. When ordered to display this data as a string, your calculator will read these numbers and translate them onto the screen as ACA.

The advantage is that you can display characters you normally couldn’t display in Ti-Basic! For instance, what if you wanted to display the “blinking block” you see on the text screen all the time?



The number for this character is 224. So by putting .db 224 in your program and telling your calculator to display it as a string, the calculator will see the number 224 and display this block character.

However, let's face it, `.db Number, Number, Number` for a bunch of letters can be tedious. Looking up the numerical translations for a bunch of characters is very time-consuming. Thus, you can enter strings directly as well with `.db`.

For example,

Text:

```
.db "Hello World", "This is my string," 224, 65, 67, 67, 65, etc.
```

Of course, you can combine string data and numbers, such as with the above example.

It's just important to understand that the string is stored as numbers, just in case you want to use letters and symbols that your computer doesn't supply, such as the arrows you see in the calculator for scrolling menus.

The built-in function `PutS` will take the numerical data, and translate them into letters that are placed on the screen as text you can see.

`B_CALL _PutS`

Displays a string specified by the label stored in HL. The string must end in a zero, or an error occurs. The zero tells the calculator where the string ends.

Examples: `LD HL, String`

`B_CALL PutS`

String:

```
.db "Hello World", 0
```

As a reminder, I don't recommend you copy this program directly, in case "copy-and-paste" bugs occur. You should retype it yourself.

```
#include "ti83plus.inc"
.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld hl, HelloWorldString
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

HelloWorldString:

    .db "Hello World", 0
```

Wouldn't it be if we could put the string anywhere we want?

If you read chapter three, you remember that the calculator has special areas of RAM reserved for its uses, each with its own addresses. For displaying text on the main screen, the calculator keeps track of the location of the cursor using `curCol` and `curRow`. `curCol` is a constant, and so is `curRow`. `curRow` is a constant for RAM address 33867. The RAM at 33867 is used for storing what row—the first row, row 0; the second row, row 1; the third row, row 2; etc.—the cursor is on the home screen. `curCol` is right after `curRow` in terms of location/address, and is used to store what column—0 to 15—the cursor is located. By manually specifying a row and a column, we can tell the calculator where we want our text. Add the lines in blue on the next page.

```
#include "ti83plus.inc"
.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld a, 3
    ld (curRow), a
    ld a, 2
    ld (curCol), a

    ld hl, HelloWorldString
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

HelloWorldString:

    .db "Hello World", 0
```

Remember, the first row is row 0, and the first column is column 0.

Some exercises are on the next page. Next lesson we'll learn about other two byte registers, by putting D and E together, and by putting B and C together. Then we'll do some more work on ASM Gorillas the lesson afterwards.

Exercises: Write programs to display strings at the specified positions on the screen.

1. The string “Get a grip” at anywhere in particular
2. The string “This is fun!!” on the first row, the first column
3. The string “Ti-83+ Z80 ASM” in the second column and the 4th row
4. The string “A” in the 16th column, the 6th row
5. The string “Hello World” preceded by an up arrow and proceeded by a down arrow. The numerical value for an up arrow is 30, and the numerical value for a down arrow is 31. Display it in the 3rd Column and the 4th row.

ANSWERS:

```
#include "ti83plus.inc"
.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld hl, String
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

String:

    .db "Get a grip", 0
```

```
#include "ti83plus.inc"
.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld a, 0
    ld (curRow), a
    ld a, 0
    ld (curCol), a

    ld hl, String
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

String:

    .db "This is fun!!", 0
```

```

#include "ti83plus.inc"

.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld a, 3
    ld (curRow), a
    ld a, 1
    ld (curCol), a

    ld hl, String
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

String:

    .db "Ti-83+ Z80 ASM", 0

```

```

#include "ti83plus.inc"

.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld a, 6
    ld (curRow), a
    ld a, 15
    ld (curCol), a

    ld hl, String
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

String:

    .db "A", 0

```

```
#include "ti83plus.inc"
.org 40339
.db t2ByteTok, tAsmCmp

    B_CALL _ClrLCDFull

    ld a, 3
    ld (curRow), a
    ld a, 2
    ld (curCol), a

    ld hl, HelloWorldString
    B_CALL _PutS
    B_CALL _getKey
    B_CALL _ClrLCDFull
    ret

HelloWorldString:

    .db 30, "Hello World", 31, 0
```