Computer Architectures exam of 10 February 2011: Assembly Programming

It is well known that Populated Manorians (a population of the Nearby Galaxy, i.e. NG) have a positional number system in base 7. The available digits are, for sake of simplicity, represented as
Z equivalent to our 0
W equivalent to our 1
V equivalent to our 2
U equivalent to our 3
T equivalent to our 4
S equivalent to our 5
R equivalent to our 6
Numbers are represented with a sign followed by a module (as in our base 10). The module of a number is represented in base 7 as a sorted sequence of digits i.e. in base 7 positional. For example, TUW corresponds to a module whose value is obtained by converting (431) from base 7 to base 10, i.e. 4*7^2 + 3* 7 + 1.

It is required to write an assembly 8086 program that emulates a very simple NG hand calculator that has the possibility to display and handle numbers in the interval -RRRRR to +RRRRR with a representation in module and sign. The internal representation of numbers is a sign on one bit, followed by the base 7 positional module where each digit takes 3 bits, and the sign takes one bit. For example, the number +TUWWZ is represented by a string of 16 bits as follows:

0 100 011 001 001 000
+ T U W W Z

The operations that are carried out by the NG calculator are the following:

- Addition of two signed five digit numbers each one stored in a 16-bits variable according to the previous notation, with a result stored with the same notation (i.e. sign and five digits)
- Subtraction of two signed five digit numbers each one stored in a 16-bits variable according to the previous notation, with a result stored with the same notation (i.e. sign and five digits)

It is not required to manage the overflow detection and signal, i.e. it can be assumed as a supplemental data of the problem that the operands never generate an overflow.

It is required that all operations are done in the native NG number representation explained above; solutions converting from-to the complete number NG representation to-from two's complement will be considered but with a much lower evaluation, since the main goal of the problem is to show the ability to manage bits and computations under different rules. On the other hand, conversions at single digit level are recommended as one of the possible alternatives.

Steps in writing the program:
Item 1. Implement the addition of two positive numbers, and the addition of two negative numbers
Item 2. Implement the subtraction of a positive minus a negative number and the subtraction of a negative minus a positive number
Item 3. Implement all the remaining combinations both for addition and subtraction

Bonus: overflow detection and management (bonus point(s) can be added only once).

Points:

Item 1. = up to 22 points;
Item 2. = up to 3 points;
Item 3. = up to 7 points;
Bonus: 1 point.

EXAMPLES

Two single digit number additions

- (+V) + (+U) == (+2) + (+3) = (+5) == (+S)
- (+V) + (-U) == (+2) + (-3) = (-1) == (-W)

- (+V) + (+S) == (+2) + (+5) = (+7) == (+Z) with a carry of 1 (i.e. +10 in base 7)

Two 5 digits number addition

(+TSUZR) + (+WWTTT): we start, as in decimal addition right to left

(R) + (T) = (U) with a carry of 1 (i.e. W)
carry + (Z) + (T) = (S) with a carry of 0
carry + (U) + (T) = (Z) with a carry of 1
carry + (S) + (W) = (Z) with a carry of 1
carry + (T) + (W) = (R) with a carry of 0, i.e. no overflow

Therefore (+TSUZR) + (+WWTTT) = (+RZZSU)

It is not required to provide the optimal (shortest, most efficient, fastest, …) solution, but a working and clear solution.

Please use carbon copy and retain one copy for home implementation and debug. Please provide your classroom submitted solution with several explanatory and significant comments. When coming to oral discussion, please mark on your "classroom" copy all modifications. Please also provide an error-free and running release of the solution, as well as with its printed list of instructions. Please consider that the above are necessary but not sufficient requirements to success the exam, since the final evaluation will be based on a number of parameters.

FAILURE TO ACCOMPLISH ALL PREVIOUS NECESSARY REQUIREMENTS WILL CAUSE NO-QUESTION-ASKED AND IMMEDIATE REJECTION.