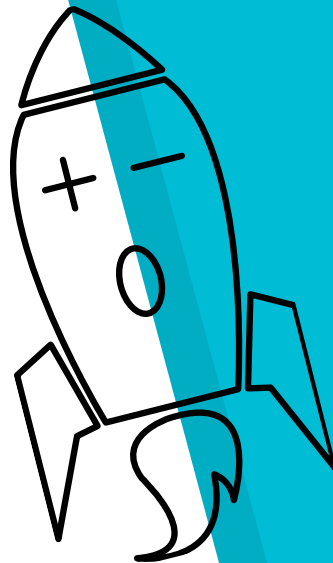


# Ternary Spacecraft



Ing. Giuseppe Talarico  
e-mail: [giustala@gmail.com](mailto:giustala@gmail.com)

# About me:

My name is **Giuseppe Talarico**.

I'm an electronic engineer from Catanzaro.

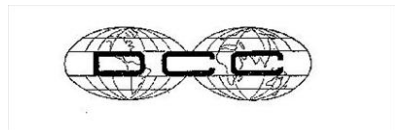
As circuit designer I worked with:



Vimercate (MI) Digital Radio Link "HTN6U"



Misterbianco (CT) Digital Speech Interpolation



Germantown - Maryland - USA

Selenia-DCC Project: **Italsat-F1 Satellite**



## ITALSAT-F1

Launched on  
16th January 1991  
from the Kourou Base  
in French Guiana



**TELETTRA**

**DIGITHON**

# How and why:

It all began in 1981 when I was a young electronic engineer at the *Telettra* in Vimercate and I heard someone talking about “Three Level Logic”.

The Internet did not exist at the time and therefore I could not investigate the subject.



....thirty three years later (2014)

A student brought me some photocopies of *prof. Douglas Jones* from the Iowa University-USA with subject: "Ternary Logic".

I started to study those documents and I discovered a world I named:

"The Galaxy of Ternary Logic".



Ercolino Scalfaro  
Catanzaro

# Who's the first?

- 1 shilling = 12 pence
- 1 florin = 2 shillings
- 1 half crown = 2 shillings and 6 pence
- £1 = 20 shillings = 240 pence

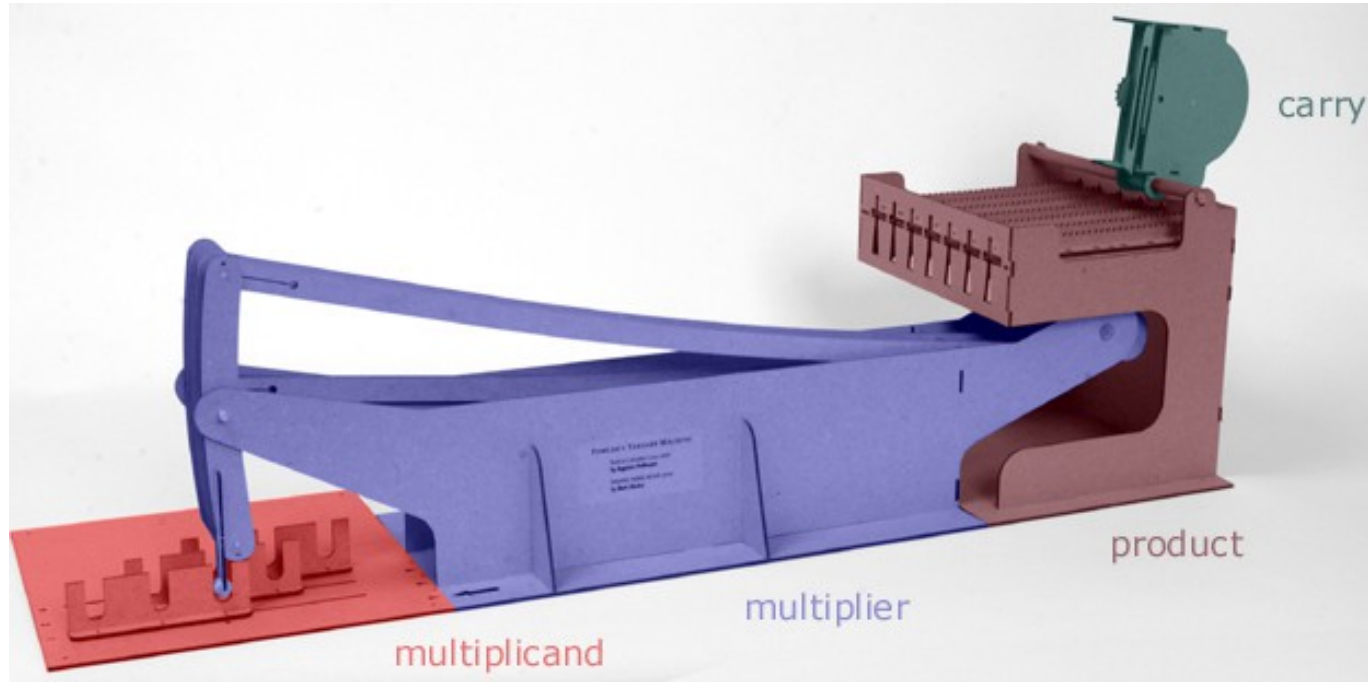
In the 1830s *Thomas Fowler* (1777 – 1843), to simplify his repetitive monetary calculations (pre-decimal British currency), began to use **Binary** and **Ternary** representations as reported in his book published in 1838:

**"Tables for Facilitating Arithmetical Calculations"**

Furthermore, Thomas created a mechanical calculator that, for the first time, used a “Balanced Ternary Notation” (-, 0, +) to perform arithmetic calculations.

The original drawings of his “55 digits calculator” were lost.

In 1997 a reduced implementation of this mechanical calculator has been constructed from a two-page description of it made in 1840 by *Augustus De Morgan*.



The figure shows a modern 3D printed construction based on De Morgan description.

# What's this Hardware?

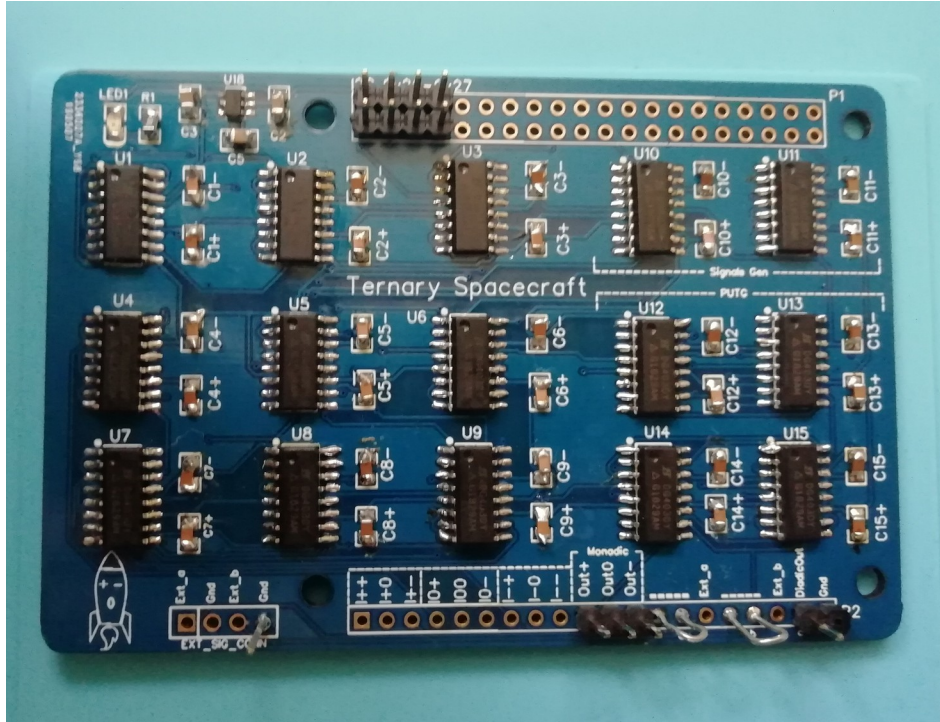


It is just:

- a Ternary Spacecraft board
- a “card computer”
- a monitor
- an Oscilloscope must be used too.



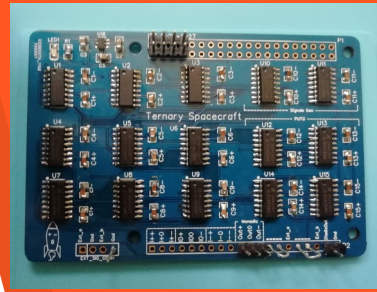
# Ternary Spacecraft board:



This board is a “raspberry HAT”

# Ternary Spacecraft

- It is a board interfaced with a “card computer” operating in **Balanced Ternary Logic (-1,0,1)**.
- Two python software modules allows to explore, using an oscilloscope, the "galaxy" of Ternary Logic.



# Binary System



In the binary system there are  $2^{(2)^k}$  possible k-argument functions.

- $k=1$ :  $c = f(a)$
- $k=2$ :  $c = f(a,b)$

So, there are:

$2^2 = 4$  Monadic functions or Truth tables

$2^4 = 16$  Dyadic functions or Truth tables








# Binary “building bricks”:

Just one of the four monadic functions is currently used as logical gate: the

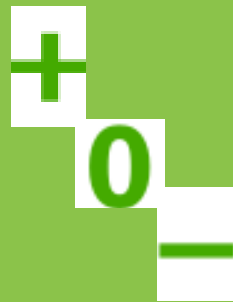
**NOT**

Six of sixteen dyadic functions give rise to logical gates that can be used in the design of logical boards:

**AND, NAND, OR, NOR, XOR, XNOR.**

AND		$A \cdot B$
OR		$A + B$
NOT		$\bar{A}$
NAND		$\overline{A \cdot B}$
NOR		$\overline{A + B}$
XOR		$A \oplus B$
XNOR		$A \odot B$ or $\overline{A \oplus B}$

# Ternary System



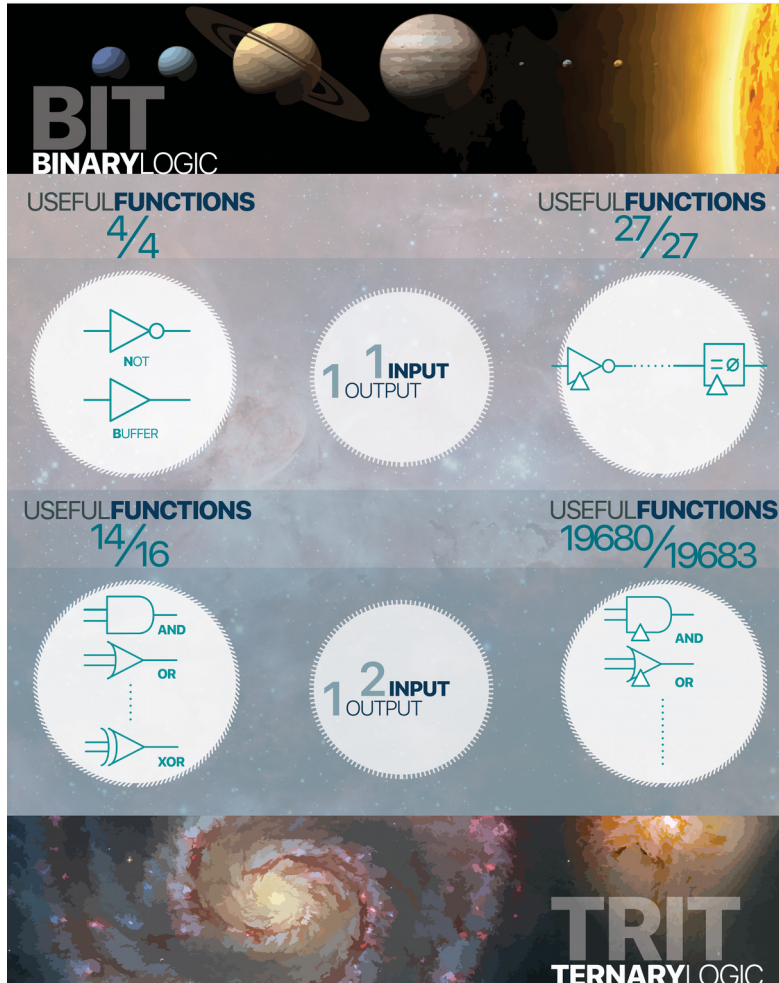
In the Ternary system there are  $3^{(3)^k}$  possible k-argument ternary functions, so we have:

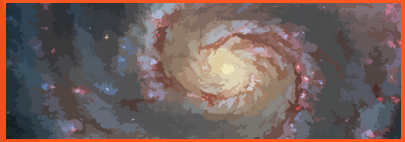
$3^3 = 27$  Monadic functions or Truth tables

$3^9 = 19'683$  Dyadic functions or Truth tables

The number of dyadic functions is **incredibly high** !

# Binary vs. Ternary:



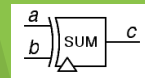
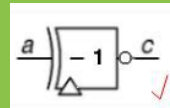
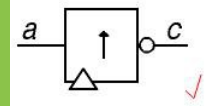
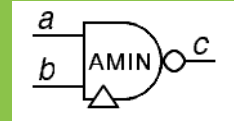
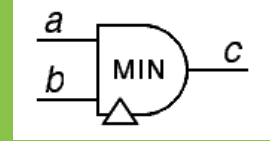
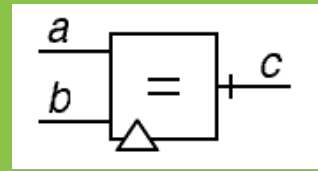


# Unknown Worlds

Nobody, until now, has ever ventured into the complete exploration of such a high number of dyadic functions (dyadic gates) also **due to the lack** of logical components operating on three levels (ternary logic).

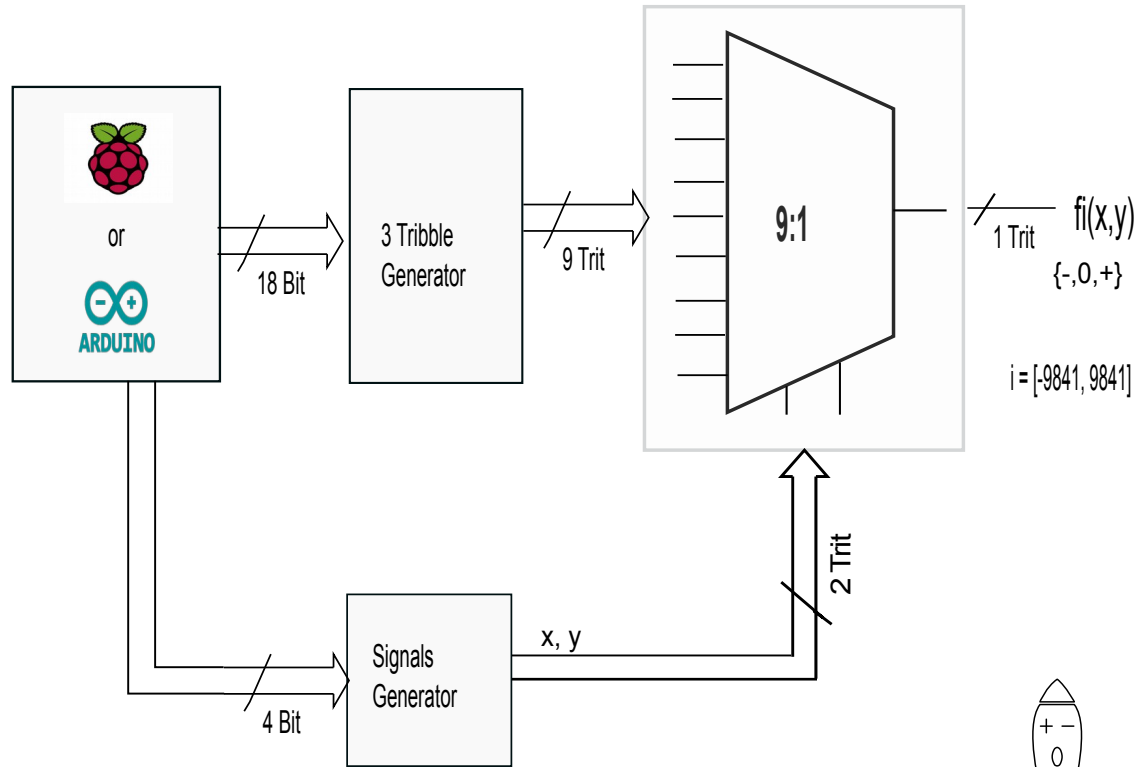
- In this galaxy of possible components, the majority of them have neither a **name** nor a **symbol**.
- Their Input-Output logical functions are almost all **unknown**.

My board allows to explore the whole “Ternary Galaxy” of possible gates by using an oscilloscope.

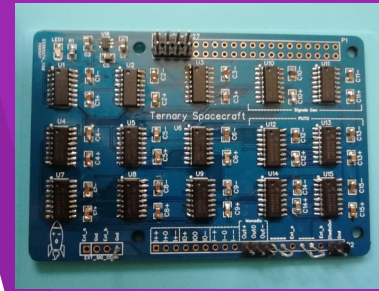




# System Block Diagram:



Ternary Spacecraft Block Diagram

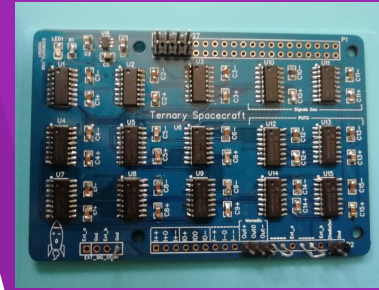


The hardware designed implements a:

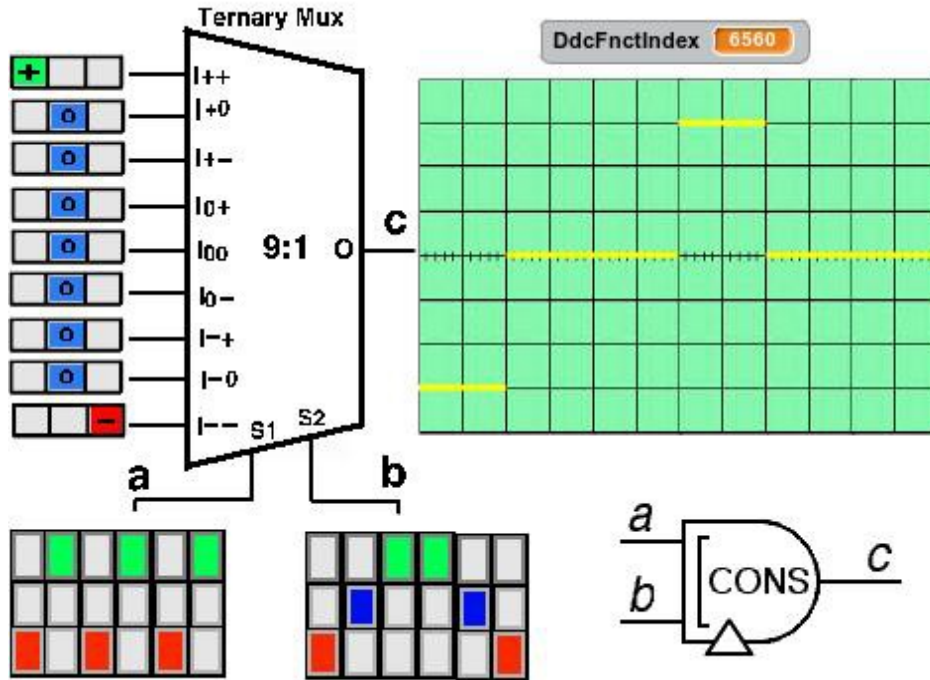
## *Programmable Universal Ternary Gate*

By programming, from time to time, the *truth table* of the inputs of the 9:1 ternary mux we can get all the 19'683 possible gates.

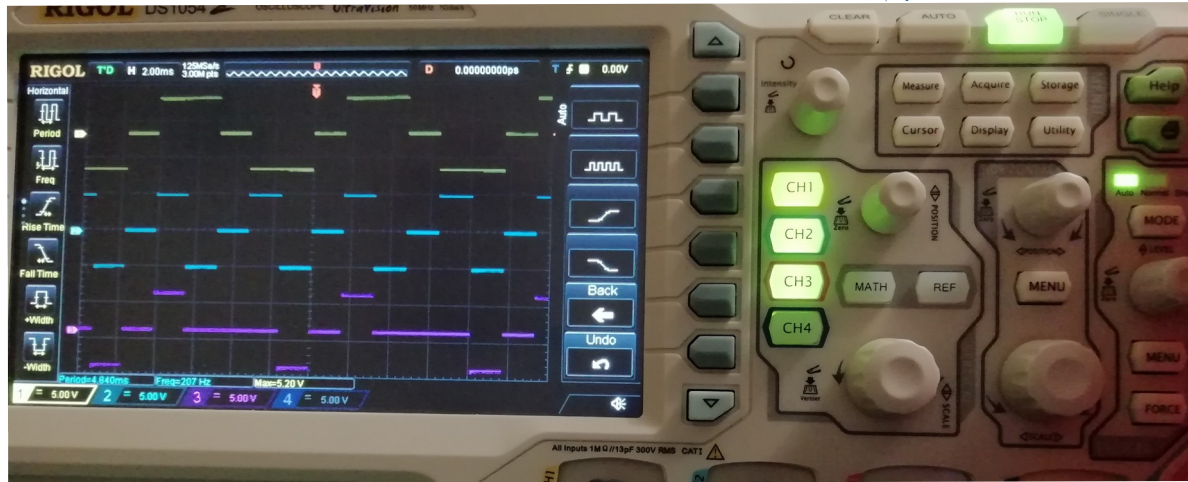
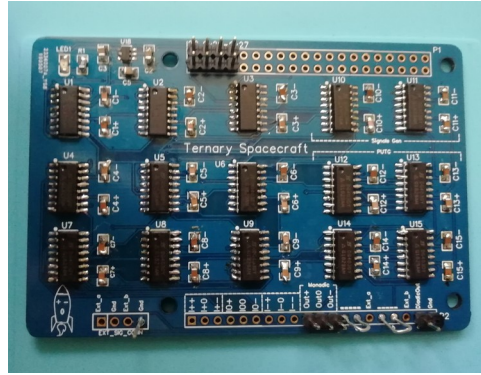
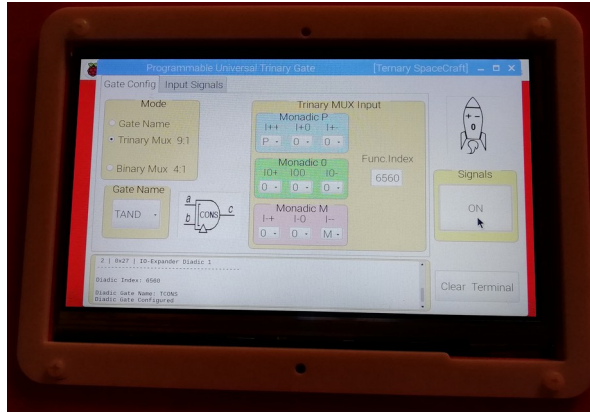
Finally, the board allows us to programming two ternary Input ( Trit signals ) and to visualize the Output Trit signal waveform.



## Simulation: “Consensus Gate”



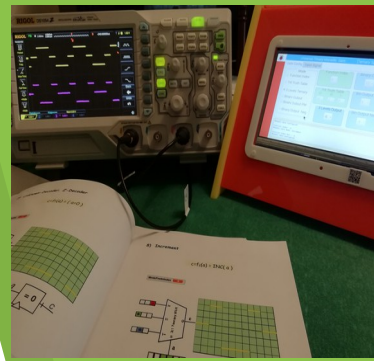
# Implementation: “Consensus Gate”



# Summing up

The board allows to explore the entire Ternary Galaxy to discover “inhabited worlds”, alias components useful for designing future logic circuits. Hence, the board is a:

- Powerfull “Investigation Intrument”.



# Monadic Subsets

The 27 Ternary Monadic functions or Truth Tables can be grouped as follow:

- 8 with the output in Pure Binary [0,1]
- 6 with Binary output but ternary levels [-1, 1]
- 7 with Binary output with negative levels [-1, 0]
- 6 with three-level output [-1, 0, 1]



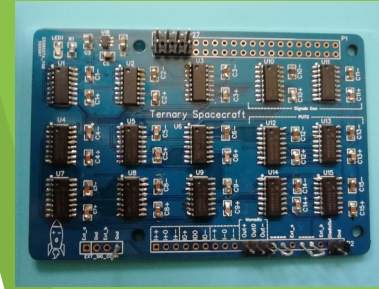
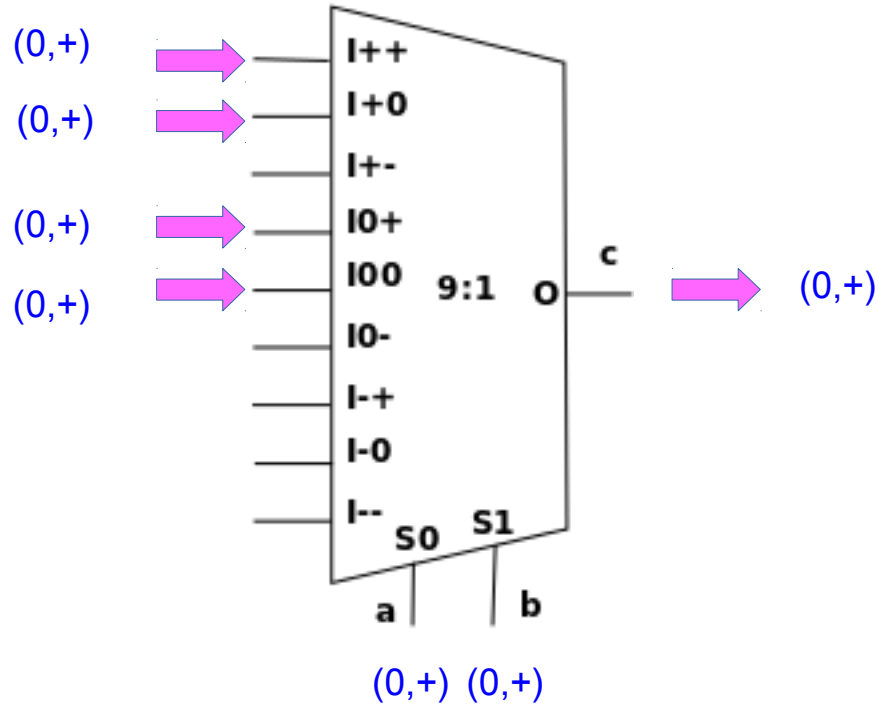
# Dyadic Subsets



The 19'683 Ternary Dyadic functions or Truth Tables can be grouped as follow: :

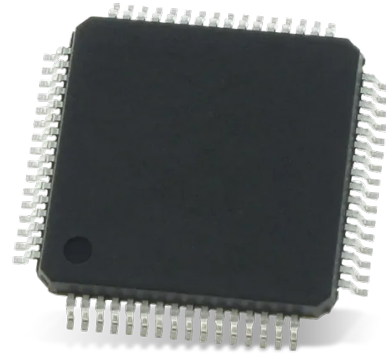
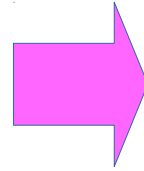
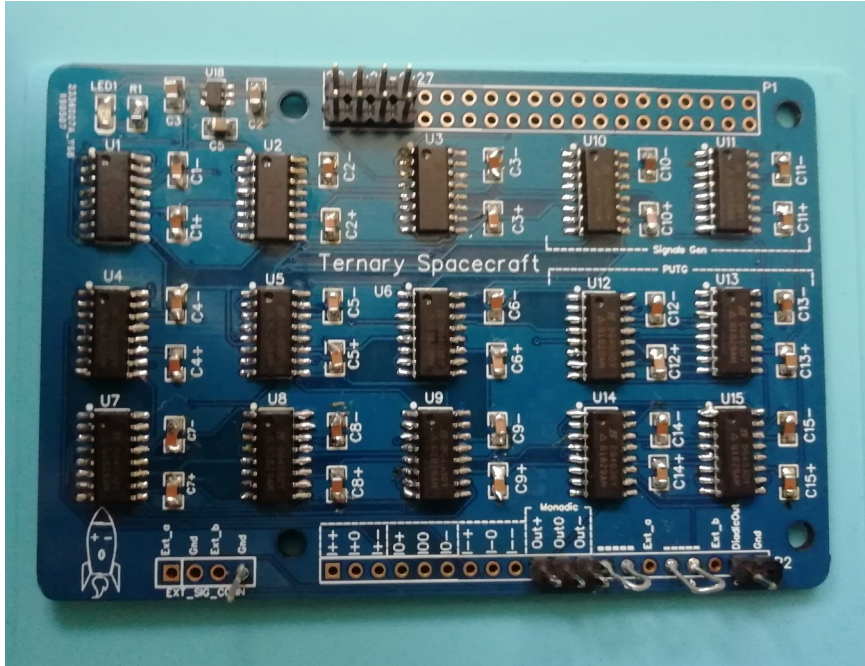
- 512 with the output in Pure Binary [0,1]
- 216 with Binary output but ternary levels [-1, 1]
- 343 with Binary output with negative levels [-1, 0]
- 18'612 with three-level output [-1, 0, 1]

# Board Binary Compatibility





# Next Step to do:



**Thanks DIGITHON**  
**Thanks Puglia.**

For more information, please visit my site:  
[giuseppetalarico.wordpress.com](https://giuseppetalarico.wordpress.com)

