Function generator

Date: Jun 2024

RTL

Description

Function generator module. The module has a selector to choose between the following four functions:
- Sine
- Cosine
- Triangular
- Square

1) It is possible to set the output signal amplitude with a range from 1 to 4.
2) The function period is 256 clock cycles. Considering a clock frequency of 100MHz (Period = 10ns), each period of the generated function would be 2.56us and its frequency would be approximately 390.6 Khz.
3) When the reset is activated all the initial signals in position 0 which for each signal is as follows:
    - Sine = 0
    - Cosine = Amplitude
    - Square = Amplitude
    - Triangular = 0
4) When the enable is activated the signal at the output will continue at the point where it stopped previously, if a different function is selected, the new waveform will continue in the direction of the LUT where the previous function stopped since all four functions will use the same direction.
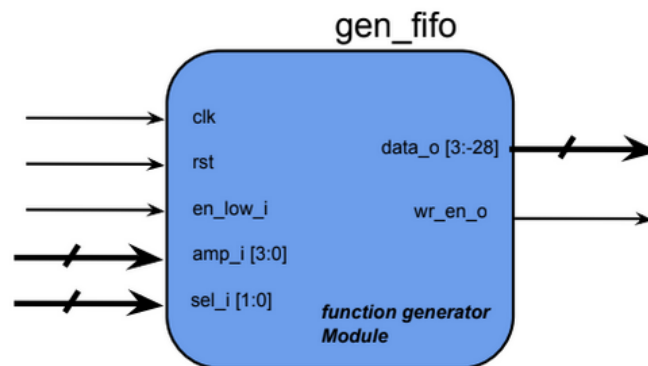

Internal sub-modules:
- Adder module
- Multiplication module
- Register module
- LUT
- FSM module
- Mux module

Input	Size	Description	Source
clk	1	Clock	Clock source
rst	1	Asynchronous reset activated	Main input
en_low_i	1	Operation enable. This enable activates the operation of the module when it is set to zero. When en_low_i = 1, the module stops its operation at the point where it was and all signals retain their value until the enable is re-asserted.	full / FIFO
amp_i	4	Amplitude of the function. It can take the integer values 1, 2, 3 and 4. It determines the amplitude of the output signal.	Main input
sel_i	2	Function selector Allows to select which waveform is the one we want to obtain in the output of the module. The function of each value of this signal is described in a table below.	Main input

| Output	Size	Description	Source
data_o	32	Data of the generated function	Top module
wr_en_o	1	This signal indicates that the data at the output are valid and will be written to a destination memory.	Top module

Table 1: Inputs/Outputs description

Sub-modules

1. Adder: 3-input adder with enable and clear. The addition is performed combinationally when the enable is active. The output is zero when the clear is activated. The clear signal has priority.
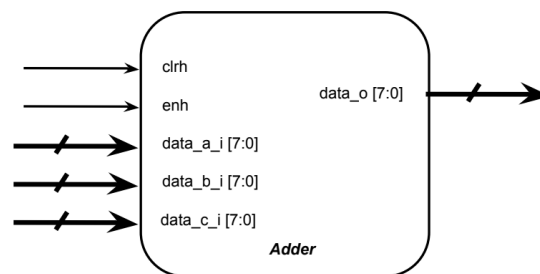
2. Multiplier: 2-input multiplier with enable. Multiplication is performed combinationally when the enable is active.
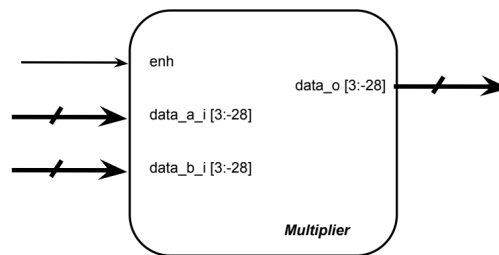
3. Register: Type D flip flop register activated on positive clock edge with enable active high and clear active high
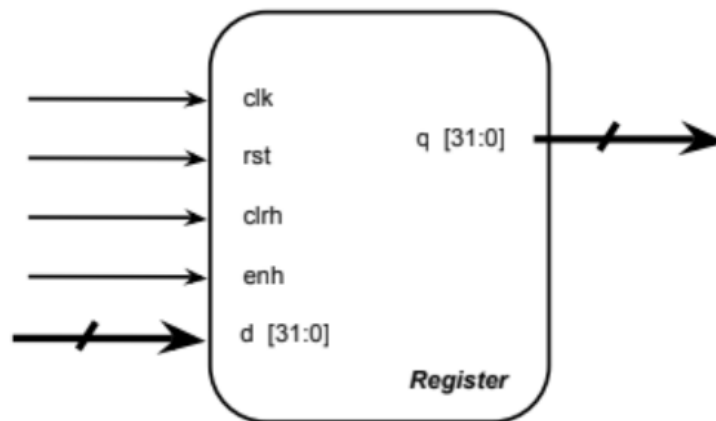
4. FSM: The state machine will control the enable of the internal modules, when to clear the information from the registers and the sequential operation of the whole RTL.

(Diagrama temporal- falta descripcion de los estados)

4
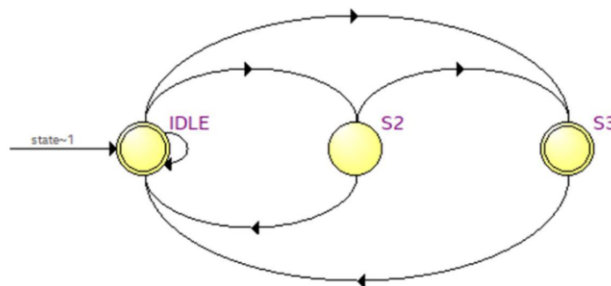
5. Mux: 4-input 1-output multiplexer with a 2-bit selector switch. The output signal corresponds to the selector value (0 to 3). Inputs and outputs are signed.
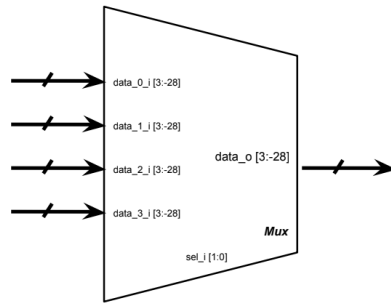
sel_i value	Output signal
0	Sine
1	Cosine
2	Triangular
3	Square

6. LUT: Stores the values of the functions. It only has the operation of reading by means of an address. Its content is loaded by means of a txt file in hexadecimal. The reading is sequential on the positive edge of the clock.

Square			Triangular		
Dec	Bin	Hex	Dec	Bin	Hex
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					
1.0000					

1.0000
1.0000
1.0000
1.0000
1.0000

1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000

1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000

-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000

```
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000

-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
```

-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000
-1.0000

Sine			Cosine		
Dec	Bin	Hex	Dec	Bin	Hex
0.0000	0000 0000000000000000000000000000	00000000	1.0000	0001 0000000000000000000000000000	10000000
0.0245	0000 0000011001000101101000011100	00645A1C	0.9997	0000 1111111111101100010101101101	0FFEC56D
0.0491	0000 0000110010010001110100010100	00C91D14	0.9988	0000 1111111110110001010110110101	0FFB15B5
0.0736	0000 0001001011010111011100110001	012D7731	0.9973	0000 1111111101001111000011011000	0FF4F0D8
0.0980	0000 0001100100010110100001110010	01916872	0.9952	0000 1111111011000101011011010101	0FEC56D5
0.1224	0000 0001111101010101100110110011	01F559B3	0.9925	0000 1111111000010100011110101110	0FE147AE
0.1467	0000 0010010110001110001000011001	0258E219	0.9892	0000 1111110100111100001101100001	0FD3C361
0.1710	0000 0010101111000110101001111110	02BC6A7E	0.9853	0000 1111110000111100100111101110	0FC3C9EE
0.1951	0000 0011000111110010000100101101	031F212D	0.9808	0000 1111101100010101101101010111	0FB15B57
0.2191	0000 0011100000010110111000000000	03816F00	0.9757	0000 1111100111000111011110011010	0F9C779A
0.2430	0000 0011111000110101001111110111	03E353F7	0.9700	0000 1111100001010001110101111000	0F851EB8
0.2667	0000 0100010001000110011100111000	04446738	0.9638	0000 1111011010111011100110001100	0F6BB98C
0.2903	0000 0100101001010001000110011100	04A5119C	0.9569	0000 1111010011110111011001011111	0F4F765F
0.3137	0000 0101000001001110101001001010	0504EA4A	0.9495	0000 1111001100010010011011101001	0F3126E9
0.3369	0000 0101011000111111000101000001	0563F141	0.9415	0000 1111000100000110001001001101	0F10624D
0.3599	0000 0101110000100010011010000000	05C22680	0.9330	0000 1110111011011001000101101000	0EED9168
0.3827	0000 0110000111111000101000001001	061F8A09	0.9239	0000 1110110010000100101101011101	0EC84B5D
0.4052	0000 0110011110111011001011111110	067BB2FE	0.9142	0000 1110101000001001000000101101	0EA0902D
0.4276	0000 0110110101110111001100011000	06D77318	0.9040	0000 1110011101101100100010110100	0E76C8B4
0.4496	0000 0111001100011000111111000101	07318FC5	0.8932	0000 1110010010101000110000010101	0E4A8C15
0.4714	0000 0111100001010110101010111001	078ADAB9	0.8819	0000 1110000111000100001100101100	0E1C432C
0.4929	0000 0111111000101110101100011100	07E2EB1C	0.8701	0000 1101111010111110110111111010	0DEBEDFA
0.5141	0000 1000001110011100000011101011	0839C0EB	0.8577	0000 1101101110010010001110100010	0DB923A2
0.5350	0000 1000100011110101110000101000	088F5C28	0.8449	0000 1101100001001011010111011100	0D84B5DC
0.5556	0000 1000111000111011110011010011	08E3BCD3	0.8315	0000 1101010011011101001011110001	0D4DD2F1
0.5758	0000 1001001101100111101000001111	09367A0F	0.8176	0000 1101000101001110001110111100	0D14E3BC
0.5957	0000 1001100001111111110010111001	0987FCB9	0.8032	0000 1100110110011110100000111110	0CD9E83E
0.6152	0000 1001110101111101101111110100	09D7DBF4	0.7883	0000 1100100111001110000001110101	0C9CE075
0.6344	0000 1010000100110100000010011101	0A26809D	0.7730	0000 1100010111100011010100111111	0C5E353F
0.6532	0000 1010011100111000000111010111	0A7381D7	0.7572	0000 1100000111010111101101101111	0C1D7DBF
0.6716	0000 1010101111101101111110100100	0ABEDFA4	0.7410	0000 1011110110110010001011010000	0BDB22D0
0.6895	0000 1011000010000011000100100110	0B083126	0.7242	0000 1011100101100101001010111101	0B9652BD
0.7071	0000 1011010100000100100000010110	0B504816	0.7071	0000 1011010100000100100000010110	0B504816
0.7242	0000 1011100101100101001010111101	0B9652BD	0.6895	0000 1011000010000011000100100110	0B083126
0.7410	0000 1011110110110010001011010000	0BDB22D0	0.6716	0000 1010101111101101111110100100	0ABEDFA4
0.7572	0000 1100000111010111101101101111	0C1D7DBF	0.6532	0000 1010011100111000000111010111	0A7381D7
0.7730	0000 1100010111100011010100111111	0C5E353F	0.6344	0000 1010000100110100000010011101	0A26809D
0.7883	0000 1100100111001110000001110101	0C9CE075	0.6152	0000 1001110101111101101111110100	09D7DBF4
0.8032	0000 1100110110011110100000111110	0CD9E83E	0.5957	0000 1001100001111111110010111001	0987FCB9
0.8176	0000 1101000101001110001110111100	0D14E3BC	0.5758	0000 1001001101100111101000001111	09367A0F
0.8315	0000 1101010011011101001011110001	0D4DD2F1	0.5556	0000 1000111000111011110011010011	08E3BCD3

0.8449	0000 1101100001001011010111011100	0D84B5DC	0.5350	0000 1000100011110101100001010000	088F5C28
0.8577	0000 1101101110010010001110100010	0DB923A2	0.5141	0000 1000001110011100000011101011	0839C0EB
0.8701	0000 1101111010111110110110111111010	0DEBEDFA	0.4929	0000 0111111000101110101100011100	07E2EB1C
0.8819	0000 1110000111000100001100101100	0E1C432C	0.4714	0000 0111100010101101101010111001	078ADAB9
0.8932	0000 1110010010101000110000010101	0E4A8C15	0.4496	0000 0111001100011000111111000101	07318FC5
0.9040	0000 1110011101101100100010110100	0E76C8B4	0.4276	0000 0110110101101110011000011000	06D77318
0.9142	0000 1110101000001001000000101101	0EA0902D	0.4052	0000 0110011110111011001011111110	067BB2FE
0.9239	0000 1110110010000100101101011101	0EC84B5D	0.3827	0000 0110000111111000101000001001	061F8A09
0.9330	0000 1110111011011001000101101000	0EED9168	0.3599	0000 0101110001000100110100000000	05C22680
0.9415	0000 1111000100000110001001001101	0F10624D	0.3369	0000 0101011000111111000101000001	0563F141
0.9495	0000 1111001100010010011011101001	0F3126E9	0.3137	0000 0101000001001110101001001010	0504EA4A
0.9569	0000 1111010011110111011001011111	0F4F765F	0.2903	0000 0100101001010001000110011100	04A5119C
0.9638	0000 1111011010111011100110001100	0F6BB98C	0.2667	0000 0100010001000110011100111000	04446738
0.9700	0000 1111100001010001111010111000	0F851EB8	0.2430	0000 0011111000110101001111110111	03E353F7
0.9757	0000 1111100111000111011110011010	0F9C779A	0.2191	0000 0011100000010110111100000000	03816F00
0.9808	0000 1111101100010101101101010111	0FB15B57	0.1951	0000 0011000111110010000100101101	031F212D
0.9853	0000 1111110000111100100111101110	0FC3C9EE	0.1710	0000 0010101111000110101001111110	02BC6A7E
0.9892	0000 1111110100111100001101100001	0FD3C361	0.1467	0000 0010010110001110001000011001	0258E219
0.9925	0000 1111111000010100011110101110	0FE147AE	0.1224	0000 0001111101010101100110110011	01F559B3
0.9952	0000 1111111011000101011011010101	0FEC56D5	0.0980	0000 0001100100010110100001110010	01916872
0.9973	0000 1111111110100111100001011000	0FF4F0D8	0.0736	0000 0001001011010111011100110001	012D7731
0.9988	0000 1111111110110001010110110101	0FFB15B5	0.0491	0000 0000110010010001110100010100	00C91D14
0.9997	0000 1111111111110110001010101101	0FFEC56D	0.0245	0000 0000011001000101101000011100	00645A1C
1.0000	0001 0000000000000000000000000000	10000000	0.0000	0000 0000000000000000000000000000	00000000
0.9997	0000 1111111111110110001010101101	0FFEC56D	-0.0245	1111 1111100110110100101111100100	FF9BA5E4
0.9988	0000 1111111110110001010110110101	0FFB15B5	-0.0491	1111 1111001101101110001011101100	FF36E2EC
0.9973	0000 1111111110100111100001011000	0FF4F0D8	-0.0736	1111 1110110100101000100011001111	FED288CF
0.9952	0000 1111111011000101011011010101	0FEC56D5	-0.0980	1111 1110011011101001011110001110	FE6E978E
0.9925	0000 1111111000010100011110101110	0FE147AE	-0.1224	1111 1110000010101010011001001101	FE0AA64D
0.9892	0000 1111110100111100001101100001	0FD3C361	-0.1467	1111 1101101001110001110111100111	FDA71DE7
0.9853	0000 1111110000111100100111101110	0FC3C9EE	-0.1710	1111 1101010000011001010110000010	FD439582
0.9808	0000 1111101100010101101101010111	0FB15B57	-0.1951	1111 1100111000001101111011010011	FCE0DED3
0.9757	0000 1111100111000111011110011010	0F9C779A	-0.2191	1111 1100011111101001000111111111	FC7E91FF
0.9700	0000 1111100001010001111010111000	0F851EB8	-0.2430	1111 1100000111001010110000001001	FC1CAC09
0.9638	0000 1111011010111011100110001100	0F6BB98C	-0.2667	1111 1011101110111001100011001000	FBBB98C8
0.9569	0000 1111010011110111011001011111	0F4F765F	-0.2903	1111 1011010110101110111001100100	FB5AEE64
0.9495	0000 1111001100010010011011101001	0F3126E9	-0.3137	1111 1010111110110001010110110110	FAFB15B6
0.9415	0000 1111000100000110001001001101	0F10624D	-0.3369	1111 1010100111000000110101111111	FA9C0EBF
0.9330	0000 1110111011011001000101101000	0EED9168	-0.3599	1111 1010001110111011001100000000	FA3DD980
0.9239	0000 1110110010000100101101011101	0EC84B5D	-0.3827	1111 1001111000000111010111110111	F9E075F7
0.9142	0000 1110101000001001000000101101	0EA0902D	-0.4052	1111 1001100001000100110100000010	F9844D02
0.9040	0000 1110011101101100100010110100	0E76C8B4	-0.4276	1111 1001001010001000110011101000	F9288CE8
0.8932	0000 1110010010101000110000010101	0E4A8C15	-0.4496	1111 1000110011100111000000111011	F8CE703B
0.8819	0000 1110000111000100001100101100	0E1C432C	-0.4714	1111 1000011101010010010101000111	F8752547
0.8701	0000 1101111010111110110110111111010	0DEBEDFA	-0.4929	1111 1000000111010001010011100100	F81D14E4
0.8577	0000 1101101110010010001110100010	0DB923A2	-0.5141	1111 0111110001100011111100010101	F7C63F15
0.8449	0000 1101100001001011010111011100	0D84B5DC	-0.5350	1111 0111011100001010001111011000	F770A3D8
0.8315	0000 1101010011011110100101111000001	0D4DD2F1	-0.5556	1111 0111000111000100001100101101	F71C432D
0.8176	0000 1101000101001110001110111100	0D14E3BC	-0.5758	1111 0110110010011000010111110001	F6C985F1
0.8032	0000 1100110110011110100000111110	0CD9E83E	-0.5957	1111 0110011110000000001101000111	F6780347
0.7883	0000 1100100111001110000001110101	0C9CE075	-0.6152	1111 0110000101000001001000000100	F628240C
0.7730	0000 1100010111100011010100111111	0C5E353F	-0.6344	1111 0101110110010111111101100011	F5D97F63
0.7572	0000 1100000111010111110110111111	0C1D7DBF	-0.6532	1111 0101100011000111111000101001	F58C7E29
0.7410	0000 1011110110110100110110101000	0BDB22D0	-0.6716	1111 0101010000010000000000011100	F541205C
0.7242	0000 1011100101100101011110111101	0B9652BD	-0.6895	1111 0100111101111100111011011010	F4F7CEDA
0.7071	0000 1011010100000100100000010110	0B504816	-0.7071	1111 0100101011111011011111101010	F4AFB7EA
0.6895	0000 1011000010000011000100100110	0B083126	-0.7242	1111 0100011010011010110101000011	F469AD43
0.6716	0000 1010101111101101111110100100	0ABEDFA4	-0.7410	1111 0100001001001101101001100000	F424DD30
0.6532	0000 1010011100111000000111010111	0A7381D7	-0.7572	1111 0011111000101000001001000001	F3E28241
0.6344	0000 1010001001101000000010011101	0A26809D	-0.7730	1111 0011101000011100101011000001	F3A1CAC1
0.6152	0000 1001110101111101101111110100	09D7DBF4	-0.7883	1111 0011011000110001111100001011	F3631F8B

0.5957	0000 1001100001111111110010111001	0987FCB9	-0.8032	1111 0011001001100001011111000010	F32617C2
0.5758	0000 1001001101100111101000001111	09367A0F	-0.8176	1111 0010111010110001110001000100	F2EB1C44
0.5556	0000 1000111000111011110011010011	08E3BCD3	-0.8315	1111 0010101100100010110100001111	F2B22D0F
0.5350	0000 1000100011110101110000101000	088F5C28	-0.8449	1111 0010011110110100101000100100	F27B4A24
0.5141	0000 1000001110011100000011101011	0839C0EB	-0.8577	1111 0010010001101101110001011110	F246DC5E
0.4929	0000 0111111000101110101100011100	07E2EB1C	-0.8701	1111 0010000101000001001000000110	F2141206
0.4714	0000 0111100010101101101010111001	078ADAB9	-0.8819	1111 0001111000111011110011010100	F1E3BCD4
0.4496	0000 0111001100011000111111000101	07318FC5	-0.8932	1111 0001101101010111001111101011	F1B573EB
0.4276	0000 0110110101110111001100011000	06D77318	-0.9040	1111 0001100010010011011101001100	F189374C
0.4052	0000 0110011110111011001011111110	067BB2FE	-0.9142	1111 0001010111110110111111010011	F15F6FD3
0.3827	0000 0110000111111000101000001001	061F8A09	-0.9239	1111 0001001101111011010010100011	F137B4A3
0.3599	0000 0101110000100010011010000000	05C22680	-0.9330	1111 0001000100100110111010011000	F1126E98
0.3369	0000 0101011000111111000101000001	0563F141	-0.9415	1111 0000111011111001110110110011	F0EF9DB3
0.3137	0000 0101000001001110101001001010	0504EA4A	-0.9495	1111 0000110011101101100100010111	F0CED917
0.2903	0000 0100101001010001000110011100	04A5119C	-0.9569	1111 0000101100001000100110100001	F0B089A1
0.2667	0000 0100010001000110011100111000	04446738	-0.9638	1111 0000100101000100011001110100	F0944674
0.2430	0000 0011111000110101001111110111	03E353F7	-0.9700	1111 0000011110101110000101001000	F07AE148
0.2191	0000 0011100000010110111100000000	03816F00	-0.9757	1111 0000011000111000100001100110	F0638866
0.1951	0000 0011000111110010000100101101	031F212D	-0.9808	1111 0000010011101010010010101001	F04EA4A9
0.1710	0000 0010101111000110101001111110	02BC6A7E	-0.9853	1111 0000001111000011011000010010	F03C3612
0.1467	0000 0010010110001110001000011001	0258E219	-0.9892	1111 0000001011000011110010011111	F02C3C9F
0.1224	0000 0001111101010101100110110011	01F559B3	-0.9925	1111 0000000111101011100001010010	F01EB852
0.0980	0000 0001100100010110100001110010	01916872	-0.9952	1111 0000000100111010100100101011	F013A92B
0.0736	0000 0001001011010111011100110001	012D7731	-0.9973	1111 0000000010110000111100101000	F00B0F28
0.0491	0000 0000110010010001110100010100	00C91D14	-0.9988	1111 0000000001001110101001001011	F004EA4B
0.0245	0000 0000011001000101101000011100	00645A1C	-0.9997	1111 0000000000010011101010010011	F0013A93
0.0000	0000 0000000000000000000000000000	00000000	-1.0000	1111 0000000000000000000000000000	F0000000

-0.0245	1111 1111100110111010010111100100	FF9BA5E4	-0.9997	1111 0000000000010011101010010011	F0013A93
-0.0491	1111 1111001101101110001011101100	FF36E2EC	-0.9988	1111 0000000001001110101001001011	F004EA4B
-0.0736	1111 1110110100101000100011001111	FED288CF	-0.9973	1111 0000000010110000111100101000	F00B0F28
-0.0980	1111 1110011011101001011110001110	FE6E978E	-0.9952	1111 0000000100111010100100101011	F013A92B
-0.1224	1111 1110000010101010011001001101	FE0AA64D	-0.9925	1111 0000000111101011100001010010	F01EB852
-0.1467	1111 1101101001110001110111100111	FDA71DE7	-0.9892	1111 0000001011000011110010011111	F02C3C9F
-0.1710	1111 1101010000111001010110000010	FD439582	-0.9853	1111 0000001111000011011000010010	F03C3612
-0.1951	1111 1100111000001101111011010011	FCE0DED3	-0.9808	1111 0000010011101010010010101001	F04EA4A9
-0.2191	1111 1100011111101001000111111111	FC7E91FF	-0.9757	1111 0000011000111000100001100110	F0638866
-0.2430	1111 1100000111001010110000001001	FC1CAC09	-0.9700	1111 0000011110101110000101001000	F07AE148
-0.2667	1111 1011101110111001100011001000	FBBB98C8	-0.9638	1111 0000100101000100011001110100	F0944674
-0.2903	1111 1011010110101110111001100100	FB5AEE64	-0.9569	1111 0000101100001000100110100001	F0B089A1
-0.3137	1111 1010111110110001010110110110	FAFB15B6	-0.9495	1111 0000110011101101100100010111	F0CED917
-0.3369	1111 1010100111000000111010111111	FA9C0EBF	-0.9415	1111 0000111011111001110110110011	F0EF9DB3
-0.3599	1111 1010001111011101100110000000	FA3DD980	-0.9330	1111 0001000100100110111010011000	F1126E98
-0.3827	1111 1001111000000111010111110111	F9E075F7	-0.9239	1111 0001001101111011010010100011	F137B4A3
-0.4052	1111 1001100001000100110100000010	F9844D02	-0.9142	1111 0001010111110110111111010011	F15F6FD3
-0.4276	1111 1001001010001000110011101000	F9288CE8	-0.9040	1111 0001100010010011011101001100	F189374C
-0.4496	1111 1000110011100111000000111011	F8CE703B	-0.8932	1111 0001101101010111001111101011	F1B573EB
-0.4714	1111 1000011101010010010101000111	F8752547	-0.8819	1111 0001111000111011110011010100	F1E3BCD4
-0.4929	1111 1000000111010001010011100100	F81D14E4	-0.8701	1111 0010000101000001001000000110	F2141206
-0.5141	1111 0111110001100011111100010101	F7C63F15	-0.8577	1111 0010010001101101110001011110	F246DC5E
-0.5350	1111 0111011100001010001111011000	F770A3D8	-0.8449	1111 0010011110110100101000100100	F27B4A24
-0.5556	1111 0111000111000100001100101101	F71C432D	-0.8315	1111 0010101100100010110100001111	F2B22D0F
-0.5758	1111 0110110010011000010111110001	F6C985F1	-0.8176	1111 0010111010110001110001000100	F2EB1C44
-0.5957	1111 0110011110000000001101000111	F6780347	-0.8032	1111 0011001001100001011111000010	F32617C2
-0.6152	1111 0110001010000010010000001100	F628240C	-0.7883	1111 0011011000110001111110001011	F3631F8B
-0.6344	1111 0101110110010111111101100011	F5D97F63	-0.7730	1111 0011101000011100101011000001	F3A1CAC1
-0.6532	1111 0101100011000111111000101001	F58C7E29	-0.7572	1111 0011111000101000001001000001	F3E28241
-0.6716	1111 0101010000010010000001011100	F541205C	-0.7410	1111 0100001001001101110100110000	F424DD30
-0.6895	1111 0100111101111100111011011010	F4F7CEDA	-0.7242	1111 0100011010011010110101000011	F469AD43
-0.7071	1111 0100101011111011011111101010	F4AFB7EA	-0.7071	1111 0100101011111011011111101010	F4AFB7EA
-0.7242	1111 0100011010011010110101000011	F469AD43	-0.6895	1111 0100111101111100111011011010	F4F7CEDA
-0.7410	1111 0100001001001101110100110000	F424DD30	-0.6716	1111 0101010000010010000001011100	F541205C

```
-0.7572  1111 0011111000101000001001000001  F3E28241      -0.6532  1111 0101100011000111111000101001  F58C7E29
-0.7730  1111 0011101000011100101011000001  F3A1CAC1      -0.6344  1111 0101110110010111111101100011  F5D97F63
-0.7883  1111 0011011000110001111110001011  F3631F8B      -0.6152  1111 0110001010000010010000001100  F628240C
-0.8032  1111 0011001001100010111111000010  F32617C2      -0.5957  1111 0110011110000000001101000111  F6780347
-0.8176  1111 0010111011011000110001000100  F2EB1C44      -0.5758  1111 0110110010011000010111110001  F6C985F1
-0.8315  1111 0010101100100010110100001111  F2B22D0F      -0.5556  1111 0111000011000100001100101101  F71C432D
-0.8449  1111 0010011110110100101000100100  F27B4A24      -0.5350  1111 0111011100001010001111011000  F770A3D8
-0.8577  1111 0010010001101101110001011110  F246DC5E      -0.5141  1111 0111110001100011111100010101  F7C63F15
-0.8701  1111 0010000101000001001000000110  F2141206      -0.4929  1111 1000000111010001010011100100  F81D14E4
-0.8819  1111 0001111000011011110011010100  F1E3BCD4      -0.4714  1111 1000011101010010010101000111  F8752547
-0.8932  1111 0001101101010111001111101011  F1B573EB      -0.4496  1111 1000110011100111000000111011  F8CE703B
-0.9040  1111 0001100010010011011101001100  F189374C      -0.4276  1111 1001001010001000110011101000  F9288CE8
-0.9142  1111 0001010111110110111111010011  F15F6FD3      -0.4052  1111 1001100001000100110100000010  F9844D02
-0.9239  1111 0001001101111011010010100011  F137B4A3      -0.3827  1111 1001111000000111010111110111  F9E075F7
-0.9330  1111 0001000100100110111010011000  F1126E98      -0.3599  1111 1010000111011011001100000000  FA3DD980
-0.9415  1111 0000111011111001110110110011  F0EF9DB3      -0.3369  1111 1010100111000000111010111111  FA9C0EBF
-0.9495  1111 0000110011101101100100010111  F0CED917      -0.3137  1111 1010111110110001010110110110  FAFB15B6
-0.9569  1111 0000101100001000100110100001  F0B089A1      -0.2903  1111 1011010110101110111001100100  FB5AEE64
-0.9638  1111 0000100101000100011001110100  F0944674      -0.2667  1111 1011101110111001100011001000  FBBB98C8
-0.9700  1111 0000011110101110000101001000  F07AE148      -0.2430  1111 1100000111001010110000001001  FC1CAC09
-0.9757  1111 0000011000111000100001100110  F0638866      -0.2191  1111 1100011111110100100011111111  FC7E91FF
-0.9808  1111 0000010011101010010010101001  F04EA4A9      -0.1951  1111 1100111000001101111011010011  FCE0DED3
-0.9853  1111 0000001111000011011000010010  F03C3612      -0.1710  1111 1101011010000011001010110000010  FD439582
-0.9892  1111 0000001011000011110010011111  F02C3C9F      -0.1467  1111 1101101001110001110111100111  FDA71DE7
-0.9925  1111 0000000111101011100001010010  F01EB852      -0.1224  1111 1110000010101010011001001101  FE0AA64D
-0.9952  1111 0000000100111010100100101011  F013A92B      -0.0980  1111 1110011011101001011110001110  FE6E978E
-0.9973  1111 0000000010110000111100101000  F00B0F28      -0.0736  1111 1110110100101000100011001111  FED288CF
-0.9988  1111 0000000001001110101001001011  F004EA4B      -0.0491  1111 1111001101011100010111101100  FF36E2EC
-0.9997  1111 0000000000010011101010010011  F0013A93      -0.0245  1111 1111110011011101001011110010 0100  FF9BA5E4
-1.0000  1111 0000000000000000000000000000  F0000000

                                                           0.0000  0000 0000000000000000000000000000  00000000
-0.9997  1111 0000000000010011101010010011  F0013A93       0.0245  0000 0000011001000101101000011100  00645A1C
-0.9988  1111 0000000001001110101001001011  F004EA4B       0.0491  0000 0000110010010001110100010100  00C91D14
-0.9973  1111000000000010110000111100101000  F00B0F28       0.0736  0000 0001001011010111011100110001  012D7731
-0.9952  1111 0000000100111010100100101011  F013A92B       0.0980  0000 0001100100010110100001110010  01916872
-0.9925  1111 0000000111101011100001010010  F01EB852       0.1224  0000 0001111101010101001101100011  01F559B3
-0.9892  1111 0000001011000011110010011111  F02C3C9F       0.1467  0000 0010010110001110001000011001  0258E219
-0.9853  1111 0000001111000011011000010010  F03C3612       0.1710  0000 0010101111000110101001111110  02BC6A7E
-0.9808  1111 0000010011101010010010101001  F04EA4A9       0.1951  0000 0011000111110010000100101101  031F212D
-0.9757  1111 0000011000111000100001100110  F0638866       0.2191  0000 0011100000010110111100000000  03816F00
-0.9700  1111 0000011110101110000101001000  F07AE148       0.2430  0000 0011111000110101001111110111  03E353F7
-0.9638  1111 0000100101000100011001110100  F0944674       0.2667  0000 0100010001000110011100111000  04446738
-0.9569  1111 0000101100001000100110100001  F0B089A1       0.2903  0000 0100101001010001000110011100  04A5119C
-0.9495  1111 0000110011101101100100010111  F0CED917       0.3137  0000 0101000001001101010010010010  0504EA4A
-0.9415  1111 0000111011111001110110110011  F0EF9DB3       0.3369  0000 0101011000111111000101000001  0563F141
-0.9330  1111 0001000100100110111010011000  F1126E98       0.3599  0000 0101110000100010011010000000  05C22680
-0.9239  1111 0001001101111011010010100011  F137B4A3       0.3827  0000 0110000111111000101000001001  061F8A09
-0.9142  1111 0001010111110110111111010011  F15F6FD3       0.4052  0000 0110011110111011001011111110  067BB2FE
-0.9040  1111 0001100010010011011101001100  F189374C       0.4276  0000 0110110101110111001100011000  06D77318
-0.8932  1111 0001101101010111001111101011  F1B573EB       0.4496  0000 0111001100011000111111000101  07318FC5
-0.8819  1111 0001111000011011110011010100  F1E3BCD4       0.4714  0000 0111100010101101101010111001  078ADAB9
-0.8701  1111 0010000101000001001000000110  F2141206       0.4929  0000 0111111000101110101100011100  07E2EB1C
-0.8577  1111 0010010001101101110001011110  F246DC5E       0.5141  0000 1000001110011100000011101011  0839C0EB
-0.8449  1111 0010011110110100101000100100  F27B4A24       0.5350  0000 1000100011110101110000101000  088F5C28
-0.8315  1111 0010101100100010110100001111  F2B22D0F       0.5556  0000 1000111100011011110011010011  08E3BCD3
-0.8176  1111 0010111011011000110001000100  F2EB1C44       0.5758  0000 1001001101100111101110000011  09367A0F
-0.8032  1111 0011001001100010111111000010  F32617C2       0.5957  0000 1001100001111111101000101001  0987FCB9
-0.7883  1111 0011011000110001111110001011  F3631F8B       0.6152  0000 1001110101111101101111110100  09D7DBF4
-0.7730  1111 0011101000011100101011000001  F3A1CAC1       0.6344  0000 1010001001101000000010011101  0A26809D
-0.7572  1111 0011111000101000001001000001  F3E28241       0.6532  0000 1010011100111000000111010111  0A7381D7
-0.7410  1111 0100000100100110111010011000  F424DD30       0.6716  0000 1010101111101101111110100100  0ABEDFA4
-0.7242  1111 0100011010011010110101000011  F469AD43       0.6895  0000 1011000010000011000100100110  0B083126
```

```
-0.7071  1111 010010101111101101111111101010  F4AFB7EA   0.7071  0000 10110101000001001000000010110  0B504816
-0.6895  1111 010011110111110011011011011010  F4F7CEDA   0.7242  0000 10111001011001010010101011101  0B9652BD
-0.6716  1111 010101000001001000000101011100  F541205C   0.7410  0000 10111101101100100010110010000  0BDB22D0
-0.6532  1111 010110001100011111100010100  F58C7E29   0.7572  0000 11000001110101111101101011111  0C1D7DBF
-0.6344  1111 010111011001011111101100011  F5D97F63   0.7730  0000 11000101110001101010011111  0C5E353F
-0.6152  1111 011000101000001001000001100  F628240C   0.7883  0000 11001001110011100000011101101  0C9CE075
-0.5957  1111 011001111000000001101000111  F6780347   0.8032  0000 11001101100111101000000111110  0CD9E83E
-0.5758  1111 011011001001100001011110001  F6C985F1   0.8176  0000 11010001010011100011101111100  0D14E3BC
-0.5556  1111 011100011100010000110010101  F71C432D   0.8315  0000 11010100110111010010111110001  0D4DD2F1
-0.5350  1111 011101110000101000111101100  F770A3D8   0.8449  0000 11011000010010110101110111000  0D84B5DC
-0.5141  1111 011111000110001111100010101  F7C63F15   0.8577  0000 11011011100100100011101000010  0DB923A2
-0.4929  1111 100000011101000101001110010  F81D14E4   0.8701  0000 11011110101011101101011111010  0DEBEDFA
-0.4714  1111 100001110101001001010100011  F8752547   0.8819  0000 11100001100001000011001100  0E1C432C
-0.4496  1111 100011001100111000000111011  F8CE703B   0.8932  0000 11100100101010001100000100101  0E4A8C15
-0.4276  1111 100100101000100011001110100  F9288CE8   0.9040  0000 11100111011011001000101101000  0E76C8B4
-0.4052  1111 100110000100010011010000010  F9844D02   0.9142  0000 11101010000010010000000101101  0EA0902D
-0.3827  1111 100111100000011101011110111  F9E075F7   0.9239  0000 11101100100000100101101011101  0EC84B5D
-0.3599  1111 101000111011101100110000000  FA3DD980   0.9330  0000 11101110110110010001011010100  0EED9168
-0.3369  1111 101010011000000111010111111  FA9C0EBF   0.9415  0000 11110001000001100010010010011  0F10624D
-0.3137  1111 101011111011000101011011011  FAFB15B6   0.9495  0000 11110011000100100110111011001  0F3126E9
-0.2903  1111 101101011010111011100110010  FB5AEE64   0.9569  0000 11110100111101110110010111111  0F4F765F
-0.2667  1111 101110111011100110000110010  FBBB98C8   0.9638  0000 11110110101110111100110001100  0F6BB98C
-0.2430  1111 110000011100101011000000100  FC1CAC09   0.9700  0000 11111000010100011101011100  0F851EB8
-0.2191  1111 110001111110100100011111111  FC7E91FF   0.9757  0000 11111001110001101111001101010  0F9C779A
-0.1951  1111 110011100000110111101101011  FCE0DED3   0.9808  0000 11111011000101011011010101011  0FB15B57
-0.1710  1111 110111101010000110010101100000 FD439582  0.9853  0000 11111100000111100100111101110  0FC3C9EE
-0.1467  1111 110110100111000111011110011  FDA71DE7   0.9892  0000 11111101001110000110110001  0FD3C361
-0.1224  1111 111000001010101000110010011  FE0AA64D   0.9925  0000 11111110000101000111101011100  0FE147AE
-0.0980  1111 111001101110100101111000111  FE6E978E   0.9952  0000 11111110110001010110110101  0FEC56D5
-0.0736  1111 111011010010100001001100111  FED288CF   0.9973  0000 11111111101001110000110110000  0FF4F0D8
-0.0491  1111 111100110110101110001011101100 FF36E2EC  0.9988  0000 11111111101110001010110110101  0FFB15B5
-0.0245  1111 111110011011101001011110100  FF9BA5E4   0.9997  0000 11111111111011100010101101101  0FFEC56D
 0.0000  0000 000000000000000000000000000000 00000000  1.0000  0001 00000000000000000000000000000  10000000
```

Verification

Formal

N#	Name	Description	Code
Assumptions			
1			
Covers			
1			
2			

14

1		

Results

Anexos:

module code