

# FPGA Harmonic Injection User Guide

SW#	Description
<b>SW0</b>	+1 to harmonic counter
<b>SW1</b>	+1 to harmonic counter
<b>SW2</b>	+1 to harmonic counter
<b>SW3</b>	load to counter

SW#	Description
<b>SW7</b>	$(-1) \times$ original signal
<b>SW8</b>	$(-1) \times 3^{\text{rd}}$ harmonic
<b>SW9</b>	$(-1) \times 9^{\text{th}}$ harmonic
<b>SW10</b>	$(-1) \times 15^{\text{th}}$ harmonic

SW#	Description
<b>SW15</b>	$\wedge/\vee$ signal on DAC_3
<b>SW16</b>	+1 to phase counter
<b>SW17</b>	+1 to phase counter

HEX#	Description
<b>HEX7</b>	"P" phase indicator
<b>HEX6</b>	Chosen phase
<b>HEX5</b>	"H" harmonic indicator
<b>HEX4</b>	Chosen harmonic
<b>HEX3</b>	1 – 9
<b>HEX2</b>	0.1 – 0.9
<b>HEX1</b>	0.01 – 0.09
<b>HEX0</b>	0.001 – 0.009

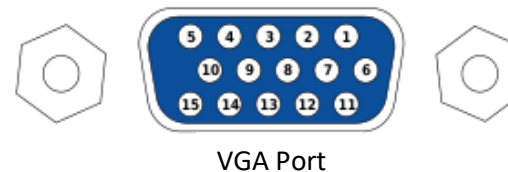
Push#	Description
<b>Push_0</b>	HEX3 control
<b>Push_1</b>	HEX2 control
<b>Push_2</b>	HEX1 control
<b>Push_3</b>	HEX0 control

SW#	Description
<b>LEDG0</b>	Phase A activated
<b>LEDG1</b>	Phase B activated
<b>LEDG2</b>	Phase C activated

## Notes:

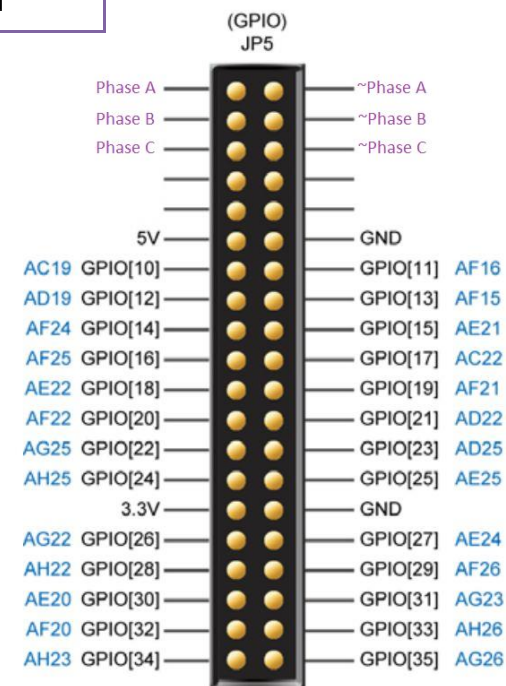
- To specify harmonic multiplier follow these steps:
  - Disable Reload switch (SW3).
  - Enter some number, shown in HEX0 – HEX3.
  - Choose the wanted harmonic using SW0 – SW2 counter.
  - Choose the wanted phase using SW16 – SW17.
  - Activate reload switch then deactivate it.
  - Effect should appear on both DAC pins and Digital pins

- The 50Hz harmonic is always activated but not loaded with m value.



VGA Port

- DAC\_1: Analog Phase A.
- DAC\_2: Analog Phase B.
- DAC\_3: if SW15 is LOW Analog Phase C, else  $\wedge/\vee$  signal.
- GND



# Examples

Ex1: Inject the following values to Phase A,  $m = 2.3$ ,  $i_3 = 0.73$ ,  $i_9 = -0.27$ ,  $i_{15} = 0.017$ .

Sol:

1. Make sure that all switches are set to LOW before begin injecting values.
2. Set SW0 and SW1 and SW2 to LOW, now we are at the original signal value(m) and set SW16 and SW17 to LOW now we activated Phase A control.
3. Use push buttons to control HEXs and set the value to 2.300.
4. Set Reload SW to HIGH (SW3 to HIGH) then set it back to LOW, the injected value is now valid.
5. Set SW0 to HIGH, the harmonic counter is now 1 which means we are at third harmonic ( $i_3$ ).
6. Use push buttons to control HEXs and set the value to 0.7300.
7. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.
8. Set SW1 to HIGH, the harmonic counter is now 2 which mean we are at the ninth harmonic ( $i_9$ ).
9. Use push buttons to control HEXs and set the value to 0.2700.
10. Since  $i_9$  is negative value set SW9 to HIGH, check tables to know how to control negative values.
11. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.
12. Set SW2 to HIGH, the harmonic counter is now 3 which mean we are at the fifteenth harmonic ( $i_{15}$ ).
13. Use push buttons to control HEXs and set the value to 0.017.
14. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.

Ex2: Inject the following values to Phase C,  $m = 4$ ,  $i_3 = -0.37$ ,  $i_9 = 0.275$ ,  $i_{15} = -0.3$ .

Sol:

1. Make sure that all switches are set to LOW before begin injecting values.
2. Set SW0 and SW1 and SW2 to LOW, now we are at the original signal value(m) and set SW16 and SW17 to HIGH now we activated Phase C control.
3. Use push buttons to control HEXs and set the value to 4.000.
4. Set Reload SW to HIGH (SW3 to HIGH) then set it back to LOW, the injected value is now valid.
5. Set SW0 to HIGH, the harmonic counter is now 1 which means we are at third harmonic ( $i_3$ ).
6. Use push buttons to control HEXs and set the value to 0.3700.
7. Since  $i_3$  is negative value set SW8 to HIGH, check tables to know how to control negative values.
8. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.
9. Set SW1 to HIGH, the harmonic counter is now 2 which mean we are at the ninth harmonic ( $i_9$ ).
10. Use push buttons to control HEXs and set the value to 0.2750.
11. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.
12. Set SW2 to HIGH, the harmonic counter is now 3 which mean we are at the fifteenth harmonic ( $i_{15}$ ).
13. Use push buttons to control HEXs and set the value to 0.300.
14. Since  $i_{15}$  is negative value set SW10 to HIGH, check tables to know how to control negative values.
15. Set SW3 to HIGH then set it back to LOW, the injected value is now valid.

# Graphical Examples

