Application note

MLX92213 – Principle of Operation

Benefit from advanced power manageability

Contents

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Benefit from advanced power manageability

1. Scope

In battery-operated applications, one of the most important design parameter to respect is the allowed power budget. It determines how much current one specific electronic block is allowed to consume. Due to the need for longer battery life, more and more systems manage this requirement through the use of different specific low power consumption modes.
This application note describes how to use the different operating modes of MLX92213 depending on the states of the Enable pin.

2. Applications

- Battery-operated / Handheld Appliances
- Rotary or Linear Contact-Less Encoders
- Scroll/Jog Wheel, Trackball (Mobile Phones, Portable Media Players, Notebooks, Computer Mice,
- Camcorders, Cameras,…)
- Home/Industrial Metering Equipment (Water Flow Meter)

3. Other components needed

Elements used in the schematics hereafter are:

- MicroPower Low-Voltage Hall effect Latch MLX92213
- SMD ceramic capacitor 10nF 16V or higher (C1)
- Regulated 1.8V or 3V power source

4. General

It is not a trivial task to design a power optimized magnetic sensor in a micropower environment. The presence on Enable pin allows the system architect to choose and easily switch between the micropower mode or the faster sampling mode of MLX92213. The following sections describe the three modes – Default, faster sampling and slower sampling operation of MLX92213.

5. Terms and Definitions

Symbol	Term	Definition
T_{AW}	Awake time	Time during which the device is “ON” and measures the magnetic field
T_{PER}	Period	Time between two consecutive measurement cycles; it defines directly the response time of the sensor in this mode
f_B	Magnetic signal frequency	Maximum frequency of the magnetic field which can be detected without omission of magnetic poles
I_{DD}	Average Supply Current	Averaged value of the supply current in the Default Sampling Operation
T_{E1}	Enable Pulse Width	Shortest pulse on the Enable pin which triggers a measurement cycle
T_{E2}	Enable Pulse Period	Shortest period of the Enable signal which will trigger a measurement cycle, without omission
t_{ID}	Enable input delay	Delay from Low-to-High transition of the Enable signal to the beginning of the Awake phase
t_{ET}	Enable transition time	Time from Low-to-High transition on the Enable pin to the corresponding refresh of the output state
t_{DT}	Disable transition time	Time from High-to-Low transition on the Enable pin to entering in Standby mode
I_{AWAV}	Average Awake Supply Current	Averaged value of the supply current during the Awake phase

6. Introduction to the enable pin (EN)

The EN pin acts as a trigger input for the internal state machine. A pulse as short as T_{E1} = 5us is enough to start the measurement cycle starting with Awake phase and ending with Standby phase (see Figure 1a).

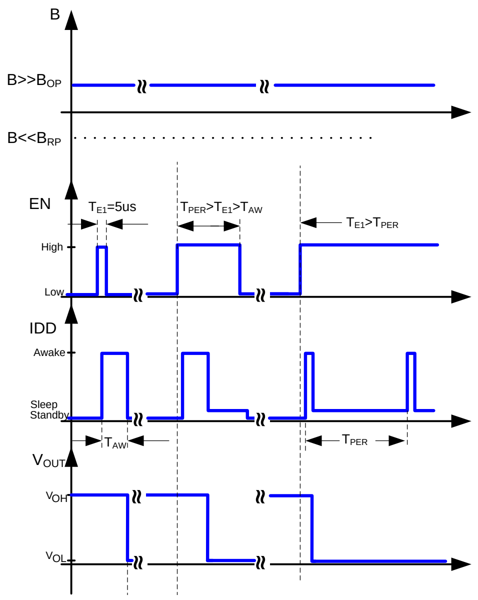


Figure 1a – Triggering pulse duration

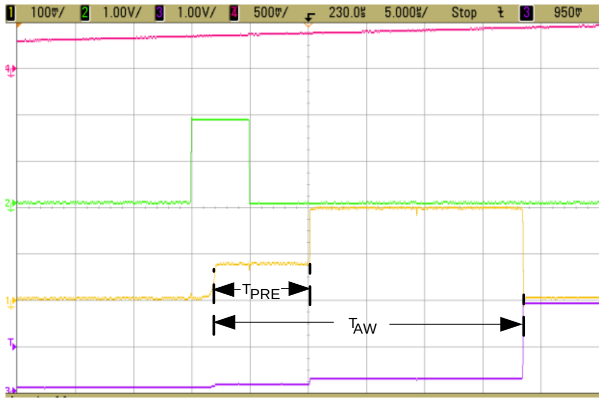


Figure 1b- Oscilloscope with the awake phase subphases

Legend (from top to bottom):
Ch1 – IDD ; Ch.2 – EN ; Ch.3 – OUT ; Ch.4 – Magnetic Field

The Awake phase consists of two subphases:

- Prewarm phase (T_{PRE})
- Awake phase (T_{AW} - T_{PRE})

The I_{AWAV} reflects the average supply current during the entire awake phase:

I_{AWAV}.≈ 0.8*I_{AW}

There is no limitation of the triggering pulse width T_{E1}. In general, if T_{E1} tends to infinite, the device will be in the Default sampling mode until the EN pin is kept in high level.

7. Default Operation

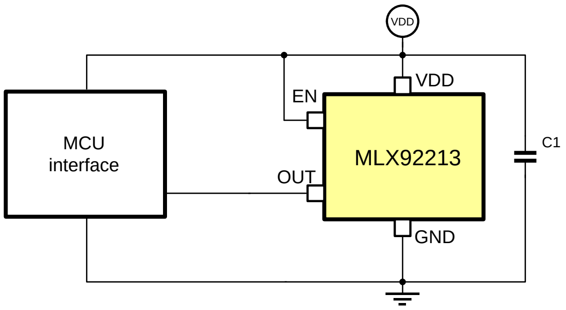


Figure 2 - Default power management application with MCU interface

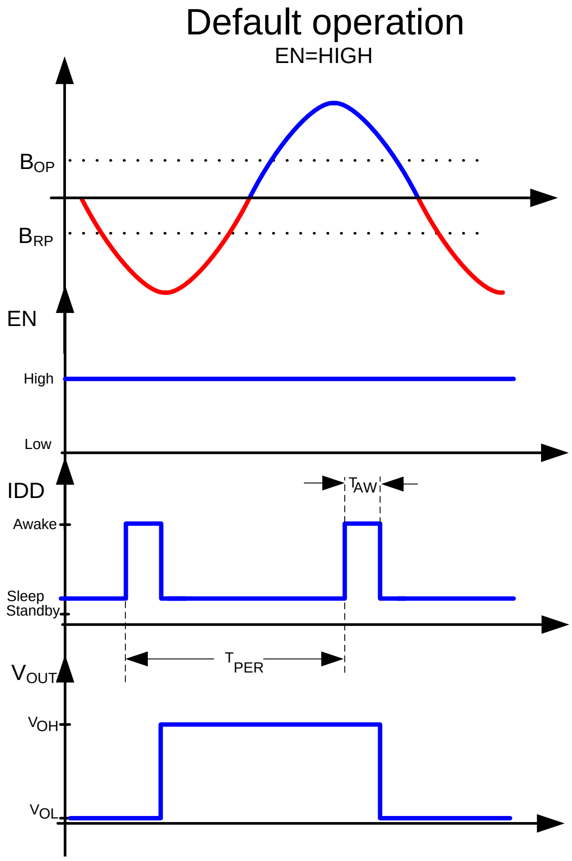


Figure 3 – Timing Diagrams

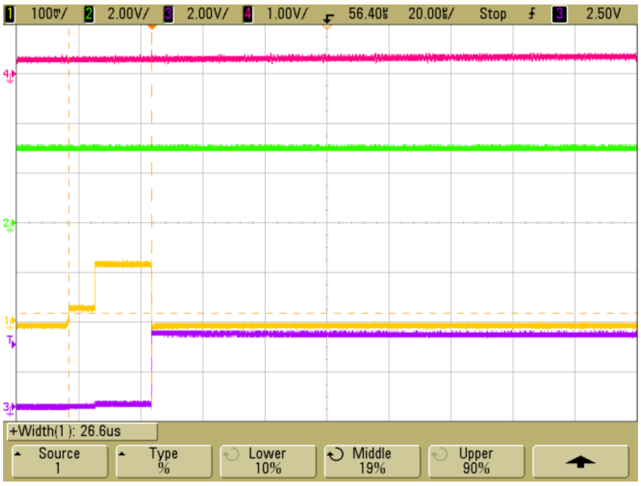


Figure 4a - Default Sampling Mode @3V (measured TAW)

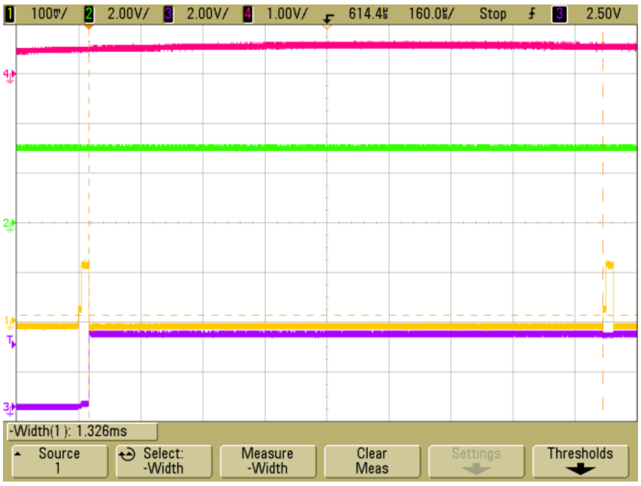


Figure 4b - Default Sampling Mode @3V (measured TPER)

Legend (from top to bottom):
Ch.4 (red) – Magnetic field signal; Ch.2 (green) – Enable pin signal
Ch.1 (yellow) – Current consumption (IDD); Ch.3 (purple) – Output pin signal;

7.1. Explanation

When the Enable pin is directly connected to VDD (or voltage equal or greater than V_{IHMIN} is applied to it) the MLX92213 is in the Default Operation mode. From electrical point of view, this mode is very similar to another Melexis micropower product – MLX90248 - the devices alternates between "Awake" and "Sleep" mode, where the timing is defined by the internal state machine. There are several parameters from the device specification which are important in this mode. These are:

- Awake time T_{AW}
- Period T_{PER}
- Magnetic signal frequency f_B
- Average supply current I_{DD}

This operating mode is very useful in applications where the response speed is not an issue (for example open-close sensor, etc.) without any need of special microcontroller to generate the Enable signal.

7.2. Default sample mode summary

VDD [V]	Maximum Switching Fequency [Hz]	IDD [uA]
1.8	360	36
3	360	48

Table 1 – Default sampling mode achievements (typical values based on limited samples characterization)

8. Faster sampling operation

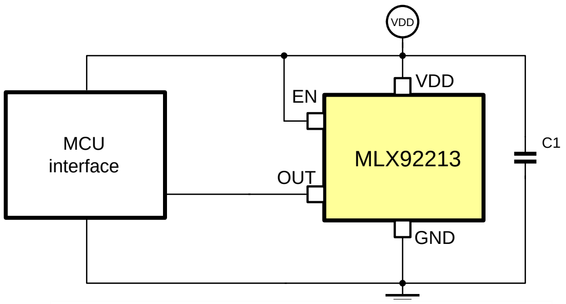


Figure 5 – Faster Sampling Operation example schematic

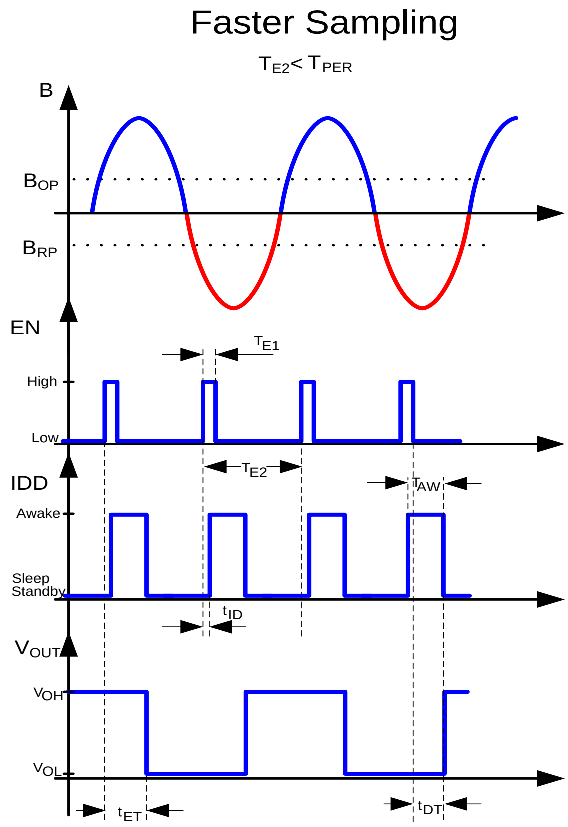


Figure 6 - Timing Diagrams

How the Timing Diagrams look like in the real world (VDD=3V):

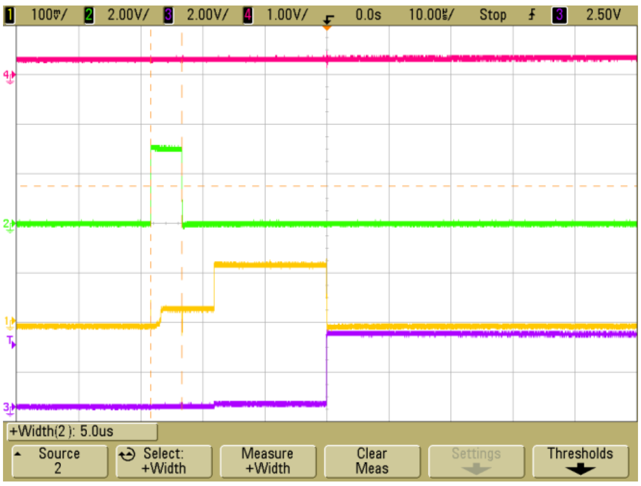


Figure 7a - Faster Sampling Mode (measured T_{AW})

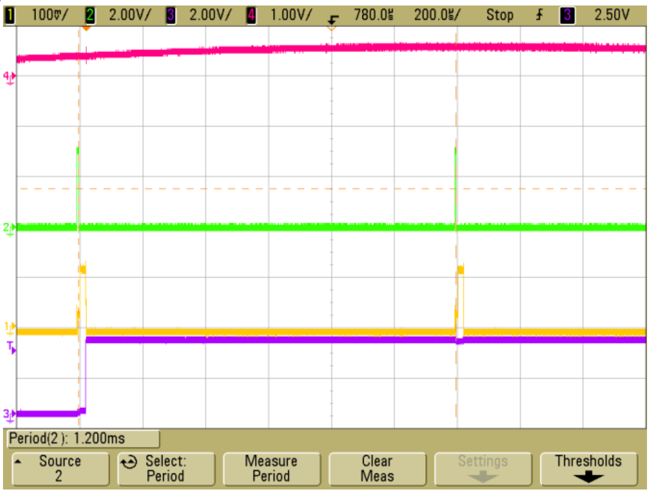


Figure 7b - Faster Sampling Mode (measured T_{PER})

Legend (from top to bottom):

Ch.4 (red) – Magnetic field signal; Ch.2 (green) – Enable pin signal (tied to VDD)

Ch.1 (yellow) – Current consumption (IDD); Ch.3 (purple) – Output pin signal;

8.1. Explanation

When the Enable pin is driven externally with TE2 < TPER the MLX92213 is in faster sampling mode. The most important parameters for this mode are:

- Enable Pulse Width T_{E1}
- Enable Pulse Period T_{E2}
- Enable input delay t_{ID}
- Enable transition time t_{ET}
- Disable transition time t_{DT}
- Awake time T_{AW}
- Average Awake Supply Current I_{AWAV}

The average current consumption in this mode will be higher than the Average Supply Current I_{DD} in Default sampling mode. In the general case it can be calculated using the equations:

- For $T_{E1} \leq T_{AW}$:

$$\mathrm{I_{DDFS}} = I_{AWAV}\frac{T_{AW}}{T_{E2}} + I_{SB}\frac{T_{E2} - T_{AW}}{T_{E2}}$$

- For $T_{E1} > T_{AW}$:

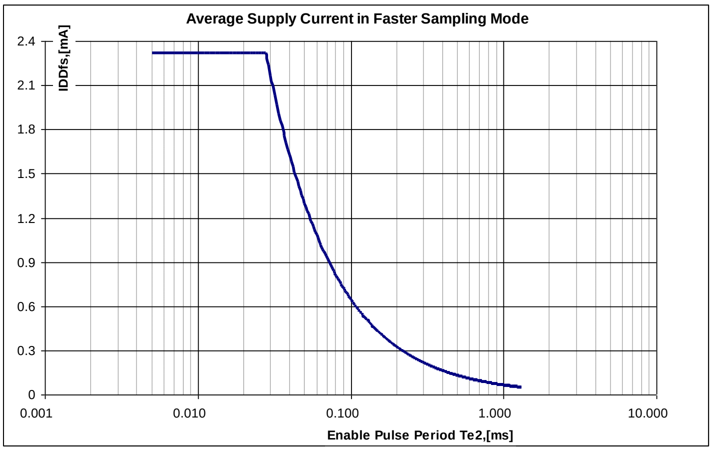
$$\mathrm{I_{DDFS}} = I_{AWAV}\frac{T_{AW}}{T_{E2}} + I_{SL}\frac{T_{E1} - T_{AW}}{T_{E2}} + I_{SB}\frac{T_{E2} - T_{E1}}{T_{E2}}$$

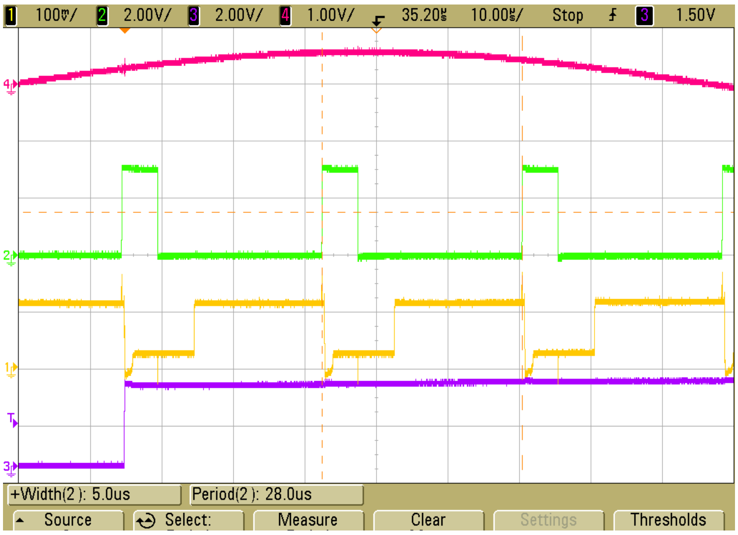
Where I_{SL} and I_{SB} are the current consumption in Sleep and Standby mode.

Taking into account that ISL and ISB are very small compared to IAWAV, the equations are reduced to:

$$\mathrm{I_{DDFS}} \approx I_{AWAV}\frac{T_{AW}}{T_{E2}}$$

From this equation it is clear that the higher the Enable strobing is, the faster the chip response is, but leading to increased average current consumption. Thus the Faster sampling mode can be combined with the Default or Slower sampling for power. Visualized, the equation looks like this:





Legend:
Ch.1 (yellow) – Current consumption (IDD)
Ch.2 (green) – Enable pin signal
Ch.3 (purple) – Output pin signal
Ch.4 (red) – Magnetic field signal

Figure 8 - Fastest Sampling Operation @3V (measured TE1 and TE2)

8.2. Faster sampling mode summary

VDD [V]	Maximum Switching Fequency [Hz]	IDD [uA]
1.8	16000	1.48
3	17800	2.14

Table 2 - Faster Sampling Mode achievements (typical values based on limited samples characterization)

9. Slower sampling operation

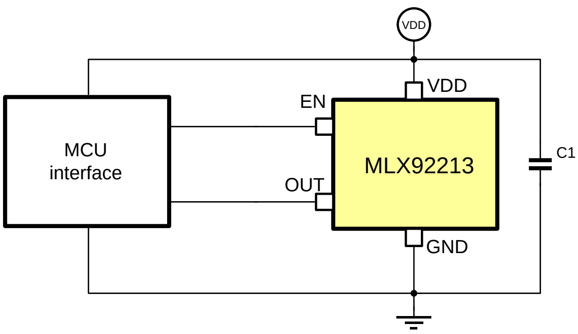


Figure 9 - Slower Sampling Operation example schematic

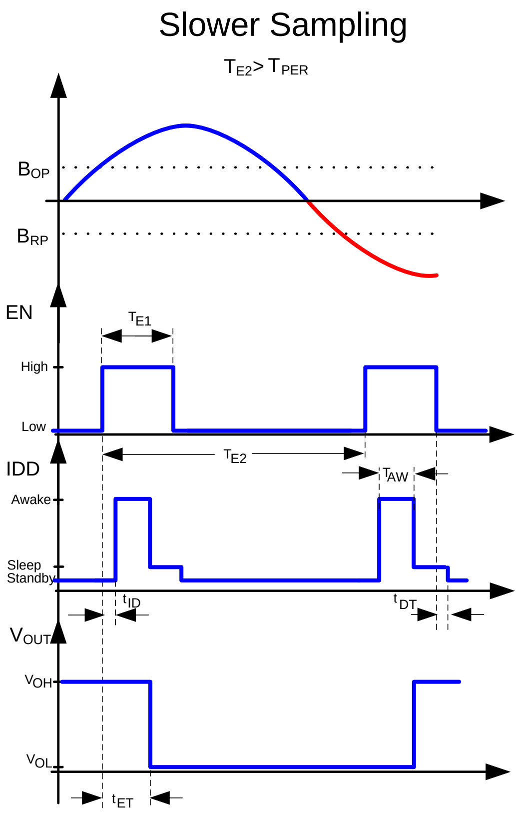
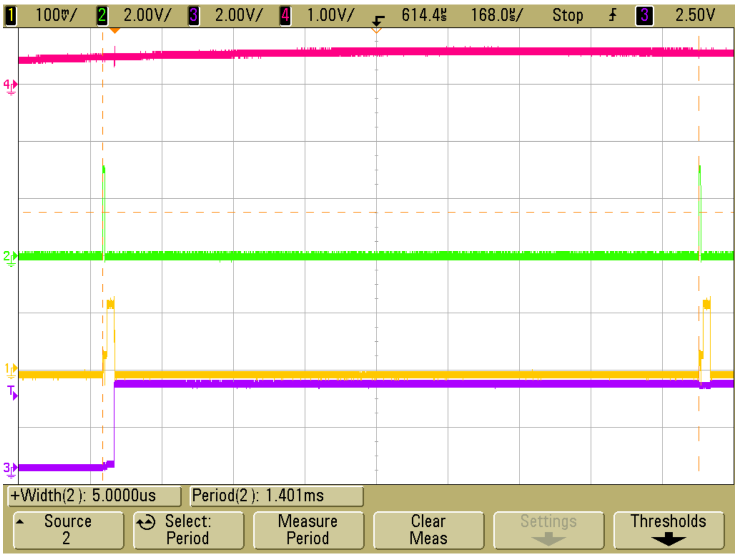


Figure 10 - Timing Diagrams

How the Timing Diagrams look like in the real world (VDD=3V)



Legend:
Ch.1 (yellow) – Current consumption (IDD)
Ch.2 (green) – Enable pin signal
Ch.3 (purple) – Output pin signal
Ch.4 (red) – Magnetic field signal

Figure 11 - Slower Sampling Mode – measured TE1 and TE2

9.1. Explanation

When the Enable pin is driven externally with $T_{E2} > T_{PER}$ the MLX92213 is in Slower sampling mode. The most important parameters are the same as those for Faster Sampling Mode. The average current consumption in this mode will be less than the Average Supply Current I_{DD} in Default sampling mode. In the general case it can be calculated using the equations:

- For $T_{E1} \leq T_{AW}$:

$$\mathrm{I_{DDFS}} = I_{AWAV}\frac{T_{AW}}{T_{E2}} + I_{SB}\frac{T_{E2}-T_{AW}}{T_{E2}}$$

- For $T_{E1} > T_{AW}$:

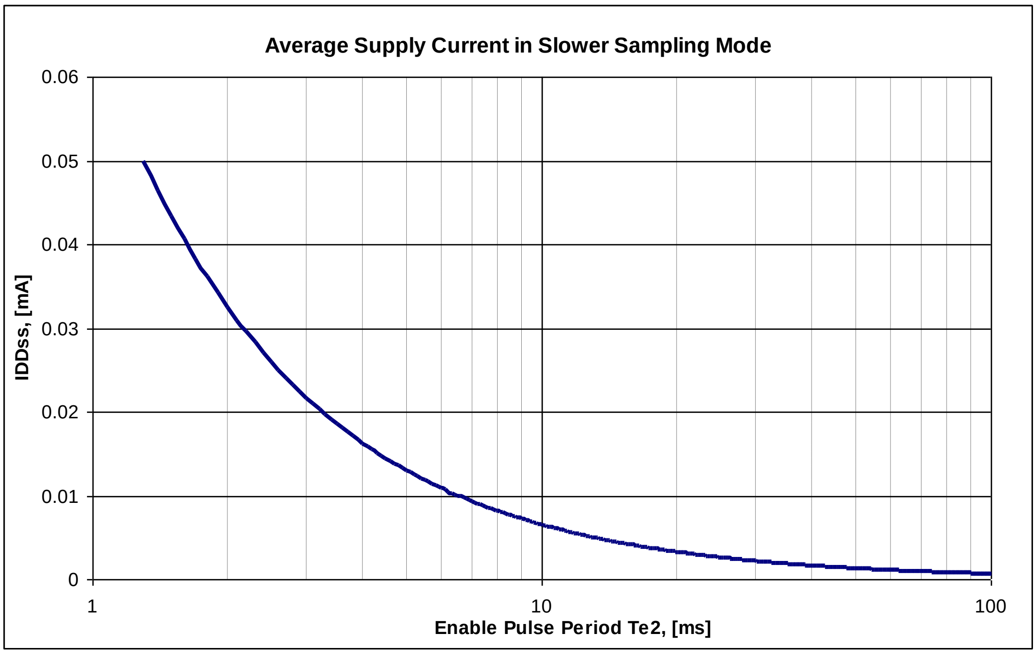
$$\mathrm{I_{DDFS}} = I_{AWAV}\frac{T_{AW}}{T_{E2}} + I_{SL}\frac{T_{E1}-T_{AW}}{T_{E2}} + I_{SB}\frac{T_{E2}-T_{E1}}{T_{E2}}$$

Where I_{SL} and I_{SB} are the current consumption in Sleep and Standby mode.

These equations are valid for $T_{E1} < T_{PER}$ (otherwise the MLX92213 will enter in Default Sampling Mode). Taking into account that I_{SL} and I_{SB} are very small compared to I_{AWAV}, the equations are reduced to:

$$\mathrm{I_{DDFS}} \approx I_{AWAV}\frac{T_{AW}}{T_{E2}}$$

Visualized, the equation looks like this:



In Slower Sampling Mode, the lowest current consumption can be achieved.

10. Application comments

It is recommended to put the bypass capacitor C1, needed to ensure the supply voltage stability. It should be placed between VDD and GND pin, as close as possible to MLX92213

11. Conclusion

The different operating modes were presented in this application note. The goal is to make these operating modes clearer for the user in order to be able to exploit their full benefit. The below graph combines the three discussed operation modes, showing the Average Supply Current versus Enable Pulse Period.