PYREOS

Application Note AN0122

ezPyro^{TM} Four Pin Operation

Version Number 3

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Table of Contents

1 DOCUMENT HISTORY

Ver.	*Date*	*Change Ref.*	*Author*	*Change Details*
1	11/04/18		ST	Initial version
2	23/4/18		GO/PW/ST	Various updates, move to 4-pin opn
3	15/5/18		ST	More analysis

2 INTRODUCTION

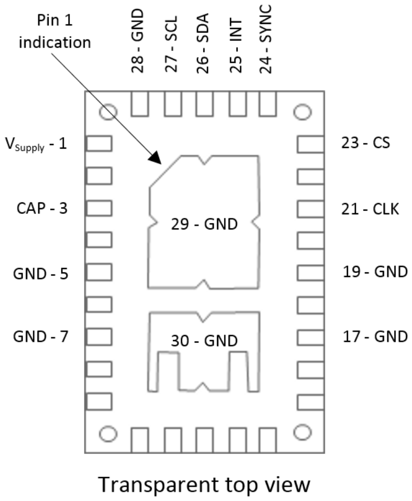
This application note covers the required hardware and operational requirements of the ezPyro sensor when only 4 pins are used.

Operational differences arise from the number of pins reduced to just the I^{2}C lines, for example in the case of ezPyro TO. The method of operation is different due to this and this document covers some options for the additional surrounding circuitry and should be used in conjunction with the corresponding document "*AN023 ezPyro TO Software Application Note*" for the software differences, and with the *ezPyro Sensor Reference Manual*.

The ezPyro range of thin film digital pyroelectric IR sensors combines high performance with a high level of configurable electronic integration in the smallest SMD package and in a TO39 package.

High sensitivity and SNR combined with fast response times ensure rapid and accurate detection. High dynamic range allows motion and flame detection nearby or over larger distances. Programmable gain and filtering offer maximum flexibility, while industry standard I^{2}C I/O enables plug-and-play connectivity to microcontrollers and easy tuning. These sensors can also be daisy-chained to allow synchronized sampling across devices and offer various low power modes, including a wake-up by signal feature.

3 SENSOR CONNECTIONS



Pin	Function	Direction
1	SDA	In/Out
2	V_{Supply}	In
3	SCL	In
4	GND	In

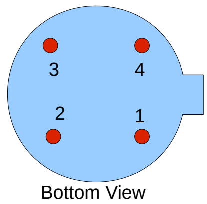


Figure 1: ezPyro SMD sensor

Figure 2: ezPyro TO sensor

The above figures show the connections available for ezPyro sensors. Functionally the ezPyro TO is equivalent to the ezPyro SMD used with only 4 pin connections.

The TO package only allows for V+, GND and the I^2C lines. This means that the following pins that can be used in the ezPyro SMD sensors are not accessible.

1. INT
2. SYNC
3. CLK
4. CS

The following sections describe the use of these pins and the impact of the restricted number of pins on the reduction in functionality.

3.1 INT

The INT pin on the ezPyro SMD indicates to the attached MCU that there is data available in the FIFO and can be read out using the appropriate I²C command. The lack of access to this pin means that the FIFO must be checked using the FIFO status command. The FIFO status packet as described on page 22 of the *ezPyro reference manual* contains the interrupt pins status in bit 0 of the returned byte and so can be used to poll the FIFO status. Also this implies that any Sleep/Wake-up function needs to be done by polling

The below graph shows the logic analyser results from during normal operation of a SMD ezPyro that has access to all the pins.

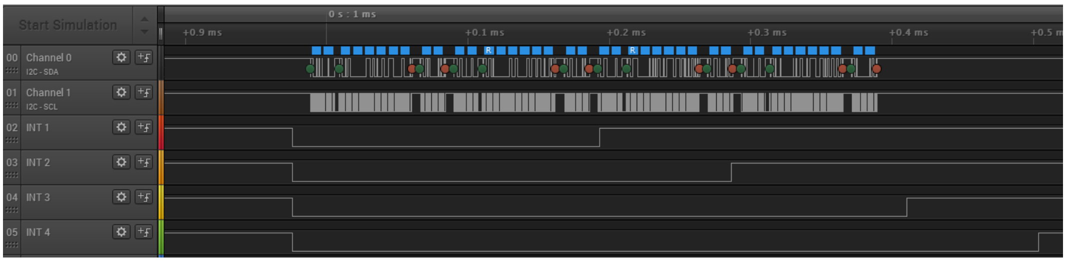


Figure 1: Interrupt Pin Operation Mode

The interrupt pins all go low at the same time due to the daisy chaining of the devices with the sync signal from the master making all sensors take a sample. As data is read out from each device and then the FIFO cleared the INT lines go low one at a time. The I2C commands to read the data out begin once the MCU has detected the INT line states.

The below graph shows the FIFO status being checked to determine data availability.

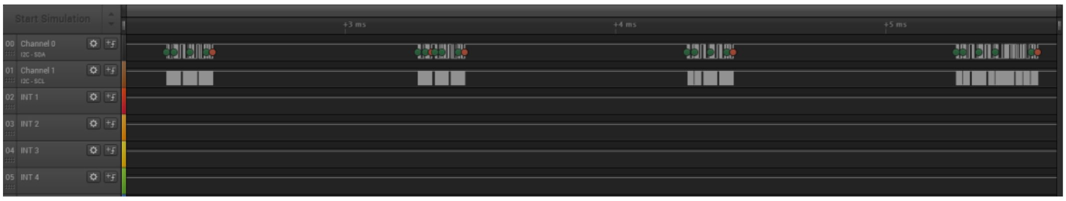


Figure 2: FIFO status Polling Operation

The above graph shows three FIFO status checks that return a FIFO status corresponding to no data and then a final FIFO status check that indicates there is data available followed by reading the data out and clearing each FIFO in turn.

3.2 SYNC and CLK

These pins on the ezPyro SMD give the synchronisation of sampling between multiple sensors. Under 4-pin operation each sensor uses its own internal CLK and SYNC signals so every ezPyro TO sensor must be set up as a master by configuring the AFE register as described in the *ezPyro reference manual* on page 24.

This has the effect of removing the ability to daisy chain the sensors they are independently clocked devices.

3.3 CS

The chip select pin is also not available in 4-pin connected sensors. On the ezPyro TO the CS is wired internally directly to the positive voltage input. So when the voltage supply is turned on the CS signal goes high.

This does mean that if multiple sensors are being powered from the same supply there needs to be a way to re-address the devices separated by powering them on in sequence. This is discussed in section 4.2.

4 SOLUTIONS

The limited number of pins on the ezPyro TO package means that a subset of the functionality of the ezPyro SMD is accessible.

The solutions are grouped into two sections, **initialisation** and **operation.**

4.1 Initialisation - Turning the Sensors ON and OFF

On the Pyreos ezPyro TO demo kit the digital IO of the MCU is being as a power supply switch signal, the other devices need to be powered from the 3V3 pin of the MCU which is connected to the output of a regulator (See section 5 figs 1 and 2).

If the MCU is reset it is desired that the sensors can be reset. The 3V3 pin of the MCU stays high if the MCU is powered. Therefore if the sensors need to be turned off separately we suggest use of a power supply switch. This must not simply be powered or floating. Floating is not a good enough state since when it is turned off you want the device to discharge very quickly. This implies that the two connections for the V supply pin should be 3V3 and grounded. This will allow quick turning on as well as quick turning off if required. The ability to turn off quickly avoids turning on from an unknown state of the registers.

This would cause a problem if the sensor has kept an old address and not defaulted to the default address as would be normal on start-up when the device is first powered.

The power switch schematic is shown in figure 4. There are connections to this in both figure 3 and figure 5.

On our demo board we have used a single power switch to turn on all the devices. This reduced the cost of the components but did introduce the requirement of being able to communicate individually with each sensor to allow re-addressing. This is solved by using additional switches for the I^2C clocks.

It does however stop the ability of powering each device independently. This can be a problem in low power applications. In this situation it could be better to use multiple power switches at greater component cost to give a lower power consumption system.

4.2 Initialisation - Independently Addressing Devices

On ezPyro SMD devices the sensors are initialised by setting the CS of one device at a time and re-addressing each device until all sensors have distinct addresses on the I^2C bus.

The operation of the ezPyro TO devices is different as there is a single power switch for all sensors. The solution is to use an IC that can allow or deny access to the I^2C clock signal to each sensor. This means that although the data is getting to all sensors the I^2C hardware is not being clocked so the incoming data is not being read.

With this additional piece of hardware the same code for the ezPyro demo board can be used since the same signals used to activate chip select are used to control sensors receiving the I^2C clock.

4.3 Operation Checking for Data

With the ezPyro SMD sensors there are various methods for the MCU determining whether there is data in the FIFO.

1. Use INT pin of ezPyro and Interrupt within the MCU
2. Use INT pin of ezPyro and Poll it with the MCU
3. Use the I^{2}C FIFO_Status command and check the bit corresponding to the INT status. This is effectively polling the FIFO_Status.

Since the first two require the INT pin of the ezPyro they cannot be used in 4-pin operation, the only method of checking whether there is data in the FIFO is to use the I^{2}C FIFO_Status command.

It is worth reminding here that when polling the FIFO_Status the I^{2}C bus is being used. Therefore to improve power usage the frequency of checking the FIFO_Status should be kept to a minimum to avoid unnecessary current consumption due to communications when the FIFO has had to chance to fill with additional data.

As an example in the ezPyro TO demo kit this has been accomplished through an interrupt that uses the current sampling rate and power mode to determine its frequency of checks.

The lack of synchronized sensor sampling produces the following result in the FIFO polling data read out mode. The narrowest I2C packets correspond to none of the sensors having data in the FIFO. The widest packets correspond to all sensors having data in the FIFO. The other I2C packets correspond to FIFO status checks that have returned only a subset of sensors with data available.

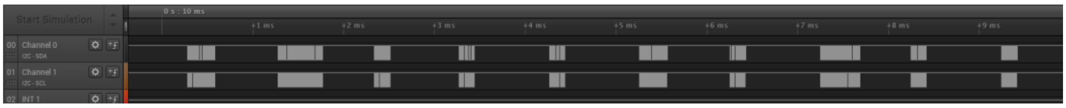


Figure 3: FIFO Polling - Effect of unsynchronized sampling

Since the sensors are independently clocked the point at which data is available for each sensor is different. Care must be taken when designing the firmware to read the sensors in order to avoid losing data.

4.4 Demo board Circuit Schematics

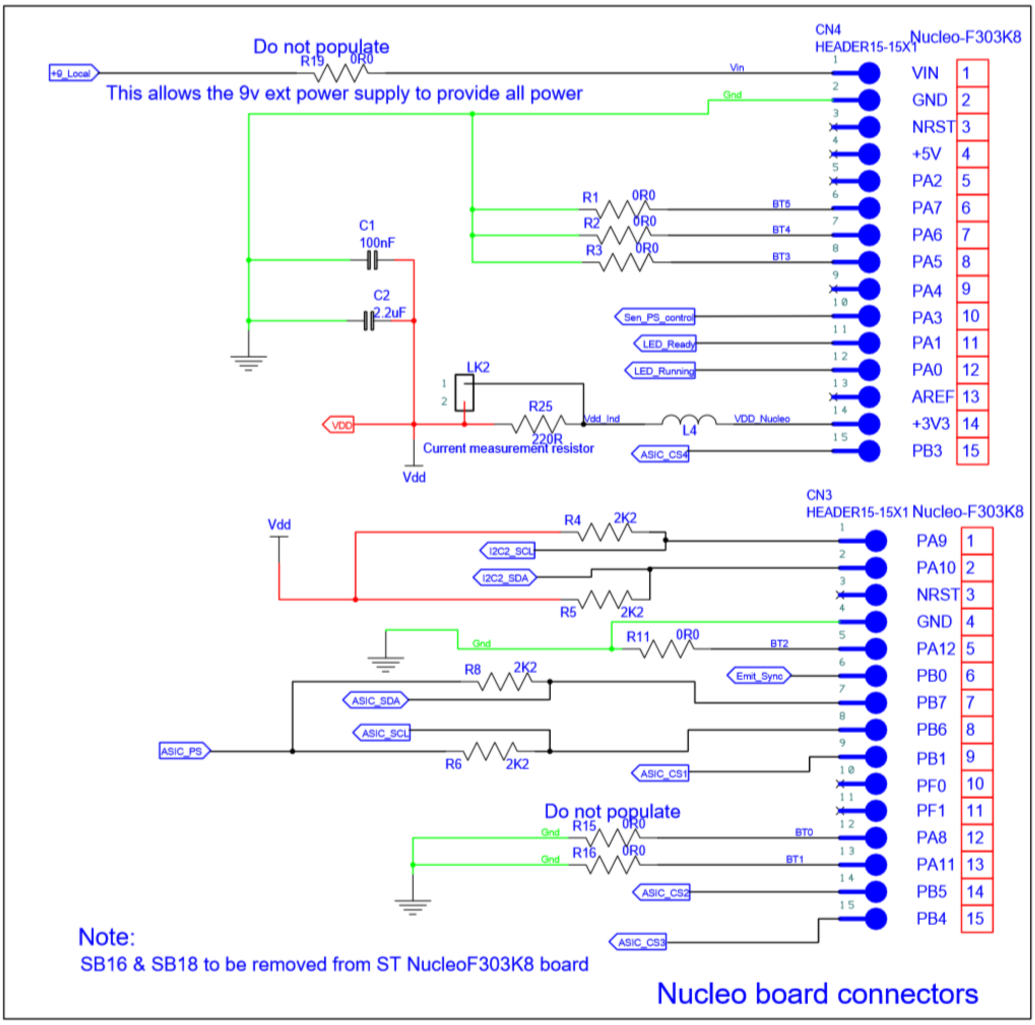


Figure 4: MCU Connections

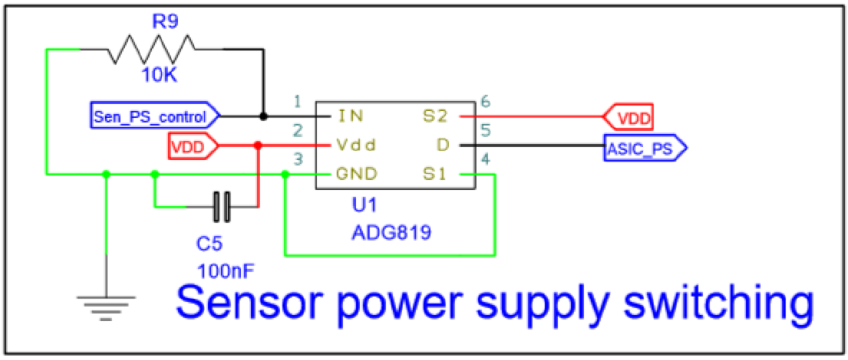


Figure 5: Power Supply Switch

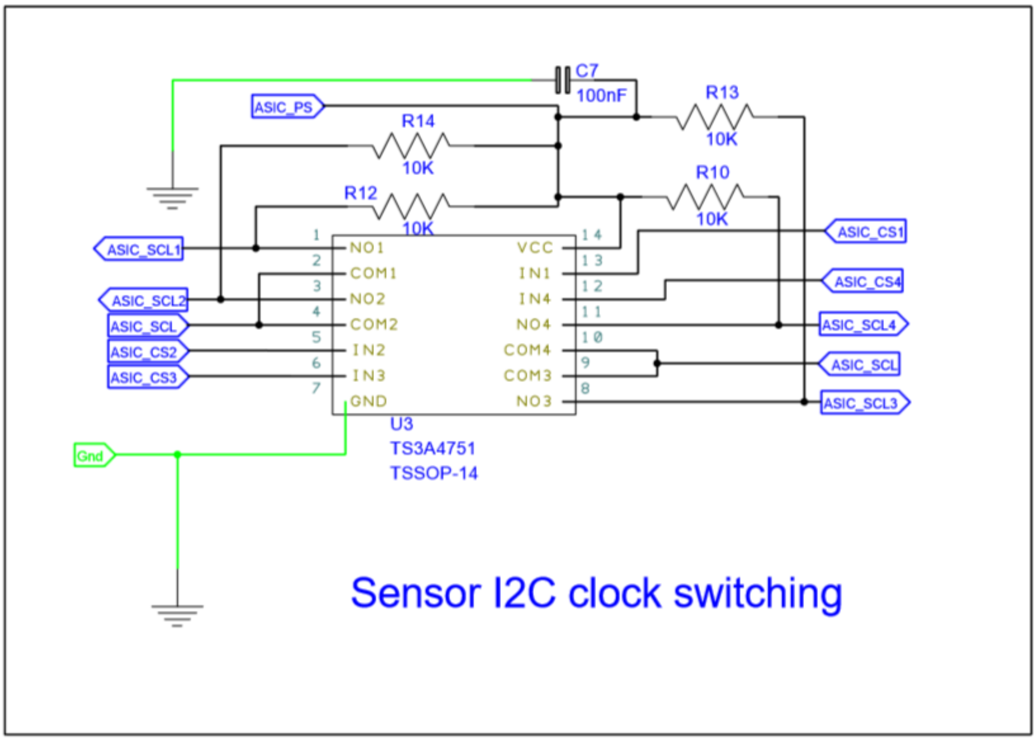


Figure 6: Sensors Clock Switches

4.4.1 Notes on Demo Kit Schematics

Developers should note that the I²C pull-ups and the I²C clock switch receive their 3V3 from the output of the power supply switch.

The reason for this is that when the ezPyro sensor does not have a 3V3 applied to its V supply pin then the other digital IO pins can feed onto the 3V3 rail of the ezPyro ASIC through protection diodes. These are in place to stop damage to the ASIC due to spikes on the digital IO pins. However if there is no 3V3 supply then any voltage over 0.6-0.7V on the other pins is fed onto the 3V3 rail and hence the device could be powered through the I²C lines. To avoid this they are kept low until the 3V3 signal is supplied.

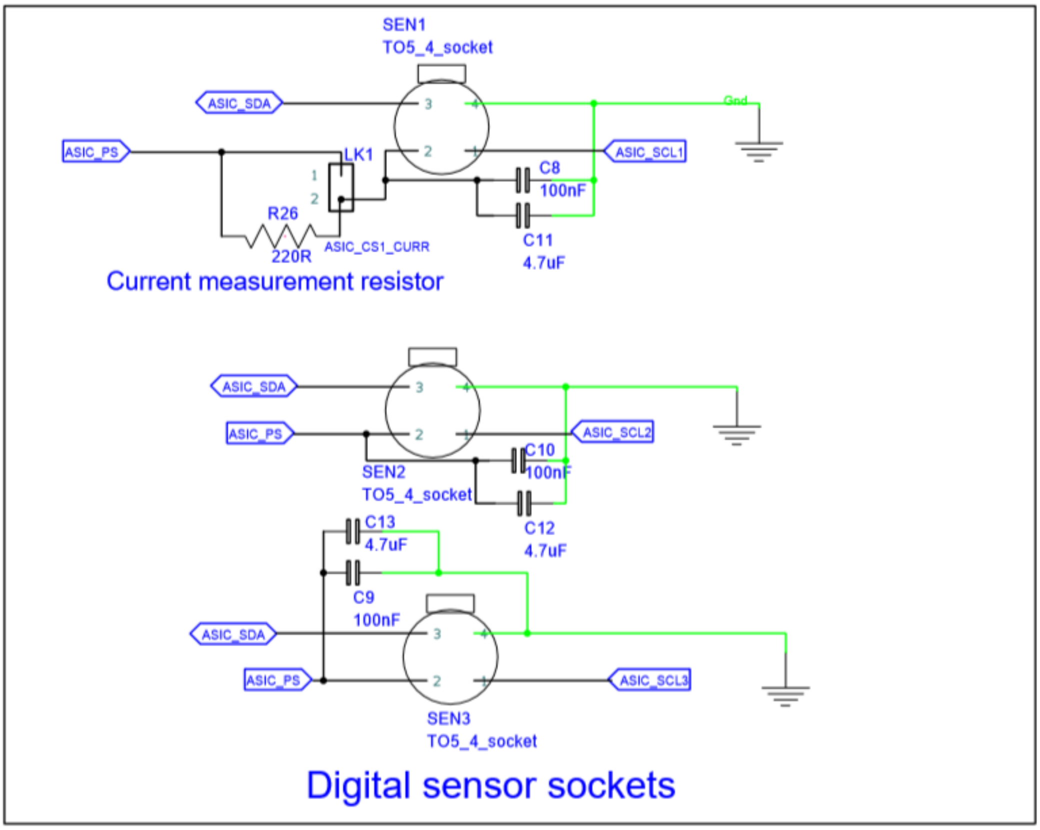


Figure 7: Sensor Connections

5 CIRCUIT FOR LOW POWER APPLICATIONS

The above descriptions are for the current version of the Pyreos demo board. This was chosen to reduce the component cost. However it does mean that the lowest current consumption for sleep mode is not achievable.

Since the sensors are all taking the power from the same source they cannot be powered independently. Allowing independent powering of the devices has benefits for certain low power applications.

Considering the flame demo kits expected usage as an example for the differences in power consumption performance for a different circuit choice. The flame demo kit should only be actively analysing the data if the flame sensor is above some threshold value. This implies that the sensors can be asleep and can make use of the wake-up parameters described in section 13.3.8 of the ezPyro reference manual. If you are unfamiliar with the WUP packet it is recommended to use the ezPyro Evaluation Tool software as it contains a useful visualization aid to setting up and testing the parameters. The ezPyro Evaluation Tool software comes with all ezPyro SMD and ezPyro TO demo kits.

5.1 Flame Demo Kit

As mentioned above the flame demo kit should ideally be asleep most of the time unless an event considered to be a fire is detected on the sensor output. This means that if the signal level is just noise then the devices should remain asleep, the level of signal required for a wake-up condition is determined by the WUP packet. If all three devices are asleep on the ezPyro TO flame demo kit then the minimum current consumption of the sensor system sits at around 18.2 µA. However since we are only interested in the flame sensors signal to determine a wake-up event we could power down the other two devices. This would put the sleep state current consumption at 7.3 µA.

The down side to the above reduction in lowest current consumption is the additional hardware cost. As is mentioned in section 4.4.1 the I2C cannot be connected to a powered down device otherwise the 3v3 feeds onto the Vcc rail of the sensor through protection diodes. Therefore if each device can have power independently it also needs to have the I2C lines connected only when it has power. This will avoid any problems with registers not initialising properly in the ASIC. This implies that there should then be a single power and two I2C signal switches per sensor.

The table below shows the component cost and corresponding current consumption.

Circuit type	Power switches In Circuit	I2C switches in Circuit	Sleep Mode - Sensor circuit current µA
Low Cost	1	1	18.2
Low Current	3	2	7.3

Here are two examples of possible solutions.

Analog Devices: ADG819BRTZ-500RL7

Texas Instruments: TS3A4751PWR