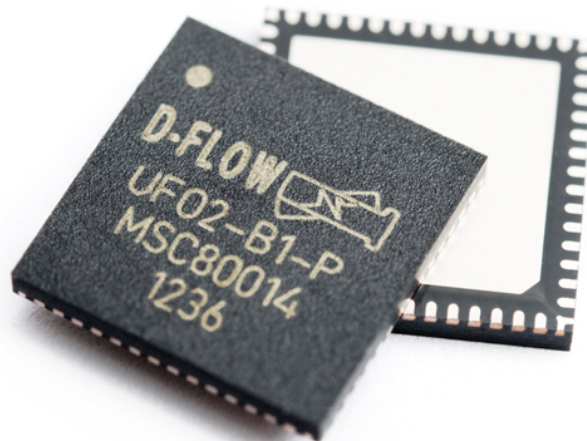


## D-Flow UFO2 ASIC Brief Data Sheet

12 April 2013

Table 1: Revision list

date	comment	author
2012-06-13	First release	Carl Carlander
2013-02-07	Figure updates	Jörgen Marklund
2013-04-12	Review (this document)	Carl Carlander



The *UFO2 ASIC* is a single chip solution for ultrasonic time of flight and temperature measurements. It is comprised of an analog measuring part and a digital micro controller part. Ultrasonic transducers can be connected directly to the ASIC as the driver interface is included on chip. The ASIC supports the use of one transducers in level applications and up to four transducers in flow meter applications. It also supports the use of multiple ASIC:s when more than four transducers are required.

Temperature measurements are sampled by the integrated high resolution ADC. Three external temperature sensors can be connected at the same time to the temperature interface. An integrated 64-bit FPU as well as an integer multiplier can be used by the microcontroller for all calculations in the application. Two separate watchdogs are also included to suit a wide range of applications.

In order to reduce the overall cost of the system, the *UFO2 ASIC* has everything needed for basic flow meter applications and temperature measurements implemented on chip. At the same time it is a versatile circuit allowing for example the transducer drive stages or the analog filter to be implemented externally. The input/output interfaces of the ASIC also support external circuits as external micro controllers or displays. It also includes a voltage regulator for external circuits.

Suitable application for the ASIC can be both high performance meters and high volume battery powered meters. Battery powered applications can use different power down features to achieve very low power consumption. Since both temperature and flow can be measured, energy metering capability can be realized. There are no practical limitation on the size of the meter where the ASIC can be used. In case of long transducer distances or high signal attenuation, external drivers can be applied.

## General

- The package for *UFO2 ASIC* is a 0.5 mm pitch QFN56 package.
- Typically average current consumption of  $40\mu\text{A}$  for a basic water flow meter. Any external circuits are not included.
- A Li 3.6 V battery can directly be connected to the ASIC.
- The allowed ambient operation temperature is between  $-40^{\circ}\text{C}$  and  $+125^{\circ}\text{C}$ .
- All pins are ESD and latch up protected.
- Basic EMC considerations are included in the chip design.

## MCU part functions

The micro controller part of the *UFO2 ASIC* is using a MSP430 compatible core. As the MSP430 series is widely used in low power designs, it's possible to reuse software code from similar products with little effort. Very low power consumption is achieved using two clock sources. The external 32 kHz crystal clock is always operational and the 16 MHz clock is activated when needed. Two independent watchdogs can be used to safeguard against software errors.

The *UFO2 ASIC* have three different serial interfaces, UART, SPI and I2C. All these interfaces have DMA ability as well as an interrupt based ability. The two UARTs can operate up to a baud-rate of 1 Mbd with either full or half duplex communication. The UART transceivers also includes a 4 stages send and receive fifo to assist the UART transceivers.

Maximum speed of the I2C interface is 400 kbit/s (Fast-mode) but 100 kbit (Standard-mode) is also supported. Support for using 7- 10 or 16 bit addressing is included directly in hardware.

The SPI module can be configured to either serve as an master or slave device. Transfer rate can be as high as 2 Mbit using SPI interface.

- A 16-bit MSP430 compatible CPU core.
- Integer multiplier, MUL16 compatible.
- 5 kB of SRAM is included.
- 32 kB of flash memory.
- A configurable WDT for 16MHz clock.
- A configurable WDT for 32kHz clock.
- 5 general purpose 16 bit counters.
- 64-bit FPU allow very fast calculations.
- Two independent DMA channels.
- GPIO consists of 12 programmable pins, all with interrupt ability
  - 2 serial UARTs
  - SPI(master/slave)
  - I2C(master/slave)
  - 2 settable PWM
  - settable pulse output
- JTAG port, 2-wire
- For power saving reasons all parts of the MCU can be switch on and off

## Ultrasonic measuring part functions

This section briefly describes the analog modules necessary to make an ultrasonic measurement. For instance, a transit time ultrasonic flow meter uses ultrasonic transducers that can both send and receive sound. The sound is transmitted between the transducers through the fluid that pass through the flow meter. The sound propagation time between the transducers is measured in both directions. These transit times are then used to calculate the flow velocity.

The *UFO2 ASIC* also features a measurement state machine, that make it easy to configure and issue a sequence of calibrations, ultrasonic measurement and temperature measurements.

- Different measuring modes are implemented in the ASIC. This makes it easy to adapt to different applications without any external components.
- 1 to 4 of D-Flow's ultrasonic 4MHz transducers can be directly connected to the ASIC with external resistors in parallel.
- Transducer drive stages are included in the ASIC for D-Flow standard 4MHz transducers.
- Transducer drive stages can also be implemented externally.
- Band pass filter is included in the ASIC for the standard 4MHz transducer.
- Band pass filter can also be implemented externally.
- There are test pins for diagnostics available. The AGC is both readable and settable.
- Single shot time resolution of the time measurement is typically 40 ps.
- Internal voltage regulators for the MCU section in the ASIC.
- Internal voltage regulators for the analog measurement section in the ASIC.
- Internal voltage regulator for the transducer drive stage.
- Internal voltage regulator for external circuits.
- There are two power saving modes, sleep mode and power cycling mode.

For performance reasons the high and low frequency crystals are placed externally.

## Temperature and analog measuring part functions

Temperature measurements are made using an high resolution ADC, included in the ASIC. The internal current generator can be configured to deliver a current between  $32\mu\text{A}$  and 2 mA. If resistive sensors such as PT resistances are used, then it's possible to measure three external temperatures. The Asic have the possibility to use two 4-wire interfaces and one 2-wire interfaces to the sensors. The same ADC can also be used to measure the internal chip temperature and the voltage applied on the ASIC's analog input pin.

- There is an on-chip temperature sensor with a  $\pm 5^\circ\text{C}$  accuracy. After a calibration during the flow meter assembly the accuracy can be improved.
- There are in total 3 RTD interfaces for external Pt100, Pt500 or Pt1000 sensors. If multiple sensors are used they need to be of the same type.
- One of the RTD interfaces connects a 2-wire sensor and two interfaces connect to 2-, 3- or 4-wire sensors.
- The temperature resolution is up to  $0.01^\circ\text{C}$ .

- The absolute temperature accuracy of the RTD interfaces is up to 0.2°C . In order to reach the highest accuracy an external 0.1% reference resistor needs to be connected.
- The differential temperature between two sensors can also be directly measured. The accuracy of the differential temperature measurement is up to ±0.1°C .
- The battery voltage and an external DC voltage can also be measured.
- For power saving reasons the RTD interfaces and the on-chip sensor can be switched on and off.

## Modules in the Asic

The ASIC is sectioned in many modules, named after their usage or function. These blocks are shown in figure 1.

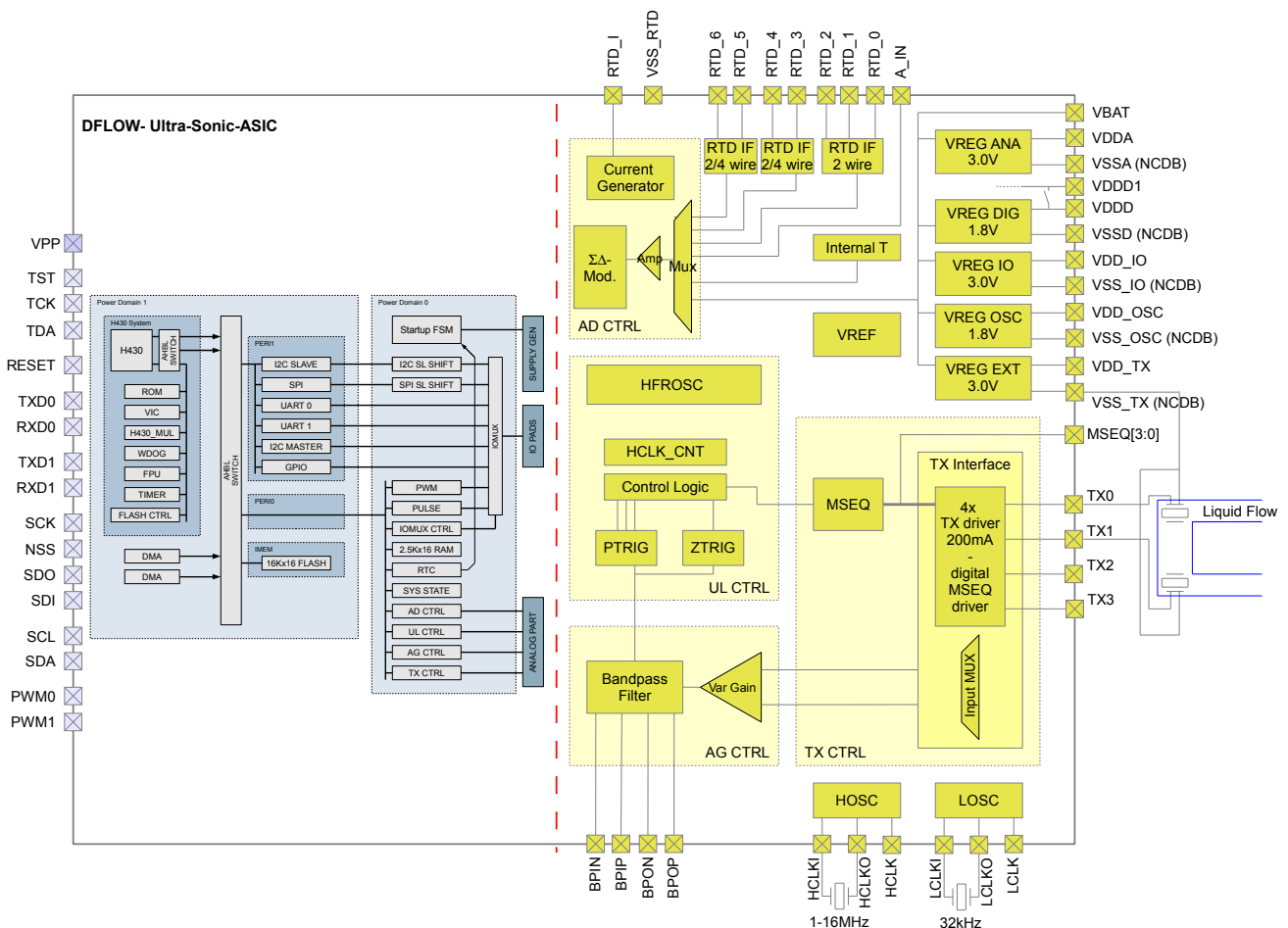


Figure 1: Block diagram of D-Flow UFO2 ASIC



## Package

The ASIC is packaged in a standard QFN package with 56 pins. Package drawing in figure 3.

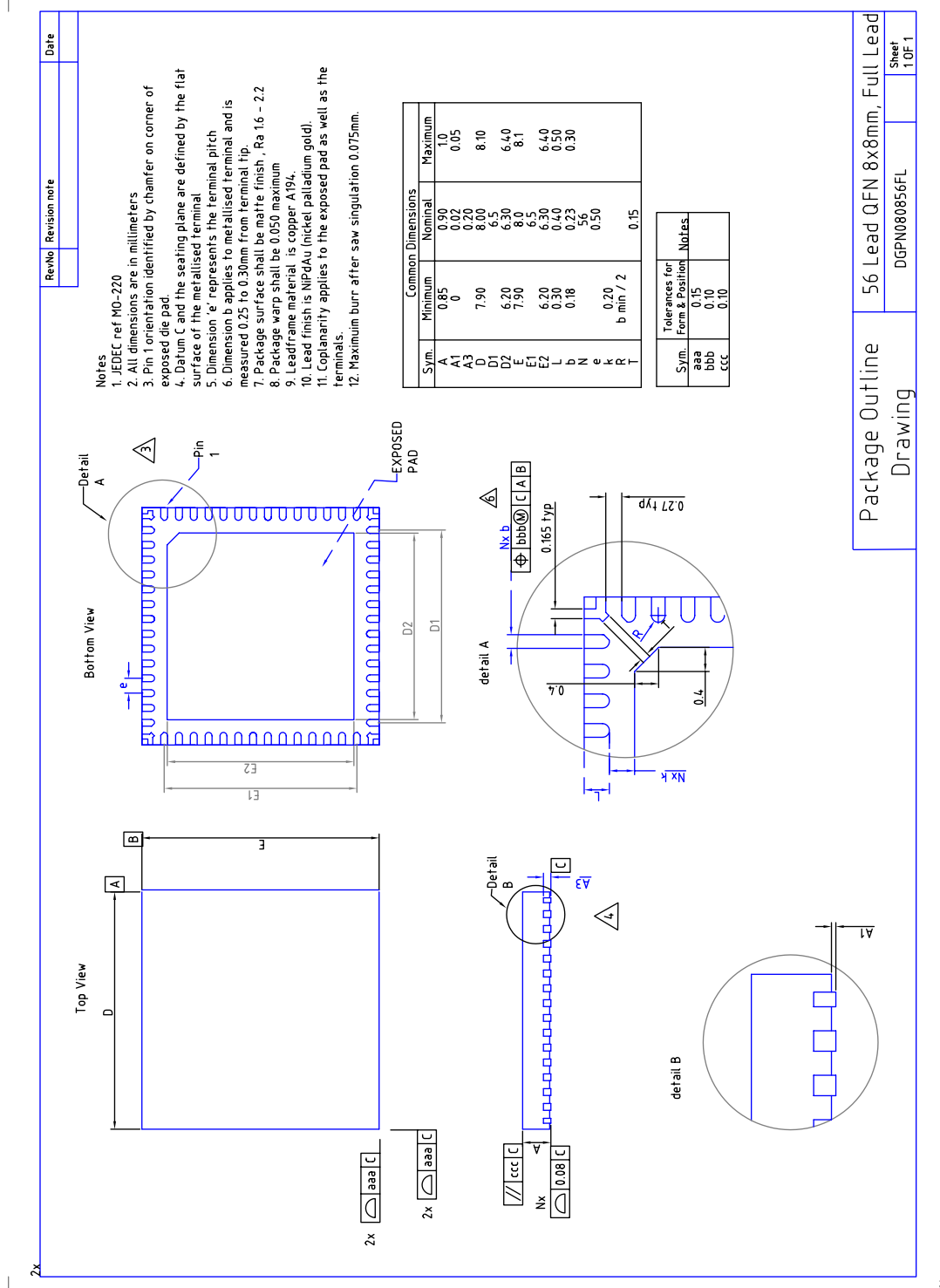


Figure 3: D-Flow UFO2 ASIC package