Application Report
SLAA619A–November 2013–Revised December 2013

TIC Digital Interface

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ABSTRACT

Interfaces for the TIC protocol are mainly based on analog circuits, containing transistor, amplifier, and comparator stages. They require effort in analog engineering, and the reliability suffers from tolerances, shifting, and aging analog components.

This application report presents a TIC Digital Interface, which considers an early analog-to-digital conversion with the help of a ΔΣ-modulator AMC1204 device and, for data processing, a MSP430 microcontroller. Out of the analog TIC signal, the AMC1204 device generates a bit stream, which is used as clock input for a MSP430 timer module. A transmitted logical “1” leads to a slow-counting frequency, whereas a “0” leads to a fast-counting frequency. The sampled data is forwarded to the application with a distinction between cases and a synchronization clock of the MSP430.

Due to its simple design and the internal isolation of the AMC1204 device, the TIC Digital Interface does not require a transformer in the signal path, unlike analog solutions, which require a transformer.

1 Objective

The goal of the project is to provide an interface for electricity meters. Those meters, used by Electricity of France (EDF), offer a 2-wire analog interface and allow monitoring of network utilization and power consumption. The digital interface is designed to convert the analog signal into a digital data stream.

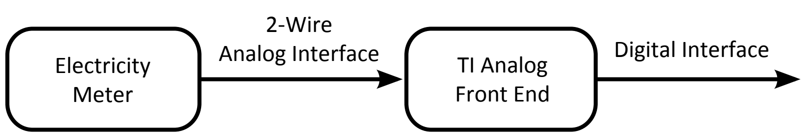

Figure 1.

The following parameters describe the input signal of the analog interface:

- Differential signal
- On-off-keying (OOK) with f = 50 kHz
- Low-Active:
  - Logical 1 = Signal off
  - Logical 0 = Signal on
- Baud rate: 1200 or 9600 Bd

2 Concept Overview

2.1 System Overview

The proposed interface consists of two components from Texas Instruments:

- ΔΣ-Modulator: AMC1204
- Microcontroller: MSP430

The electricity meter is connected via a 2-wire interface (differential signaling) to the AMC1204 device. The information, sent by the meter, is transmitted with a baud rate of 1200 Bd or 9600 Bd. The modulator generates a serial bit stream (see Section 2.2), which is captured by the MSP430. Besides the capturing this stream, the MSP430 has to process the data and it also provides realtime functionality to generate a synchronized data stream (see Section 2.3).

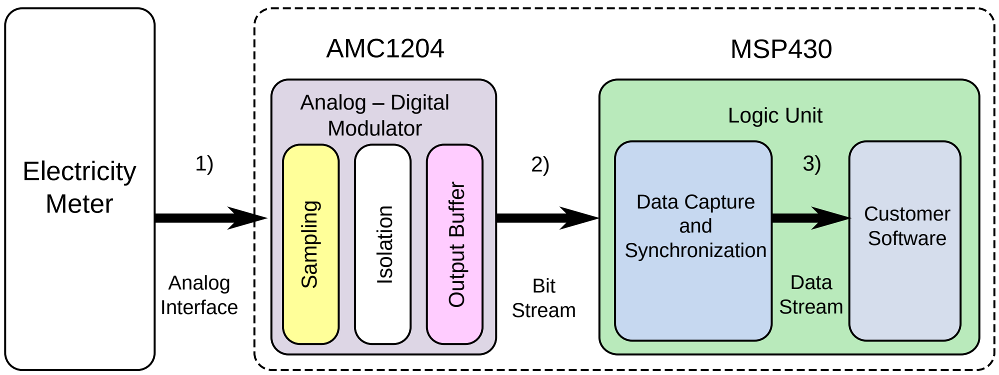

Figure 2. System Overview

2.2 Expected Signals and Streams

The relationship of the modulator output to the input difference is described in the AMC1204 device data sheet:

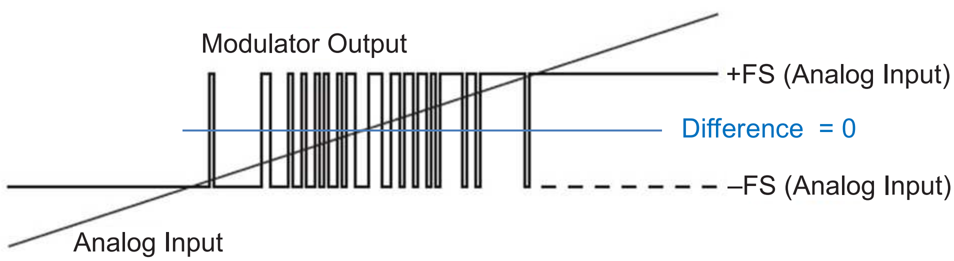

Figure 3. Analog Input versus Modulator Output [(1)]

With this information, the following bit stream is expected:

(1) Texas Instruments, data sheet AMC1204

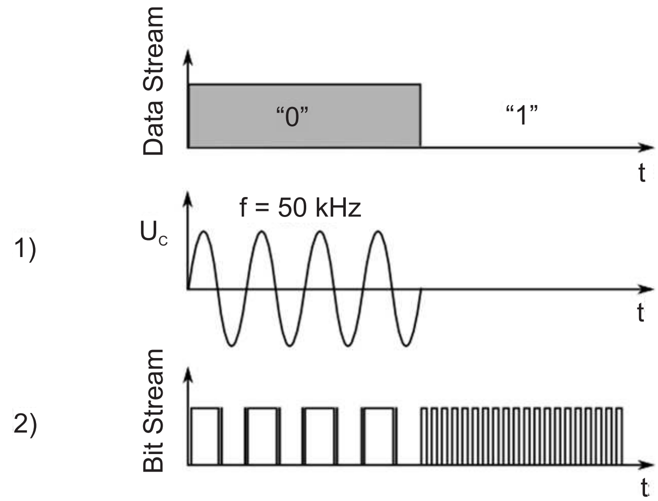

Figure 4. Expected Bit Stream from the AMC Modulator

If the amplitude of the input signal is high, the AMC input stage is saturated and the output stage generates a rectangular signal with f = 50 kHz. With an input signal difference of “0”, the output stage generates a high-frequency signal, which is expected to range in MHz (depending on the input clock of the AMC).

2.3 *Software Model: Data Sampling and Digital Data Stream*

As described in the system overview, the microcontroller MSP430 has two tasks:

1. Sampling the information of the input signal
2. Synchronization and generation of a digital data stream with a baud rate of 1200 or 9600 Bd

For these tasks, two timers are used.

Timer A – Counter Mode for Sampling Data

The clock input of the first timer is connected to the data output pin of the ΔΣ-Modulator AMC1204 device. Section 2.2) shows that a low-input difference (transmitting a “1”) at the modulator generates a high-frequency signal, which makes the timer count fast. If the input difference is high (transmitting a “0”), the output signal does not count many edges and timer A counts slowly.

Timer B – Synchronization

The second timer module is used to generate an interrupt event. The event is triggered five times within the time of a symbol. The following is an example for the higher baud rate:

- Baud rate: $\nu = 9600\ \text{Bd}$
- Time of a transmitted symbol: $T_{sym} = \frac{1}{\nu} = \frac{1}{9600\ \text{Bd}} = 104.1\overline{6}\ \mu s$
- Oversampling: $n = 5$
- Time of Timer A's counter value: $T_{ISR} = \frac{T_{sym}}{n} = \frac{104.1\overline{6}\ \mu s}{5} = 20.8\overline{3}\ \mu s$

The main clock MCLK of the microcontroller is set to f_{MCLK} = 12 MHz. The counter compare value is set to:

- Timer B's counter compare value: $n = T_{ISR} \times f_{MCLK} = 20.8\overline{3}\ \mu s \times 12\ \text{MHz} = 250$

If the difference between the counter values n(t) to the previous n(t – 1) is higher than a value THRESHOLD, the value “0” is saved in a local buffer.

Timer B – ISR for Data Processing

If the timer B event was launched five times, a simple average algorithm checks if the last five values were a “0” or “1”. The algorithm can be improved to provide a more reliable system.

3 Prototype

To build a prototype, the following EVM and launchpad from Texas Instruments were used:

- AMC1204EVM
- MSP430 Launchpad with MSP430G2553

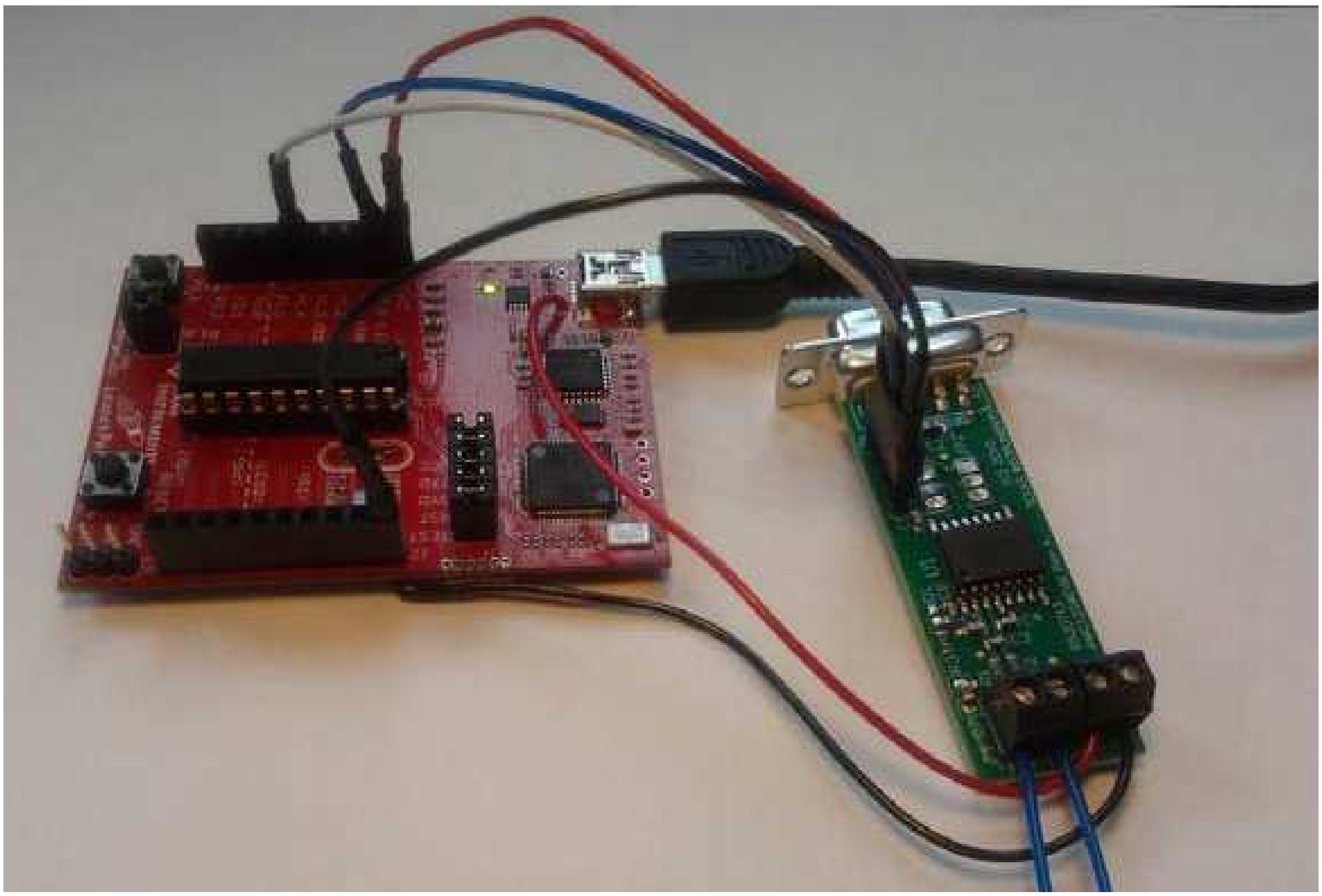

Figure 5. Prototype

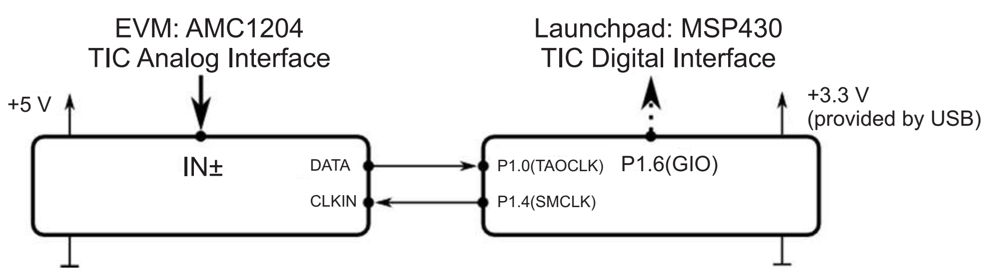

Figure 6. Prototype Design – EVM Board Connection

The software is written in Code Composer Studio™ 5.4, which can be downloaded for free.

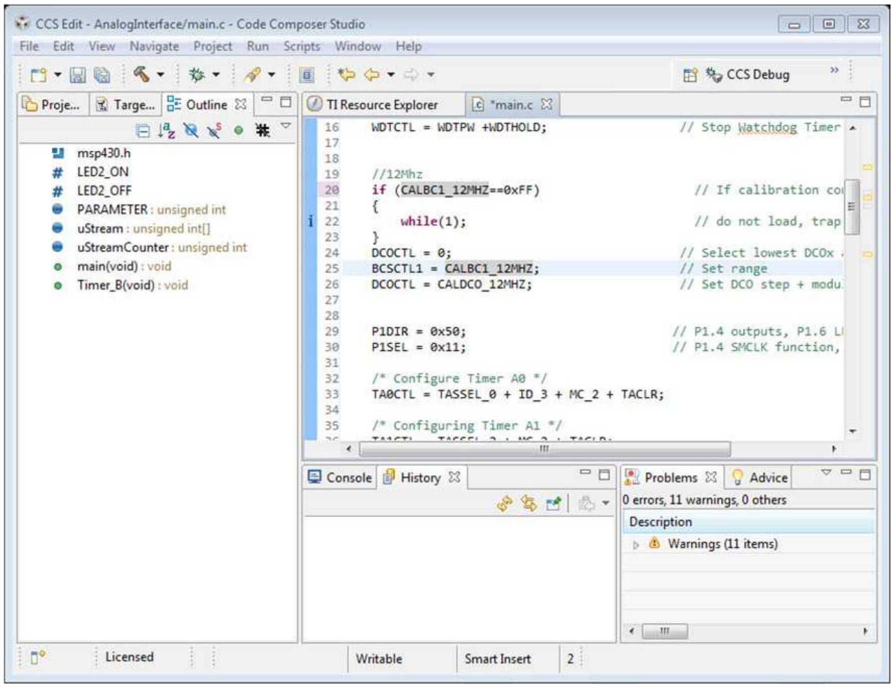

Figure 7. Code Composer Studio™ 5.4

Verifying the expected waveforms and signals:

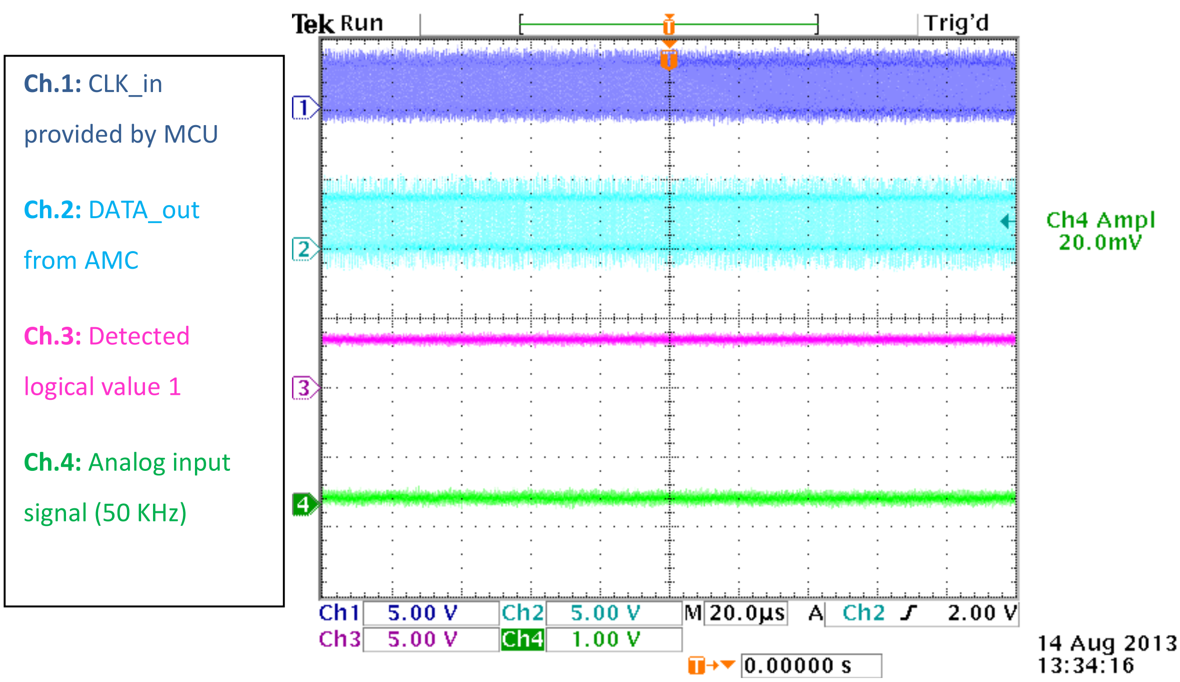

Figure 8. Transmitting a Logical "1"

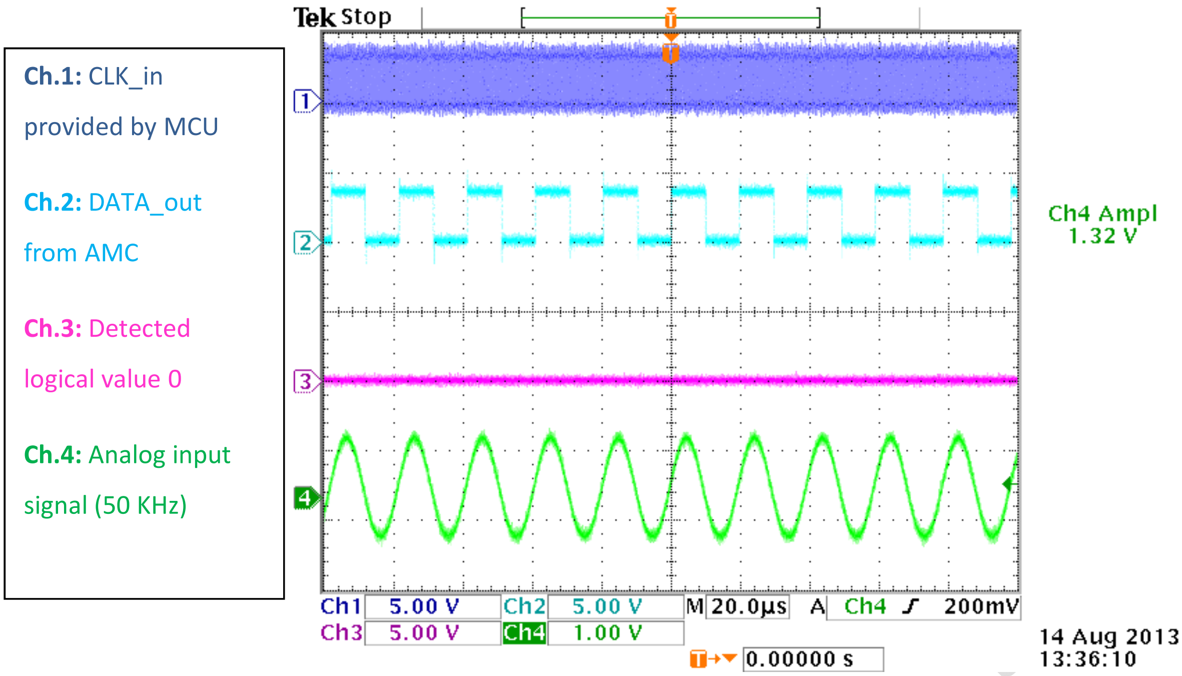

Figure 9. Transmitting a Logical "0"

4 Summary

In this application study, a frontend is considered which uses a ΔΣ-modulator AMC1204 device and a microcontroller of the MSP430 family from Texas Instruments. A short summary is shown in Figure 10:

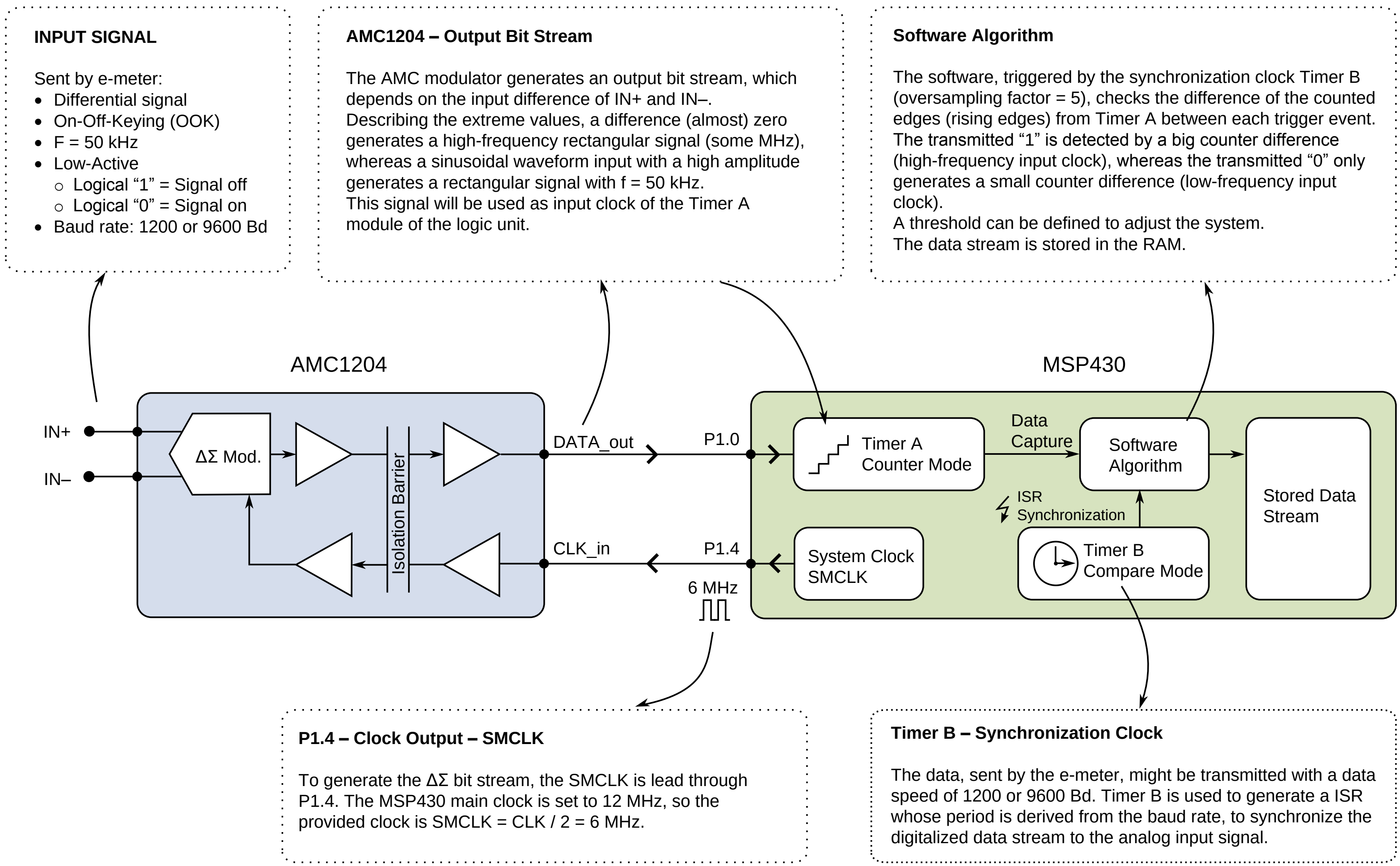

Figure 10. Concept Overview

The TIC Digital Interface was built with official TI evaluation modules: AMC1204 Evaluation Module and MSP430 LaunchPad Value Line Development Kit. The principle was tested and proved in the laboratory.

Recommended next work packages:

- **Test in a real environment:** As the TIC digital interface was only tested in the laboratory without an actual meter, TI recommends to prove this concept with an electricity meter.
- **Termination:** The principle was tested with a TTL output of the waveform generator. Optional impedance matching has to be designed.
- **Isolation:** Referring to the data sheet, the AMC1204 device allows isolation:
  - Isolation Voltage: 4250 V_{PEAK} (AMC1204B device)
  - Working Voltage: 1200 V_{PEAK}

NOTE: The isolation level must be confirmed with official regulations and specifications.

5 Test Setting and Results

To verify the concept, the system is tested with following setup:

1. **Data stream generator:** A pseudo-random data stream is used as the trigger input for the waveform generator (2) – dark blue line (indicated by "Ch 1" label in Figure 11)
2. **Waveform generator:** With the trigger input, the waveform generator generates the OOK-signal (see Section 1). The analog signal is used as the input signal for the frontend – turquoise line (indicated by "Ch 2" label in Figure 11)
3. **TI analog front end:** connections → see Figure 10; internal delta-sigma stream – pink line (indicated by "Ch 3" label in Figure 11) between AMC EVM and MSP430 Launchpad
4. **Oscilloscope:** The oscilloscope measures the following signals:
   Ch.1: Generated bit stream – dark blue line
   Ch.2: OOK- Signal waveform generator – turquoise line
   Ch.3: Delta-sigma stream – pink line
   Ch.4: Output data – green testpoint

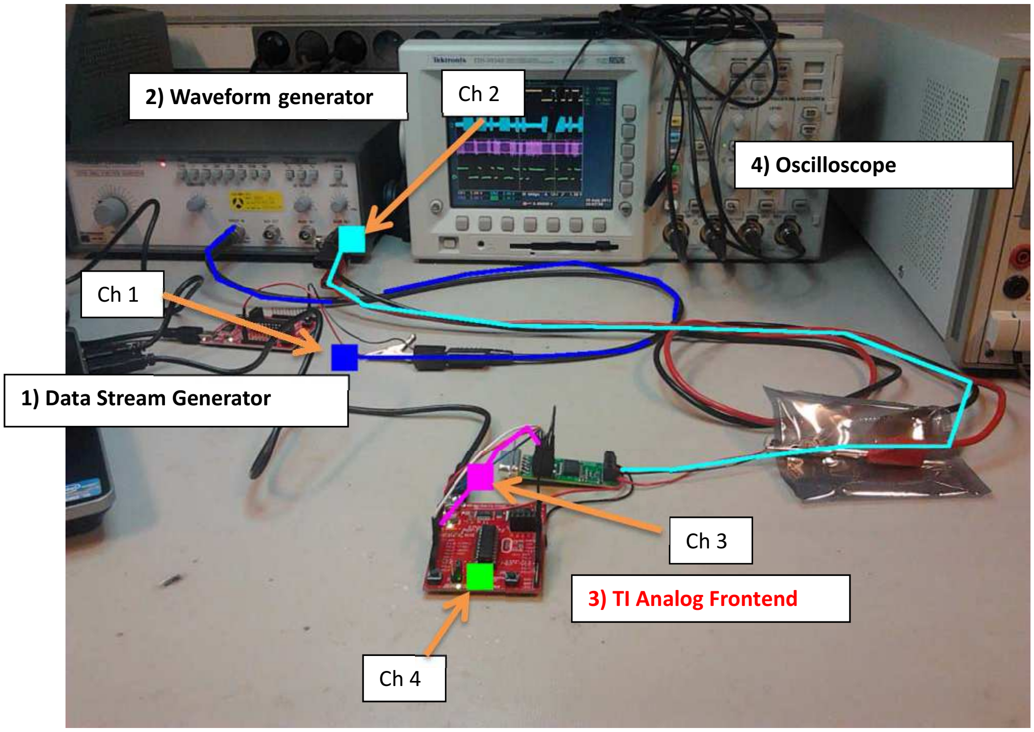

Figure 11. Test Setup

Figure 12 shows the test results:

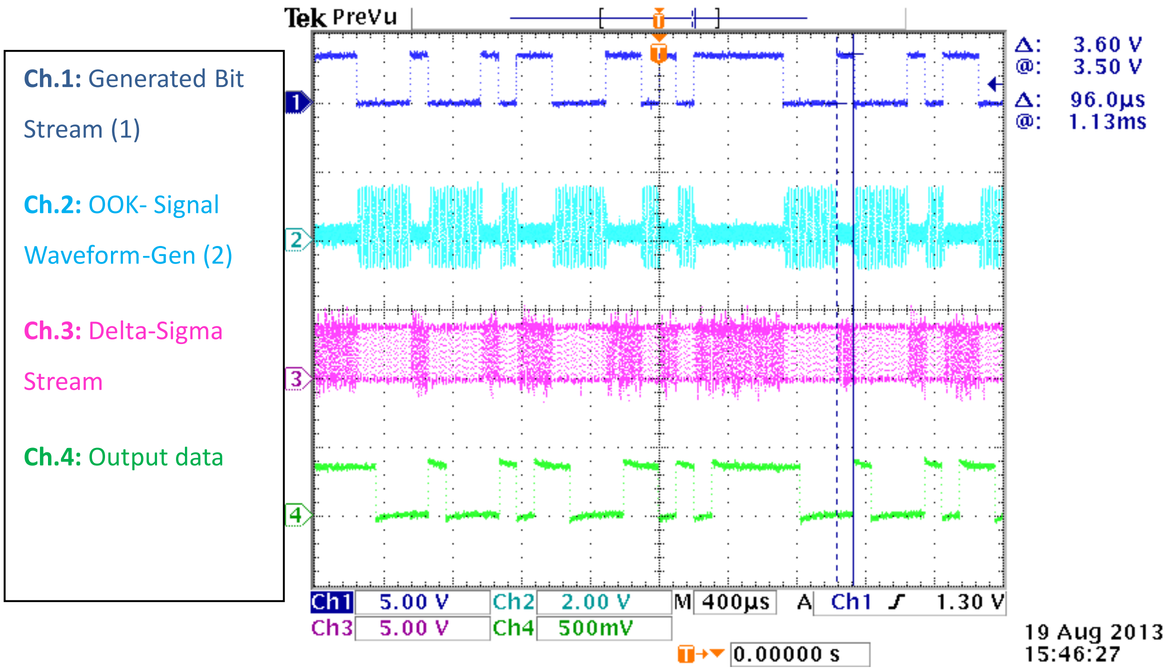

Figure 12. Test Results

The oscilloscope shows that the input data are correctly digitalized from the analog OOK signal. Due to data processing, a latency of ≈100 µs is measured.

Appendix A References With Links

- Texas Instruments, AMC1204 data sheet
- Texas Instruments, AMC1204 Evaluation Module
- Texas Instruments, MSP430 LaunchPad Value Line development kit
- Texas Instruments, MSP430G2553
- Texas Instruments, Code Composer Studio 5.4
- EDF, "Sorties de télé-information client des appareils de comptage électroniques utilisés par ERDF"

Revision History

Changes from Original (November 2013) to A Revision **Page**

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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