Připojování termočlánku k MCU

Demonstrační cvičení IMP

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Termočlánek?

- Jeden z nejuniverzálnějších snímačů teploty.
- Široký rozsah, odolný a spolehlivý, levný.
- Výstupem je napětí úměrné teplotě. Téměř lineární, ale malé!
- Pro dobrou přesnost se musí kompenzovat tzv. srovnávací spoj („studený konec“).

Figure 2. K-type Thermocouple with Cold Junction at 0 °C

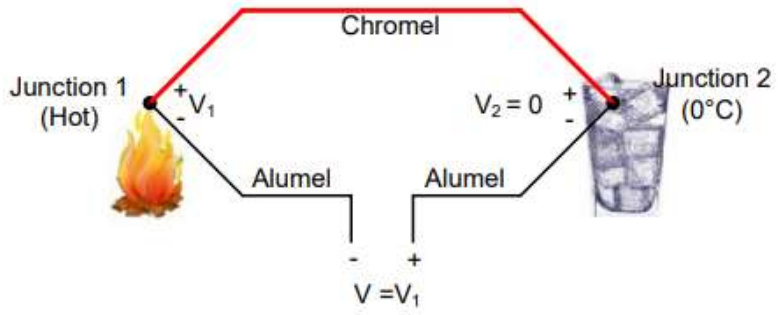
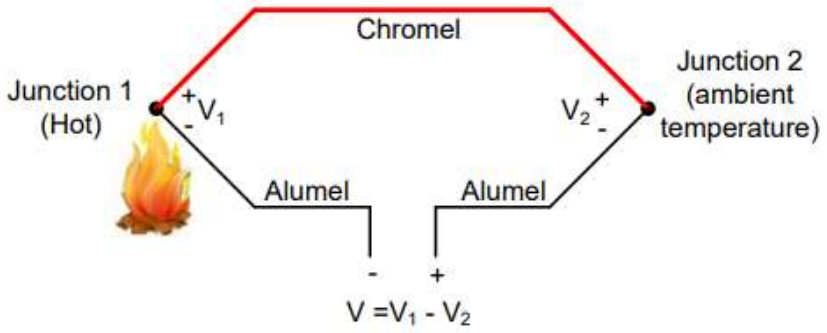


Figure 4. Cold Junction not at 0 °C



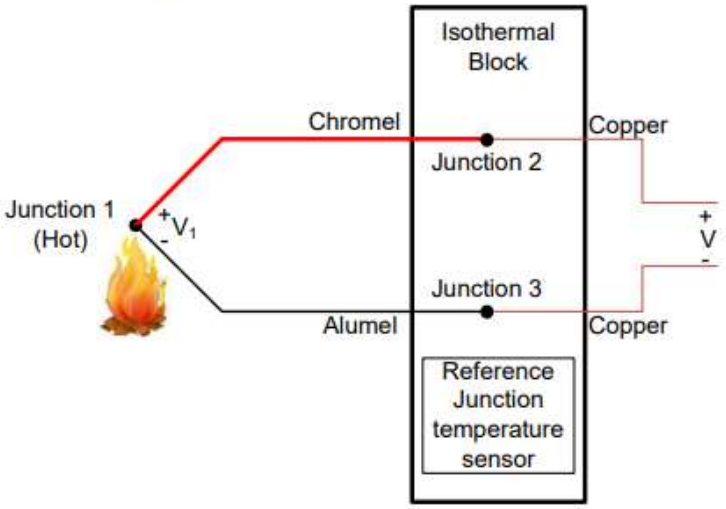
Srovnání snímačů teploty

Table 1. Comparison of Temperature Sensors

Parameter	RTD	Thermocouple	Thermistor	Diode
Temperature range (0 °C)	–200 to +850	–250 to +2350	–100 to +300	–50 to +150
Sensitivity at 25 °C	0.387 Ω/°C	40 µV/°C (K-type)	416 Ω/°C	250 µV/°C
Accuracy	High	Medium to High	Medium	Low
Linearity	Good	Fair	Poor	Good
Typical cost (US $)	$3–$80	$3–$15	$0.2–$10	<$0.2
Typical distance of sensing	Surface mount for on-board temperature 3- and 4-wire up to a few hundred meters	<100 meters	Surface mount for on-board temperature Leaded for <1 meter	On-board temperature
Resource requirement	Excitation current, amplifier, ADC, reference resistor	Amplifier, ADC, voltage reference, and another temperature sensor for cold junction	Excitation current, ADC, reference resistor	Excitation current, amplifier, ADC
Response time	Slow	Fast	Fast	Slow
Computational complexity (best possible accuracy)	High	Very high	Very high	Medium

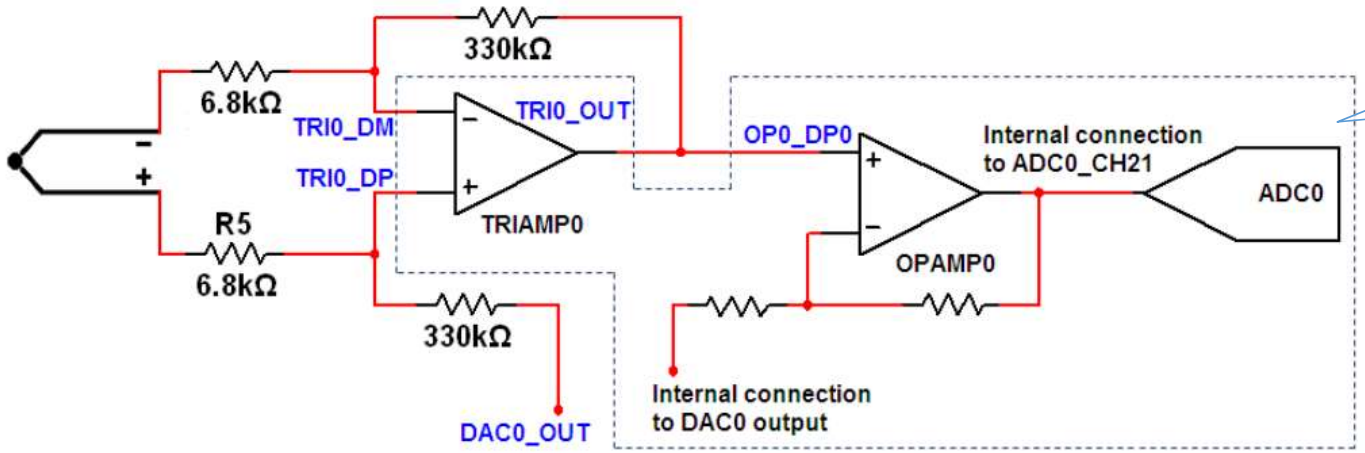
Praktické měření s termočlánkem

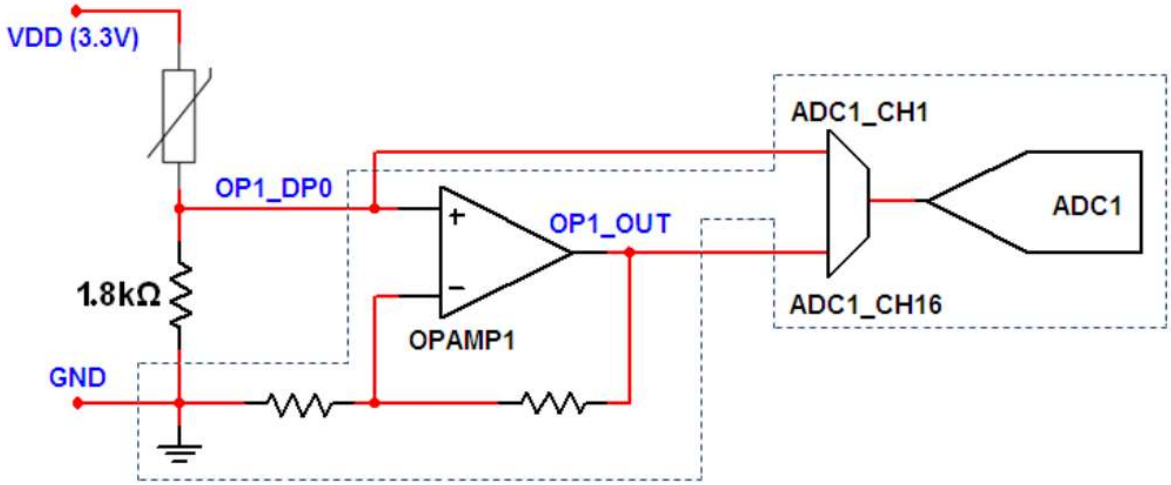
Figure 6. Practical Thermocouple




```
void main()
{
    int32 coldJnTemp, tcColdJnuVolt, tcHotJnuVolt, tcuVolt, tcTemp ;
    /* Measure cold junction temperature.

    coldJnTemp = MeasureColdJnSensorTemp();

    /* ColdJunctionTempTomVolt() API is used to convert temp to microvolts */
    tcColdJnuVolt = Thermocouple _1_GetVoltage (coldJnTemp);

    /* MeasureHotJnTemp () API finds the hot junction voltage in millivolts */
    tcHotJnuVolt = MeasureHotJnVoltage();

    /* Add cold junction compensation voltage to hot junction voltage */
    tcuVolt = tcColdJnuVolt + tcHotJnuVolt;

    /* mVoltToTemp() API is used for converting thermo emf to temperature */
    tcTemp = Thermocouple_1_GetTemperature (tcuVolt);
}
```

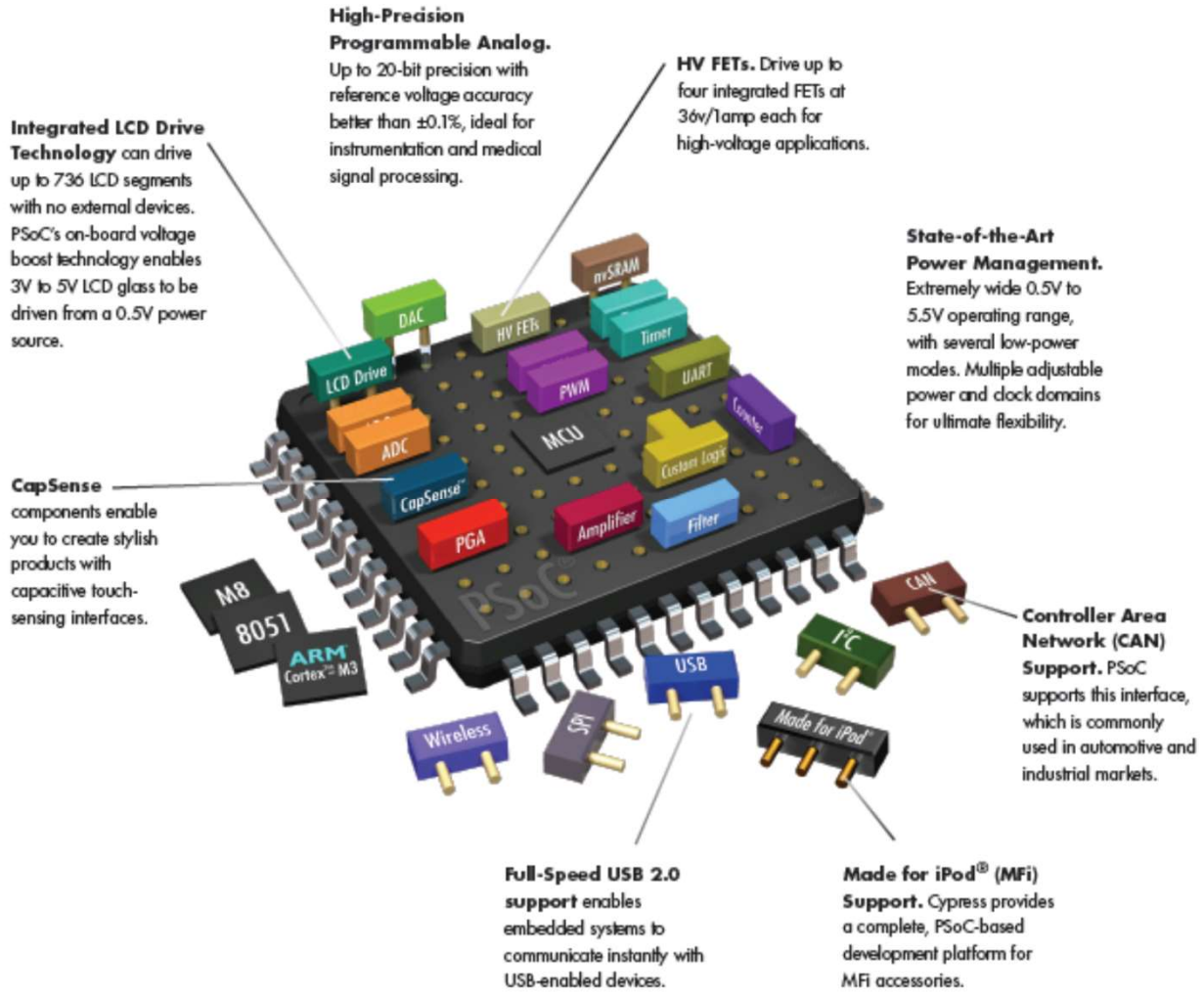
Jak to zapojit? Příklad s Kinetis K53



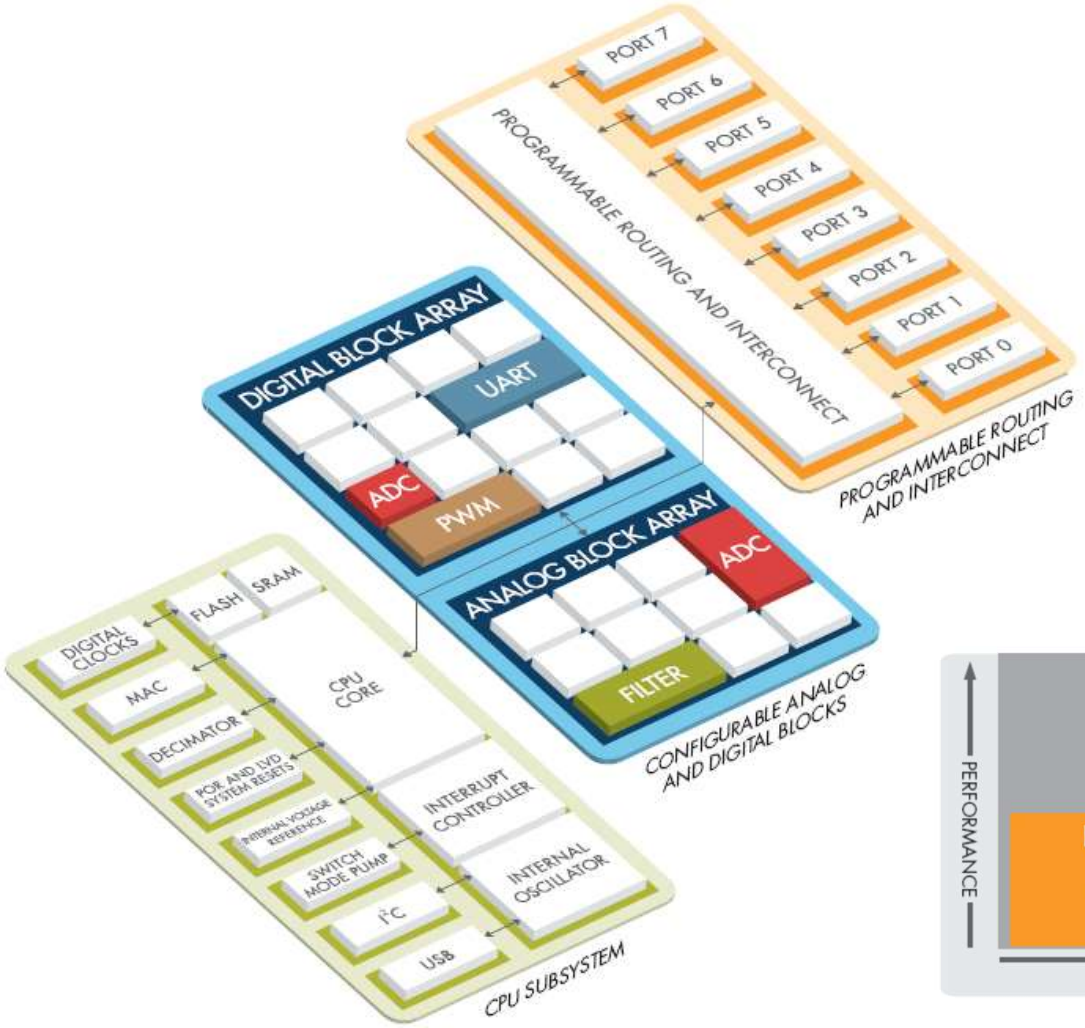


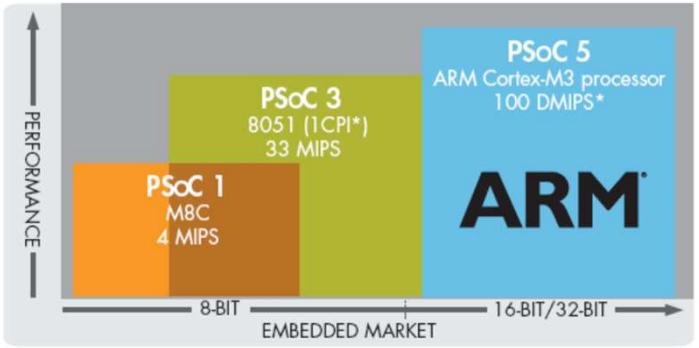
Prvky uvnitř čárkovaně ohraničené oblasti jsou uvnitř MCU

Cypress PSoC

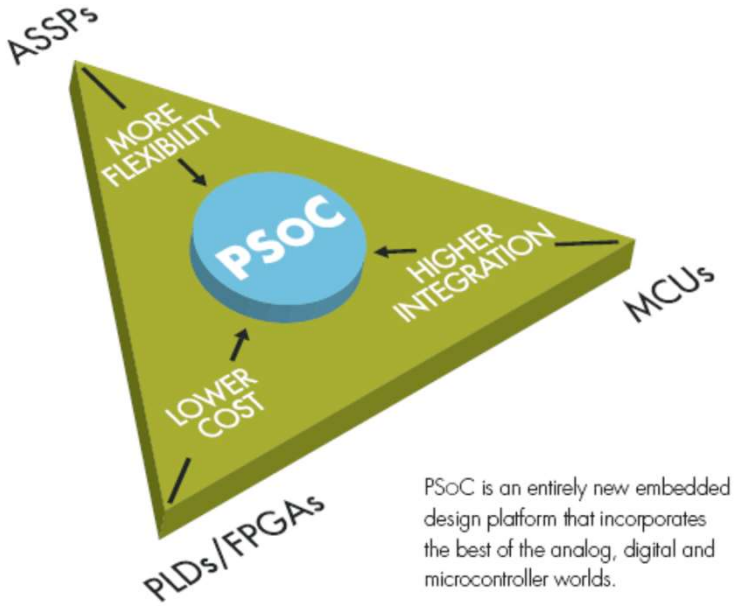


Cypress PSoC





Cypress PSoC

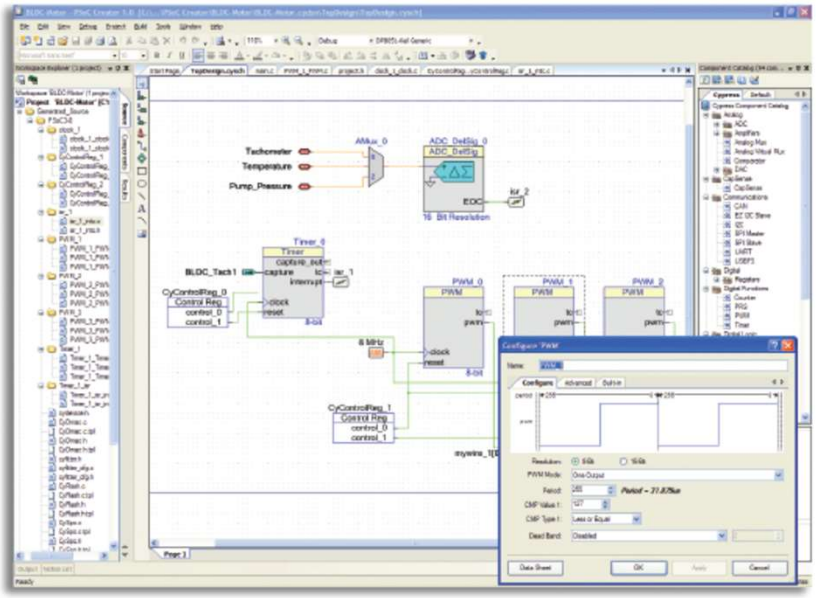


PSoC is an entirely new embedded design platform that incorporates the best of the analog, digital and microcontroller worlds.

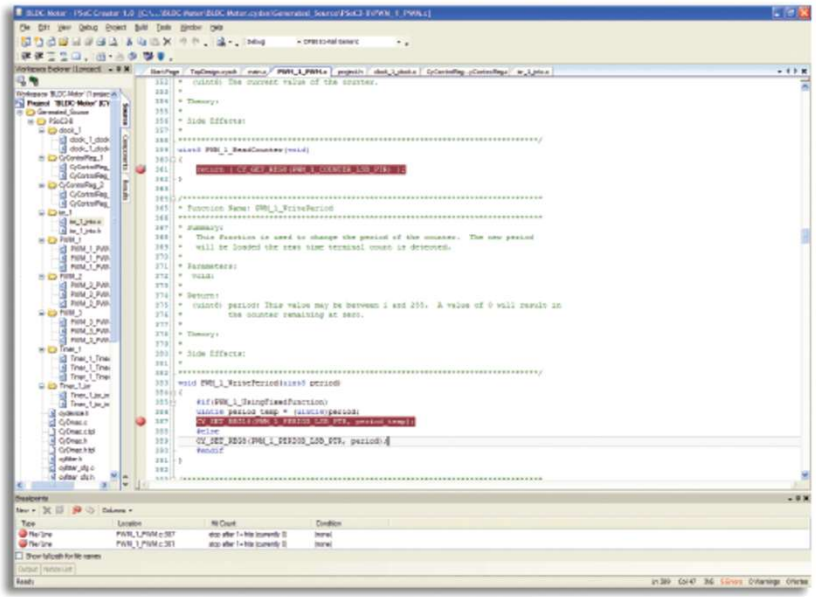
Cypress PSoC

PSoC CREATOR™ – SOFTWARE FOR PSoC 3 AND PSoC 5

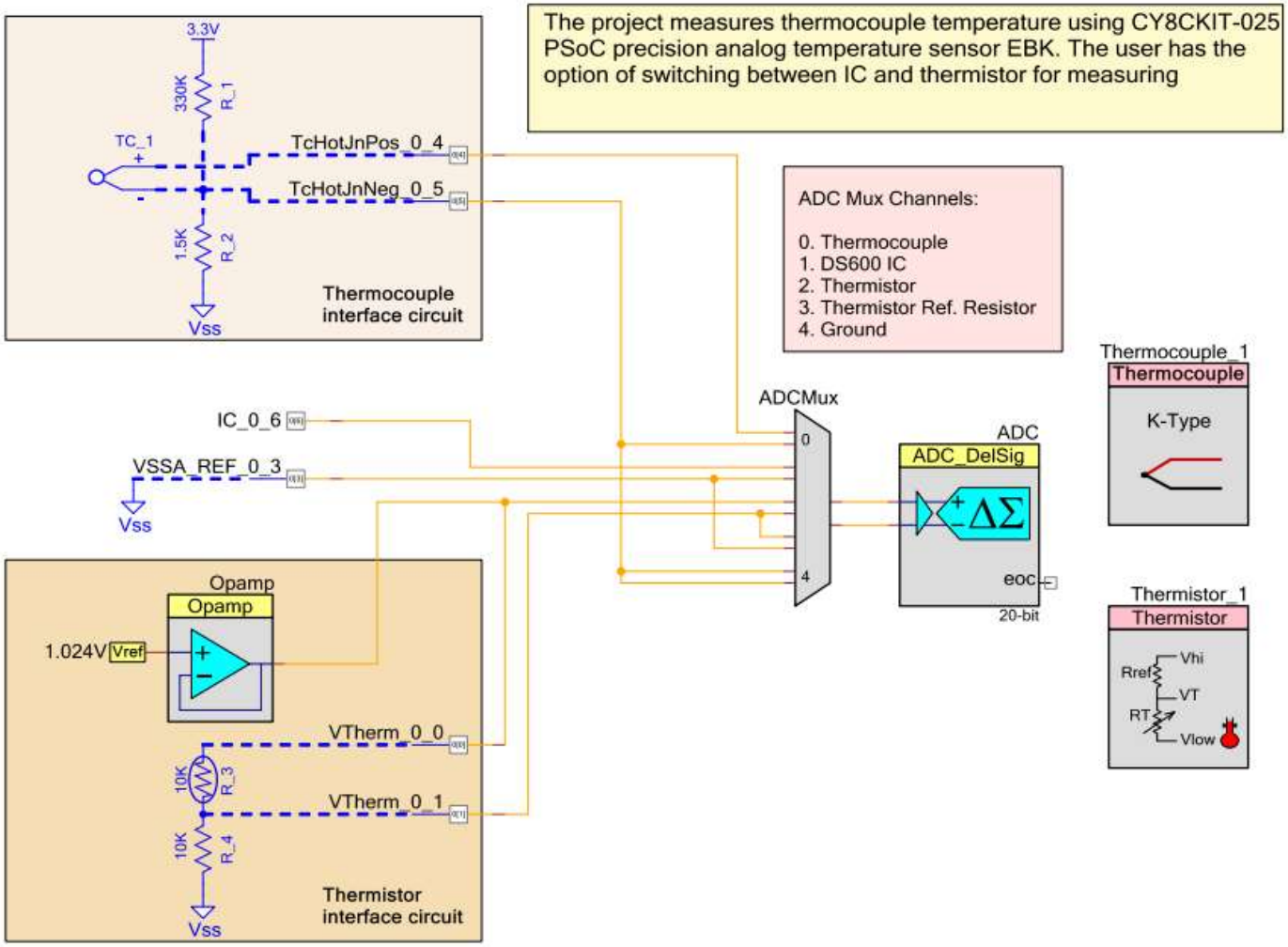
FOR HARDWARE ENGINEERS



FOR SOFTWARE ENGINEERS

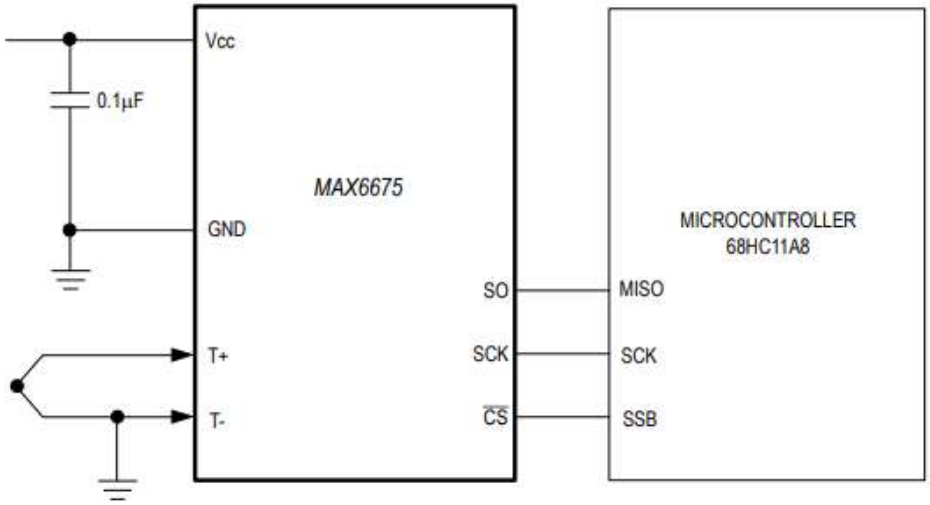


Jak to zapojit? Příklad s Cypress PSOC



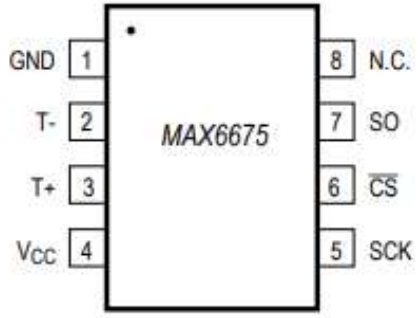
Jak to zapojit? Příklad s externím „interface“

MAX6675 **Cold-Junction-Compensated K-Thermocouple-to-Digital Converter (0°C to +1024°C)**



Features

- Direct Digital Conversion of Type -K Thermocouple Output
- Cold-Junction Compensation
- Simple SPI-Compatible Serial Interface
- 12-Bit, 0.25°C Resolution
- Open Thermocouple Detection



Komunikace s MAX 6675

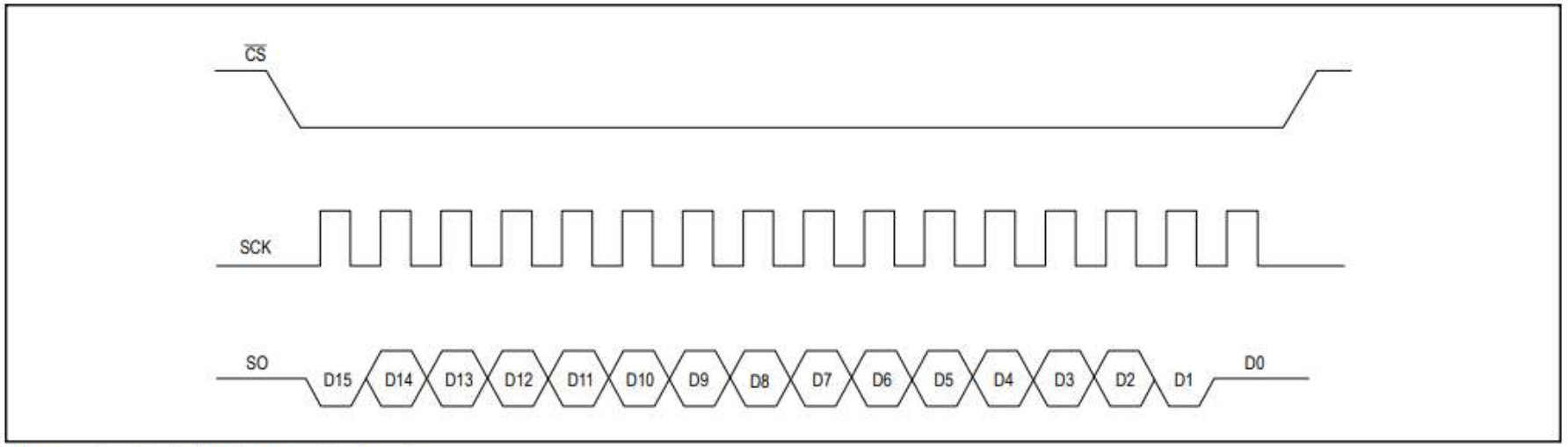
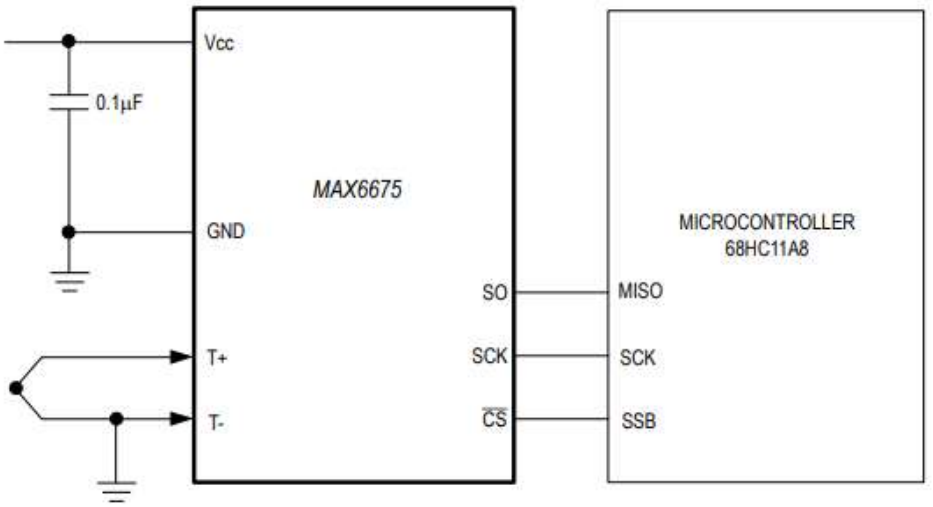


Figure 1a. Serial Interface Protocol

Kód pro komunikaci přes SPI

```
GPIO_ClearPinsOutput(GPIOC, 1<<4);  // Chip Select

while( !(SPI0->S & SPI_S_SPTEF_MASK) );
 SPI0->DH = 0x0; /* vyslat prazdna data */
 SPI0->DL = 0xCC; /* vyslat prazdna data */
while( !(SPI0->S & SPI_S_SPRF_MASK));
temp = ((SPI0->DH << 24) | (SPI0->DL << 16));

while( !(SPI0->S & SPI_S_SPTEF_MASK) );
 SPI0->DH = 0x0; /* vyslat prazdna data */
 SPI0->DL = 0xCC; /* vyslat prazdna data */
while( !(SPI0->S & SPI_S_SPRF_MASK));
temp |= ((SPI0->DH <<8) | SPI0->DL);

GPIO_SetPinsOutput(GPIOC, 1<<4);  // konec Chip Select
```



Snímek skutečné komunikace SPI s MAX6675