MSPM0 amplifier module introduction
—— MSPM0 peripheral training series

Presented by Eason Zhou
### MCU level overview

**MSPM0Lxx series**

#### MSPM0L13x3/4/5/6

**CPU**
- ARM Cortex-M0+
- 32 MHz
- NVIC / 3-ch DMA

**On-chip Memory**
- 8, 16, 32 or 64 kB flash
- 2 or 4 kB SRAM

**Data Integrity & Security**
- CRC accelerator (16 and 32 bit)

**Programming & Debug**
- ARM SWID interface
- ROM UART & I2C BSL
- Leaded packages: SOT-16, VSOP-20/28
- No-lead packages: WQFN-16, VQFN-24/32

**Power & Clocking**
- POR / BOR / SVS
- Internal LF 32kHz (5%)
- Internal HF 4-32MHz (1%)

**Communication**
- UART w/ LIN (1)
- UART (1)
- SPI (1)
- I2C (2) w/ FastMode+

**IO**
- Up to 28 GPIO
- Up to 2 low Ib OPA inputs

**Precision Analog**
- 12-bit SAR ADC 1Mps (1)
- ULP/HS Comparator (1)
- 8-bit reference DAC (1)
- Zero-drift chopper op-amps (2)
- General purpose amp (1)
- General purpose ADC reference (2.5%) 16
- Temperature sensor
- General purpose 16-bit 2 CC (4)
- Windowed watchdog

**Amplifiers**
- Zero-drift chopper op-amps (OPA)
- General purpose amp (GPAMP)

32 MHz MCU with up to 64kB flash, 32 pins, 12-bit ADC, dual zero-drift OPA/PGA, COMP
MSPM0 OPA overview

Key Features

High flexibility:
- Configurable amplifier modes
- Rich selection of external/internal input options
- Output to ADC, OPA and comparator
- Programmable gain amplifier (PGA) up to 32x
- Burnout current source to detect sensor status

High performance:
- Chopper stabilization to reduce offset, drift, and 1/f noise, 0.1 mV Vos, 1-µV/°C Vos drift with chopping
- Rail-to-rail input & output
- 6MHz GBW
- Lower to 100µA quiescent current

Some Use Cases

- Use internal OPAs to replace external OPAs
- Switch between IOs to use one OPA to realize two OPA functions
- Dynamic change OPA settings to calibrate voltage offset and internal Gain with ADC and DAC

Differences between G and L MCUs

- MSPM0L134x has dedicated IN- pin to reach 10pA bias current for TIA(Transimpedance amplifier) application
## OPA key parameters summary

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value without chopper</th>
<th>Value without chopper</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail-to-rail</td>
<td>60 ~ VDD-60</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>GBW (typ)</td>
<td>6</td>
<td>~0.125/Gain</td>
<td>MHz</td>
</tr>
<tr>
<td>Slew rate (typ)</td>
<td>4</td>
<td></td>
<td>V/µs</td>
</tr>
<tr>
<td>Vos (25°C max)</td>
<td>±2</td>
<td>±0.3</td>
<td>mV</td>
</tr>
<tr>
<td>Offset drift (typ)</td>
<td>±5.2</td>
<td>±0.5</td>
<td>µV/°C</td>
</tr>
<tr>
<td>Vn at 1 kHz (typ)</td>
<td>240</td>
<td>NA</td>
<td>nV√Hz</td>
</tr>
<tr>
<td>Input bias current (25°C typ)</td>
<td>150 (Shared OPA pin)</td>
<td>1000 (Shared OPA pin)</td>
<td>pA</td>
</tr>
<tr>
<td></td>
<td>10 (Dedicated OPA pin)</td>
<td>800 (Dedicated OPA pin)</td>
<td></td>
</tr>
<tr>
<td>CMRR (typ)</td>
<td>89</td>
<td>95</td>
<td>dB</td>
</tr>
<tr>
<td>Iout (typ)</td>
<td>1</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Iq per channel (typ)</td>
<td>0.1</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Internal Gain</td>
<td>0~32</td>
<td></td>
<td>V/V</td>
</tr>
</tbody>
</table>
OPA flexibility

General-Purpose Mode:

Non-inverting PGA Mode:

Buffer Mode:

Inverting PGA Mode:
OPA flexibility

Cascade Amplifier Mode:

Differential Amplifier Mode:
MSPM0 GPAMP overview

Key Features

Flexibility:
- Output to ADC and OPA
- Programmable internal unity gain feedback loop

Performance:
- Chopper stabilization to reduce offset, drift, and 1/f noise
- Rail-to-rail input & output
- 350KHz GBW

Some Use Cases
- General purpose amplifier
- Signal buffer

OPA vs GPAMP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OPA</th>
<th>GPAMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>Input MUX: External/ADC/DAC/REF/OPA/GPAMP</td>
<td>External/OPA/GPAMP</td>
</tr>
<tr>
<td></td>
<td>PGA: 1~32</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>burnout current source</td>
<td>Support</td>
</tr>
<tr>
<td>Performance</td>
<td>GBW: 6MHz</td>
<td>350KHz</td>
</tr>
<tr>
<td></td>
<td>Quiescent current: 100uA</td>
<td>100uA</td>
</tr>
<tr>
<td></td>
<td>Vos with chopper: &lt;0.3mV</td>
<td>&lt;0.39mV</td>
</tr>
<tr>
<td></td>
<td>Ios no chopper: 150pA</td>
<td>16pA</td>
</tr>
</tbody>
</table>
OPA module quick start

Academy
OPA introduction lab

Driverlib Examples
MSPM0G350x:
- opa_dac@output_buffer
- opa_general-purpose_rri
- opa_inverting_pga_with_dac
- opa_non_inverting_pga
- opa_signal_chain_to_adc

MSPM0L13xx:
- opa_dac@output_buffer
- opa_general-purpose_rri
- opa_non_inverting_pga

Related Links
MSPM0 online resource
MSPM0 quick start guide
MSPM0 Sysconfig user's guide
MSPM0G350x datasheet
MSPM0L13xx datasheet
MSPM0Gxx technical reference manual
MSPM0Lxx technical reference manual

Launchpad
LP-MSPM0G3507
LP-MSPM0L1306

Sysconfig Entrance for OPA Setting

Step 1:
- Name: OPA_0
- Selected Peripheral: OPA0

Quick Profiles
- OPA Pre-Set Configuration
  - Non-Inverting Channel (PSEL): Open
  - Inverting Channel (NSEL): Open
  - Input MUX (MSEL): Open
  - Gain: Non-Inverting: 1x / Inverting: Invalid

Step 2:
- ADD
- REMOVE ALL
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- Ti.com.cn
- WeChat (德州仪器公众号)
- Bilibili
- 21IC