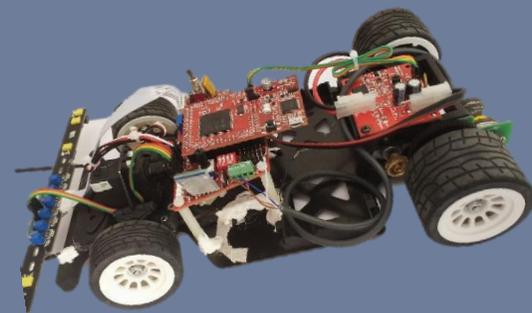


# 第十五届全国大学生智能汽车竞赛

The National University Students Intelligent Car Race

## 智能小车用英飞凌单片机TC264 线上培训

立足培养 · 重在参与 · 鼓励探索 · 追求卓越



英飞凌



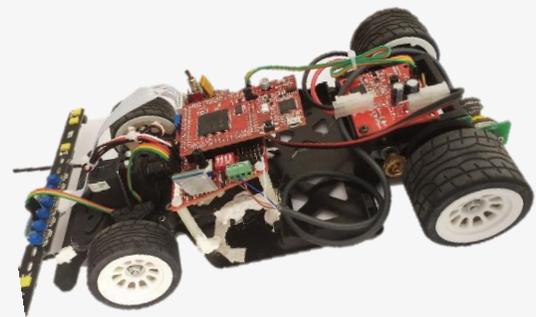
英飞凌汽车电子生态圈



乾勤科技

# TC264开发板原理设计介绍

- 智能小车用英飞凌单片机TC264 线上培训



北京乾勤科技发展有限公司

Wxj 2020-4



英飞凌



英飞凌汽车电子生态圈

QianQin

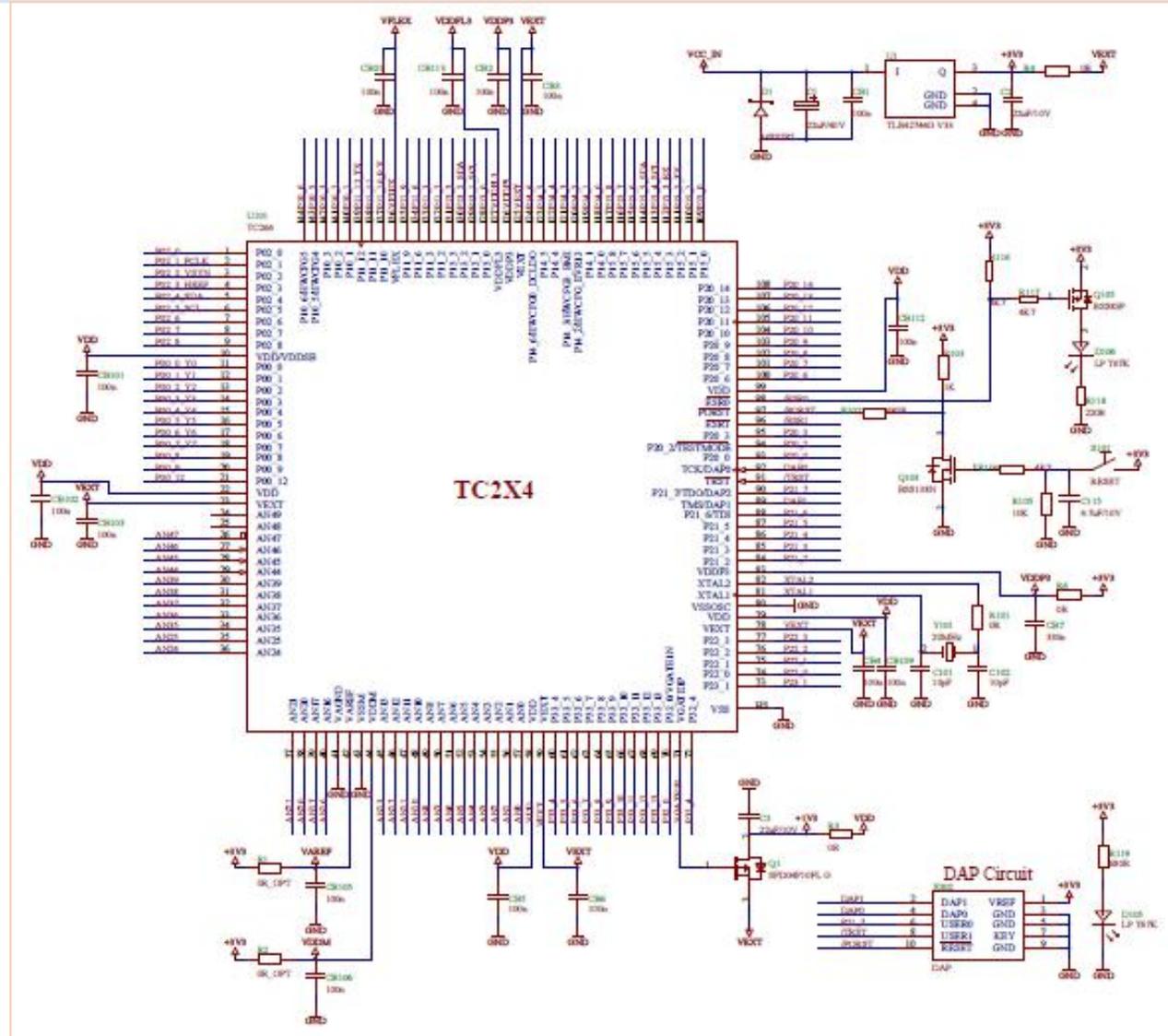
乾勤科技

- TC264 核心板 MCU最小系统
- TC264 PCB设计注意事项
- 电路板焊接调试注意事项



# 单片机最小系统

- MCU-TC264
- MCU供电电路
- MCU复位电路
- MCU时钟电路
- MCU仿真下载电路
- MCU故障指示电路



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# MCU\_电源电路

## Port/Pad domain (VEXT)

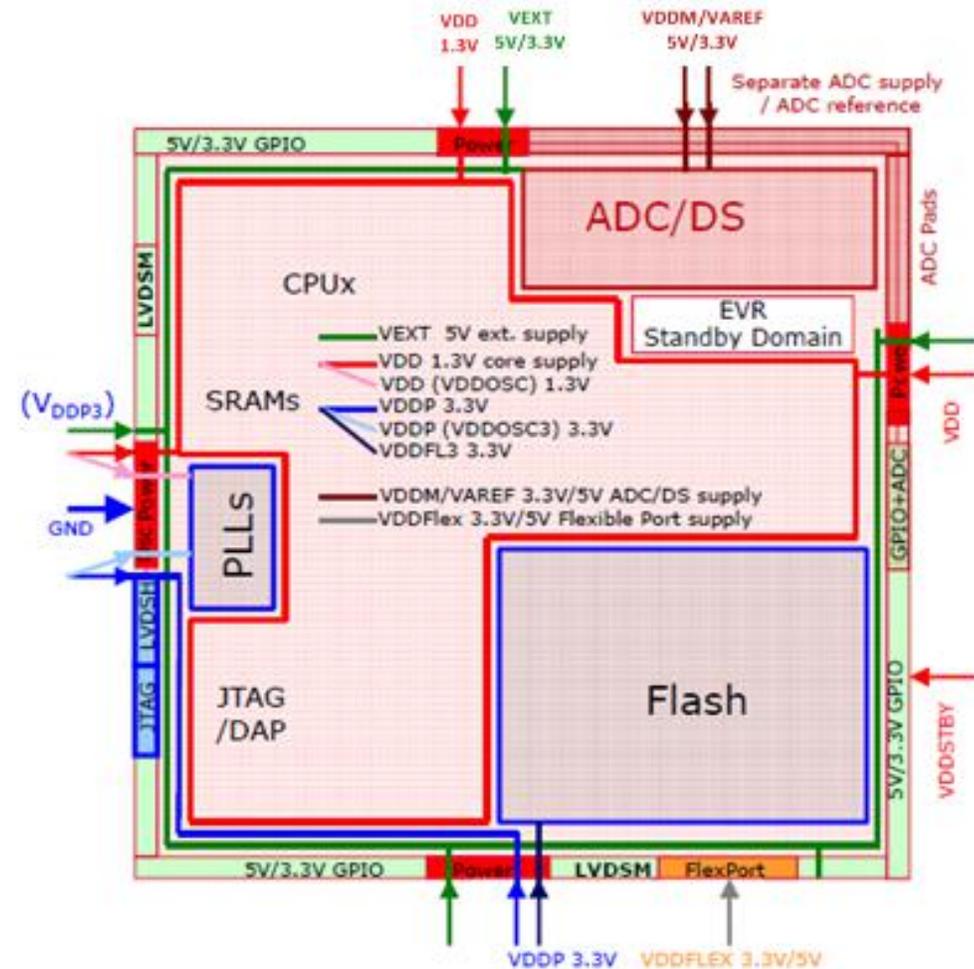
- 3.0V - 5.5V LP/MP/LVDSM
- GPIO overlaid with ADC

## Core domain (VDD)

- $1.3V \pm 10\%$
- VSS : Exposed Die-pad

## Flash, Osc., JTAG, LVDSH

- $3.3V \pm 10\%$
- VSSOSC : Separate Osc GND



# MCU\_电源电路

## ADC domain (VDDM/VAREF)

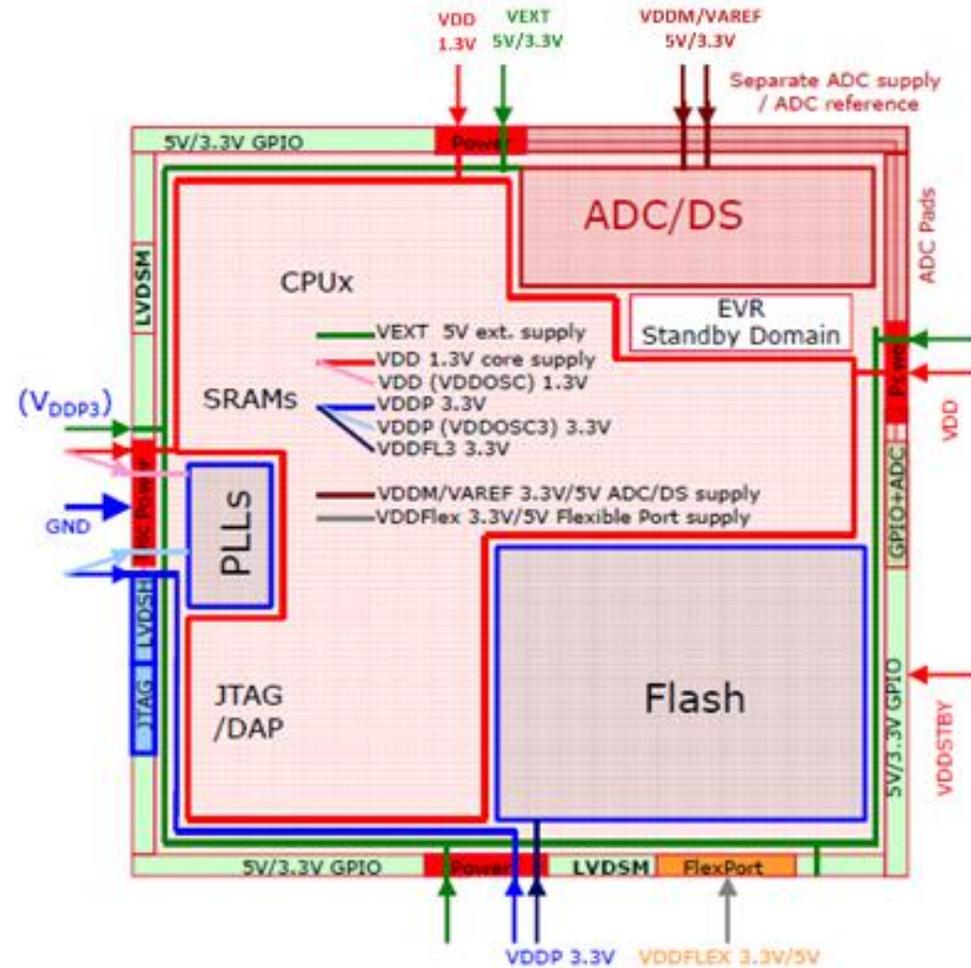
- 5.0V  $\pm$  10 % or
- 3.3V  $\pm$  10 %
- VSSM/VAGND : ADC GND

## Flexpad domain (VFLEX)

- 3.0V - 5.5V LP/MP

## Standby domain (VEXT)

- 3.0V - 5.5V





# MCU电源模式选择

## 5 V单电源供电

- 3.3V内部输出
- 1.3V内部输出

## EVR LDO拓扑结构

| No. | HWCFG [0:2] <sup>1)</sup> | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup> | Supply Pin Voltage Level / Source  | Selected Supply Scheme   |
|-----|---------------------------|--|--|--|
| b.) | 111 <sub>B</sub>          | VGATE1P shall be connected to ground.          | $V_{EXT} = 5.0\text{ V}$<br>$V_{DDM}/V_{AREF_x} = 5\text{ V} / 3.3\text{ V}$<br>$V_{FLEX} = 5\text{ V} / 3.3\text{ V}$<br>$V_{DDP3}/V_{DDFL3} = \text{EVR33}$<br>$V_{DD} = \text{EVR13}$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0\text{ V}$ | 5 V single source supply, EVR13 in LDO mode with internal pass devices, EVR33 in LDO mode. 5 V or 3.3 V ADC domain. 5 V or 3.3 V Flexport domain. Standby Mode supported |

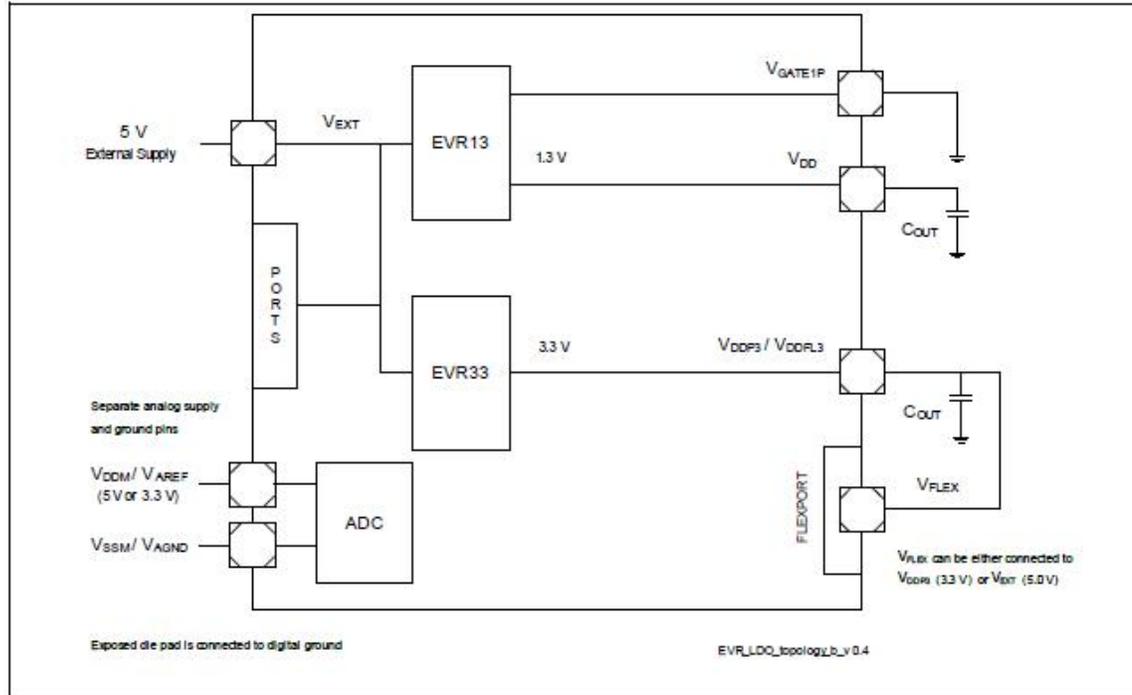


Figure 7-24 EVR LDO topology (b) - 5 V single supply with int. pass device



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# MCU电源模式选择

## □ 5 V单电源供电

- 3.3V内部输出
- 1.3V内部输出

## □ EVR LDO拓扑结构

| No. | HWCFG [0:2] <sup>1)</sup> | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup> | Supply Pin Voltage Level / Source   | Selected Supply Scheme   |
|-----|---------------------------|--|---|--|
| c.) | 111 <sub>B</sub>          | VGATE1P shall be connected to P-ch. MOSFET.    | $V_{EXT} = 5.0\text{ V}$<br>$V_{DDM}/V_{AREFX} = 5\text{ V} / 3.3\text{ V}$<br>$V_{FLEX} = 5\text{ V} / 3.3\text{ V}$<br>$V_{DDP3}/V_{DDFL3} = \text{EVR33}$<br>$V_{DD} = \text{EVR13}$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0\text{ V}$ | 5 V single source supply, EVR13 in LDO mode with external pass device, EVR33 in LDO mode. 5 V or 3.3 V ADC domain. 5 V or 3.3 V Flexport domain. Standby Mode supported. |

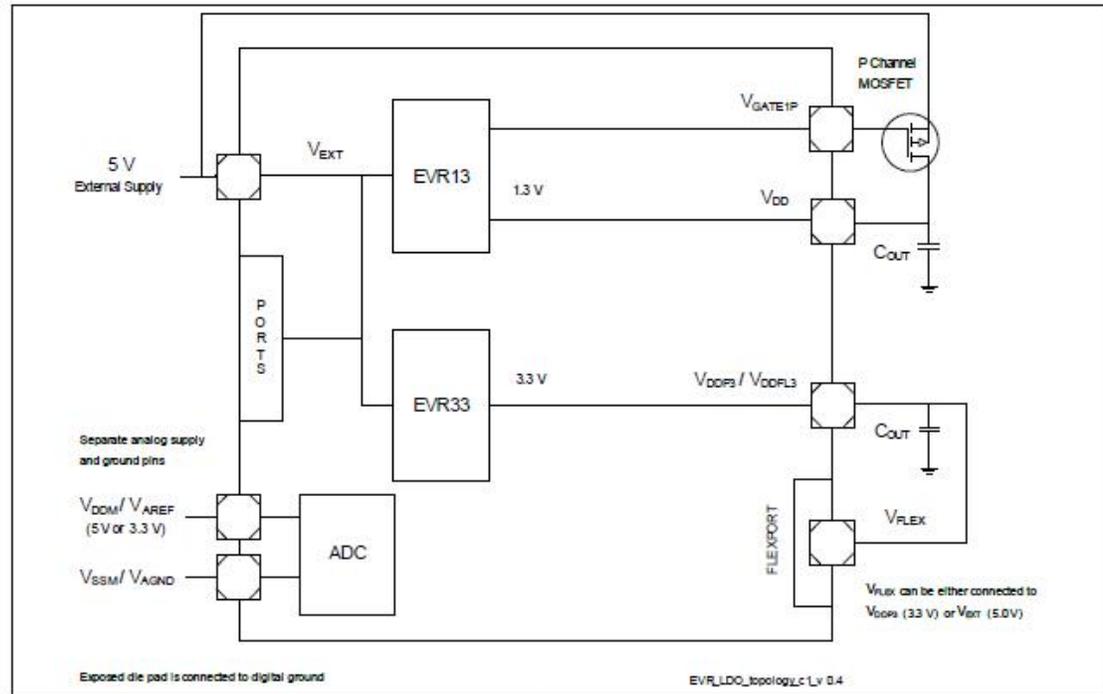


Figure 7-23 EVR LDO topology (c) - 5 V single supply with ext. pass device



英飞凌汽车电子生态圈

# MCU电源模式选择

## 外部供电模式

- 5V外部供电
- 1.3V外部供电
- 3.3V内部输出

| No. | HWCFG [0:2] <sup>1)</sup> | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup>  | Supply Pin Voltage Level / Source  | Selected Supply Scheme  |
|-----|---------------------------|---|--|---|
| d.) | X10 <sub>B</sub>          | VGATE1P has int. pull-up active when left open. | $V_{EXT} = 5.0\text{ V}$<br>$V_{DDM}/V_{AREFX} = 5\text{ V} / 3.3\text{ V}$<br>$V_{FLEX} = 5\text{ V} / 3.3\text{ V}$<br>$V_{DDP3}/V_{DDFL3} = \text{EVR33}$<br>$V_{DD} = 1.3\text{ V external}$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0\text{ V}$ | 5 V & 1.3 V external supply, EVR13 inactive, EVR33 in LDO mode.<br>5 V or 3.3 V ADC domain.<br>5 V or 3.3 V Flexport domain.<br>Standby Mode is supported and 1.3V supply shall be switched off by external regulator after Standby state is entered. |

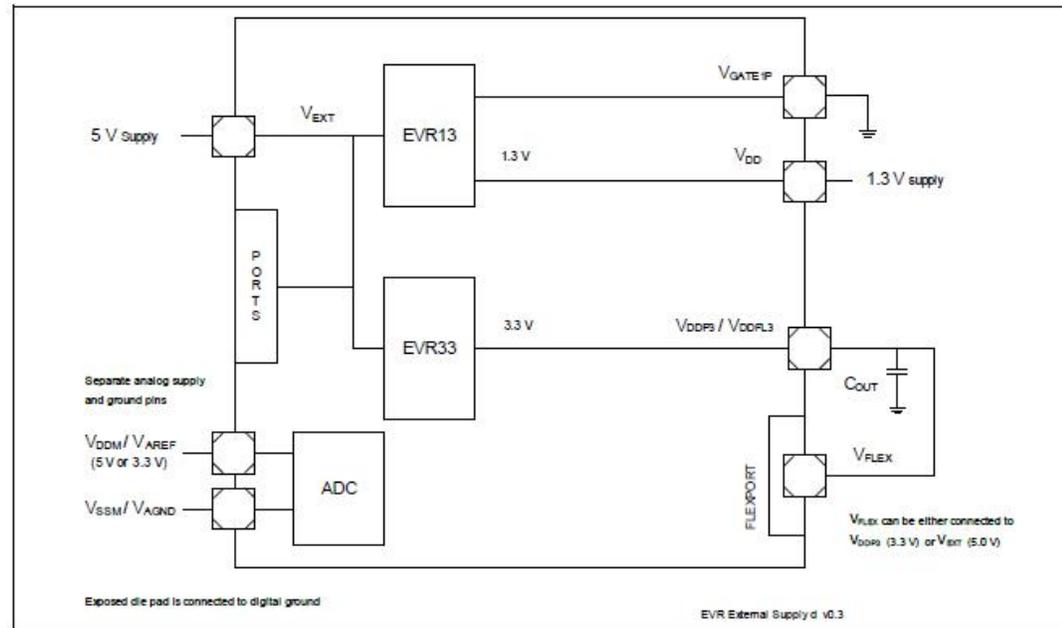


Figure 7-30 External Supply mode (d) - 5 V and 1.3 V externally supplied



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# MCU电源模式选择

## □ 3.3 V单电源供电 ■ 1.3V内部输出

## □ EVR开关模式拓扑结构

| No. | HWCFG [0:2] <sup>1)</sup>      | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup>                         | Supply Pin Voltage Level / Source   | Selected Supply Scheme   |
|-----|--------------------------------|--|---|--|
| e.) | 001 <sub>B</sub> <sup>4)</sup> | VGATE1P/<br>VGATE1N<br>connected<br>to gate of P-<br>/N-ch.<br>MOSFET. | $V_{EXT}/V_{DDP3}/V_{DDFL3} = 3.3V$<br>$V_{DDM}/V_{AREFX} = 5V / 3.3V$<br>$V_{FLEX} = 3.3V$<br>$V_{DD} = EVR13$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0V$ | 3.3 V single source supply,<br>EVR13 in SMPS mode,<br>EVR33 inactive.<br>5 V or 3.3 V ADC domain.<br>3.3 V Flexport domain.<br>Standby Mode supported. |

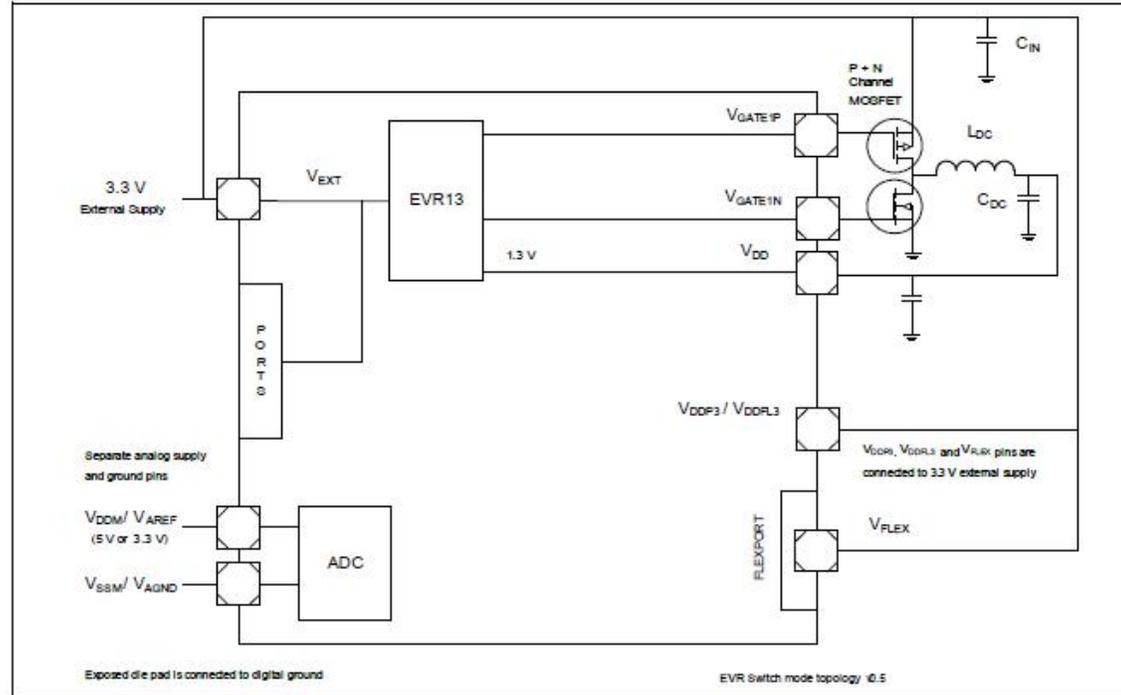


Figure 7-28 EVR Switch mode topology (e) - 3.3 V single supply



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# MCU电源模式选择

## □ 3.3V单电源供电

### ■ 1.3V内部输出

## □ EVR LDO拓扑结构

| No  | HWCFG [0:2] <sup>1)</sup>      | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup> | Supply Pin Voltage Level / Source   | Selected Supply Scheme   |
|-----|--------------------------------|--|---|--|
| g.) | 101 <sub>B</sub> <sup>4)</sup> | VGATE1P connected to P-ch. MOSFET.             | $V_{EXT}/V_{DDP3}/V_{DDFL3} = 3.3V$<br>$V_{DDM}/V_{AREFX} = 5V / 3.3V$<br>$V_{FLEX} = 3.3V$<br>$V_{DD} = EVR13$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0V$ | 3.3 V single source supply, EVR13 in LDO mode with external pass device, EVR33 inactive.<br>5 V or 3.3 V ADC domain.<br>3.3 V Flexport domain.<br>Standby Mode supported |

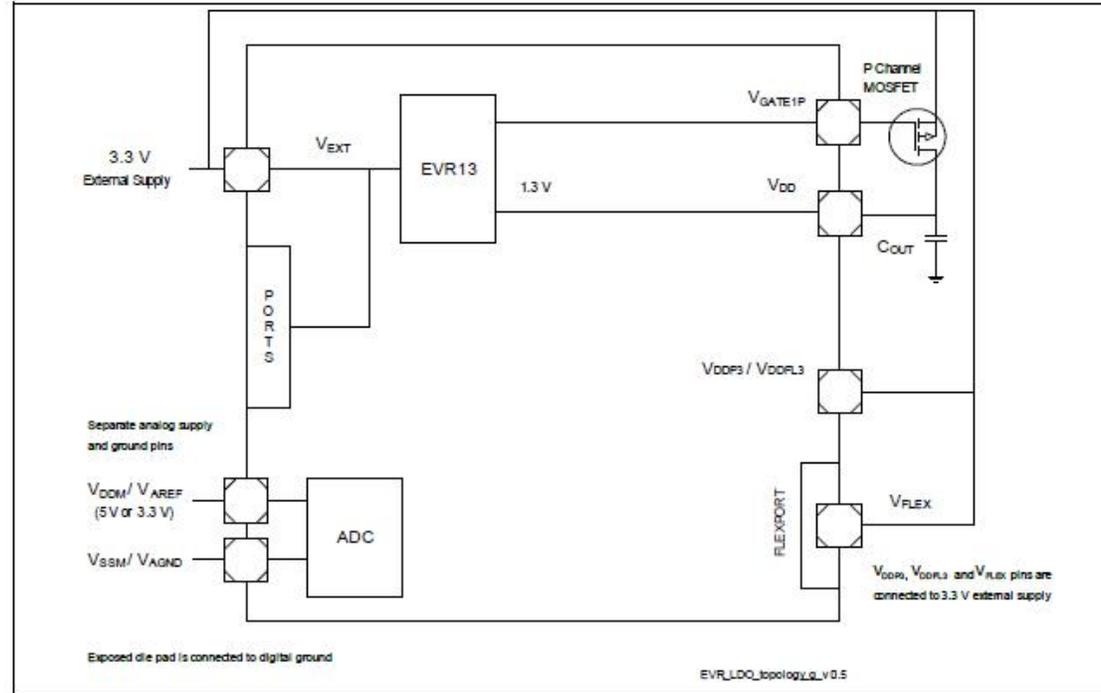


Figure 7-25 EVR LDO topology (g) - 3.3 V single supply with ext. pass device



# MCU电源模式选择

## 外部供电模式

■ 5V外部供电

■ 3.3V外部供电

■ 1.3V外部供电

| No. | HWCFG [0:2] <sup>1)</sup> | VGATE1P <sup>2)</sup><br>VGATE1N <sup>3)</sup>  | Supply Pin Voltage Level / Source  | Selected Supply Scheme  |
|-----|---------------------------|---|--|---|
| h.) | X00 <sub>B</sub>          | VGATE1P has int. pull-up active when left open. | $V_{EXT} = 5\text{ V or }3.3\text{ V}$<br>$V_{DDM}/V_{AREF_x} = 5\text{ V / }3.3\text{ V}$<br>$V_{FLEX} = 5\text{ V or }3.3\text{ V}$<br>$V_{DDP3}/V_{DDL3} = 3.3\text{ V}$<br>$V_{DD} = 1.3\text{ V}$<br>$V_{SS}/V_{SSM}/V_{AGND} = 0\text{ V}$ | 5 V, 3.3 V and 1.3 V are supplied externally, EVR13 and EVR33 inactive. 5 V or 3.3 V ADC domain. 5 V or 3.3 V Flexport domain. Standby Mode is supported and 3.3V and 1.3V supplies shall be switched off by external regulator after Standby state is entered. |

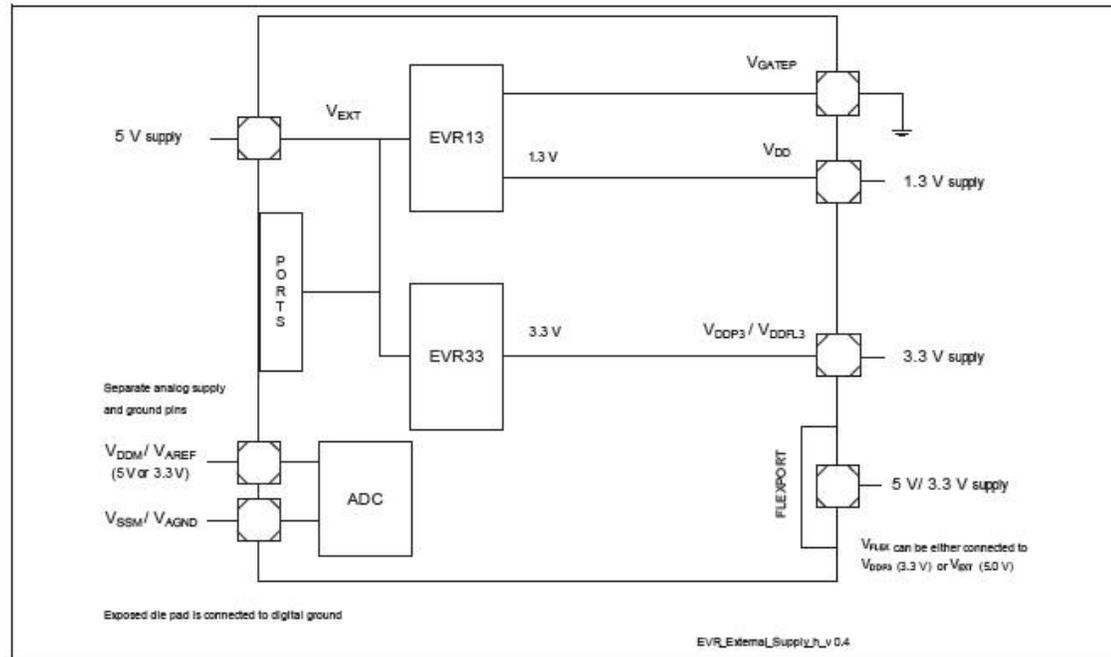


Figure 7-31 External Supply mode (h) - 5 V, 3.3 V & 1.3 V externally supplied

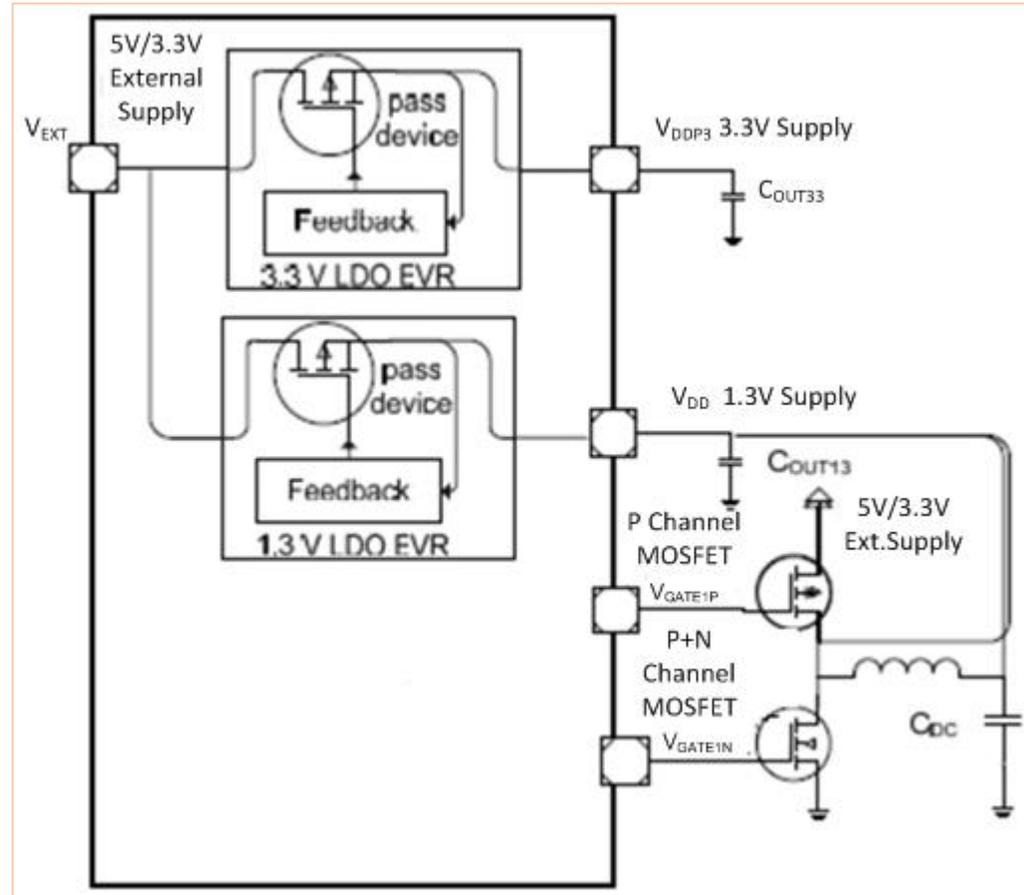


英飞凌汽车电子生态圈

# MCU电源模式选择总结

## □ 内核电的供电选择

- 当功耗小于200mA的时候，选择内部LDO直接输出模式（b、f）
- 当功耗大于200mA的时候，选择内部LDO输出+外接MOS的方式（c、g）
- 当需要大电流的时候，选择1.3V SMPS稳压器（a、e）



# MCU电源模式选择

| HWCFG [0]<br>P14.6  | HWCFG [1]<br>P14.5  | HWCFG [2]<br>P14.2  | HWCFG [3]<br>P14.3   | HWCFG [4]<br>P10.5  | HWCFG [5]<br>P10.6  | HWCFG [6]<br>P14.4  |
|---|---|---|--|---|---|---|
|  |  |  |  |    |  |  |
| 0 - SMPS<br>1 - LDO<br>(default)  | 0 - EVR33OFF<br>1 - EVR33ON<br>(default)  | 0 - EVR13OFF<br>1 - EVR13ON<br>(default)  | 0 - Boot from pins<br>HWCFG [5:4]<br>1 - Flash BMI boot<br>(default)               | HWCFG [4:5]<br>[0 0]- Generic Bootstrap (P14.0/1)<br>[0 1]- ABM, Generic Bootstrap on fail (P14.0/1)<br>[1 0]- ABM, ASC Bootstrap on fail (P15.2/3)<br>[1 1]- Internal start from Flash (default) |   | Default Pad state<br>0 - Pins in tristate<br>1 - Pins with pull-up<br>(default)     |

- 1.) HWCFG [6] has weak internal pull-up active at start-up if the pin is left unconnected.
- 2.) If HWCFG [6] is left unconnected or is externally pulled high, HWCFG [0:5] pins have weak internal pull-ups active at start-up.
- 3.) If HWCFG [6] is connected to ground, HWCFG [0:5] pins are in tristate. External pull devices required for all HWCFG pins.
- 4.) In packages smaller than QFP 144, HWCFG [0:2] pins are absent & internally pulled high ensuring EVR13 (LDO) & EVR33 is active
- 5.) HWCFG [0:2] and HWCFG [6] pins are latched during supply ramp-up (VEXT < 2.97V) and stored in PMSWSTAT.HWCFGEVR & TRIST register bits. The remaining HWCFG pins are latched on internal reset release (between 100us – 180us after reset assertion) and stored in STSTAT register.



# MCU\_复位系统

## □/PORST是双向复位引脚

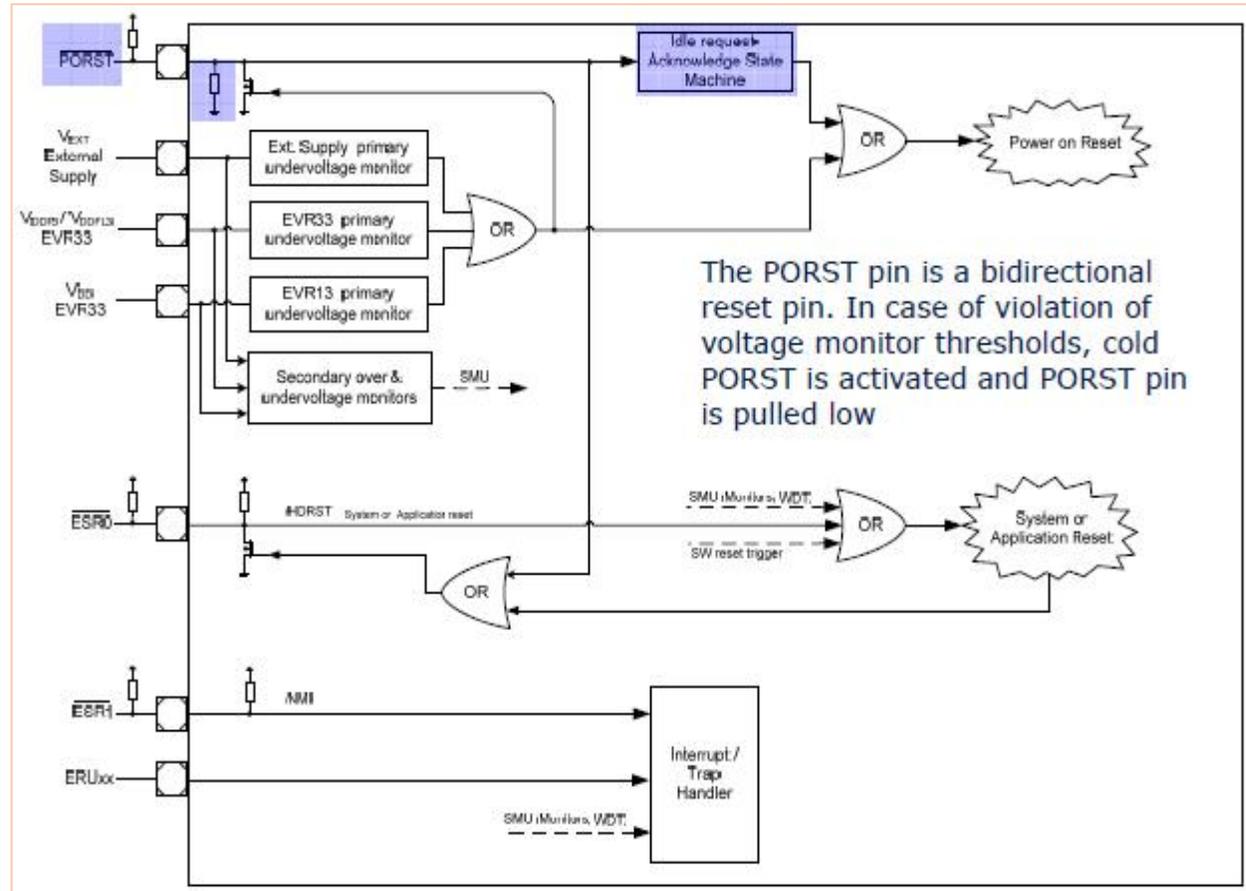
- 复位输入引脚
- supply电源故障时重置输出

## □/ESR0是默认的复位输出引脚

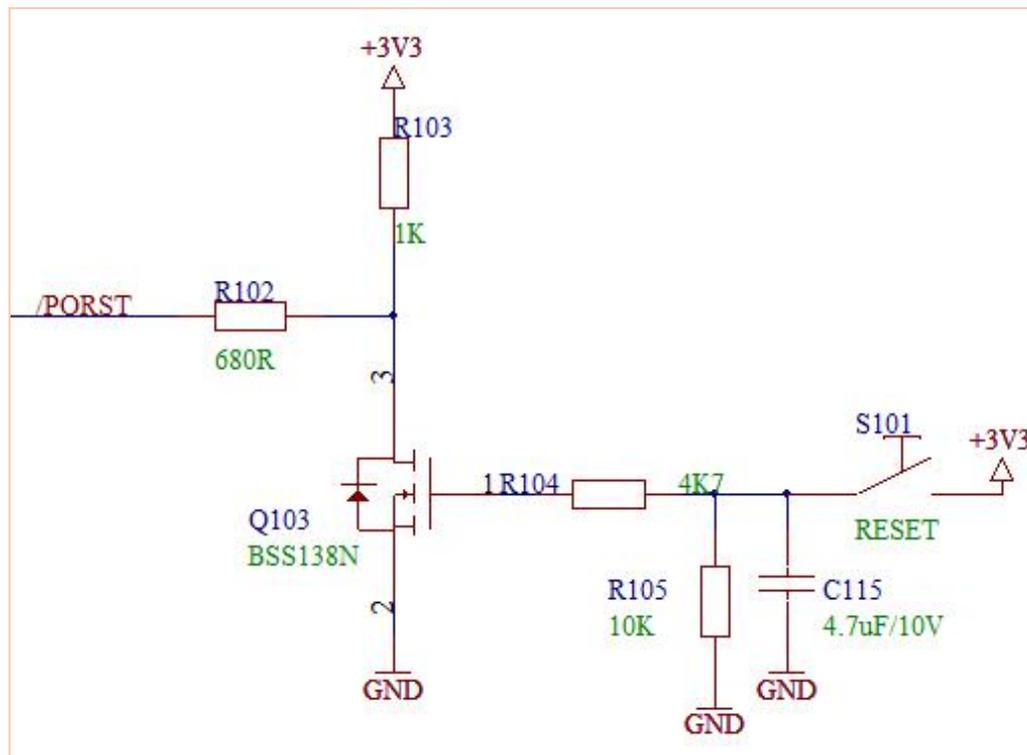
- 可配置为复位输入/输出/ GPIO

## □/ESR1是默认的NMI引脚

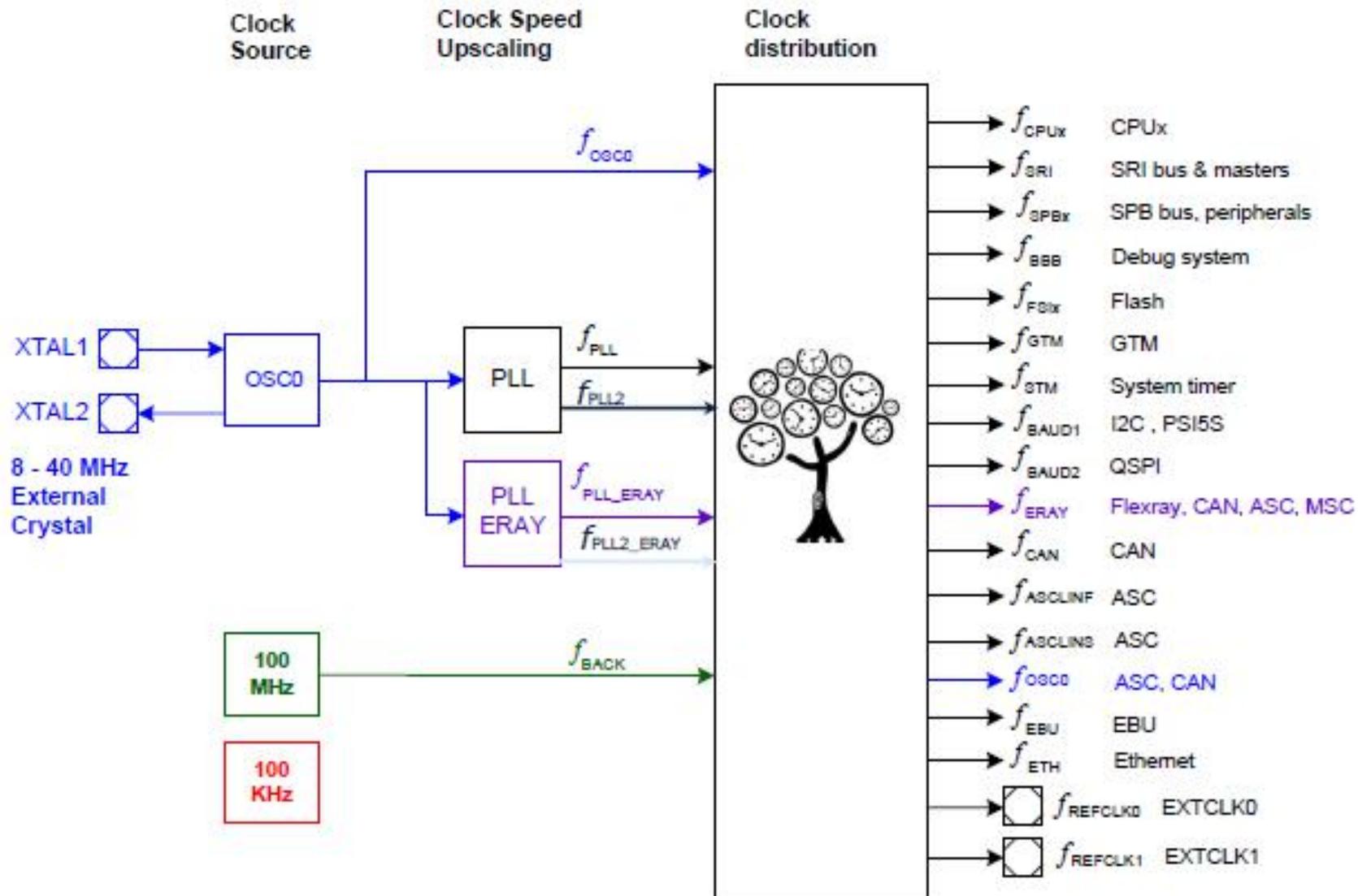
- 可配置为复位输入/输出/ GPIO



- 实际电路
  - 按键复位

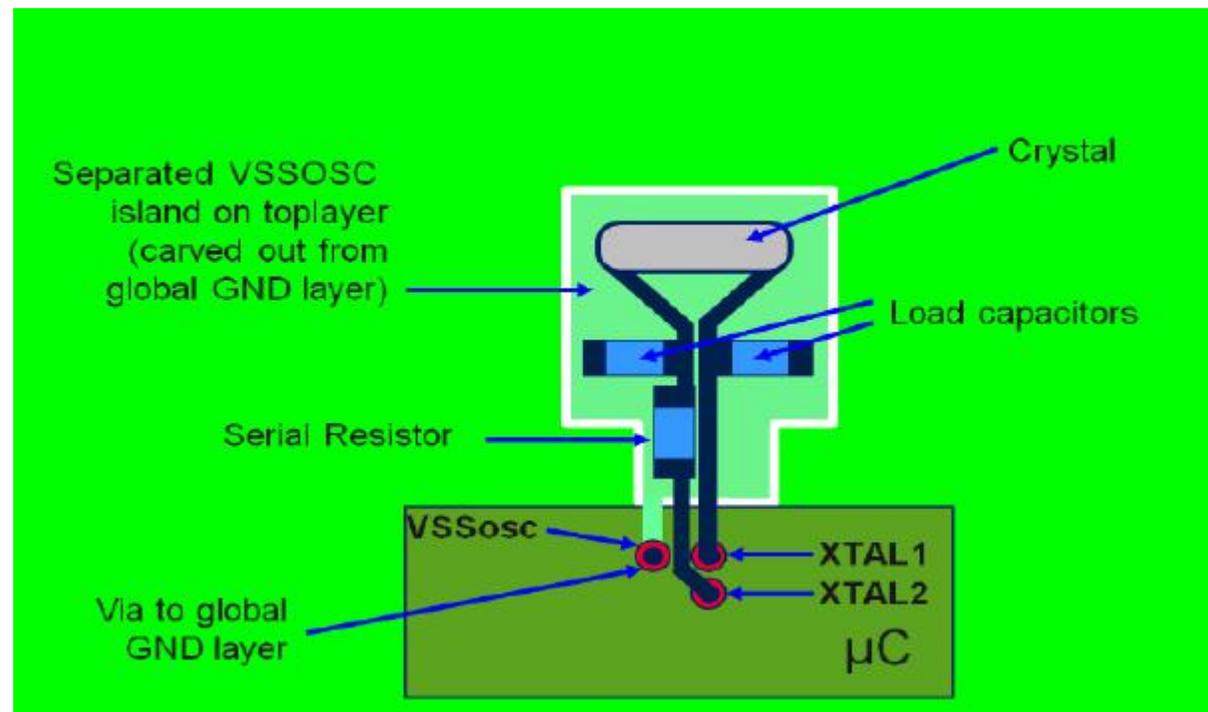
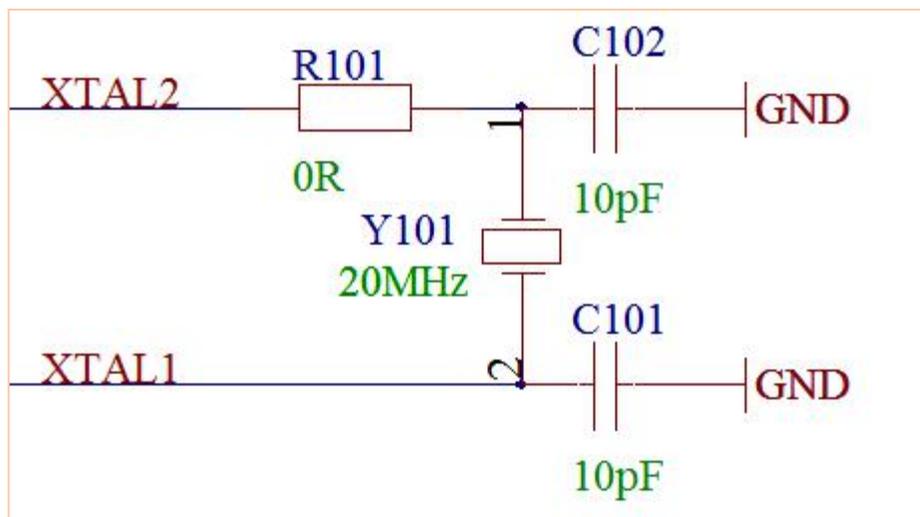


# MCU时钟系统



英飞凌汽车电子生态圈

## 实际电路

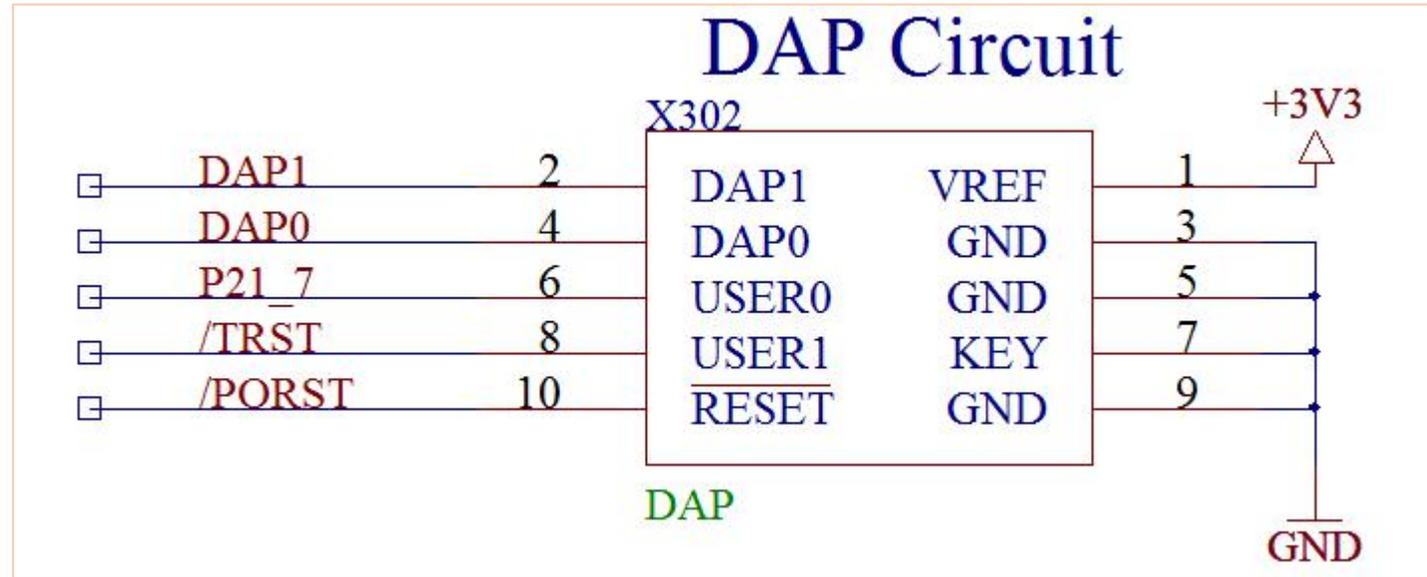


# MCU仿真下载电路

□ MCU的仿真下载口  
有两种形式:

- JTAG: 16PIN接口
- DAP: 10PIN接口

□ 实际电路: DAP接口

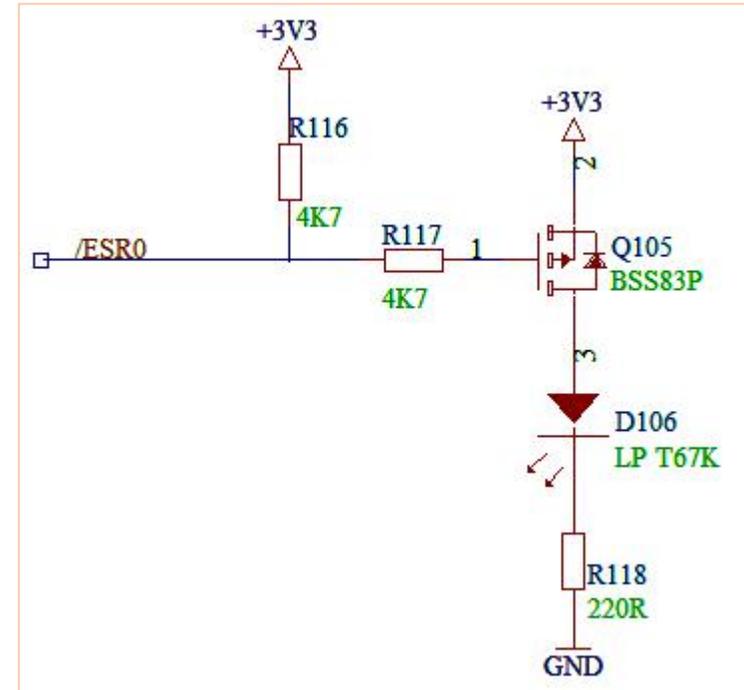


# 故障指示电路

□ LED灯亮，故障提示，分析原因

- 程序进入TRAP
- 电源短路

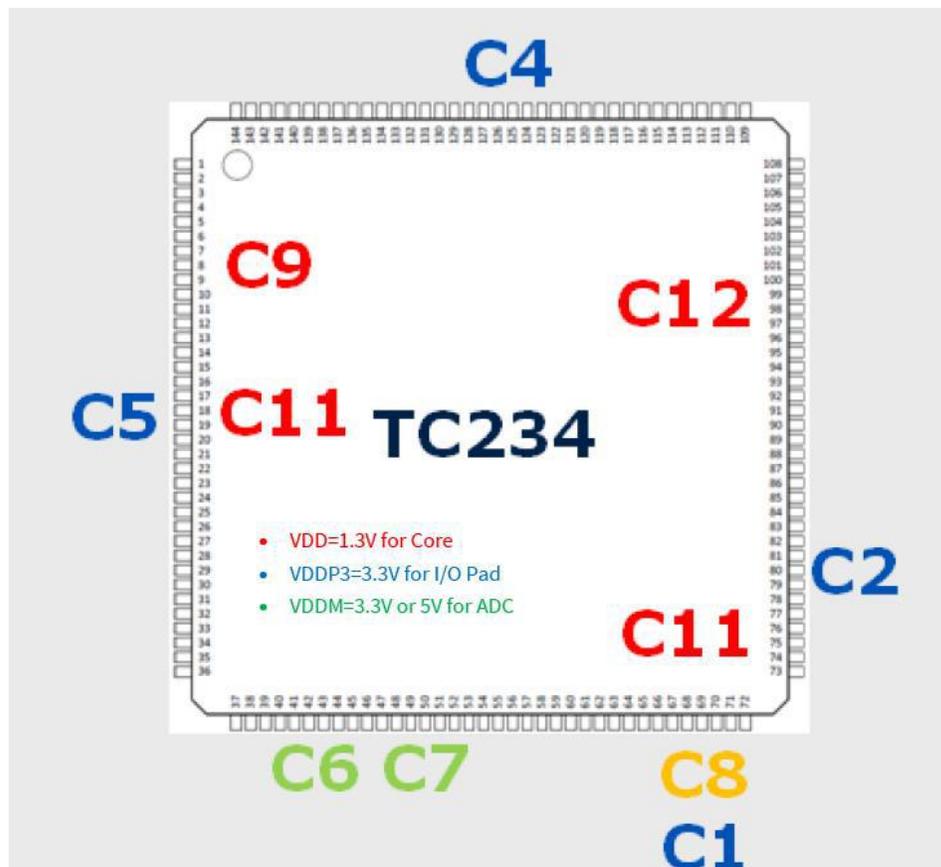
■ MCU引脚互相有短接



□ TC264 封装

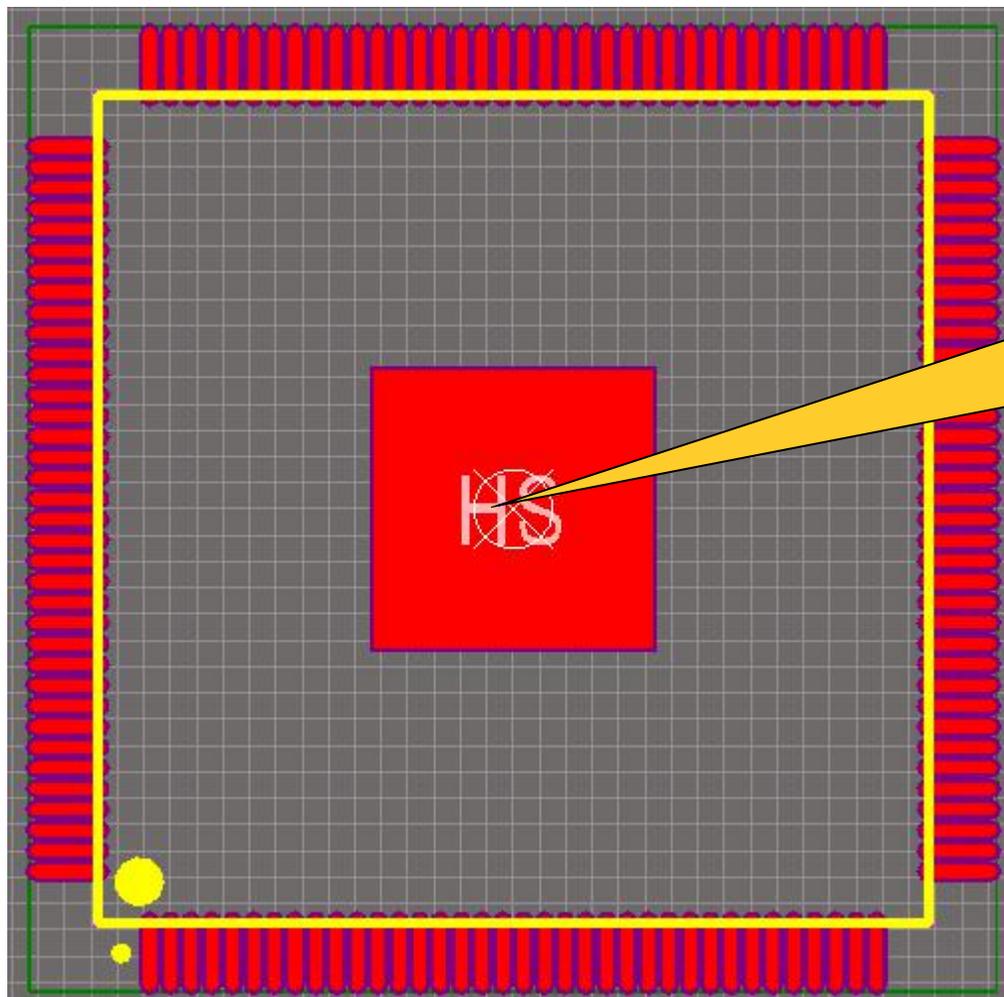
□ TC264布局

□ TC264 布线



英飞凌汽车电子生态圈

- TC264采用TQFP144封装
- 中间有接地和散热焊盘

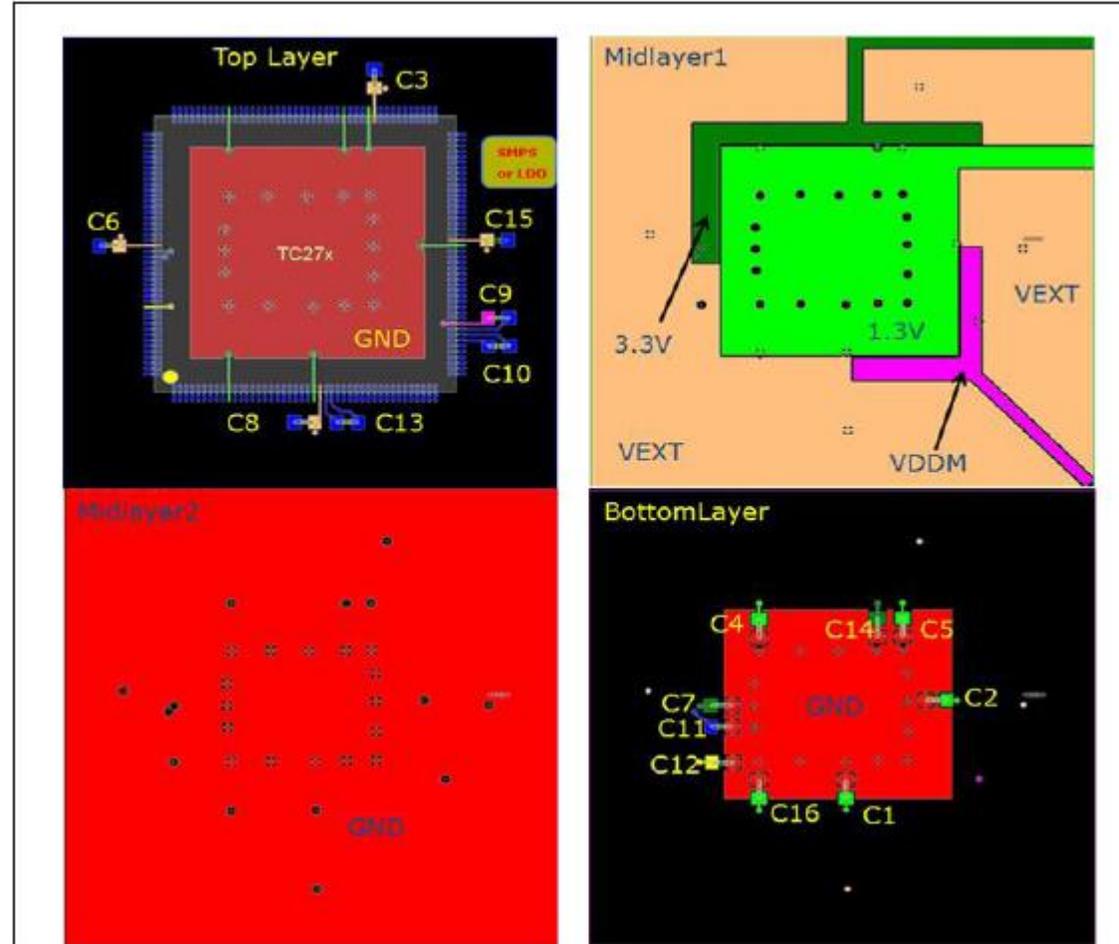


一定要连到  
0V上  
(GND)



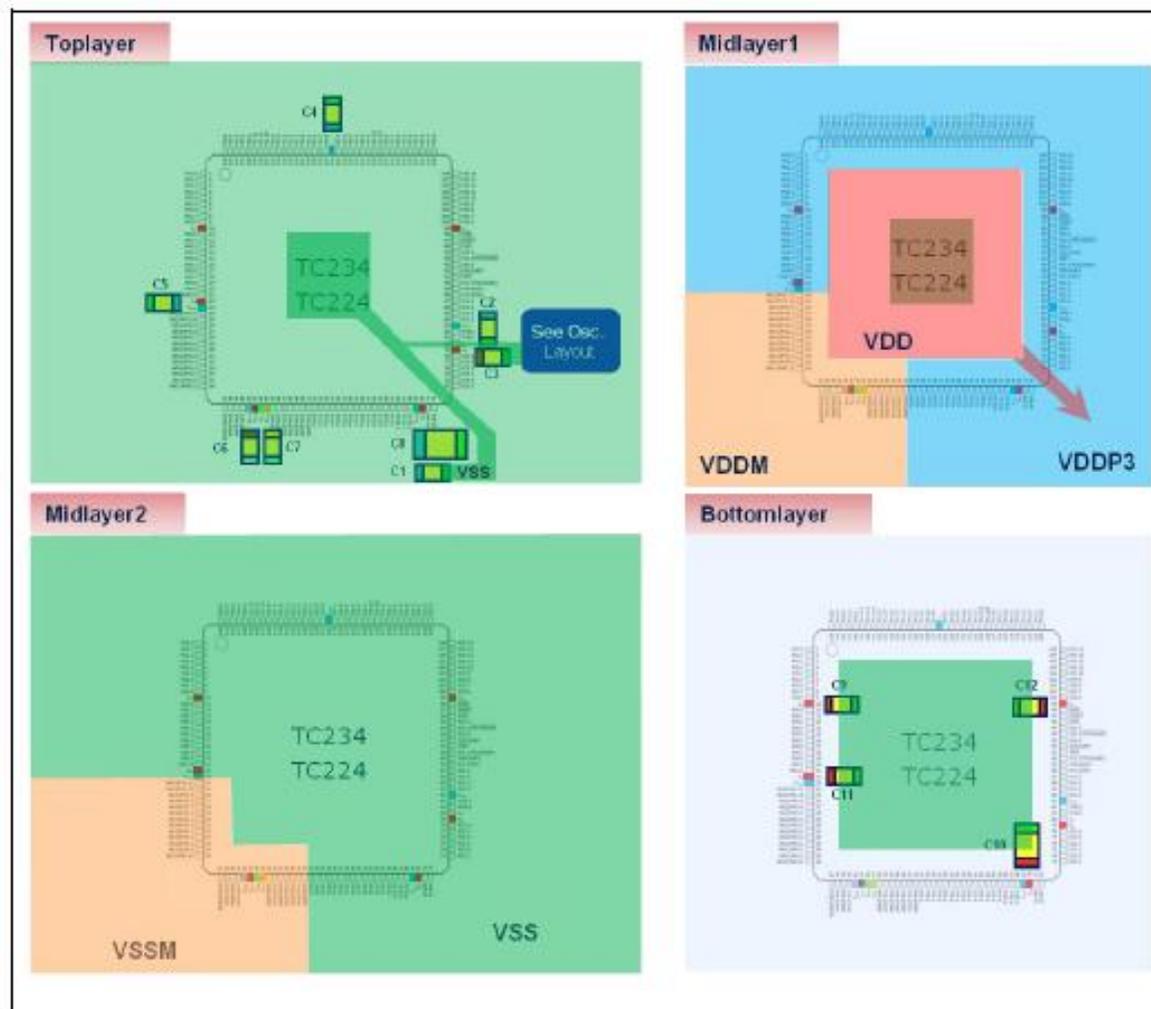
# TC264 PCB 布局 (1)

- 按功能模块布局
- 电源的电容再放在电源附近
- 要尽量保证信号线最短
- 注意晶振要放在晶振信号附近，信号线尽量短
- 1.3V输出外接MOS要放在对应引脚附近
- 对需要测试的地方，可以添加焊盘测试点



■ 各电源和地线区域的划分

■ 备注：234和264类似



De-coupling capacitor list for TQFP-144 package

| Capacitor          | Value  | Supply                                | TQFP-144 pin  |
|--------------------|--|---------------------------------------|---|
| C12,<br>C9,<br>C11 | 3 x 100nF  | V <sub>DD</sub>                       | 99,<br>10 (V <sub>DD</sub> SB for ADAS device),<br>22 |
| C3                 | 1 x 2.2μF for TC224 with LDO mode<br>1 x 100nF for all other cases   | V <sub>DD</sub>                       | 79  |
| C10                | 1 x 100nF for TC234 for external supply mode<br>1 x 2.2uF for TC234 for LDO mode<br>1 x 10uF for TC234 for SMPS mode | V <sub>DD</sub>                       | 70  |
| C2                 | 1 x 330nF  | V <sub>DDP3</sub>                     | 83  |
| C1                 | 1 x 4.7uF for TC234 in SMPS mode<br>1 x 100nF for all other cases  | V <sub>DDP3</sub>                     | 69  |
| C4,<br>C5          | 2 x 100nF  | V <sub>DDP3</sub>                     | 126,<br>23  |
| C8                 | 1 x 1uF for TC234 in SMPS mode<br>No cap required for all other cases  | V <sub>CAP0</sub> -V <sub>CAP1</sub>  | 71//72  |
| C6                 | 1 x 100nF  | V <sub>AREF</sub> //V <sub>AGND</sub> | 41//42  |
| C7                 | 1 x 100nF  | V <sub>DDM</sub> //V <sub>SSM</sub>   | 44//43  |



## □PCB 布线

- 线宽：不要超过MCU管脚的宽度（6mil）
- 过孔：信号线过孔一般0.3/0.6mm即可（内径/外径）
- 晶振：晶振下面不能走线
- 电源：地线线宽要大于电源线，具体根据电流大小来判断
- 内核电源：内核电源1.3V线尽量宽，芯片下面尽量敷铜平面，保持电流流通性
- MCU散热：MCU 散热焊盘要打孔，而且各个层最好都敷铜，使各个层连接起来，增加散热面积
- 丝印标注：对需要测试的电源、信号添加丝印标注，接插件尽量标注出1脚，比如仿真下载口



## □ 焊接

- 由于MCU需要散热，所以焊机要注意热风枪温度350°C左右即可。
- MCU焊接完成后，用镊子确认下各个引脚是不是都焊接上了。
- 所有的电路都焊接完成后，需要用万用表通断档，测试下各个电源和地之间是否有短路现象，然后方可上电。



# 电路板焊接调试注意事项

## □ 调试

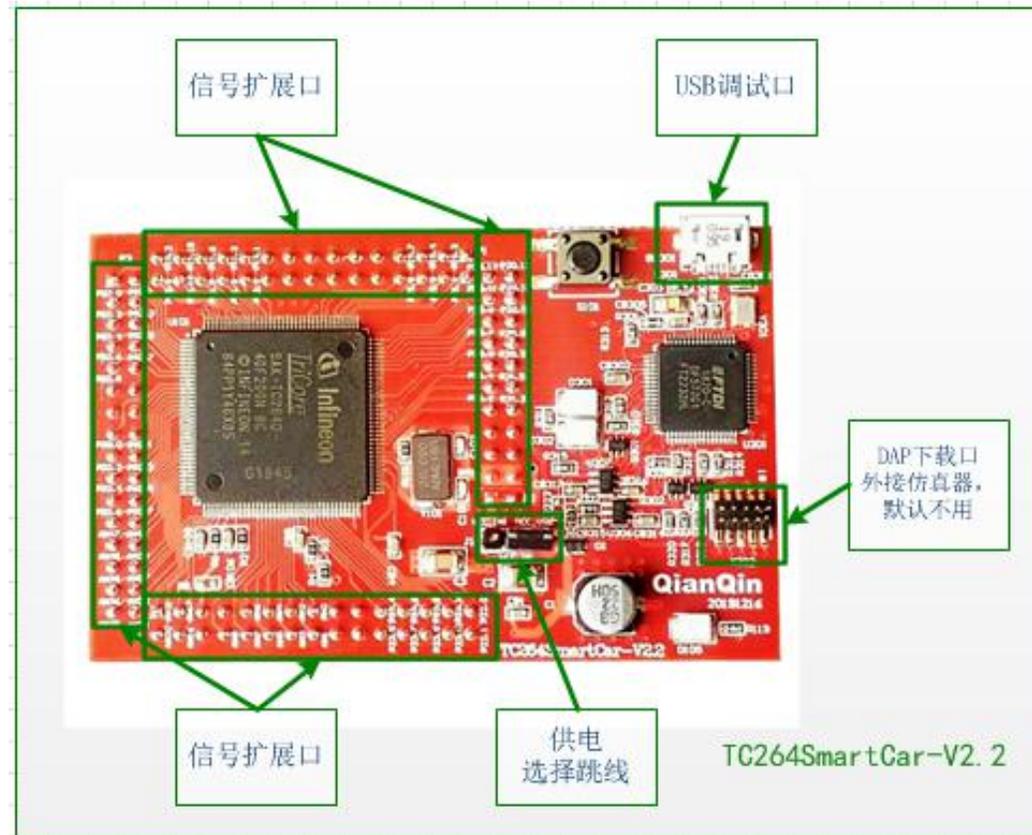
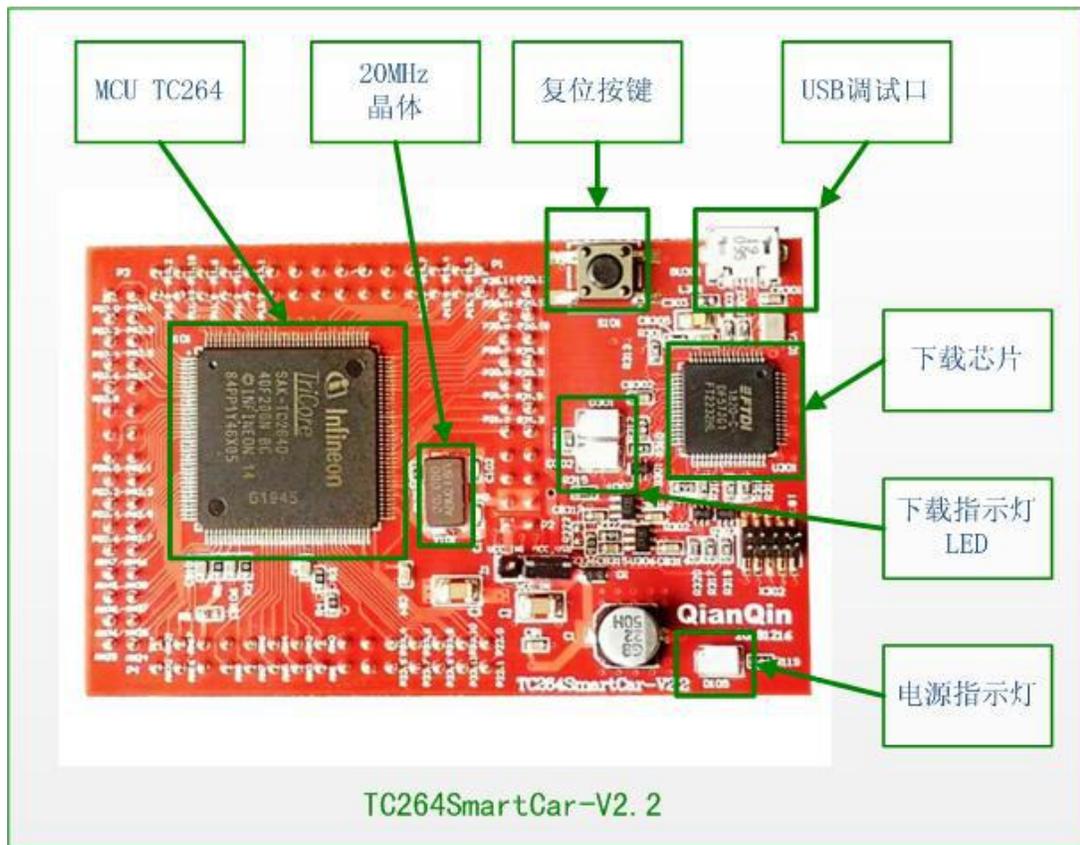
- 调试是在焊接完成，在测量电路板没有短路的前提下，给电路板上电和调试。

## □ 调试步骤

- 测电源：先测电源是否正常，比如3.3V，1.3V等。
- 测复位：如，按下复位键，故障灯亮，松开按键，故障灯灭，复位电路正常。
- 测晶振：用示波器测晶振的两端是否有波形。
- 测仿真下载口：连接仿真器，下载程序。



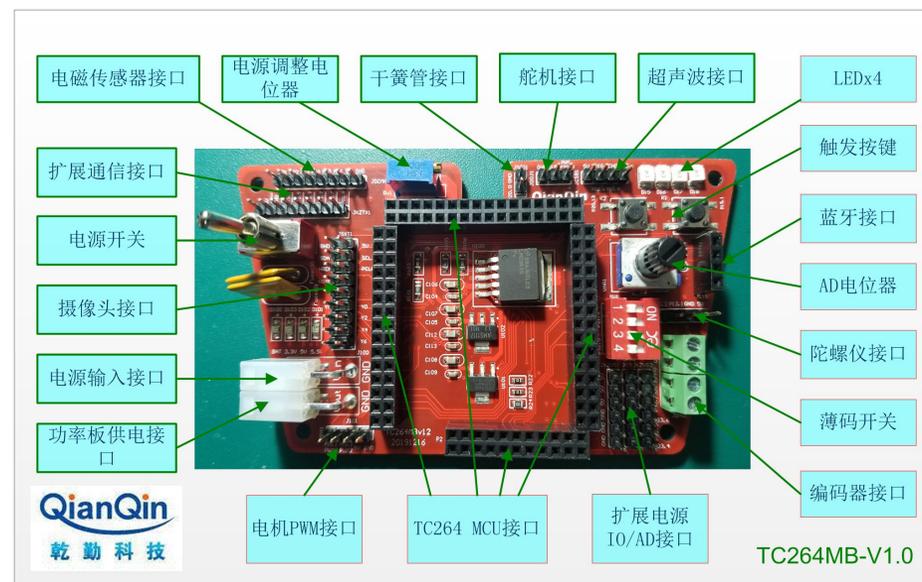
# TC264核心板实物图



# 仿真器和TC264扩展板



**乾勤** 智能车大赛专供



## ■ 大学生智能车竞赛技术支持群



## ■ 北京乾勤科技发展有限公司

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