

# k60 Control - libbase

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## Introduction

This sections include controls to basic peripherals provided by the MCU. In your SmartCar development, you may seldom use these configurations, but these can help you a lot since you have a greater freedom using libbase than libsc. Understanding these could also allow you to develop the project with a more appropriate mindset.

## Pin Configuration

There are 144 pins in a k60 chip and each pin has a specific role. Consider the following excerpt on pin assignments of k60 chips.

144 LQFP	144 MAP BGA	Pin Name	Default	ALT0	ALT1	ALT2	ALT3	ALT4	ALT5	ALT6	ALT7	EzPort
—	L5	RTC_WAKEUP_B	RTC_WAKEUP_B	RTC_WAKEUP_B								
—	M5	NC	NC	NC								
—	A10	NC	NC	NC								
—	B10	NC	NC	NC								
—	C10	NC	NC	NC								
1	D3	PTE0	ADC1_SE4a	ADC1_SE4a	PTE0	SPH_PCS1	UART1_TX	SDHC0_D1		I2C1_SDA	RTC_CLKOUT	
2	D2	PTE1/LLWU_P0	ADC1_SE5a	ADC1_SE5a	PTE1/LLWU_P0	SPH_SOUT	UART1_RX	SDHC0_D0		I2C1_SCL	SPH_SIN	

Each pin has a default functionality, but one can alter its functionality through pin configuration. Consider pin #1, its default is a pin for ADC (Analog-Digital Converter), but you can alter it by changing it to a GPIO pin (PTE0), a SPI pin and a UART pin, etc.

The pin configurations are defined in `libsc/inc/libsc/k60/config/<group name>.h` For example for `2017_inno.h`, we have the following excerpt.

```
1 #define LIBSC_ST7735R_RST libbase::k60::Pin::Name::kPte3
2 #define LIBSC_ST7735R_DC libbase::k60::Pin::Name::kPte0
3 #define LIBSC_ST7735R_CS libbase::k60::Pin::Name::kPte4
4 #define LIBSC_ST7735R_SDAT libbase::k60::Pin::Name::kPte1
5 #define LIBSC_ST7735R_SCLK libbase::k60::Pin::Name::kPte2
```

Here it defines the five pins of `ST7735R` to correspond to the five pins (according to the pin names) of the chip. Since the module uses SPI (you will learn it in later sections), we will find a `SpiMaster` definition in `libsc/inc/libsc/st7735r.h`.

```
1 SpiMaster m_spi;
```

When the class `St7735r` is being constructed, the following member initialization is triggered.

```

1 St7735r::St7735r(const Config &config)
2 : m_spi(GetSpiConfig()) /* ... */ { /* ... */ }

```

The function `GetSpiConfig()` is defined in `libsgcc/src/libsc/st7735r.cpp`

```

1 St7735r::SpiMaster::Config GetSpiConfig()
2 {
3     St7735r::SpiMaster::Config config;
4     config.sout_pin = LIBSC_ST7735R_SDAT;
5     config.sck_pin = LIBSC_ST7735R_SCLK;
6     /* OMITTED */
7     return config;
8 }

```

We can see the pin is being used to configure the module by passing it to SPI configurations.

As a `SpiMaster` class is created, its constructor located at `libsgcc/src/libbase/k60/spi_master.cpp` is called.

```

1 SpiMaster::SpiMaster(const Config &config)
2 : m_sin(nullptr),
3   m_sout(nullptr),
4   m_sck(nullptr),
5   m_is_init(false)
6 {
7     /* OMITTED */
8     InitPin(config);
9     /* OMITTED */
10 }

```

Inside `InitPin(const Config)`, we have

```

1 void SpiMaster::InitPin(const Config &config)
2 {
3     if (config.sin_pin != Pin::Name::kDisable)
4     {
5         Pin::Config sin_config;
6         sin_config.pin = config.sin_pin; // specifies Pin
7         sin_config.mux = PINOUT::GetSpiSinMux(config.sin_pin); // specifies Alt
8         m_sin = Pin(sin_config);
9     }
10
11     /* OMITTED */
12 }

```

And finally, the function `PINOUT::GetSpiSinMux(Pin::Name)` in `libsgcc/src/libbase/k60/pinout/<mcu_name>.cpp` allows one to alter the functionalities of the pins.

```

1 Pin::Config::MuxControl Mk60f15Lqfp144::GetSpiSinMux(const Pin::Name pin)
2 {
3     switch (pin)
4     {
5     default:
6         assert(false);
7         // no break
8
9     case Pin::Name::kPta17:
10    case Pin::Name::kPtb17:
11    case Pin::Name::kPtb23:
12    case Pin::Name::kPtc7:
13    case Pin::Name::kPtd3:
14    case Pin::Name::kPtd14:
15    case Pin::Name::kPte3:
16        return Pin::Config::MuxControl::kAlt2;
17
18    case Pin::Name::kPte1:
19        return Pin::Config::MuxControl::kAlt7;
20    }
21 }

```

In `Pin::Config::MuxControl::kAlt#`, the pins are configured to have the functionalities of `ALT#` in the pin assignment.

The pin configurations are similar for other protocols, just that the functions for them are located in different places (located at `InitPin(Pin::Name)` function of respective library).

## GPIO

GPIO, which stands for **General-purpose Input/Output**, is a generic pin which allow either high (1) or low (0) state. In GPIO, pins can be further divided into an input pin (**GPI**) and an output pin (**GPO**).

Location: `libbase/k60/gpio.h`

### GPI

A GPI (**General-purpose Input**) pin allows to be read with either high or low state.

Config	Datatype	Description
pin	Pin::Name	Pin name
interrupt	Pin::Config::Interrupt	Could be <code>kDisable</code> , <code>kRising</code> , <code>kFalling</code> and <code>kBoth</code> for no interrupt, interrupt at rising edge, interrupt at falling edge and interrupt at both rising and falling edge
config	std::bitset<6>	Specify the configuration of the pin, either allow <code>kOpenDrain</code> , <code>kPassiveFilter</code> , <code>kPullEnable</code> and <code>kPullUp</code> for open drain, low pass filter and pull-up/pull-down.
isr	void(Gpi*)	Gpi listener

Sample code:

```

1 void GPIListener(Gpi *gpi) {
2     if (gpi->Get()) { // get state of GPI
3         // if high
4     } else {
5         // if low
6     }
7 }
8
9 Gpi::Config ConfigGPI;
10 ConfigGPI.pin = Pin::Name::kPtb0;
11 ConfigGPI.interrupt = Pin::Config::Interrupt::kBoth;
12 ConfigGPI.config.set(Pin::Config::kPassiveFilter);
13 ConfigGPI.isr = listener;
14 Gpi gpi(ConfigGPI);

```

## GPO

A GPO (**General-Purpose Output**) pin allows to be written with either high or low state.

Config	Datatype	Description
pin	Pin::Name	Pin name
config	std::bitset<6>	Specify the configuration of the pin, either allow <code>kHighDriveStrength</code> and <code>kSlowSlewRate</code> for low/high drive strength and slow/fast slew rate
is_high	bool	Default output state of the pin

Sample code:

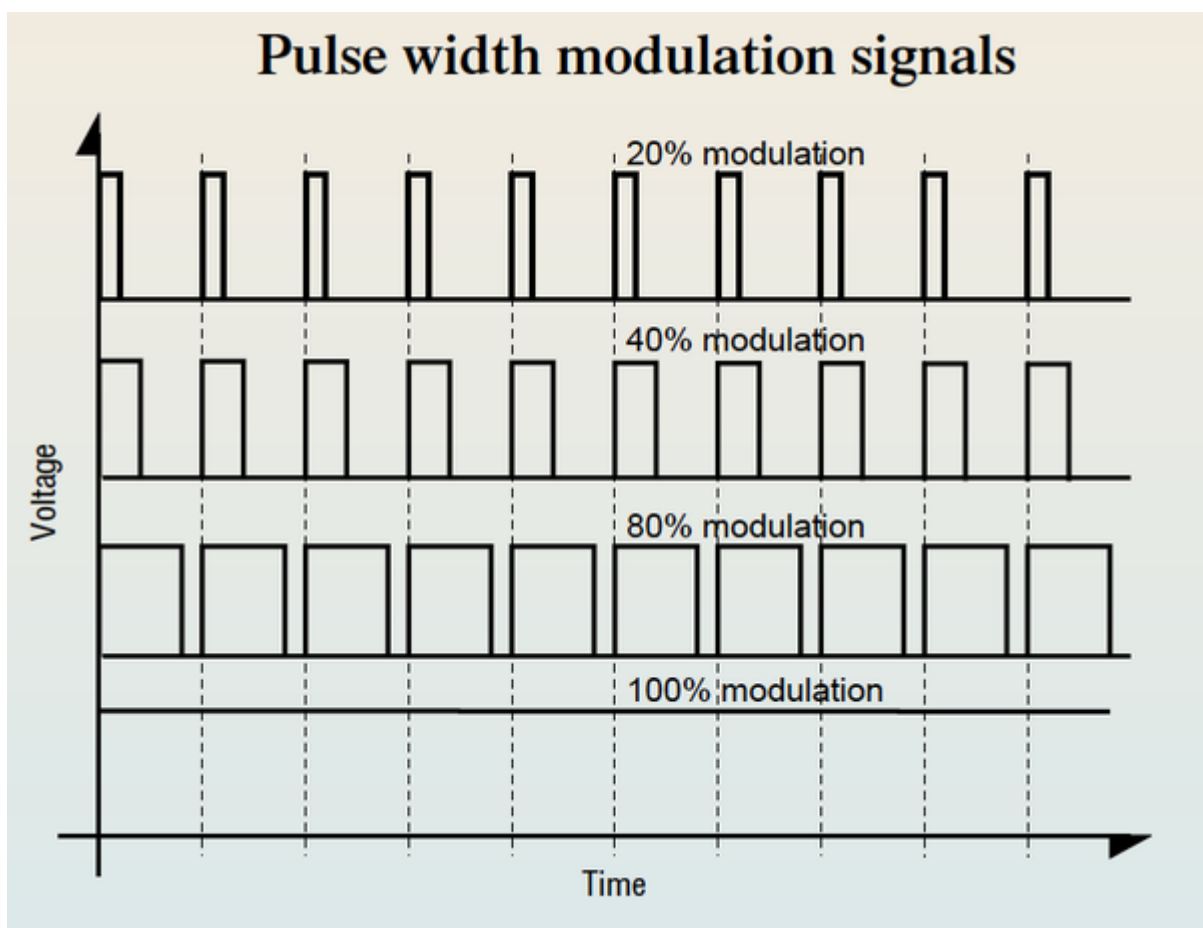
```

1 Gpo::Config ConfigGPO;
2 ConfigGPO.pin = Pin::Name::kPtB0;
3 ConfigGPO.is_high = false
4 Gpo gpo(ConfigGPO);
5
6 gpo.Set(true); // set output to 1
7 gpo.Set(false); // set output to 0
8 gpo.Turn(); // toggle output to 1
9 gpo.Turn(); // toggle output to 0

```

## PWM

PWM, which stands for **Pulse-Width Modulation**, is essentially a signal of square wave, which components like motors and servos use it to input the percentage power/angle.



Location: `libbase/k60/ftm_pwm.h`

Config	Datatype	Description
pin	Pin::Name	Pin name
period	uint32_t	Period of a cycle
pos_width	uint32_t	Pulse width in a cycle
precision	Precision	Unit for period and pulse width, either in us (default) or in ns
alignment	Alignment	Alignment of PWM signals, either with edge of period or center of period

Sample code:

```

1 FtmPwm::Config ConfigPWM;
2 ConfigPWM.pin = Pin::Name::kPta0; // need Pin with Ftm functionality
3 ConfigPWM.period = 10;
4 ConfigPWM.pos_width = 2;
5 ConfigPWM.alignment = FtmPwm::Config::Alignment::kEdge;
6 FtmPwm pwm(ConfigPWM);
7 // the pin PTA0 is now in 20% modulation with 10us cycle

```

## ADC

ADC, which means **Analog Digital Converter**, converts analog signals into digital signals.

Config	Datatype	Description
pin	Pin::Name	Pin name (override <code>adc</code> )
adc	Adc::Name	Adc name (can specify certain ADC for pins that support multiple ADCs)
is_diff_mode	bool	Determine whether the ADC uses differential conversion
resolution	Resolution	Resolution of the ADC, determines the output type, either 8, 10, 12 or 16 bit
speed	Speed	Speed of the ADC
is_continuous_mode	bool	Allow continuous conversion (?)
avg_pass	AveragePass	Number of sample average used for output
conversion_isr	void(Adc*, uint16_t)	Listener when a conversion is finished

Sample code:

```

1  Adc::Config ConfigADC;
2  ConfigADC.adc = Adc::Name::kAdc3Ad6A; // ADC3 AD6A (ADC3_SE6a in Pta6)
3  ConfigADC.speed = Adc::Config::SpeedMode::kExSlow;
4  ConfigADC.is_continuous_mode = true;
5  ConfigADC.avg_pass = Adc::Config::AveragePass::k32;
6  Adc adc(ConfigADC);
7
8  adc.StartConvert(); // start ADC
9  adc.GetResult(); // get result in int
10 adc.GetResultF(); // get result in float [0, 3.3]
11 adc.StopConvert(); // stop ADC

```

## UART

UART, which means **Universal Asynchronous Receiver-Transmitter**, is a protocol for serial communication between modules, usually used in Bluetooth for the case of SmartCar.

Location: `libsc/k60/uart_device.h`

Config	Datatype	Description
<code>id</code>	<code>uint8_t</code>	UART id
<code>baud_rate</code>	<code>Uart::Config::BaudRate</code>	Baud rate of UART communication, usually use <code>k115200</code>
<code>rx_isr</code>	<code>bool(const Byte*, const size_t)</code>	UART listener, return true if the data is consumed

Sample code:

```

1  bool UARTListener(const Byte *data, const size_t size) { // for RX
2      /* ... */
3      return true;
4  }
5
6  UartDevice::Config ConfigUART;
7  ConfigUART.id = 0;
8  ConfigUART.baud_rate = Uart::Config::BaudRate::k115200;
9  ConfigUART.isr = UARTListener;
10 UartDevice uart(ConfigUART);
11
12 // for TX
13 uart.SendStr("Hello World");
14 Byte byte = 20;
15 uart.SendBuffer(&Byte, 1);

```

## PIT

PIT, which means **Periodic Interrupt Timer**, is a listener function will be triggered periodically when the timer count a specific time, during the program run time. Be careful, when PIT is triggered, the normal program rundown will pause. Therefore, if PIT is called too frequently, your program cannot run.

Location: `libbase/k60/pit.h`

Config	Datatype	Description
<code>channel</code>	<code>uint8_t</code>	0~3, different
<code>count</code>	<code>uint32_t</code>	1 count = timer oscillate once
<code>isr</code>	<code>void(Pit*)</code>	pit listener

The following code is a led blink per 250ms using pit as control.

```
1  #include "libbase/k60/pit.h"
2  #include "libsc/led.h"
3
4  namespace libbase {
5      namespace k60 {
6          Mcg::Config Mcg::GetMcgConfig() {
7              Mcg::Config config;
8              config.external_oscillator_khz = 50000;
9              config.core_clock_khz = 150000;
10             return config;
11         }
12     } // namespace k60
13 } // namespace libbase
14
15 using libbase::k60::Pit;
16 using libsc::Led;
17
18 Led* pLed = nullptr;
19
20 void blink(Pit*){
21     pLed->Switch();
22 }
23
24 int main(){
25     Led::Config ledConfig;
26     ledConfig.id = 0;
27     Led led(ledConfig);
28     Pit::Config pitConfig;
29     pitConfig.channel = 0;
30     pitConfig.count = 75000*250;
31     pitConfig.isr = &blink;
32     Pit pit(pitConfig);
33     while(1);
34     return 0;
35 }
```

## SPI



# I2C

## Flash

Flash is the permanent memory in the MCU, which means you can get back the variable value when your smart car is turned off. Be careful, memory may crash if you turn off your smartcar while saving value to flash.

Location : `libbase/k60/flash.h`

Config	Datatype	Description
<code>sectorStartIndex</code>	<code>uint8_t</code>	start sector, change only if you are sure what are you doing
<code>size</code>	<code>size_t</code>	memory size, default is 4096 Byte, don't waste memory

### Read/Write to Flash

If you have only one type of variables to save, you can directly pass an array pointer to the function.

```
1  #include "libbase/k60/flash.h"
2  namespace libbase {
3  namespace k60 {
4  Mcg::Config Mcg::GetMcgConfig() {
5      Mcg::Config config;
6      config.external_oscillator_khz = 50000;
7      config.core_clock_khz = 150000;
8      return config;
9  }
10 } // namespace k60
11 } // namespace libbase
12 using libbase::k60::Flash;
13
14 int main(){
15     Flash flash(Flash::Config);
16     int myArray[10] = {};
17     memset(myArray, 0, sizeof(myArray));
18     flash.Read(myArray, sizeof(myArray));
19     //first time: destroyed datas, all nan
20     //second time onwards: {0,1,2,3,4,5,6,7,8,9}
21     for(int i=0;i<10;i++) myArray[i]=i;
22     flash.Write(myArray, sizeof(myArray));
23     return 0;
24 }
```

If you need to save more than one type of variables, I will suggest you to build a new byte array and use `memcpy()` to copy values.

```

1  Byte byte[15];
2  int v1 = 0;
3  float v2 = 0;
4  bool v3 = true;
5  uint16_t v4 = 0;
6  char v5 = '';
7  char* v6 = "hi";
8
9  //retriving stored data here
10 flash.Read(byte,15);
11 memcpy(v1,byte,4);
12 memcpy(v2,byte+4,4);
13 memcpy(v3,byte+8,1);
14 memcpy(v4,byte+9,2);
15 memcpy(v5,byte+11,1);
16 memcpy(v6,byte+12,3);
17
18 //saving data
19 memcpy(byte,v1,4);
20 memcpy(byte+4,v2,4);
21 memcpy(byte+8,v3,1);
22 memcpy(byte+9,v4,2);
23 memcpy(byte+11,v5,1);
24 memcpy(byte+12,v6,3);
25 flash.Write(byte,15);

```

To ensure the data is not `nan`, you can use `==` operator.

```

1  if(variable==variable){
2      //this variable is a number
3  }
4  else{
5      //this varialbe is not a number
6  }

```