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\*/

#if defined(ARDUINO\_ARCH\_SAM)

#include <Arduino.h>

#include <Servo.h>

#define usToTicks(\_us) (( clockCyclesPerMicrosecond() \* \_us) / 32) // converts microseconds to ticks

#define ticksToUs(\_ticks) (( (unsigned)\_ticks \* 32)/ clockCyclesPerMicrosecond() ) // converts from ticks back to microseconds

#define TRIM\_DURATION 2 // compensation ticks to trim adjust for digitalWrite delays

static servo\_t servos[MAX\_SERVOS]; // static array of servo structures

uint8\_t ServoCount = 0; // the total number of attached servos

static volatile int8\_t Channel[\_Nbr\_16timers ]; // counter for the servo being pulsed for each timer (or -1 if refresh interval)

// convenience macros

#define SERVO\_INDEX\_TO\_TIMER(\_servo\_nbr) ((timer16\_Sequence\_t)(\_servo\_nbr / SERVOS\_PER\_TIMER)) // returns the timer controlling this servo

#define SERVO\_INDEX\_TO\_CHANNEL(\_servo\_nbr) (\_servo\_nbr % SERVOS\_PER\_TIMER) // returns the index of the servo on this timer

#define SERVO\_INDEX(\_timer,\_channel) ((\_timer\*SERVOS\_PER\_TIMER) + \_channel) // macro to access servo index by timer and channel

#define SERVO(\_timer,\_channel) (servos[SERVO\_INDEX(\_timer,\_channel)]) // macro to access servo class by timer and channel

#define SERVO\_MIN() (MIN\_PULSE\_WIDTH - this->min \* 4) // minimum value in us for this servo

#define SERVO\_MAX() (MAX\_PULSE\_WIDTH - this->max \* 4) // maximum value in us for this servo

/\*\*\*\*\*\*\*\*\*\*\*\* static functions common to all instances \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

//------------------------------------------------------------------------------

/// Interrupt handler for the TC0 channel 1.

//------------------------------------------------------------------------------

void Servo\_Handler(timer16\_Sequence\_t timer, Tc \*pTc, uint8\_t channel);

#if defined (\_useTimer1)

void HANDLER\_FOR\_TIMER1(void) {

Servo\_Handler(\_timer1, TC\_FOR\_TIMER1, CHANNEL\_FOR\_TIMER1);

}

#endif

#if defined (\_useTimer2)

void HANDLER\_FOR\_TIMER2(void) {

Servo\_Handler(\_timer2, TC\_FOR\_TIMER2, CHANNEL\_FOR\_TIMER2);

}

#endif

#if defined (\_useTimer3)

void HANDLER\_FOR\_TIMER3(void) {

Servo\_Handler(\_timer3, TC\_FOR\_TIMER3, CHANNEL\_FOR\_TIMER3);

}

#endif

#if defined (\_useTimer4)

void HANDLER\_FOR\_TIMER4(void) {

Servo\_Handler(\_timer4, TC\_FOR\_TIMER4, CHANNEL\_FOR\_TIMER4);

}

#endif

#if defined (\_useTimer5)

void HANDLER\_FOR\_TIMER5(void) {

Servo\_Handler(\_timer5, TC\_FOR\_TIMER5, CHANNEL\_FOR\_TIMER5);

}

#endif

void Servo\_Handler(timer16\_Sequence\_t timer, Tc \*tc, uint8\_t channel)

{

// clear interrupt

tc->TC\_CHANNEL[channel].TC\_SR;

if (Channel[timer] < 0) {

tc->TC\_CHANNEL[channel].TC\_CCR |= TC\_CCR\_SWTRG; // channel set to -1 indicated that refresh interval completed so reset the timer

} else {

if (SERVO\_INDEX(timer,Channel[timer]) < ServoCount && SERVO(timer,Channel[timer]).Pin.isActive == true) {

digitalWrite(SERVO(timer,Channel[timer]).Pin.nbr, LOW); // pulse this channel low if activated

}

}

Channel[timer]++; // increment to the next channel

if( SERVO\_INDEX(timer,Channel[timer]) < ServoCount && Channel[timer] < SERVOS\_PER\_TIMER) {

tc->TC\_CHANNEL[channel].TC\_RA = tc->TC\_CHANNEL[channel].TC\_CV + SERVO(timer,Channel[timer]).ticks;

if(SERVO(timer,Channel[timer]).Pin.isActive == true) { // check if activated

digitalWrite( SERVO(timer,Channel[timer]).Pin.nbr,HIGH); // it's an active channel so pulse it high

}

}

else {

// finished all channels so wait for the refresh period to expire before starting over

if( (tc->TC\_CHANNEL[channel].TC\_CV) + 4 < usToTicks(REFRESH\_INTERVAL) ) { // allow a few ticks to ensure the next OCR1A not missed

tc->TC\_CHANNEL[channel].TC\_RA = (unsigned int)usToTicks(REFRESH\_INTERVAL);

}

else {

tc->TC\_CHANNEL[channel].TC\_RA = tc->TC\_CHANNEL[channel].TC\_CV + 4; // at least REFRESH\_INTERVAL has elapsed

}

Channel[timer] = -1; // this will get incremented at the end of the refresh period to start again at the first channel

}

}

static void \_initISR(Tc \*tc, uint32\_t channel, uint32\_t id, IRQn\_Type irqn)

{

pmc\_enable\_periph\_clk(id);

TC\_Configure(tc, channel,

TC\_CMR\_TCCLKS\_TIMER\_CLOCK3 | // MCK/32

TC\_CMR\_WAVE | // Waveform mode

TC\_CMR\_WAVSEL\_UP\_RC ); // Counter running up and reset when equals to RC

/\* 84 MHz, MCK/32, for 1.5 ms: 3937 \*/

TC\_SetRA(tc, channel, 2625); // 1ms

/\* Configure and enable interrupt \*/

NVIC\_EnableIRQ(irqn);

// TC\_IER\_CPAS: RA Compare

tc->TC\_CHANNEL[channel].TC\_IER = TC\_IER\_CPAS;

// Enables the timer clock and performs a software reset to start the counting

TC\_Start(tc, channel);

}

static void initISR(timer16\_Sequence\_t timer)

{

#if defined (\_useTimer1)

if (timer == \_timer1)

\_initISR(TC\_FOR\_TIMER1, CHANNEL\_FOR\_TIMER1, ID\_TC\_FOR\_TIMER1, IRQn\_FOR\_TIMER1);

#endif

#if defined (\_useTimer2)

if (timer == \_timer2)

\_initISR(TC\_FOR\_TIMER2, CHANNEL\_FOR\_TIMER2, ID\_TC\_FOR\_TIMER2, IRQn\_FOR\_TIMER2);

#endif

#if defined (\_useTimer3)

if (timer == \_timer3)

\_initISR(TC\_FOR\_TIMER3, CHANNEL\_FOR\_TIMER3, ID\_TC\_FOR\_TIMER3, IRQn\_FOR\_TIMER3);

#endif

#if defined (\_useTimer4)

if (timer == \_timer4)

\_initISR(TC\_FOR\_TIMER4, CHANNEL\_FOR\_TIMER4, ID\_TC\_FOR\_TIMER4, IRQn\_FOR\_TIMER4);

#endif

#if defined (\_useTimer5)

if (timer == \_timer5)

\_initISR(TC\_FOR\_TIMER5, CHANNEL\_FOR\_TIMER5, ID\_TC\_FOR\_TIMER5, IRQn\_FOR\_TIMER5);

#endif

}

static void finISR(timer16\_Sequence\_t timer)

{

#if defined (\_useTimer1)

TC\_Stop(TC\_FOR\_TIMER1, CHANNEL\_FOR\_TIMER1);

#endif

#if defined (\_useTimer2)

TC\_Stop(TC\_FOR\_TIMER2, CHANNEL\_FOR\_TIMER2);

#endif

#if defined (\_useTimer3)

TC\_Stop(TC\_FOR\_TIMER3, CHANNEL\_FOR\_TIMER3);

#endif

#if defined (\_useTimer4)

TC\_Stop(TC\_FOR\_TIMER4, CHANNEL\_FOR\_TIMER4);

#endif

#if defined (\_useTimer5)

TC\_Stop(TC\_FOR\_TIMER5, CHANNEL\_FOR\_TIMER5);

#endif

}

static boolean isTimerActive(timer16\_Sequence\_t timer)

{

// returns true if any servo is active on this timer

for(uint8\_t channel=0; channel < SERVOS\_PER\_TIMER; channel++) {

if(SERVO(timer,channel).Pin.isActive == true)

return true;

}

return false;

}

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* end of static functions \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

Servo::Servo()

{

if (ServoCount < MAX\_SERVOS) {

this->servoIndex = ServoCount++; // assign a servo index to this instance

servos[this->servoIndex].ticks = usToTicks(DEFAULT\_PULSE\_WIDTH); // store default values

} else {

this->servoIndex = INVALID\_SERVO; // too many servos

}

}

uint8\_t Servo::attach(int pin)

{

return this->attach(pin, MIN\_PULSE\_WIDTH, MAX\_PULSE\_WIDTH);

}

uint8\_t Servo::attach(int pin, int min, int max)

{

timer16\_Sequence\_t timer;

if (this->servoIndex < MAX\_SERVOS) {

pinMode(pin, OUTPUT); // set servo pin to output

servos[this->servoIndex].Pin.nbr = pin;

// todo min/max check: abs(min - MIN\_PULSE\_WIDTH) /4 < 128

this->min = (MIN\_PULSE\_WIDTH - min)/4; //resolution of min/max is 4 us

this->max = (MAX\_PULSE\_WIDTH - max)/4;

// initialize the timer if it has not already been initialized

timer = SERVO\_INDEX\_TO\_TIMER(servoIndex);

if (isTimerActive(timer) == false) {

initISR(timer);

}

servos[this->servoIndex].Pin.isActive = true; // this must be set after the check for isTimerActive

}

return this->servoIndex;

}

void Servo::detach()

{

timer16\_Sequence\_t timer;

servos[this->servoIndex].Pin.isActive = false;

timer = SERVO\_INDEX\_TO\_TIMER(servoIndex);

if(isTimerActive(timer) == false) {

finISR(timer);

}

}

void Servo::write(int value)

{

// treat values less than 544 as angles in degrees (valid values in microseconds are handled as microseconds)

if (value < MIN\_PULSE\_WIDTH)

{

if (value < 0)

value = 0;

else if (value > 180)

value = 180;

value = map(value, 0, 180, SERVO\_MIN(), SERVO\_MAX());

}

writeMicroseconds(value);

}

void Servo::writeMicroseconds(int value)

{

// calculate and store the values for the given channel

byte channel = this->servoIndex;

if( (channel < MAX\_SERVOS) ) // ensure channel is valid

{

if (value < SERVO\_MIN()) // ensure pulse width is valid

value = SERVO\_MIN();

else if (value > SERVO\_MAX())

value = SERVO\_MAX();

value = value - TRIM\_DURATION;

value = usToTicks(value); // convert to ticks after compensating for interrupt overhead

servos[channel].ticks = value;

}

}

int Servo::read() // return the value as degrees

{

return map(readMicroseconds()+1, SERVO\_MIN(), SERVO\_MAX(), 0, 180);

}

int Servo::readMicroseconds()

{

unsigned int pulsewidth;

if (this->servoIndex != INVALID\_SERVO)

pulsewidth = ticksToUs(servos[this->servoIndex].ticks) + TRIM\_DURATION;

else

pulsewidth = 0;

return pulsewidth;

}

bool Servo::attached()

{

return servos[this->servoIndex].Pin.isActive;

}

#endif // ARDUINO\_ARCH\_SAM