

**Simulavr**

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## 1 Simulavr Internals

### 1.1 Introduction

This chapter documents the internals of simulavr for those wishing to work with the source code to fix bugs, add features, or to just see how it all works. If you only wish to know how to use simulavr, you don't need to read this.

Internals Topics:

- [Memory Management](#)
- [Objects](#)
- [Instruction Decoder](#)
- [Interrupts](#)
- [Virtual Devices](#)
- [External Devices](#)
- [Breakpoints and Watchpoints](#)

## 2 Memory Management

Every program ever written has had to deal with memory management. Simulavr is no exception. For portability and to potentially aid in memory debugging, simulavr supplies it's own functions and macros for handling the allocation and releasing of memory resources.

For memory which could be used by many differing parts of the simulator, an object referencing system has been implemented (see [Objects](#)).

### 2.1 Memory Functions

The following functions provide wrappers for all library functions that return memory which simulavr must manage.

- [avr\\_malloc\(\)](#)

- [avr\\_malloc0\(\)](#)
- [avr\\_realloc\(\)](#)
- [avr\\_strdup\(\)](#)
- [avr\\_free\(\)](#)

All functions which return allocated memory will only return if the allocation was successful. If the allocation failed, an error message is issued and the program is aborted. Thus, the developer does not need write any code to check the returned value.

## 2.2 Memory Macros

The following C-preprocessor macro definitions are provided for convenience and should be used instead of the underlying functions. These macros relieve the programmer from having to perform manual type-casting thus making the code easier to read.

- [avr\\_new\(\)](#)
- [avr\\_new0\(\)](#)
- [avr\\_renew\(\)](#)

## 3 Objects

Simulavr uses a simple object oriented system for handling the data structure creation and destruction. Since simulavr is written in C, a class system must be manually implemented and the basis for this class system is the `AvrClass` structure. All higher level structures are ultimately based on the `AvrClass` structure.

How the `AvrClass` structure is defined is not as import as how it is used as a base or parent class structure. A concrete example of simulavr's object system will be discussed (see [Derived Class Example](#)), but before jumping into the example, the `AvrClass` method functions will be introduced.

### 3.1 AvrClass Methods

The following functions provide the user interfaces to the `AvrClass` structure.

- [class\\_new\(\)](#)
- [class\\_construct\(\)](#)

- `class_destroy()`
- `class_overload_destroy()`
- `class_ref()`
- `class_unref()`

All classes must provide their own creation function, `<class>_new()`. The purpose of the creation function is to:

- Allocate memory for the class's data structure.
- Call `class_overload_destroy()` to install the class's own destroy method.
- Call the class's constructor method to fill in the data structure information.

### 3.2 Derived Class Example

Simulavr's inheritance mechanism is a little more complicated than that of C++, but is still relatively easy to use once it is understood. An example should make it clear how the system works.

First we need to create some objects. Assume that we need to add two new objects to simulavr, `foo` and `bar`. To keep things simple, they are both integers. Another requirement is that any time we need to access a `foo`, we'll also need to access a `bar`, but sometimes we only need a `bar` without a `foo`. Thus, we will have a class hierarchy `FooClass->BarClass->AvrClass`, or `FooClass` derives from `BarClass` which derives from `AvrClass`. To achieve this, we create the following two data structures:

```
// Define BarClass with AvrClass as parent

typedef struct _BarClass BarClass;
struct _BarClass {
    AvrClass parent;
    int      bar;
};

// Define FooClass with BarClass as parent

typedef struct _FooClass FooClass;
struct _FooClass {
    BarClass parent;
    int      foo;
};
```

Notice that in both struct definitions, the parent element is not a pointer. When you allocate memory for a `BarClass`, you automatically allocate memory for an `AvrClass`

at the same time. It's important that the parent is always the first element of any derived class structure.

The trick here is that once we have a class object, we can get at any object in it's class hierarchy with a simple type-cast.

```
void func( void )
{
    int num;
    FooClass *Foo = foo_new( 12, 21 );

    // get foo from FooClass
    num = Foo->foo;

    // get bar from BarClass
    num = ((BarClass *)Foo)->bar;

    class_unref( (AvrClass *)Foo );
}
```

Although the example above works, it assumes that the programmer knows what the FooClass and BarClass structures look like. The programmer has broken the encapsulation of both FooClass and BarClass objects. To solve this problem, we need to write method functions for both classes.

Here's the methods for BarClass:

```
// BarClass allocator
BarClass *bar_new( int bar )
{
    BarClass *bc;

    bc = avr_new( BarClass, 1 );
    bar_construct( bc, bar );
    class_overload_destroy( (AvrClass *)bc, bar_destroy );

    return bc;
}

// BarClass constructor
void bar_construct( BarClass *bc, int bar )
{
    class_construct( (AvrClass *)bc );
    bc->bar = bar;
}

// BarClass destructor
void bar_destroy( void *bc )
{
    if (bc == NULL)
        return;

    class_destroy( bc );
}
```

```
// BarClass public data access methods
int  bar_get_bar( BarClass *bc )          { return bc->bar; }
void bar_set_bar( BarClass *bc, int val ) { bc->bar = val; }
```

And here's the methods for FooClass :

```
// FooClass allocator
FooClass *foo_new( int foo, int bar )
{
    FooClass *fc;

    fc = avr_new( FooClass, 1 );
    foo_construct( fc, foo, bar );
    class_overload_destroy( (AvrClass *)fc, foo_destroy );

    return fc;
}

// FooClass constructor
void foo_construct( FooClass *fc, int foo, bar )
{
    bar_construct( (BarClass *)fc, bar );
    fc->foo = foo;
}

// FooClass destructor
void foo_destroy( void *fc )
{
    if (fc == NULL)
        return;

    class_destroy( fc );
}

// FooClass public data access methods

int  foo_get_foo( FooClass *fc )          { return fc->foo; }
void foo_set_foo( FooClass *fc, int val ) { fc->foo = val; }

int  foo_get_bar( FooClass *fc )
{
    return bar_get_bar( (BarClass *)fc );
}

void foo_set_bar( FooClass *fc, int val )
{
    bar_set_bar( (BarClass *)fc, val );
}
```

Take a good look at the \*\_new(), \*\_construct() and \*\_destroy() functions in the above examples and make sure you understand what's going on. Of particular importance is how the constructor and destructor functions are chained up along the various classes. This pattern is used extensively throughout the simulavr source code and once understood, makes some complicated concepts incredibly easy to implement.



Now that we have the method functions, we can rewrite our original example function without the broken encapsulation.

```
void func( void )
{
    int num;
    FooClass *Foo = foo_new( 12, 21 );

    num = foo_get_foo( Foo );
    num = foo_get_bar( Foo );

    class_unref( (AvrClass *)Foo );
}
```

Now that's better, but you might think that we are breaking encapsulation when we cast `Foo` to `AvrClass`. Well, in a way we are, but since *all* class objects *must* be derived from `AvrClass` either directly or indirectly, this is acceptable.

### 3.3 Object Referencing

You may have noticed by this point that we haven't called `avr_free()` to free the memory we allocated for our objects. We called `class_unref()` instead. This mechanism allows us to store many references to a single object without having to keep track of all of them.

The only thing we must do when we store a reference to an object in a new variable, is call `class_ref()` on the object. Then, when that stored reference is no longer needed, we simply call `class_unref()` on the object. Once the reference count reaches zero, the object's destroy method is automatically called for us. The only hard part for us is knowing when to ref and unref the object.

Here's an example from the `simulavr` code for callbacks:

```
void callback_construct( Callback *cb,
                        Callback_FP func,
                        AvrClass *data )
{
    if (cb == NULL)
        avr_error( "passed null ptr");

    class_construct( (AvrClass *)cb );

    cb->func = func;

    cb->data = data;
    class_ref( data );
}

void callback_destroy( void *cb )
{
    Callback *_cb = (Callback *)cb;
```

```
if (cb == NULL)
    return;

class_unref( _cb->data );

class_destroy( cb );
}
```

Notice that `data` is a pointer to `AvrClass` and thus can be any class defined by `simulavr`. `CallBack` is another class which happens to store a reference to `data` and must therefore call `class_ref()` on the `data` object. When the callback is destroyed (because the reference count reached zero), the callback destroy method calls `class_unref()` on the `data` object. It is assumed that the original reference to `data` still exists when the callback is created, but may or may not exist when the callback is destroyed.

## 4 Instruction Decoder

Instruction decoding and processing is implemented in the `decode.c` file.

The heart of the instruction decoder is the `decode_opcode()` function.

The `decode_opcode()` function examines the given opcode to determine which instruction applies and returns a pointer to a function to handle performing the instruction's operation. If the given opcode does not map to an instruction handler, `NULL` is returned indicating an invalid instruction.

Nearly every instruction in Atmel's Instruction Set Data Sheet will have a handler function defined. Each handler will perform all the operations described in the data sheet for a given instruction. A few instructions have synonyms. For example, `CBR` is a synonym for `ANDI`.

This should all be fairly straight forward.

## 5 Interrupts

**FIXME:** empty place holder

## 6 Virtual Devices

**FIXME:** empty place holder

## 7 External Devices

**FIXME:** empty place holder

## 8 Breakpoints and Watchpoints

Using gdb, it is possible to set breakpoints.

Watch points are not currently implemented.

**This is only an idea right now:** The way breakpoints are implemented within simulavr, it would be possible at init time to read a file containing breakpoint information. Then, as breakpoints are reached, have something happen which allows the user to check the state of the program. Anyone interested in implementing this, please step forward.

## 9 Todo List

Global [avr\\_core\\_run\(AvrCore \\*core\)](#) Should add some basic breakpoint handling here. Maybe allow continuing, and simple breakpoint management (disable, delete, set)

File [ports.c](#) Remove the pins argument and the mask field. That's handled at a higher level so is obsolete here now.

## 10 Deprecated List

Global [mem\\_get\\_vdevice\\_by\\_name\(Memory \\*mem, char \\*name\)](#)

## 11 File Index

### 11.1 File List

Here is a list of all documented files with brief descriptions:

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## 12 File Documentation

### 12.1 [adc.c](#) File Reference

Module to simulate the AVR's ADC module.

#### Functions

- VDevice \* [adc\\_int\\_create](#) (int addr, char \*name, int rel\_addr, void \*data)
- ADCIntr\_T \* [adc\\_intr\\_new](#) (int addr, char \*name, int rel\_addr)
- void [adc\\_intr\\_construct](#) (ADCIntr\_T \*adc, int addr, char \*name, int rel\_addr)
- void [adc\\_intr\\_destroy](#) (void \*adc)
- VDevice \* [adc\\_create](#) (int addr, char \*name, int rel\_addr, void \*data)
- ADC\_T \* [adc\\_new](#) (int addr, char \*name, uint8\_t uier, int rel\_addr)
- void [adc\\_construct](#) (ADC\_T \*adc, int addr, char \*name, uint8\_t uier, int rel\_addr)
- void [adc\\_destroy](#) (void \*adc)
- uint16\_t [adc\\_port\\_rd](#) (uint8\_t mux)
- void [adc\\_port\\_wr](#) (uint8\_t val)

#### 12.1.1 Detailed Description

Module to simulate the AVR's ADC module.

Definition in file [adc.c](#).

#### 12.1.2 Function Documentation

##### 12.1.2.1 VDevice\* [adc\\_int\\_create](#) ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new ADC interrupt.

Definition at line 79 of file [adc.c](#).

**12.1.2.2 void adc\_intr\_construct ( ADCIntr\_T \* *adc*, int *addr*, char \* *name*, int *rel\_addr* )**

Constructor for adc interrupt object.

Definition at line 99 of file adc.c.

References avr\_error, and vdev\_construct().

**12.1.2.3 void adc\_intr\_destroy ( void \* *adc* )**

Destructor for adc interrupt object.

Definition at line 138 of file adc.c.

References vdev\_destroy().

**12.1.2.4 VDevice\* adc\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )**

Allocate a new ADC structure.

Definition at line 292 of file adc.c.

References avr\_error.

**12.1.2.5 void adc\_construct ( ADC\_T \* *adc*, int *addr*, char \* *name*, uint8\_t *uier*, int *rel\_addr* )**

Constructor for ADC object.

Definition at line 318 of file adc.c.

References avr\_error, and vdev\_construct().

**12.1.2.6 void adc\_destroy ( void \* *adc* )**

Destructor for ADC object.

Definition at line 357 of file adc.c.

References `vdev_destroy()`.

## 12.2 avrclass.c File Reference

Methods to provide user interfaces to the `AvrClass` structure.

### Functions

- `AvrClass * class_new` (void)
- void `class_construct` (`AvrClass *klass`)
- void `class_destroy` (void \*`klass`)
- void `class_overload_destroy` (`AvrClass *klass`, `AvrClassFP_Destroy` `destroy`)
- void `class_ref` (`AvrClass *klass`)
- void `class_unref` (`AvrClass *klass`)

### 12.2.1 Detailed Description

Methods to provide user interfaces to the `AvrClass` structure. This module provides the basis for `simulavr`'s object mechanism. For a detailed discussion on using `simulavr`'s class mechanism, see the `simulavr` users manual. FIXME: [TRoth 2002/03/19] move the discussion here.

Definition in file `avrclass.c`.

### 12.2.2 Function Documentation

#### 12.2.2.1 `AvrClass* class_new ( void )`

This function should never be used.

The only potential use for it as a template for derived classes. Do Not Use This Function!

Definition at line 46 of file `avrclass.c`.

References `avr_new`, and `class_construct()`.

#### 12.2.2.2 `void class_construct ( AvrClass * klass )`

Initializes the `AvrClass` data structure.

A derived class should call this function from their own `<klass>_construct()` function. All classes should have their constructor function call their parent's constructor function.

Definition at line 61 of file `avrclass.c`.

References `avr_error`, `class_destroy()`, and `class_overload_destroy()`.

Referenced by `class_new()`, `mem_construct()`, `stack_construct()`, and `vdev_construct()`.

### 12.2.2.3 void class\_destroy ( void \* *klass* )

Releases resources allocated by class's `<klass>_new()` function.

This function should never be called except as the last statement of a directly derived class's destroy method. All classes should have their destroy method call their parent's destroy method.

Definition at line 78 of file `avrclass.c`.

References `avr_free()`.

Referenced by `avr_core_destroy()`, `class_construct()`, `mem_destroy()`, `stack_destroy()`, and `vdev_destroy()`.

### 12.2.2.4 void class\_overload\_destroy ( AvrClass \* *klass*, AvrClassFP\_Destroy *destroy* )

Overload the default destroy method.

Derived classes will call this to replace `class_destroy()` with their own destroy method.

Definition at line 92 of file `avrclass.c`.

References `avr_error`.

Referenced by `avr_core_new()`, `class_construct()`, `flash_new()`, `hwstack_new()`, `mem_new()`, `memstack_new()`, `stack_new()`, and `vdev_new()`.

### 12.2.2.5 void class\_ref ( AvrClass \* *klass* )

Increments the reference count for the `klass` object.

The programmer must call this whenever a reference to an object is stored in more than one place.



Definition at line 106 of file avrclass.c.

References `avr_error`.

Referenced by `mem_attach()`, and `memstack_construct()`.

#### 12.2.2.6 void class\_unref ( AvrClass \* klass )

Decrements the reference count for the klass object.

When the reference count reaches zero, the class's destroy method is called on the object.

Definition at line 120 of file avrclass.c.

References `avr_error`.

Referenced by `avr_core_destroy()`, `dlist_add()`, `dlist_delete()`, `dlist_delete_all()`, `mem_destroy()`, and `memstack_destroy()`.

## 12.3 avrcore.c File Reference

Module for the core AvrCore object, which is the AVR CPU to be simulated.

### Defines

- `#define BREAK_OPCODE 0x9598`

### Functions

- void `avr_core_dump_core` (AvrCore \*core, FILE \*f\_core)
- int `avr_core_load_program` (AvrCore \*core, char \*file, int format)
- int `avr_core_load_eeprom` (AvrCore \*core, char \*file, int format)

### AvrCore handling methods

- AvrCore \* `avr_core_new` (char \*dev\_name)
- void `avr_core_destroy` (void \*core)
- void `avr_core_get_sizes` (AvrCore \*core, int \*flash, int \*sram, int \*sram\_start, int \*eeprom)
- void `avr_core_attach_vdev` (AvrCore \*core, uint16\_t addr, char \*name, VDevice \*vdev, int flags, uint8\_t reset\_value, uint8\_t rd\_mask, uint8\_t wr\_mask)
- VDevice \* `avr_core_get_vdev_by_name` (AvrCore \*core, char \*name)
- VDevice \* `avr_core_get_vdev_by_addr` (AvrCore \*core, int addr)
- void `avr_core_set_state` (AvrCore \*core, StateType state)

- int [avr\\_core\\_get\\_state](#) (AvrCore \*core)
- void [avr\\_core\\_set\\_sleep\\_mode](#) (AvrCore \*core, int sleep\_mode)
- int [avr\\_core\\_get\\_sleep\\_mode](#) (AvrCore \*core)

### Program Memory Space Access Methods

### Data Memory Space Access Methods

### Status Register Access Methods

- int [avr\\_core\\_sreg\\_get\\_bit](#) (AvrCore \*core, int b)
- void [avr\\_core\\_sreg\\_set\\_bit](#) (AvrCore \*core, int b, int v)

### RAMPZ access methods

- uint8\_t [avr\\_core\\_rampz\\_get](#) (AvrCore \*core)
- void [avr\\_core\\_rampz\\_set](#) (AvrCore \*core, uint8\_t v)

### Direct I/O Register Access Methods

*IO Registers are mapped in memory directly after the 32 (0x20) general registers.*

- void [avr\\_core\\_io\\_display\\_names](#) (AvrCore \*core)
- uint8\_t [avr\\_core\\_io\\_read](#) (AvrCore \*core, int reg)
- void [avr\\_core\\_io\\_write](#) (AvrCore \*core, int reg, uint8\_t val)

### Stack Methods

- uint32\_t [avr\\_core\\_stack\\_pop](#) (AvrCore \*core, int bytes)
- void [avr\\_core\\_stack\\_push](#) (AvrCore \*core, int bytes, uint32\_t val)

### Program Counter Methods

- int32\_t [avr\\_core\\_PC\\_size](#) (AvrCore \*core)
- void [avr\\_core\\_PC\\_incr](#) (AvrCore \*core, int val)

### Methods for accessing CK and instruction Clocks

- uint64\_t [avr\\_core\\_CK\\_get](#) (AvrCore \*core)
- void [avr\\_core\\_CK\\_incr](#) (AvrCore \*core)
- int [avr\\_core\\_inst\\_CKS\\_get](#) (AvrCore \*core)
- void [avr\\_core\\_inst\\_CKS\\_set](#) (AvrCore \*core, int val)

### Interrupt Access Methods.

- IntVect \* [avr\\_core\\_irq\\_get\\_pending](#) (AvrCore \*core)
- void [avr\\_core\\_irq\\_raise](#) (AvrCore \*core, unsigned int irq)

- void [avr\\_core\\_irq\\_clear](#) (AvrCore \*core, IntVect \*irq)
- void [avr\\_core\\_irq\\_clear\\_all](#) (AvrCore \*core)

#### Break point access methods.

- void [avr\\_core\\_insert\\_breakpoint](#) (AvrCore \*core, int pc)
- void [avr\\_core\\_remove\\_breakpoint](#) (AvrCore \*core, int pc)
- void [avr\\_core\\_disable\\_breakpoints](#) (AvrCore \*core)
- void [avr\\_core\\_enable\\_breakpoints](#) (AvrCore \*core)

#### Program control methods

- int [avr\\_core\\_step](#) (AvrCore \*core)
- void [avr\\_core\\_run](#) (AvrCore \*core)
- void [avr\\_core\\_reset](#) (AvrCore \*core)

#### Callback Handling Methods

- void [avr\\_core\\_add\\_ext\\_rd\\_wr](#) (AvrCore \*core, int addr, PortFP\_ExtRd ext\_rd, PortFP\_ExtWr ext\_wr)
- void [avr\\_core\\_clk\\_cb\\_add](#) (AvrCore \*core, Callback \*cb)
- void [avr\\_core\\_async\\_cb\\_add](#) (AvrCore \*core, Callback \*cb)
- void [avr\\_core\\_clk\\_cb\\_exec](#) (AvrCore \*core)
- void [avr\\_core\\_async\\_cb\\_exec](#) (AvrCore \*core)

#### Variables

- int [global\\_debug\\_inst\\_output](#) = 0

#### 12.3.1 Detailed Description

Module for the core AvrCore object, which is the AVR CPU to be simulated.

Definition in file [avrcore.c](#).

#### 12.3.2 Function Documentation

##### 12.3.2.1 AvrCore\* [avr\\_core\\_new](#) ( char \* *dev\_name* )

Allocate a new AvrCore object.

Definition at line 355 of file [avrcore.c](#).

References [avr\\_core\\_destroy\(\)](#), [avr\\_new](#), [class\\_overload\\_destroy\(\)](#), and [dev\\_supp\\_lookup\\_device\(\)](#).

### 12.3.2.2 void avr\_core\_destroy ( void \* *core* )

Destructor for the AvrCore class.

Not to be called directly, except by a derived class. Called via class\_unref.

Definition at line 549 of file avrcore.c.

References class\_destroy(), class\_unref(), and dlist\_delete\_all().

Referenced by avr\_core\_new().

### 12.3.2.3 void avr\_core\_get\_sizes ( AvrCore \* *core*, int \* *flash*, int \* *sram*, int \* *sram\_start*, int \* *eeprom* )

Query the sizes of the 3 memory spaces: flash, sram, and eeprom.

Definition at line 572 of file avrcore.c.

References flash\_get\_size().

### 12.3.2.4 void avr\_core\_attach\_vdev ( AvrCore \* *core*, uint16\_t *addr*, char \* *name*, VDevice \* *vdev*, int *flags*, uint8\_t *reset\_value*, uint8\_t *rd\_mask*, uint8\_t *wr\_mask* )

Attach a virtual device into the Memory.

### 12.3.2.5 VDevice\* avr\_core\_get\_vdev\_by\_name ( AvrCore \* *core*, char \* *name* )

Returns the VDevice with the name *name*.

### 12.3.2.6 VDevice\* avr\_core\_get\_vdev\_by\_addr ( AvrCore \* *core*, int *addr* )

Returns the VDevice which handles the address *addr*.

**12.3.2.7 void avr\_core\_set\_state ( AvrCore \* core, StateType state )**

Sets the device's state (running, stopped, breakpoint, sleep).

**12.3.2.8 int avr\_core\_get\_state ( AvrCore \* core )**

Returns the device's state (running, stopped, breakpoint, sleep).

Referenced by avr\_core\_step().

**12.3.2.9 void avr\_core\_set\_sleep\_mode ( AvrCore \* core, int sleep\_mode )**

Sets the device to a sleep state.

**Parameters**

<i>core</i>	Pointer to the core.
<i>sleep_mode</i>	The BITNUMBER of the sleepstate.

**12.3.2.10 int avr\_core\_get\_sleep\_mode ( AvrCore \* core )**

Return the device's sleepmode.

**12.3.2.11 int avr\_core\_sreg\_get\_bit ( AvrCore \* core, int b )**

Get the value of bit *b* of the status register.

**12.3.2.12 void avr\_core\_sreg\_set\_bit ( AvrCore \* core, int b, int v )**

Set the value of bit *b* of the status register.

**12.3.2.13 uint8\_t avr\_core\_rampz\_get ( AvrCore \* core )**

Get the value of the rampz register.

**12.3.2.14 void avr\_core\_rampz\_set ( AvrCore \* core, uint8\_t v )**

Set the value of the rampz register.

**12.3.2.15 void avr\_core\_io\_display\_names ( AvrCore \* core )**

Displays all registers.

Definition at line 733 of file avrcore.c.

References [display\\_io\\_reg\\_name\(\)](#), and [mem\\_io\\_fetch\(\)](#).

**12.3.2.16 uint8\_t avr\_core\_io\_read ( AvrCore \* core, int reg )**

Reads the value of a register.

**Parameters**

<i>core</i>	Pointer to the core.
<i>reg</i>	The registers address. This address is counted above the beginning of the registers memory block (0x20).

**12.3.2.17 void avr\_core\_io\_write ( AvrCore \* core, int reg, uint8\_t val )**

Writes the value of a register. See [avr\\_core\\_io\\_read\(\)](#) for a discussion of *reg*.

**12.3.2.18 uint32\_t avr\_core\_stack\_pop ( AvrCore \* core, int bytes )**

Pop 1-4 bytes off of the stack.

See [stack\\_pop\(\)](#) for more details.

**12.3.2.19 void avr\_core\_stack\_push ( AvrCore \* *core*, int *bytes*, uint32\_t *val* )**

Push 1-4 bytes onto the stack.

See [stack\\_push\(\)](#) for more details.

**12.3.2.20 int32\_t avr\_core\_PC\_size ( AvrCore \* *core* )**

Returns the size of the Program Counter in bytes.

Most devices have a 16-bit PC (2 bytes), but some larger ones (e.g. mega256), have a 22-bit PC (3 bytes).

**12.3.2.21 void avr\_core\_PC\_incr ( AvrCore \* *core*, int *val* )**

Increment the Program Counter by *val*.

*val* can be either positive or negative.

If the result of the increment is outside the valid range for PC, it is adjusted to fall in the valid range. This allows addresses to wrap around the end of the insn space.

**12.3.2.22 uint64\_t avr\_core\_CK\_get ( AvrCore \* *core* )**

Get the current clock counter.

Referenced by `avr_core_run()`.

**12.3.2.23 void avr\_core\_CK\_incr ( AvrCore \* *core* )**

Increment the clock counter.

Referenced by `avr_core_step()`.

**12.3.2.24 int avr\_core\_inst\_CKS\_get ( AvrCore \* *core* )**

Get the number of clock cycles remaining for the currently executing instruction.

#### 12.3.2.25 void avr\_core\_inst\_CKS\_set ( AvrCore \* core, int val )

Set the number of clock cycles for the instruction being executed.

Referenced by avr\_core\_reset().

#### 12.3.2.26 IntVect\* avr\_core\_irq\_get\_pending ( AvrCore \* core )

Gets the first pending irq.

Definition at line 846 of file avrcore.c.

#### 12.3.2.27 void avr\_core\_irq\_raise ( AvrCore \* core, unsigned int irq )

Raises an irq by adding it's data to the irq\_pending list.

Definition at line 854 of file avrcore.c.

References avr\_message.

#### 12.3.2.28 void avr\_core\_irq\_clear ( AvrCore \* core, IntVect \* irq )

Calls the interrupt's callback to clear the flag.

Definition at line 867 of file avrcore.c.

#### 12.3.2.29 void avr\_core\_irq\_clear\_all ( AvrCore \* core )

Removes all irqs from the irq\_pending list.

Referenced by avr\_core\_reset().

#### 12.3.2.30 void avr\_core\_insert\_breakpoint ( AvrCore \* core, int pc )



Inserts a break point.

Definition at line 884 of file avrcore.c.

References `flash_read()`, and `flash_write()`.

#### 12.3.2.31 void avr\_core\_remove\_breakpoint ( AvrCore \* core, int pc )

Removes a break point.

Definition at line 898 of file avrcore.c.

References `flash_write()`.

#### 12.3.2.32 void avr\_core\_disable\_breakpoints ( AvrCore \* core )

Disable breakpoints.

Disables all breakpoints that where set using [avr\\_core\\_insert\\_breakpoint\(\)](#). The breakpoints are not removed from the breakpoint list.

Definition at line 955 of file avrcore.c.

#### 12.3.2.33 void avr\_core\_enable\_breakpoints ( AvrCore \* core )

Enable breakpoints.

Enables all breakpoints that where previous disabled.

Definition at line 968 of file avrcore.c.

#### 12.3.2.34 int avr\_core\_step ( AvrCore \* core )

Process a single program instruction, all side effects and peripheral stimuli.

Executes instructions, calls callbacks, and checks for interrupts.

Definition at line 1093 of file avrcore.c.

References `avr_core_async_cb_exec()`, `avr_core_CK_incr()`, `avr_core_clk_cb_exec()`, and `avr_core_get_state()`.

Referenced by `avr_core_run()`.

**12.3.2.35 void avr\_core\_run ( AvrCore \* core )**

Start the processing of instructions by the simulator.

The simulated device will run until one of the following occurs:

- The state of the core is no longer STATE\_RUNNING.
- The simulator receives a SIGINT signal.
- A breakpoint is reached (currently causes core to stop running).
- A fatal internal error occurs.

**Note**

When running simulavr in gdb server mode, this function is not used. The [avr\\_core\\_step\(\)](#) function is called repeatedly in a loop when the continue command is issued from gdb. As such, the functionality in this loop should be kept to a minimum.

**Todo**

Should add some basic breakpoint handling here. Maybe allow continuing, and simple breakpoint management (disable, delete, set)

Definition at line 1150 of file avrcore.c.

References [avr\\_core\\_CK\\_get\(\)](#), [avr\\_core\\_reset\(\)](#), [avr\\_core\\_step\(\)](#), [avr\\_message](#), [get\\_program\\_time\(\)](#), [signal\\_has\\_occurred\(\)](#), [signal\\_watch\\_start\(\)](#), and [signal\\_watch\\_stop\(\)](#).

**12.3.2.36 void avr\_core\_reset ( AvrCore \* core )**

Sets the simulated CPU back to its initial state.

Zeroes out PC, IRQ's, clock, and memory.

Definition at line 1204 of file avrcore.c.

References [avr\\_core\\_inst\\_CKS\\_set\(\)](#), [avr\\_core\\_irq\\_clear\\_all\(\)](#), [display\\_clock\(\)](#), and [mem\\_reset\(\)](#).

Referenced by [avr\\_core\\_run\(\)](#).

**12.3.2.37 void avr\_core\_add\_ext\_rd\_wr ( AvrCore \* core, int addr, PortFP\_ExtRd ext\_rd, PortFP\_ExtWr ext\_wr )**

For adding external read and write callback functions.

rd and wr should come in pairs, but it is safe to add empty function via passing a NULL pointer for either function.

#### Parameters

<i>core</i>	A pointer to an AvrCore object.
<i>port_id</i>	The ID for handling the simulavr inheritance model.
<i>ext_rd</i>	Function for the device core to call when it needs to communicate with the external world via I/O Ports.
<i>ext_wr</i>	Function for the device core to call when it needs to communicate with the external world via I/O Ports.

Definition at line 1244 of file avrcore.c.

References avr\_warning, mem\_get\_vdevice\_by\_addr(), and port\_add\_ext\_rd\_wr().

#### 12.3.2.38 void avr\_core\_clk\_cb\_add ( AvrCore \* core, Callback \* cb )

Add a new clock callback to list.

#### 12.3.2.39 void avr\_core\_async\_cb\_add ( AvrCore \* core, Callback \* cb )

Add a new asynchronous callback to list.

#### 12.3.2.40 void avr\_core\_clk\_cb\_exec ( AvrCore \* core )

Run all the callbacks in the list.

If a callback returns non-zero (true), then it is done with it's job and wishes to be removed from the list.

The time argument has dual meaning. If the callback list is for the clock callbacks, time is the value of the CK clock counter. If the callback list is for the asynchronous callback, time is the number of milliseconds from some unknown, arbitrary time on the host system.

Referenced by avr\_core\_step().

**12.3.2.41 void avr\_core\_async\_cb\_exec ( AvrCore \* *core* )**

Run all the asynchronous callbacks.

Referenced by avr\_core\_step().

**12.3.2.42 void avr\_core\_dump\_core ( AvrCore \* *core*, FILE \* *f\_core* )**

Dump the contents of the entire CPU core.

**Parameters**

<i>core</i>	A pointer to an AvrCore object.
<i>f_core</i>	An open file descriptor.

Definition at line 1294 of file avrcore.c.

References flash\_dump\_core(), and mem\_dump\_core().

**12.3.2.43 int avr\_core\_load\_program ( AvrCore \* *core*, char \* *file*, int *format* )**

Load a program from an input file.

Definition at line 1307 of file avrcore.c.

References flash\_load\_from\_file().

**12.3.2.44 int avr\_core\_load\_eeprom ( AvrCore \* *core*, char \* *file*, int *format* )**

Load a program from an input file.

Definition at line 1314 of file avrcore.c.

References mem\_get\_vdevice\_by\_name().

**12.3.3 Variable Documentation****12.3.3.1 int global\_debug\_inst\_output = 0**

Flag for enabling output of instruction debug messages.

Definition at line 64 of file avrcore.c.

## 12.4 avrerror.c File Reference

Functions for printing messages, warnings and errors.

### Defines

- #define [avr\\_message](#)(fmt, args...) private\_avr\_message(\_\_FILE\_\_, \_\_LINE\_\_, fmt, ## args)
- #define [avr\\_warning](#)(fmt, args...) private\_avr\_warning(\_\_FILE\_\_, \_\_LINE\_\_, fmt, ## args)
- #define [avr\\_error](#)(fmt, args...) private\_avr\_error(\_\_FILE\_\_, \_\_LINE\_\_, fmt, ## args)

### 12.4.1 Detailed Description

Functions for printing messages, warnings and errors. This module provides output printing facilities.

Definition in file [avrerror.c](#).

### 12.4.2 Define Documentation

#### 12.4.2.1 #define avr\_message( *fmt*, *args...* ) private\_avr\_message(\_\_FILE\_\_, \_\_LINE\_\_, *fmt*, ## args)

Print an ordinary message to stdout.

Definition at line 42 of file avrerror.c.

Referenced by avr\_core\_irq\_raise(), avr\_core\_run(), and decode\_init\_lookup\_table().

#### 12.4.2.2 #define avr\_warning( *fmt*, *args...* ) private\_avr\_warning(\_\_FILE\_\_, \_\_LINE\_\_, *fmt*, ## args)

Print a warning message to stderr.

Definition at line 46 of file avrerror.c.

Referenced by `avr_core_add_ext_rd_wr()`, `display_open()`, `display_send_msg()`, `flash_load_from_file()`, `mem_read()`, `mem_write()`, `signal_has_occurred()`, `signal_watch_start()`, `signal_watch_stop()`, `vdev_add_addr()`, and `vdev_def_AddAddr()`.

#### 12.4.2.3 `#define avr_error( fmt, args... ) private_avr_error(__FILE__, __LINE__, fmt, ## args)`

Print an error message to `stderr` and terminate program.

Definition at line 50 of file `avrerror.c`.

Referenced by `adc_construct()`, `adc_create()`, `adc_intr_construct()`, `avr_malloc()`, `avr_malloc0()`, `avr_realloc()`, `avr_strdup()`, `class_construct()`, `class_overload_destroy()`, `class_ref()`, `class_unref()`, `display_eeprom()`, `display_flash()`, `display_send_msg()`, `display_sram()`, `dlist_delete()`, `dlist_iterator()`, `dlist_lookup()`, `flash_construct()`, `gdb_interact()`, `get_program_time()`, `hwstack_construct()`, `mem_attach()`, `mem_construct()`, `mem_get_vdevice_by_name()`, `memstack_construct()`, `ocreg16_construct()`, `ocreg16_create()`, `spi_construct()`, `spi_intr_construct()`, `stack_construct()`, `timer0_construct()`, `timer16_construct()`, `timer16_create()`, `timer_int_create()`, `timer_intr_construct()`, `uart_construct()`, `uart_int_create()`, `uart_intr_construct()`, `usb_construct()`, `usb_intr_construct()`, `usbi_create()`, and `vdev_construct()`.

## 12.5 avrmalloc.c File Reference

Memory Management Functions.

### Defines

- `#define avr_new(type, count) ((type *) avr_malloc ((unsigned) sizeof (type) * (count)))`
- `#define avr_new0(type, count) ((type *) avr_malloc0 ((unsigned) sizeof (type) * (count)))`
- `#define avr_renew(type, mem, count) ((type *) avr_realloc (mem, (unsigned) sizeof (type) * (count)))`

### Functions

- `void * avr_malloc (size_t size)`
- `void * avr_malloc0 (size_t size)`
- `void * avr_realloc (void *ptr, size_t size)`
- `char * avr_strdup (const char *s)`
- `void avr_free (void *ptr)`

### 12.5.1 Detailed Description

Memory Management Functions. This module provides facilities for managing memory.

There is no need to check the returned values from any of these functions. Any memory allocation failure is considered fatal and the program is terminated.

We want to wrap all functions that allocate memory. This way we can add secret code to track memory usage and debug memory leaks if we want. Right now, I don't want to ;).

Definition in file [avrmalloc.c](#).

### 12.5.2 Define Documentation

**12.5.2.1** `#define avr_new( type, count ) ((type *) avr_malloc ((unsigned) sizeof (type) * (count)))`

Macro for allocating memory.

#### Parameters

<i>type</i>	The C type of the memory to allocate.
<i>count</i>	Allocate enough memory hold count types.

This macro is just a wrapper for [avr\\_malloc\(\)](#) and should be used to avoid the repetitive task of casting the returned pointer.

Definition at line 57 of file [avrmalloc.c](#).

Referenced by [avr\\_core\\_new\(\)](#), [class\\_new\(\)](#), [flash\\_new\(\)](#), [hwstack\\_new\(\)](#), [memstack\\_new\(\)](#), and [stack\\_new\(\)](#).

**12.5.2.2** `#define avr_new0( type, count ) ((type *) avr_malloc0 ((unsigned) sizeof (type) * (count)))`

Macro for allocating memory and initializing it to zero.

#### Parameters

<i>type</i>	The C type of the memory to allocate.
<i>count</i>	Allocate enough memory hold count types.

This macro is just a wrapper for [avr\\_malloc0\(\)](#) and should be used to avoid the repetitive task of casting the returned pointer.

Definition at line 67 of file avrmalloc.c.

Referenced by [decode\\_init\\_lookup\\_table\(\)](#), [display\\_send\\_msg\(\)](#), [hwstack\\_construct\(\)](#), [mem\\_construct\(\)](#), [mem\\_new\(\)](#), and [vdev\\_new\(\)](#).

**12.5.2.3** `#define avr_renew( type, mem, count ) ((type *) avr_realloc (mem, (unsigned) sizeof (type) * (count)))`

Macro for allocating memory.

#### Parameters

<i>type</i>	The C type of the memory to allocate.
<i>mem</i>	Pointer to existing memory.
<i>count</i>	Allocate enough memory hold count types.

This macro is just a wrapper for [avr\\_malloc\(\)](#) and should be used to avoid the repetitive task of casting the returned pointer.

Definition at line 78 of file avrmalloc.c.

### 12.5.3 Function Documentation

#### 12.5.3.1 `void* avr_malloc ( size_t size )`

Allocate memory and initialize to zero.

Use the [avr\\_new\(\)](#) macro instead of this function.

There is no need to check the returned value, since this function will terminate the program if the memory allocation fails.

No memory is allocated if passed a size of zero.

Definition at line 93 of file avrmalloc.c.

References [avr\\_error](#).

#### 12.5.3.2 `void* avr_malloc0 ( size_t size )`

Allocate memory and initialize to zero.



Use the [avr\\_new0\(\)](#) macro instead of this function.

There is no need to check the returned value, since this function will terminate the program if the memory allocation fails.

No memory is allocated if passed a size of zero.

Definition at line 117 of file avrmalloc.c.

References [avr\\_error](#).

#### 12.5.3.3 void\* avr\_realloc ( void \* *ptr*, size\_t *size* )

Wrapper for realloc(). x Resizes and possibly allocates more memory for an existing memory block.

Use the [avr\\_renew\(\)](#) macro instead of this function.

There is no need to check the returned value, since this function will terminate the program if the memory allocation fails.

No memory is allocated if passed a size of zero.

Definition at line 143 of file avrmalloc.c.

References [avr\\_error](#).

#### 12.5.3.4 char\* avr\_strdup ( const char \* *s* )

Wrapper for strdup().

Returns a copy of the passed in string. The returned copy must be free'd.

There is no need to check the returned value, since this function will terminate the program if the memory allocation fails.

It is safe to pass a NULL pointer. No memory is allocated if a NULL is passed.

Definition at line 168 of file avrmalloc.c.

References [avr\\_error](#).

#### 12.5.3.5 void avr\_free ( void \* *ptr* )

Free malloc'd memory.

It is safe to pass a null pointer to this function.

Definition at line 187 of file avrmalloc.c.

Referenced by `class_destroy()`, `display_send_msg()`, `hwstack_destroy()`, and `mem_destroy()`.

## 12.6 decoder.c File Reference

Module for handling opcode decoding.

### Enumerations

- enum `decoder_operand_masks` {  
    `mask_Rd_2` = 0x0030,  
    `mask_Rd_3` = 0x0070,  
    `mask_Rd_4` = 0x00f0,  
    `mask_Rd_5` = 0x01f0,  
    `mask_Rr_3` = 0x0007,  
    `mask_Rr_4` = 0x000f,  
    `mask_Rr_5` = 0x020f,  
    `mask_K_8` = 0x0F0F,  
    `mask_K_6` = 0x00CF,  
    `mask_k_7` = 0x03F8,  
    `mask_k_12` = 0x0FFF,  
    `mask_k_22` = 0x01F1,  
    `mask_reg_bit` = 0x0007,  
    `mask_sreg_bit` = 0x0070,  
    `mask_q_displ` = 0x2C07,  
    `mask_A_5` = 0x00F8,  
    `mask_A_6` = 0x060F }

### Functions

- int `avr_op_UNKNOWN` (AvrCore \*core, uint16\_t opcode, unsigned int arg1, unsigned int arg2)
- void `decode_init_lookup_table` (void)
- struct opcode\_info \* `decode_opcode` (uint16\_t opcode)

## Variables

- struct opcode\_info \* **global\_opcode\_lookup\_table**

### 12.6.1 Detailed Description

Module for handling opcode decoding. The heart of the instruction decoder is the [decode\\_opcode\(\)](#) function.

The [decode\\_opcode\(\)](#) function examines the given opcode to determine which instruction applies and returns a pointer to a function to handler performing the instruction's operation. If the given opcode does not map to an instruction handler, NULL is returned.

Nearly every instruction in Atmel's Instruction Set Data Sheet will have a handler function defined. Each handler will perform all the operations described in the data sheet for a given instruction. A few instructions have synonyms. For example, CBR is a synonym for ANDI.

This should all be fairly straight forward.

Definition in file [decoder.c](#).

### 12.6.2 Enumeration Type Documentation

#### 12.6.2.1 enum decoder\_operand\_masks

Masks to help extracting information from opcodes.

#### Enumerator:

- mask\_Rd\_2* 2 bit register id ( R24, R26, R28, R30 )
- mask\_Rd\_3* 3 bit register id ( R16 - R23 )
- mask\_Rd\_4* 4 bit register id ( R16 - R31 )
- mask\_Rd\_5* 5 bit register id ( R00 - R31 )
- mask\_Rr\_3* 3 bit register id ( R16 - R23 )
- mask\_Rr\_4* 4 bit register id ( R16 - R31 )
- mask\_Rr\_5* 5 bit register id ( R00 - R31 )
- mask\_K\_8* for 8 bit constant
- mask\_K\_6* for 6 bit constant
- mask\_k\_7* for 7 bit relative address
- mask\_k\_12* for 12 bit relative address

*mask\_k\_22* for 22 bit absolute address  
*mask\_reg\_bit* register bit select  
*mask\_sreg\_bit* status register bit select  
*mask\_q\_displ* address displacement (q)  
*mask\_A\_5* 5 bit register id ( R00 - R31 )  
*mask\_A\_6* 6 bit IO port id

Definition at line 77 of file decoder.c.

### 12.6.3 Function Documentation

#### 12.6.3.1 void decode\_init\_lookup\_table ( void )

Initialize the decoder lookup table.

This is automatically called by avr\_core\_construct().

It is safe to call this function many times, since it will only create the table the first time it is called.

Definition at line 3869 of file decoder.c.

References avr\_message, and avr\_new0.

#### 12.6.3.2 struct opcode\_info\* decode\_opcode ( uint16\_t opcode ) [read]

Decode an opcode into the opcode handler function.

Generates a warning and returns NULL if opcode is invalid.

Returns a pointer to the function to handle the opcode.

## 12.7 device.c File Reference

VDevice methods.

### Functions

- VDevice \* [vdev\\_new](#) (char \*name, VDevFP\_Read rd, VDevFP\_Write wr, VDevFP\_Reset reset, VDevFP\_AddAddr add\_addr)

- void [vdev\\_def\\_AddAddr](#) (VDevice \*dev, int addr, char \*name, int related\_addr, void \*data)
- void [vdev\\_construct](#) (VDevice \*dev, VDevFP\_Read rd, VDevFP\_Write wr, VDevFP\_Reset reset, VDevFP\_AddAddr add\_addr)
- void [vdev\\_destroy](#) (void \*dev)
- uint8\_t [vdev\\_read](#) (VDevice \*dev, int addr)
- void [vdev\\_write](#) (VDevice \*dev, int addr, uint8\_t val)
- void [vdev\\_reset](#) (VDevice \*dev)
- void [vdev\\_set\\_core](#) (VDevice \*dev, AvrClass \*core)
- AvrClass \* [vdev\\_get\\_core](#) (VDevice \*dev)
- void [vdev\\_add\\_addr](#) (VDevice \*dev, int addr, char \*name, int rel\_addr, void \*data)

### 12.7.1 Detailed Description

VDevice methods. These functions are the base for all other devices mapped into the device space.

Definition in file [device.c](#).

### 12.7.2 Function Documentation

#### 12.7.2.1 VDevice\* vdev\_new ( char \* name, VDevFP\_Read rd, VDevFP\_Write wr, VDevFP\_Reset reset, VDevFP\_AddAddr add\_addr )

Create a new VDevice.

Definition at line 62 of file device.c.

References [avr\\_new0](#), [class\\_overload\\_destroy\(\)](#), [vdev\\_construct\(\)](#), and [vdev\\_destroy\(\)](#).

#### 12.7.2.2 void vdev\_def\_AddAddr ( VDevice \* dev, int addr, char \* name, int related\_addr, void \* data )

Default AddAddr method.

This generate a warning that the should let the developer know that the vdev needs to be updated.

Definition at line 80 of file device.c.

References [avr\\_warning](#).

**12.7.2.3 void vdev\_construct ( VDevice \* *dev*, VDevFP\_Read *rd*,  
VDevFP\_Write *wr*, VDevFP\_Reset *reset*, VDevFP\_AddAddr *add\_addr*  
)**

Constructor for a VDevice.

Definition at line 89 of file device.c.

References `avr_error`, and `class_construct()`.

Referenced by `adc_construct()`, `adc_intr_construct()`, `ocreg16_construct()`, `spi_construct()`, `spi_intr_construct()`, `timer0_construct()`, `timer16_construct()`, `timer_intr_construct()`, `uart_construct()`, `uart_intr_construct()`, `usb_construct()`, `usb_intr_construct()`, and `vdev_new()`.

**12.7.2.4 void vdev\_destroy ( void \* *dev* )**

Destructor for a VDevice.

Definition at line 105 of file device.c.

References `class_destroy()`.

Referenced by `adc_destroy()`, `adc_intr_destroy()`, `spi_destroy()`, `spi_intr_destroy()`, `timer0_destroy()`, `timer_intr_destroy()`, `uart_destroy()`, `uart_intr_destroy()`, `usb_destroy()`, `usb_intr_destroy()`, and `vdev_new()`.

**12.7.2.5 uint8\_t vdev\_read ( VDevice \* *dev*, int *addr* )**

Reads the device's value in the register at *addr*.

Definition at line 161 of file device.c.

Referenced by `mem_io_fetch()`, and `mem_read()`.

**12.7.2.6 void vdev\_write ( VDevice \* *dev*, int *addr*, uint8\_t *val* )**

Writes an value to the register at *addr*.

Definition at line 168 of file device.c.

Referenced by `mem_write()`.

**12.7.2.7 void vdev\_reset ( VDevice \* *dev* )**

Resets a device.

Definition at line 175 of file device.c.

Referenced by mem\_reset().

**12.7.2.8 void vdev\_set\_core ( VDevice \* *dev*, AvrClass \* *core* )**

Set the core field.

Definition at line 182 of file device.c.

**12.7.2.9 AvrClass\* vdev\_get\_core ( VDevice \* *dev* )**

Get the core field.

**12.7.2.10 void vdev\_add\_addr ( VDevice \* *dev*, int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )**

Inform the vdevice that it needs to handle another address.

This is primarily used when creating the core in dev\_supp\_create\_core().

Definition at line 195 of file device.c.

References avr\_warning.

**12.8 devsupp.c File Reference**

Contains definitions for device types (i.e. at90s8515, at90s2313, etc.)

**Functions**

- int **dev\_supp\_has\_ext\_io\_reg** (DevSuppDefn \**dev*)
- int **dev\_supp\_get\_flash\_sz** (DevSuppDefn \**dev*)
- int **dev\_supp\_get\_PC\_sz** (DevSuppDefn \**dev*)
- int **dev\_supp\_get\_stack\_sz** (DevSuppDefn \**dev*)

- int **dev\_supp\_get\_vtab\_idx** (DevSuppDefn \*dev)
- int **dev\_supp\_get\_sram\_sz** (DevSuppDefn \*dev)
- int **dev\_supp\_get\_eeprom\_sz** (DevSuppDefn \*dev)
- int **dev\_supp\_get\_xram\_sz** (DevSuppDefn \*dev)
- DevSuppDefn \* **dev\_supp\_lookup\_device** (char \*dev\_name)
- void **dev\_supp\_list\_devices** (FILE \*fp)
- void **dev\_supp\_attach\_io\_regs** (AvrCore \*core, DevSuppDefn \*dev)

### 12.8.1 Detailed Description

Contains definitions for device types (i.e. at90s8515, at90s2313, etc.) This module is used to define the attributes for each device in the AVR family. A generic constructor is used to create a new AvrCore object with the proper ports, built-in peripherals, memory layout, registers, and interrupt vectors, etc.

Definition in file [devsupp.c](#).

### 12.8.2 Function Documentation

#### 12.8.2.1 DevSuppDefn\* dev\_supp\_lookup\_device ( char \* *dev\_name* )

Look up a device name in support list.

#### Returns

An opaque pointer to DevSuppDefn or NULL if not found.

Definition at line 272 of file devsupp.c.

Referenced by `avr_core_new()`.

#### 12.8.2.2 void dev\_supp\_list\_devices ( FILE \* *fp* )

Print a list of supported devices to a file pointer.

Definition at line 292 of file devsupp.c.

## 12.9 display.c File Reference

Interface for using display coprocesses.



### Enumerations

- enum { **MAX\_BUF** = 1024 }

### Functions

- int [display\\_open](#) (char \*prog, int no\_xterm, int flash\_sz, int sram\_sz, int sram\_start, int eeprom\_sz)
- void [display\\_close](#) (void)
- void [display\\_send\\_msg](#) (char \*msg)
- void [display\\_clock](#) (int clock)
- void [display\\_pc](#) (int val)
- void [display\\_reg](#) (int reg, uint8\_t val)
- void [display\\_io\\_reg](#) (int reg, uint8\_t val)
- void [display\\_io\\_reg\\_name](#) (int reg, char \*name)
- void [display\\_flash](#) (int addr, int len, uint16\_t \*vals)
- void [display\\_sram](#) (int addr, int len, uint8\_t \*vals)
- void [display\\_eeprom](#) (int addr, int len, uint8\_t \*vals)

#### 12.9.1 Detailed Description

Interface for using display coprocesses. Simulavr has the ability to use a coprocess to display register and memory values in near real time.

Definition in file [display.c](#).

#### 12.9.2 Function Documentation

##### 12.9.2.1 int display\_open ( char \*prog, int no\_xterm, int flash\_sz, int sram\_sz, int sram\_start, int eeprom\_sz )

Open a display as a coprocess.

#### Parameters

<i>prog</i>	The program to use as a display coprocess.
<i>no_xterm</i>	If non-zero, don't run the display in an xterm.
<i>flash_sz</i>	The size of the flash memory space in bytes.
<i>sram_sz</i>	The size of the sram memory space in bytes.
<i>sram_start</i>	The addr of the first byte of sram (usually 0x60 or 0x100).
<i>eeprom_sz</i>	The size of the eeprom memory space in bytes.

Try to start up a helper program as a child process for displaying registers and memory. If the prog argument is NULL, don't start up a display.

Returns an open file descriptor of a pipe used to send data to the helper program.

Returns -1 if something failed.

Definition at line 85 of file display.c.

References avr\_warning.

### 12.9.2.2 void display\_close ( void )

Close a display and send coprocess a quit message.

Definition at line 181 of file display.c.

References display\_send\_msg().

### 12.9.2.3 void display\_send\_msg ( char \* msg )

Encode the message and send to display.

#### Parameters

<i>msg</i>	The message string to be sent to the display process.
------------	---

Encoding is the same as that used by the gdb remote protocol: '\$...#CC' where '...' is msg, CC is checksum. There is no newline termination for encoded messages.

FIXME: TRoth: This should be a private function. It is only public so that dtest.c can be kept simple. dtest.c should be changed to avoid direct use of this function. [dtest.c has served it's purpose and will be retired soon.]

Definition at line 220 of file display.c.

References avr\_error, avr\_free(), avr\_new0, and avr\_warning.

Referenced by display\_clock(), display\_close(), display\_eeprom(), display\_flash(), display\_io\_reg(), display\_io\_reg\_name(), display\_pc(), display\_reg(), and display\_sram().

### 12.9.2.4 void display\_clock ( int clock )

Update the time in the display.

**Parameters**

<i>clock</i>	The new time in number of clocks.
--------------	-----------------------------------

Definition at line 255 of file display.c.

References display\_send\_msg().

Referenced by avr\_core\_reset().

**12.9.2.5 void display\_pc ( int *val* )**

Update the Program Counter in the display.

**Parameters**

<i>val</i>	The new value of the program counter.
------------	---------------------------------------

Definition at line 269 of file display.c.

References display\_send\_msg().

**12.9.2.6 void display\_reg ( int *reg*, uint8\_t *val* )**

Update a register in the display.

**Parameters**

<i>reg</i>	The register number.
<i>val</i>	The new value of the register.

Definition at line 284 of file display.c.

References display\_send\_msg().

**12.9.2.7 void display\_io\_reg ( int *reg*, uint8\_t *val* )**

Update an IO register in the display.

**Parameters**

<i>reg</i>	The IO register number.
<i>val</i>	The new value of the register.

Definition at line 299 of file display.c.

References `display_send_msg()`.

Referenced by `mem_write()`.

#### 12.9.2.8 void display\_io\_reg\_name ( int reg, char \* name )

Specify a name for an IO register.

##### Parameters

<i>reg</i>	The IO register number.
<i>name</i>	The symbolic name of the register.

Names of IO registers may be different from device to device.

Definition at line 316 of file display.c.

References `display_send_msg()`.

Referenced by `avr_core_io_display_names()`.

#### 12.9.2.9 void display\_flash ( int addr, int len, uint16\_t \* vals )

Update a block of flash addresses in the display.

##### Parameters

<i>addr</i>	Address of beginning of the block.
<i>len</i>	Length of the block (number of words).
<i>vals</i>	Pointer to an array of <i>len</i> words.

The display will update each *addr* of the block to the corresponding value in the *vals* array.

Each address in the flash references a single 16-bit wide word (or opcode or instruction). Therefore, flash addresses are aligned to 16-bit boundaries. It is simplest to consider the flash an array of 16-bit values indexed by the address.

Definition at line 340 of file display.c.

References `avr_error`, and `display_send_msg()`.

Referenced by `flash_write()`.

**12.9.2.10 void display\_sram ( int *addr*, int *len*, uint8\_t \* *vals* )**

Update a block of sram addresses in the display.

**Parameters**

<i>addr</i>	Address of beginning of the block.
<i>len</i>	Length of the block (number of bytes).
<i>vals</i>	Pointer to an array of <i>len</i> bytes.

The display will update each *addr* of the block to the corresponding value in the *vals* array.

Definition at line 372 of file display.c.

References `avr_error`, and `display_send_msg()`.

**12.9.2.11 void display\_eeprom ( int *addr*, int *len*, uint8\_t \* *vals* )**

Update a block of eeprom addresses in the display.

**Parameters**

<i>addr</i>	Address of beginning of the block.
<i>len</i>	Length of the block (number of bytes).
<i>vals</i>	Pointer to an array of <i>len</i> bytes.

The display will update each *addr* of the block to the corresponding value in the *vals* array.

Definition at line 404 of file display.c.

References `avr_error`, and `display_send_msg()`.

**12.10 flash.c File Reference**

Flash memory methods.

**Functions**

- uint16\_t [flash\\_read](#) (Flash \*flash, int addr)
- void [flash\\_write](#) (Flash \*flash, int addr, uint16\_t val)
- void [flash\\_write\\_lo8](#) (Flash \*flash, int addr, uint8\_t val)

- void [flash\\_write\\_hi8](#) (Flash \*flash, int addr, uint8\_t val)
- Flash \* [flash\\_new](#) (int size)
- void [flash\\_construct](#) (Flash \*flash, int size)
- void [flash\\_destroy](#) (void \*flash)
- int [flash\\_load\\_from\\_file](#) (Flash \*flash, char \*file, int format)
- int [flash\\_get\\_size](#) (Flash \*flash)
- void [flash\\_dump\\_core](#) (Flash \*flash, FILE \*f\_core)

### 12.10.1 Detailed Description

Flash memory methods. This module provides functions for reading and writing to flash memory. Flash memory is the program (.text) memory in AVR's Harvard architecture. It is completely separate from RAM, which is simulated in the [memory.c](#) file.

Definition in file [flash.c](#).

### 12.10.2 Function Documentation

#### 12.10.2.1 uint16\_t flash\_read ( Flash \**flash*, int *addr* )

Reads a 16-bit word from flash.

##### Returns

A word.

Referenced by [avr\\_core\\_insert\\_breakpoint\(\)](#), and [flash\\_dump\\_core\(\)](#).

#### 12.10.2.2 void flash\_write ( Flash \**flash*, int *addr*, uint16\_t *val* )

Reads a 16-bit word from flash.

##### Parameters

<i>flash</i>	A pointer to a flash object.
<i>addr</i>	The address to which to write.
<i>val</i>	The byte to write there.

Definition at line 86 of file [flash.c](#).

References [display\\_flash\(\)](#).

Referenced by `avr_core_insert_breakpoint()`, and `avr_core_remove_breakpoint()`.

#### 12.10.2.3 `void flash_write_lo8 ( Flash *flash, int addr, uint8_t val )`

Write the low-order byte of an address.

AVRs are little-endian, so lo8 bits in odd addresses.

Definition at line 98 of file `flash.c`.

#### 12.10.2.4 `void flash_write_hi8 ( Flash *flash, int addr, uint8_t val )`

Write the high-order byte of an address.

AVRs are little-endian, so hi8 bits in even addresses.

Definition at line 109 of file `flash.c`.

#### 12.10.2.5 `Flash* flash_new ( int size )`

Allocate a new Flash object.

Definition at line 117 of file `flash.c`.

References `avr_new`, `class_overload_destroy()`, `flash_construct()`, and `flash_destroy()`.

#### 12.10.2.6 `void flash_construct ( Flash *flash, int size )`

Constructor for the flash object.

Definition at line 131 of file `flash.c`.

References `avr_error`.

Referenced by `flash_new()`.

#### 12.10.2.7 `void flash_destroy ( void *flash )`

Destructor for the flash class.

Not to be called directly, except by a derived class. Called via `class_unref`.

Definition at line 153 of file `flash.c`.

Referenced by `flash_new()`.

#### 12.10.2.8 `int flash_load_from_file ( Flash *flash, char *file, int format )`

Load program data into flash from a file.

Definition at line 164 of file `flash.c`.

References `avr_warning`.

Referenced by `avr_core_load_program()`.

#### 12.10.2.9 `int flash_get_size ( Flash *flash )`

Accessor method to get the size of a flash.

Definition at line 210 of file `flash.c`.

Referenced by `avr_core_get_sizes()`.

#### 12.10.2.10 `void flash_dump_core ( Flash *flash, FILE *f_core )`

Dump the contents of the flash to a file descriptor in text format.

##### Parameters

<i>flash</i>	A pointer to a flash object.
<i>f_core</i>	An open file descriptor.

Definition at line 223 of file `flash.c`.

References `flash_read()`.

Referenced by `avr_core_dump_core()`.

## 12.11 gdbserver.c File Reference

Provide an interface to gdb's remote serial protocol.



## Functions

- void [gdb\\_interact](#) (GdbComm\_T \*comm, int port, int debug\_on)

### 12.11.1 Detailed Description

Provide an interface to gdb's remote serial protocol. This module allows a program to be used by gdb as a remote target. The remote target and gdb communicate via gdb's remote serial protocol. The protocol is documented in the gdb manual and will not be repeated here.

Hitting Ctrl-c in gdb can be used to interrupt the remote target while it is processing instructions and return control back to gdb.

Issuing a 'signal SIGxxx' command from gdb will send the signal to the remote target via a "continue with signal" packet. The target will process and interpret the signal, but not pass it on to the AVR program running in the target since it really makes no sense to do so. In some circumstances, it may make sense to use the gdb signal mechanism as a way to initiate some sort of external stimulus to be passed on to the virtual hardware system.

Signals from gdb which are processed have the following meanings:

- `SIGHUP` Initiate a reset of the target. (Simulates a hardware reset)

Definition in file [gdbserver.c](#).

### 12.11.2 Function Documentation

#### 12.11.2.1 void [gdb\\_interact](#) ( GdbComm\_T \* *comm*, int *port*, int *debug\_on* )

Start interacting with gdb.

#### Parameters

<i>comm</i>	A previously initialized simulator comm
<i>port</i>	Port which server will listen for connections on.
<i>debug_on</i>	Turn on gdb debug diagnostic messages.

Start a tcp server socket on localhost listening for connections on the given port. Once a connection is established, enter an infinite loop and process command requests from gdb using the remote serial protocol. Only a single connection is allowed at a time.

Definition at line 1320 of file [gdbserver.c](#).

References `avr_error`, `signal_has_occurred()`, `signal_watch_start()`, and `signal_watch_stop()`.

## 12.12 memory.c File Reference

Memory access functions.

### Functions

- Memory \* [mem\\_new](#) (int `gpwr_end`, int `io_reg_end`, int `sram_end`, int `xram_end`)
- void [mem\\_construct](#) (Memory \*`mem`, int `gpwr_end`, int `io_reg_end`, int `sram_end`, int `xram_end`)
- void [mem\\_destroy](#) (void \*`mem`)
- void [mem\\_attach](#) (Memory \*`mem`, int `addr`, char \*`name`, VDevice \*`vdev`, int `flags`, uint8\_t `reset_value`, uint8\_t `rd_mask`, uint8\_t `wr_mask`)
- VDevice \* [mem\\_get\\_vdevice\\_by\\_addr](#) (Memory \*`mem`, int `addr`)
- VDevice \* [mem\\_get\\_vdevice\\_by\\_name](#) (Memory \*`mem`, char \*`name`)
- void [mem\\_set\\_addr\\_name](#) (Memory \*`mem`, int `addr`, char \*`name`)
- uint8\_t [mem\\_read](#) (Memory \*`mem`, int `addr`)
- void [mem\\_write](#) (Memory \*`mem`, int `addr`, uint8\_t `val`)
- void [mem\\_reset](#) (Memory \*`mem`)
- void [mem\\_io\\_fetch](#) (Memory \*`mem`, int `addr`, uint8\_t \*`val`, char \*`buf`, int `bufsiz`)
- void [mem\\_dump\\_core](#) (Memory \*`mem`, FILE \*`f_core`)

### 12.12.1 Detailed Description

Memory access functions. This module provides functions for reading and writing to simulated memory. The Memory class is a subclass of `AvrClass`.

Definition in file [memory.c](#).

### 12.12.2 Function Documentation

#### 12.12.2.1 Memory\* mem\_new ( int *gpwr\_end*, int *io\_reg\_end*, int *sram\_end*, int *xram\_end* )

Allocates memory for a new memory object.

Definition at line 66 of file `memory.c`.

References `avr_new0`, `class_overload_destroy()`, `mem_construct()`, and `mem_destroy()`.

**12.12.2.2 void mem\_construct ( Memory \* *mem*, int *gpwr\_end*, int *io\_reg\_end*, int *sram\_end*, int *xram\_end* )**

Constructor for the memory object.

Definition at line 80 of file memory.c.

References `avr_error`, `avr_new0`, and `class_construct()`.

Referenced by `mem_new()`.

**12.12.2.3 void mem\_destroy ( void \* *mem* )**

Destructor for the memory object.

Definition at line 99 of file memory.c.

References `avr_free()`, `class_destroy()`, and `class_unref()`.

Referenced by `mem_new()`.

**12.12.2.4 void mem\_attach ( Memory \* *mem*, int *addr*, char \* *name*, VDevice \* *vdev*, int *flags*, uint8\_t *reset\_value*, uint8\_t *rd\_mask*, uint8\_t *wr\_mask* )**

Attach a device to the device list.

Devices that are accessed more often should be attached last so that they will be at the front of the list.

A default virtual device can be overridden by attaching a new device ahead of it in the list.

Definition at line 130 of file memory.c.

References `avr_error`, and `class_ref()`.

**12.12.2.5 VDevice\* mem\_get\_vdevice\_by\_addr ( Memory \* *mem*, int *addr* )**

Find the VDevice associated with the given address.

Definition at line 159 of file memory.c.

Referenced by `avr_core_add_ext_rd_wr()`, and `memstack_construct()`.

### 12.12.2.6 VDevice\* mem\_get\_vdevice\_by\_name ( Memory \* *mem*, char \* *name* )

Find the VDevice associated with the given name.

#### Deprecated

Definition at line 169 of file memory.c.

References `avr_error`, and `dlist_lookup()`.

Referenced by `avr_core_load_eeeprom()`.

### 12.12.2.7 uint8\_t mem\_read ( Memory \* *mem*, int *addr* )

Reads byte from memory and sanity-checks for valid address.

#### Parameters

<i>mem</i>	A pointer to the memory object
<i>addr</i>	The address to be read

#### Returns

The byte found at that address *addr*

Definition at line 220 of file memory.c.

References `avr_warning`, and `vdev_read()`.

### 12.12.2.8 void mem\_write ( Memory \* *mem*, int *addr*, uint8\_t *val* )

Writes byte to memory and updates display for io registers.

#### Parameters

<i>mem</i>	A pointer to a memory object
<i>addr</i>	The address to be written to
<i>val</i>	The value to be written there

Definition at line 255 of file memory.c.

References `avr_warning`, `display_io_reg()`, and `vdev_write()`.

#### 12.12.2.9 void mem\_reset ( Memory \* mem )

Resets every device in the memory object.

##### Parameters

<i>mem</i>	A pointer to the memory object.
------------	---------------------------------

Definition at line 292 of file memory.c.

References `vdev_reset()`.

Referenced by `avr_core_reset()`.

#### 12.12.2.10 void mem\_io\_fetch ( Memory \* mem, int addr, uint8\_t \* val, char \* buf, int bufsiz )

Fetch the name and value of the io register (addr).

##### Parameters

<i>mem</i>	A pointer to the memory object.
<i>addr</i>	The address to fetch from.
<i>val</i>	A pointer where the value of the register is to be copied.
<i>buf</i>	A pointer to where the name of the register should be copied.
<i>bufsiz</i>	The maximum size of the the buf string.

Definition at line 330 of file memory.c.

References `vdev_read()`.

Referenced by `avr_core_io_display_names()`.

#### 12.12.2.11 void mem\_dump\_core ( Memory \* mem, FILE \* f\_core )

Dump all the various memory locations to a file descriptor in text format.

**Parameters**

<i>mem</i>	A memory object.
<i>f_core</i>	An open file descriptor.

Definition at line 491 of file memory.c.

Referenced by `avr_core_dump_core()`.

**12.13 ports.c File Reference**

Module for accessing simulated I/O ports.

**Functions**

- `VDevice * port_create` (int *addr*, char \**name*, int *rel\_addr*, void \**data*)
- void `port_ext_disable` (Port \**p*)
- void `port_ext_enable` (Port \**p*)
- void `port_add_ext_rd_wr` (Port \**p*, PortFP\_ExtRd *ext\_rd*, PortFP\_ExtWr *ext\_wr*)

**12.13.1 Detailed Description**

Module for accessing simulated I/O ports. Defines an abstract Port class as well as subclasses for each individual port.

**Todo**

Remove the pins argument and the mask field. That's handled at a higher level so is obsolete here now.

Definition in file `ports.c`.

**12.13.2 Function Documentation****12.13.2.1 VDevice\* port\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )**

Create a new Port instance.

This should only be used in DevSuppDefn initializers.

Definition at line 100 of file `ports.c`.

### 12.13.2.2 void port\_ext\_disable ( Port \* *p* )

Disable external port functionality.

This is only used when dumping memory to core file. See [mem\\_io\\_fetch\(\)](#).

Definition at line 200 of file ports.c.

### 12.13.2.3 void port\_ext\_enable ( Port \* *p* )

Enable external port functionality.

This is only used when dumping memory to core file. See [mem\\_io\\_fetch\(\)](#).

Definition at line 210 of file ports.c.

### 12.13.2.4 void port\_add\_ext\_rd\_wr ( Port \* *p*, PortFP\_ExtRd *ext\_rd*, PortFP\_ExtWr *ext\_wr* )

Attaches read and write functions to a particular port.

I think I may have this backwards. Having the virtual hardware supply functions for the core to call on every io read/write, might cause missed events (like edge triggered). I'm really not too sure how to handle this.

In the future, it might be better to have the core supply a function for the virtual hardware to call when data is written to the device. The device supplied function could then check if an interrupt should be generated or just simply write to the port data register.

For now, leave it as is since it's easier to test if you can block when the device is reading from the virtual hardware.

Definition at line 231 of file ports.c.

Referenced by `avr_core_add_ext_rd_wr()`.

## 12.14 sig.c File Reference

Public interface to signal handlers.

### Functions

- void [signal\\_watch\\_start](#) (int signo)

- void [signal\\_watch\\_stop](#) (int signo)
- int [signal\\_has\\_occurred](#) (int signo)
- void [signal\\_reset](#) (int signo)

#### 12.14.1 Detailed Description

Public interface to signal handlers. This module provides a way for the simulator to process signals generated by the native host system. Note that these signals in this context have nothing to do with signals or interrupts as far as a program running in the simulator is concerned.

Definition in file [sig.c](#).

#### 12.14.2 Function Documentation

##### 12.14.2.1 void [signal\\_watch\\_start](#) ( int *signo* )

Start watching for the occurrence of the given signal.

This function will install a signal handler which will set a flag when the signal occurs. Once the watch has been started, periodically call [signal\\_has\\_occurred\(\)](#) to check if the signal was raised.

Definition at line 67 of file [sig.c](#).

References [avr\\_warning](#).

Referenced by [avr\\_core\\_run\(\)](#), and [gdb\\_interact\(\)](#).

##### 12.14.2.2 void [signal\\_watch\\_stop](#) ( int *signo* )

Stop watching signal.

Restores the default signal handler for the given signal and resets the signal flag.

Definition at line 97 of file [sig.c](#).

References [avr\\_warning](#), and [signal\\_reset\(\)](#).

Referenced by [avr\\_core\\_run\(\)](#), and [gdb\\_interact\(\)](#).

##### 12.14.2.3 int [signal\\_has\\_occurred](#) ( int *signo* )



Check to see if a signal has occurred.

### Returns

Non-zero if signal has occurred. The flag will always be reset automatically.

Definition at line 119 of file sig.c.

References `avr_warning`.

Referenced by `avr_core_run()`, `gdb_interact()`, and `signal_reset()`.

#### 12.14.2.4 void signal\_reset ( int signo )

Clear the flag which indicates that a signal has occurred.

Use `signal_reset` to manually reset (i.e. clear) the flag.

Definition at line 142 of file sig.c.

References `signal_has_occurred()`.

Referenced by `signal_watch_stop()`.

## 12.15 spi.c File Reference

Module to simulate the AVR's SPI module.

### Functions

- VDevice \* [spii\\_create](#) (int addr, char \*name, int rel\_addr, void \*data)
- SPIIntr\_T \* [spi\\_intr\\_new](#) (int addr, char \*name)
- void [spi\\_intr\\_construct](#) (SPIIntr\_T \*spi, int addr, char \*name)
- void [spi\\_intr\\_destroy](#) (void \*spi)
- VDevice \* [spi\\_create](#) (int addr, char \*name, int rel\_addr, void \*data)
- SPI\_T \* [spi\\_new](#) (int addr, char \*name, int rel\_addr)
- void [spi\\_construct](#) (SPI\_T \*spi, int addr, char \*name, int rel\_addr)
- void [spi\\_destroy](#) (void \*spi)
- uint8\_t [spi\\_port\\_rd](#) (int addr)
- void [spi\\_port\\_wr](#) (uint8\_t val)

#### 12.15.1 Detailed Description

Module to simulate the AVR's SPI module.

Definition in file [spi.c](#).

### 12.15.2 Function Documentation

#### 12.15.2.1 VDevice\* spii\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new SPI interrupt.

Definition at line 78 of file spi.c.

#### 12.15.2.2 void spi\_intr\_construct ( SPIIntr\_T \* *spi*, int *addr*, char \* *name* )

Constructor for spi interrupt object.

Definition at line 98 of file spi.c.

References avr\_error, and vdev\_construct().

#### 12.15.2.3 void spi\_intr\_destroy ( void \* *spi* )

Destructor for spi interrupt object.

Definition at line 134 of file spi.c.

References vdev\_destroy().

#### 12.15.2.4 VDevice\* spi\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new SPI structure.

Definition at line 247 of file spi.c.

#### 12.15.2.5 void spi\_construct ( SPI\_T \* *spi*, int *addr*, char \* *name*, int *rel\_addr* )

Constructor for SPI object.

Definition at line 267 of file spi.c.

References avr\_error, and vdev\_construct().

### 12.15.2.6 `void spi_destroy ( void * spi )`

Destructor for SPI object.

Definition at line 300 of file `spi.c`.

References `vdev_destroy()`.

## 12.16 `stack.c` File Reference

Module for the definition of the stack.

### Functions

- `Stack * stack_new` (`StackFP_Pop pop`, `StackFP_Push push`)
- `void stack_construct` (`Stack *stack`, `StackFP_Pop pop`, `StackFP_Push push`)
- `void stack_destroy` (`void *stack`)
- `uint32_t stack_pop` (`Stack *stack`, `int bytes`)
- `void stack_push` (`Stack *stack`, `int bytes`, `uint32_t val`)
- `HWStack * hwstack_new` (`int depth`)
- `void hwstack_construct` (`HWStack *stack`, `int depth`)
- `void hwstack_destroy` (`void *stack`)
- `VDevice * sp_create` (`int addr`, `char *name`, `int rel_addr`, `void *data`)
- `MemStack * memstack_new` (`Memory *mem`, `int spl_addr`)
- `void memstack_construct` (`MemStack *stack`, `Memory *mem`, `int spl_addr`)
- `void memstack_destroy` (`void *stack`)

### 12.16.1 Detailed Description

Module for the definition of the stack. Defines the classes `stack`, `hw_stack`, and `mem_stack`.

FIXME: Ted, I would really really really love to put in a description of what is the difference between these three classes and how they're used, but I don't understand it myself.

Definition in file `stack.c`.

### 12.16.2 Function Documentation

#### 12.16.2.1 `Stack* stack_new ( StackFP_Pop pop, StackFP_Push push )`

Allocates memory for a new Stack object.

This is a virtual method for higher level stack implementations and as such should not be used directly.

Definition at line 82 of file stack.c.

References `avr_new`, `class_overload_destroy()`, `stack_construct()`, and `stack_destroy()`.

#### 12.16.2.2 **void stack\_construct ( Stack \* *stack*, StackFP\_Pop *pop*, StackFP\_Push *push* )**

Constructor for the Stack class.

This is a virtual method for higher level stack implementations and as such should not be used directly.

Definition at line 99 of file stack.c.

References `avr_error`, and `class_construct()`.

Referenced by `hwstack_construct()`, `memstack_construct()`, and `stack_new()`.

#### 12.16.2.3 **void stack\_destroy ( void \* *stack* )**

Destructor for the Stack class.

This is a virtual method for higher level stack implementations and as such should not be used directly.

Definition at line 116 of file stack.c.

References `class_destroy()`.

Referenced by `hwstack_destroy()`, `memstack_destroy()`, and `stack_new()`.

#### 12.16.2.4 **uint32\_t stack\_pop ( Stack \* *stack*, int *bytes* )**

Pops a byte or a word off the stack and returns it.

##### Parameters

<i>stack</i>	A pointer to the Stack object from which to pop
<i>bytes</i>	Number of bytes to pop off the stack (1 to 4 bytes).

**Returns**

The 1 to 4 bytes value popped from the stack.

This method provides access to the derived class's pop() method.

Definition at line 133 of file stack.c.

**12.16.2.5 void stack\_push ( Stack \* *stack*, int *bytes*, uint32\_t *val* )**

Pushes a byte or a word of data onto the stack.

**Parameters**

<i>stack</i>	A pointer to the Stack object from which to pop.
<i>bytes</i>	Size of the value being pushed onto the stack (1 to 4 bytes).
<i>val</i>	The value to be pushed.

This method provides access to the derived class's push() method.

Definition at line 146 of file stack.c.

**12.16.2.6 HWStack\* hwstack\_new ( int *depth* )**

Allocate a new HWStack object.

This is the stack implementation used by devices which lack SRAM and only have a fixed size hardware stack (e.i., the at90s1200)

Definition at line 163 of file stack.c.

References avr\_new, class\_overload\_destroy(), hwstack\_construct(), and hwstack\_destroy().

**12.16.2.7 void hwstack\_construct ( HWStack \* *stack*, int *depth* )**

Constructor for HWStack object.

Definition at line 177 of file stack.c.

References avr\_error, avr\_new0, and stack\_construct().

Referenced by hwstack\_new().

**12.16.2.8 void hwstack\_destroy ( void \* *stack* )**

Destructor for HWStack object.

Definition at line 191 of file `stack.c`.

References `avr_free()`, and `stack_destroy()`.

Referenced by `hwstack_new()`.

**12.16.2.9 VDevice\* sp\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )**

Create the Stack Pointer VDevice.

This should only be used in the DevSuppDefn io reg init structure.

Definition at line 272 of file `stack.c`.

**12.16.2.10 MemStack\* memstack\_new ( Memory \* *mem*, int *spl\_addr* )**

Allocate a new MemStack object.

Definition at line 388 of file `stack.c`.

References `avr_new`, `class_overload_destroy()`, `memstack_construct()`, and `memstack_destroy()`.

**12.16.2.11 void memstack\_construct ( MemStack \* *stack*, Memory \* *mem*, int *spl\_addr* )**

Constructor for MemStack object.

Definition at line 402 of file `stack.c`.

References `avr_error`, `class_ref()`, `mem_get_vdevice_by_addr()`, and `stack_construct()`.

Referenced by `memstack_new()`.

**12.16.2.12 void memstack\_destroy ( void \* *stack* )**

Destructor for MemStack object.

Definition at line 423 of file stack.c.

References `class_unref()`, and `stack_destroy()`.

Referenced by `memstack_new()`.

## 12.17 timers.c File Reference

Module to simulate the AVR's on-board timer/counters.

### Functions

- `VDevice * timer_int_create` (int addr, char \*name, int rel\_addr, void \*data)
- `TimerIntr_T * timer_intr_new` (int addr, char \*name, uint8\_t func\_mask)
- `void timer_intr_construct` (TimerIntr\_T \*ti, int addr, char \*name, uint8\_t func\_mask)
- `void timer_intr_destroy` (void \*ti)
- `VDevice * timer0_create` (int addr, char \*name, int rel\_addr, void \*data)
- `Timer0_T * timer0_new` (int addr, char \*name, int rel\_addr)
- `void timer0_construct` (Timer0\_T \*timer, int addr, char \*name, int rel\_addr)
- `void timer0_destroy` (void \*timer)

### 16 Bit Timer Functions

- `VDevice * timer16_create` (int addr, char \*name, int rel\_addr, void \*data)
- `Timer16_T * timer16_new` (int addr, char \*name, int rel\_addr, Timer16Def timerdef)
- `void timer16_construct` (Timer16\_T \*timer, int addr, char \*name, int rel\_addr, Timer16Def timerdef)

### 16 Bit Output Compare Register Functions

- `VDevice * ocreg16_create` (int addr, char \*name, int rel\_addr, void \*data)
- `OCReg16_T * ocreg16_new` (int addr, char \*name, OCReg16Def ocrdef)
- `void ocreg16_construct` (OCReg16\_T \*ocreg, int addr, char \*name, OCReg16Def ocrdef)

#### 12.17.1 Detailed Description

Module to simulate the AVR's on-board timer/counters. This currently only implements the timer/counter 0.

Definition in file `timers.c`.

## 12.17.2 Function Documentation

### 12.17.2.1 VDevice\* timer\_int\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new timer interrupt.

Definition at line 138 of file timers.c.

References `avr_error`.

### 12.17.2.2 void timer\_intr\_construct ( TimerIntr\_T \* *ti*, int *addr*, char \* *name*, uint8\_t *func\_mask* )

Constructor for timer interrupt object.

Definition at line 163 of file timers.c.

References `avr_error`, and `vdev_construct()`.

### 12.17.2.3 void timer\_intr\_destroy ( void \* *ti* )

Destructor for timer interrupt object.

Definition at line 205 of file timers.c.

References `vdev_destroy()`.

### 12.17.2.4 VDevice\* timer0\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new timer/counter 0.

Definition at line 350 of file timers.c.

### 12.17.2.5 void timer0\_construct ( Timer0\_T \* *timer*, int *addr*, char \* *name*, int *rel\_addr* )

Constructor for timer/counter 0 object.



Definition at line 370 of file timers.c.

References `avr_error`, and `vdev_construct()`.

#### 12.17.2.6 void timer0\_destroy ( void \* *timer* )

Destructor for timer/counter 0 object.

Definition at line 387 of file timers.c.

References `vdev_destroy()`.

#### 12.17.2.7 VDevice\* timer16\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new 16 bit timer/counter.

Definition at line 582 of file timers.c.

References `avr_error`.

#### 12.17.2.8 void timer16\_construct ( Timer16\_T \* *timer*, int *addr*, char \* *name*, int *rel\_addr*, Timer16Def *timerdef* )

Constructor for 16 bit timer/counter object.

Definition at line 608 of file timers.c.

References `avr_error`, and `vdev_construct()`.

#### 12.17.2.9 VDevice\* ocreg16\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new 16 bit Output Compare Register.

##### Parameters

<i>ocrdef</i>	The definition struct for the <i>OCR</i> to be created
---------------	--

Definition at line 909 of file timers.c.

References [avr\\_error](#).

**12.17.2.10** `void ocreg16_construct ( OReg16_T * ocreg, int addr, char * name, OReg16Def ocrdef )`

Constructor for 16 bit Output Compare Register object.

Definition at line 935 of file [timers.c](#).

References [avr\\_error](#), and [vdev\\_construct\(\)](#).

## 12.18 **uart.c** File Reference

Module to simulate the AVR's uart module.

### Functions

- `VDevice * uart\_int\_create (int addr, char *name, int rel_addr, void *data)`
- `UARTIntr_T * uart\_intr\_new (int addr, char *name, void *data)`
- `void uart\_intr\_construct (UARTIntr_T *uart, int addr, char *name)`
- `void uart\_intr\_destroy (void *uart)`
- `VDevice * uart\_create (int addr, char *name, int rel_addr, void *data)`
- `UART_T * uart\_new (int addr, char *name, int rel_addr)`
- `void uart\_construct (UART_T *uart, int addr, char *name, int rel_addr)`
- `void uart\_destroy (void *uart)`
- `uint16_t uart\_port\_rd (int addr)`
- `void uart\_port\_wr (uint8_t val)`

### Variables

- unsigned int `UART_Int_Table []`
- unsigned int `UART0_Int_Table []`
- unsigned int `UART1_Int_Table []`

#### 12.18.1 Detailed Description

Module to simulate the AVR's uart module.

Definition in file [uart.c](#).

## 12.18.2 Function Documentation

### 12.18.2.1 VDevice\* uart\_int\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new uart interrupt.

Definition at line 95 of file uart.c.

References `avr_error`.

### 12.18.2.2 void uart\_intr\_construct ( UARTIntr\_T \* *uart*, int *addr*, char \* *name* )

Constructor for uart interrupt object.

Definition at line 128 of file uart.c.

References `avr_error`, and `vdev_construct()`.

### 12.18.2.3 void uart\_intr\_destroy ( void \* *uart* )

Destructor for uart interrupt object.

Definition at line 179 of file uart.c.

References `vdev_destroy()`.

### 12.18.2.4 VDevice\* uart\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new uart structure.

Definition at line 335 of file uart.c.

### 12.18.2.5 void uart\_construct ( UART\_T \* *uart*, int *addr*, char \* *name*, int *rel\_addr* )

Constructor for uart object.

Definition at line 356 of file uart.c.

References `avr_error`, and `vdev_construct()`.

#### 12.18.2.6 void uart\_destroy ( void \* *uart* )

Destructor for uart object.

Definition at line 389 of file uart.c.

References `vdev_destroy()`.

### 12.18.3 Variable Documentation

#### 12.18.3.1 unsigned int UART\_Int\_Table[]

**Initial value:**

```
{
    irq_vect_table_index (UART_RX),
    irq_vect_table_index (UART_UDRE),
    irq_vect_table_index (UART_TX)
}
```

Definition at line 74 of file uart.c.

#### 12.18.3.2 unsigned int UART0\_Int\_Table[]

**Initial value:**

```
{
    irq_vect_table_index (USART0_RX),
    irq_vect_table_index (USART0_UDRE),
    irq_vect_table_index (USART0_TX)
}
```

Definition at line 80 of file uart.c.

#### 12.18.3.3 unsigned int UART1\_Int\_Table[]

**Initial value:**

```
{
    irq_vect_table_index (USART1_RX),
    irq_vect_table_index (USART1_UDRE),
    irq_vect_table_index (USART1_TX)
}
```

Definition at line 86 of file `uart.c`.

## 12.19 usb.c File Reference

Module to simulate the AVR's USB module.

### Functions

- void **usb\_port\_wr** (char \*name, uint8\_t val)
- uint8\_t **usb\_port\_rd** (char \*name)
- VDevice \* **usbi\_create** (int addr, char \*name, int rel\_addr, void \*data)
- USBInter\_T \* **usb\_intr\_new** (int addr, char \*name, uint8\_t func\_mask)
- void **usb\_intr\_construct** (USBInter\_T \*usb, int addr, char \*name, uint8\_t func\_mask)
- void **usb\_intr\_destroy** (void \*usb)
- VDevice \* **usb\_create** (int addr, char \*name, int rel\_addr, void \*data)
- USB\_T \* **usb\_new** (int addr, char \*name)
- void **usb\_construct** (USB\_T \*usb, int addr, char \*name)
- void **usb\_destroy** (void \*usb)

### 12.19.1 Detailed Description

Module to simulate the AVR's USB module.

Definition in file `usb.c`.

### 12.19.2 Function Documentation

#### 12.19.2.1 VDevice\* usbi\_create ( int addr, char \* name, int rel\_addr, void \* data )

Allocate a new USB interrupt.

Definition at line 78 of file `usb.c`.

References `avr_error`.

#### 12.19.2.2 void usb\_intr\_construct ( USBInter\_T \* usb, int addr, char \* name, uint8\_t func\_mask )

Constructor for usb interrupt object.

Definition at line 103 of file usb.c.

References avr\_error, and vdev\_construct().

#### 12.19.2.3 void usb\_intr\_destroy ( void \* *usb* )

Destructor for usb interrupt object.

Definition at line 181 of file usb.c.

References vdev\_destroy().

#### 12.19.2.4 VDevice\* usb\_create ( int *addr*, char \* *name*, int *rel\_addr*, void \* *data* )

Allocate a new USB structure.

Definition at line 301 of file usb.c.

#### 12.19.2.5 void usb\_construct ( USB\_T \* *usb*, int *addr*, char \* *name* )

Constructor for new USB object.

Definition at line 321 of file usb.c.

References avr\_error, and vdev\_construct().

#### 12.19.2.6 void usb\_destroy ( void \* *usb* )

Destructor for USB object.

Definition at line 480 of file usb.c.

References vdev\_destroy().

### 12.20 utils.c File Reference

Utility functions.

## Functions

- `int str2ffmt (char *str)`
- `uint8_t set_bit_in_byte (uint8_t src, int bit, int val)`
- `uint16_t set_bit_in_word (uint16_t src, int bit, int val)`
- `uint64_t get_program_time (void)`
- `DList * dlist_add (DList *head, AvrClass *data, DListFP_Cmp cmp)`
- `DList * dlist_add_head (DList *head, AvrClass *data)`
- `DList * dlist_delete (DList *head, AvrClass *data, DListFP_Cmp cmp)`
- `void dlist_delete_all (DList *head)`
- `AvrClass * dlist_lookup (DList *head, AvrClass *data, DListFP_Cmp cmp)`
- `AvrClass * dlist_get_head_data (DList *head)`
- `DList * dlist_iterator (DList *head, DListFP_Iter func, void *user_data)`

### 12.20.1 Detailed Description

Utility functions. This module provides general purpose utilities.

Definition in file `utils.c`.

### 12.20.2 Function Documentation

#### 12.20.2.1 `int str2ffmt ( char * str )`

Utility function to convert a string to a FileFormatType code.

Definition at line 50 of file `utils.c`.

#### 12.20.2.2 `uint8_t set_bit_in_byte ( uint8_t src, int bit, int val )`

Set a bit in *src* to 1 if *val* != 0, clears bit if *val* == 0.

#### 12.20.2.3 `uint16_t set_bit_in_word ( uint16_t src, int bit, int val )`

Set a bit in *src* to 1 if *val* != 0, clears bit if *val* == 0.

#### 12.20.2.4 uint64\_t get\_program\_time ( void )

Return the number of milliseconds of elapsed program time.

##### Returns

an unsigned 64 bit number. Time zero is not well defined, so only time differences should be used.

Definition at line 76 of file utils.c.

References `avr_error`.

Referenced by `avr_core_run()`.

#### 12.20.2.5 DList\* dlist\_add ( DList \* head, AvrClass \* data, DListFP\_Cmp cmp )

Add a new node to the end of the list.

If `cmp` argument is not NULL, use `cmp()` to see if node already exists and don't add node if it exists.

It is the responsibility of this function to unref data if not added.

Definition at line 159 of file utils.c.

References `class_unref()`.

#### 12.20.2.6 DList\* dlist\_add\_head ( DList \* head, AvrClass \* data )

Add a new node at the head of the list.

Definition at line 196 of file utils.c.

#### 12.20.2.7 DList\* dlist\_delete ( DList \* head, AvrClass \* data, DListFP\_Cmp cmp )

Conditionally delete a node from the list.

Delete a node from the list if the node's data matches the specified data. Returns the head of the modified list.



Definition at line 215 of file utils.c.

References `avr_error`, and `class_unref()`.

Referenced by `dlist_iterator()`.

#### 12.20.2.8 void dlist\_delete\_all ( DList \* head )

Blow away the entire list.

Definition at line 266 of file utils.c.

References `class_unref()`.

Referenced by `avr_core_destroy()`.

#### 12.20.2.9 AvrClass\* dlist\_lookup ( DList \* head, AvrClass \* data, DListFP\_Cmp cmp )

Lookup an item in the list.

Walk the list pointed to by head and return a pointer to the data if found. If not found, return NULL.

##### Parameters

<i>head</i>	The head of the list to be iterated.
<i>data</i>	The data to be passed to the func when it is applied.
<i>cmp</i>	A function to be used for comparing the items.

##### Returns

A pointer to the data found, or NULL if not found.

Definition at line 291 of file utils.c.

References `avr_error`.

Referenced by `mem_get_vdevice_by_name()`.

#### 12.20.2.10 AvrClass\* dlist\_get\_head\_data ( DList \* head )

Extract the data from the head of the list.

Returns the data element for the head of the list. If the list is empty, return a NULL pointer.

**Parameters**

<i>head</i>	The head of the list.
-------------	-----------------------

**Returns**

A pointer to the data found, or NULL if not found.

Definition at line 321 of file utils.c.

**12.20.2.11 DList\* dlist\_iterator ( DList \* *head*, DListFP\_Iter *func*, void \* *user\_data* )**

Iterate over all elements of the list.

For each element, call the user supplied iterator function and pass it the node data and the *user\_data*. If the iterator function return non-zero, remove the node from the list.

**Parameters**

<i>head</i>	The head of the list to be iterated.
<i>func</i>	The function to be applied.
<i>user_data</i>	The data to be passed to the func when it is applied.

**Returns**

A pointer to the head of the possibly modified list.

Definition at line 357 of file utils.c.

References `avr_error`, and `dlist_delete()`.

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