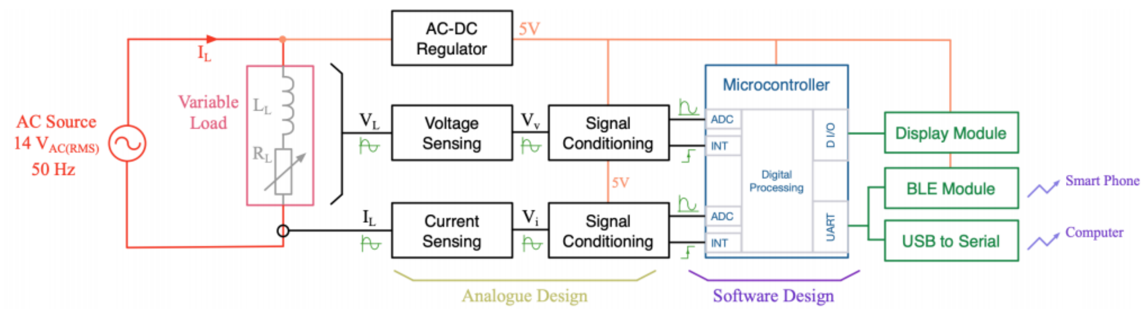
ENGGEN209 - Team 2 - Project Specifications:

Overview Of System To Impliment:

System to Implement

- To simplify the design, we will consider a scaled-down system, which uses a low-voltage AC source
  - An AC load, consisting of a variable resistor in series with a fixed inductor, is used to emulate an house-hold appliance



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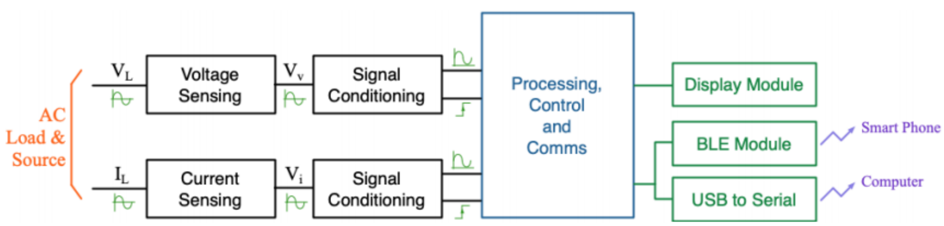
How Does an Energy Monitor Work?



- To implement the core energy monitor functionalities we have to
  - Measure the load current and voltage
  - Process these measurements to calculate the power and energy used by the load
- To implement a suitable user interface we may need to
  - Control a display to show the voltage, current, power and energy measurements to the user(s)
  - Communicate these measurements wirelessly with smart devices
  - Communicate these measurements through serial with a computer

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Key Design Specifications:

Key Design Specifications

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Parameter	Value
Source Voltage	14 V_{RMS} ± 10%
Source Frequency	50 Hz ± 2%
Load Range	2.5 VA to 7.5 VA
Load Power Factor	0.75 to 0.99
Measurement Accuracy	5% of full-scale reading
ADC Conversion Rate	1 kHz or slower
LCD Display Information	Voltage, Current, Power and Energy
LCD Display Units	V_{RMS}, A_{pk}, W and W.min
LCD Scroll Rate	1 s
UART Baud Rate	9600 Baud
Information Transferred Via UART	Voltage, Current, Power and Energy
PCB Size	20000 mm²
PCB Technology	Double Layer with PTH
Device Technology	TH or SMT

Planner

Course Calendar

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		Monday	Tuesday	Wednesday	Thursday	Friday
Wk 1	Jul	27	28	29 Lec – Intro *Wrk – Colab. Tools*	30	31 Lec – Sensors *Wrk – Colab. Tools*
Wk 2	Aug	03 *Lab – AC Circuits (S)*	04 *Lab – AC Circuits (S)*	05 Lec – Amplifiers *Lab – AC Circuits (S)*	06	07 Lec – Filters *Lab – AC Circuits (S)*
Wk 3	Aug	10 *Lab – AC Circuits (M)*	11 *Lab – AC Circuits (M)*	12 Lec – Regulators *Lab – Signal Con. (S)*	13	14 Lec – Micros *Lab – Signal Con. (S)*
Wk 4	Aug	17 *Lab – Signal Con. (M)*	18 *Lab – Signal Con. (M)*	19 Lec – UART *Lab – UART (S)*	20	21 Lec – ADC *Lab – UART (S)*
Wk 5	Aug	24 *Lab – UART (M)*	25 *Lab – UART (M)*	26 Lec – Conversion *Lab – Support*	27 **Test 1**	28 Lec – Prototyping *Lab – Support*
Wk 6	Aug/Sep	31 **Progress Review**	01 **Progress Review**	02 Lec – Components *Wrk – Altium*	03	04 Industry Seminar *Wrk – Altium*
	Sep	07	08 *Lab – Support*	09	10 *Lab – Support*	11
	Sep	14	15 *Lab – Support*	16	17	18 *Lab – Support*
Wk 7	Sep	21 *Lab – Support*	22 *Lab – Support*	23 Lec – Interrupts *Lab – ADC (S)*	24 **PCB Submission**	25 Lec – Timers *Lab – ADC (S)*
Wk 8	Sep/Oct	28 *Lab – ADC (M)*	29 *Lab – ADC (M)*	30 Lec – Instruments *Lab – Timers (S)*	01	02 Lec – Q&A *Lab – Timers (S)*
Wk 9	Oct	05 *Lab – Timers (M)*	06 *Lab – Timers (M)*	07 *Lab – Displays (S)*	08	09 *Lab – Displays (S)*
Wk 10	Oct	12 *Lab – Displays (M)*	13 *Lab – Displays (M)*	14 *Lab – Support*	15 **Test 2**	16 *Lab – Support*
Wk 11	Oct	19 *Lab – Support*	20 *Lab – Support*	21 *Lab – Support*	22	23 *Lab – Support*
Wk 12	Oct	26 **Labour Day**	27 **Interviews**	28 **Interviews**	29 **Interviews**	30 Rap Lecture

Circuitry to sense the voltage and current supplied to the load:

- Signal conditioning circuitry to amplify and filter the sensed voltage and current signals.
- A software-based digital processing system, which uses an ATmega328P microcontroller, to convert the analogue signals provided by the signal conditioning circuit to digital form and calculate the voltage, current, power and energy.
- AC to DC regulator circuitry to generate a 5 V DC supply for the analogue (and digital) circuitry employed in the energy monitor.
- A 7-segment LCD display module, which is connected to the microcontroller via a shift-register, to show the calculated information.
- A Bluetooth LE module, which is connected to the microcontroller via Universal Asynchronous Receiver/Transmitter (UART), to communicate information with a smart device like a phone.
- A USB interface with serial emulation, which is connected to the microcontroller via UART, to communicate information with a laptop/PC.

Provided Items

- The source configuration circuit.
- An Xplained Mini 328PB microcontroller module with headers providing easy access to the ports
- An HM-10 Bluetooth LE module which contains a CC2540 system-on-chip (SoC) and associated circuitry needed to interface directly with the UART port of the microcontroller
- A 4-digit seven-segment LCD display module which contains a 74HC595 shift-register and the logic circuitry required to interface with digital IO pins of the microcontroller.

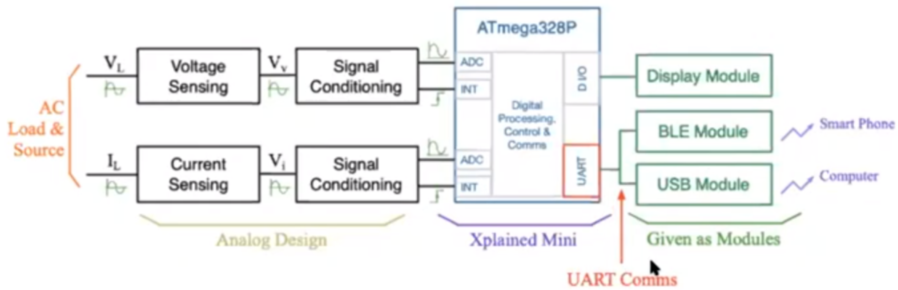
Bluetooth Module UART Specs:

UART Specifications for Project

Parameter	Setting
Baud Rate	9600
Parity	None
Stop Bits	1
Transmission Mode	Asynchronous

UART Communication Specifications:

UART Communication in Your Project



- Your energy monitor need to communicate with a PC and a smart phone
  - A USB module connects the energy monitor with a PC
  - A BLE radio transceiver module is used to communication with smart phone
- Both these module communicate with the microcontroller via UART
  - Data you send to these modules will be received by the PC and smart phone in UART format
  - Received data can be viewed using a terminal program (or developing your own application)

ADC Register Configuration:

Configuring the ADC

- First we need to configure the ADC as per our needs
  - Need to set the bits of the ADMUX, ADCSRA, ADCSRB and DIDR0 registers
  - Do this in an initialization function
- In the lectures, as an example, we will configure the ADC to operate in the single conversion mode
  - For the project you are required to operate the ADC in the auto triggered mode using a timer as the trigger source

```
// This function configures the ADC to use AVCC as reference and read ADC0 in single conversion mode
void adc_init(void){
  ADMUX = 0b01000000;      //AVCC set as reference, ADC0 selected and results are right adjusted
  ADCSRA = 0b10000111;     //Set ADEN bit to 1 (enable ADC) and prescaler to 111 (i.e. 128)
                           //To improve readability write in the form "ADCSRA = (1<<ADEN) | (7<<ADPS0);"
  ADCSRB = 0b00000000;     //Using the single conversion mode (for project you have to use auto trigger mode)
  DIDR0 = 0b00000000;      //Buffers are not disabled (for project you may disable the buffers to save power)
}
```

PCB Design Considerations:

PCB Design Considerations

- Arrangement of components is critical
  - MCU pins in use, allocation of Op-Amps, etc. need to be selected to help achieve a good design
  - Arrange in to functional blocks for example digital, power, signal conditioning, etc.
- Use appropriate track widths and clearances and for your UG projects use
  - Track widths of at least 0.5mm
  - Clearances of at least 0.5mm between tracks and 1mm between tracks and plane
- Minimize parasitic effects
  - Longer track introduces unwanted inductances and will pickup noise
  - Avoid sharp corners and use shortest path for traces
  - Use effective ground planes
- Allow sufficient clearance between components
  - Allow space for connectors, mountings, heat-sinks, etc.
- Make sure test points are accessible