# About

This index provides an initial material to help HW engineers gathering the basic knowledge in this field. Our target is to build HW capacity capable of implementing complete, ready to manufacture electronic products for our local market. This list is just a kick start and requires continuous maintenance and enhancements. Currently, it does not cover IC design, FPGA, Antennas or any RF or microwave circuits but may we can consider in the future.

# HW Training Materials

## Basic Electronics

### Circuit Simulation Tool (LTSpice)

**Objective**: To master LTSpice simulation tool and use it to:

1. Simulate linear and nonlinear circuits given during the course
2. Learn how evaluate different design approaches using (Transient, AC, DC, Worst case analysis, Parametric sweep, Analog behavioral modeling using controlled sources)
3. Add new third party components
4. Design Hierarchy

**Available materials**:

LTSpice is free and comes with a lot of built in examples and tutorials that can be used directly for example:

1. <https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html>

### ADC Types, Performance and Limitations

**Objective**: To understand ADC types, Parameters, Quantization and other Noise sources, Aliasing and Practical limits.

**Available materials**:

1. <https://www.analog.com/en/education/education-library/linear-circuit-design-handbook.html>
2. <https://catedra.ing.unlp.edu.ar/electrotecnia/islyd/apuntes/ABCs_of_ADCs.pdf>
3. <https://www.allaboutcircuits.com/technical-articles/understanding-amplitude-quantization-error-analog-digital-converters/>
4. <https://www.kistler.com/en/glossary/term/sampling-rate-and-aliasing-effect/#:~:text=The%20aliasing%20effect%20is%20a,signal%20is%20not%20acquired%20correctly>.
5. <https://thewolfsound.com/what-is-aliasing-what-causes-it-how-to-avoid-it/>
6. <https://en.wikipedia.org/wiki/Aliasing>
7. <https://www.tutorialspoint.com/digital_communication/digital_communication_quantization.htm>
8. [**https://www.tutorialspoint.com/digital\_communication/digital\_communication\_quantization.htm**](https://www.tutorialspoint.com/digital_communication/digital_communication_quantization.htm)

### Transcedusers and Analog Signal Conditioning

**Objective**: To practice interfacing with different types of sensors, understand their physical characteristics, operating ranges, accuracy, and typical interface circuits for famous sensors like but not limited to: Temp, Voltage, Current, Pressure, Level, Flow, Acceleration

**Available materials:**

1. <https://www.analog.com/en/education/education-library/transducer-interfacing-handbook.html>
2. <https://www.ti.com/analogrefguide>
3. Shunt resistor Kelvin connection: <https://www.analog.com/en/analog-dialogue/articles/optimize-high-current-sensing-accuracy.html>

### Oscillators, MCU Supervisory (Watch dog and Brownout)

**Objectives:** Learn how it works, how to calculate external elements, Accuracy and calibration, Temperature dependency, Types and applications ([**XO**](https://abracon.com/parametric/oscillators?part_status=Active&brand=Fox), [**TCXO**](https://abracon.com/parametric/oscillators?part_type=TCXO&part_status=Active&brand=Fox), [**VCXO**](https://abracon.com/parametric/oscillators?part_type=VCXO&part_status=Active&brand=Fox)). Additionally the

**Available materials:**

1. <https://www.elsevier.com/books/practical-oscillator-handbook/gottlieb/978-0-7506-3102-0>
2. <https://www.st.com/resource/en/application_note/cd00221665-oscillator-design-guide-for-stm8afals-stm32-mcus-and-mpus-stmicroelectronics.pdf>
3. <https://lnct.ac.in/wp-content/uploads/2020/03/Analog-Circuit-EC-405-Oscillator.pdf>
4. [**https://www.analog.com/media/en/technical-documentation/tech-articles/supervisory-circuits-keep-your-microprocessor-under-control.pdf**](https://www.analog.com/media/en/technical-documentation/tech-articles/supervisory-circuits-keep-your-microprocessor-under-control.pdf)
5. [**http://ww1.microchip.com/downloads/en/AppNotes/00686a.pdf**](http://ww1.microchip.com/downloads/en/AppNotes/00686a.pdf)
6. [**https://www.ti.com/lit/slyy167**](https://www.ti.com/lit/slyy167)

### Galvanic Isolation

**Objectives:** Importance of Isolation, Isolation Design Parameters, Power, Analog and Digital Isolation techniques.

**Available materials:**

1. <https://dewesoft.com/daq/galvanic-isolation-in-daq-system#:~:text=and%20digital%20isolation.-,Three%20Basic%20Isolation%20Techniques,Capacitive%20isolation>
2. <https://www.elprocus.com/what-is-galvanic-isolation-working-its-applications/>
3. <https://www.ti.com/lit/pdf/slla284>
4. <https://www.ti.com/lit/pdf/slla284>
5. <https://www.analog.com/media/en/technical-documentation/tech-articles/MS-2234.pdf>
6. <https://www.digikey.com/en/articles/how-to-implement-galvanic-isolation-for-power-and-signal-lines>
7. <https://www.digikey.com/en/articles/how-select-galvanic-isolation-technology-for-iot-sensors>

### Circuit Protection

**Objectives:** To learn the causes, models, standards of Fast Transients/Surge and ESD and common protection devices and sizing and PCB layout

**Available materials:**

1. Varistor Selection (prepared by Mohamed Fouly): <https://www.slideshare.net/MohammedFouly/varistor-selection-for-circuit-protection-against-surge-signals>
2. <https://resources.system-analysis.cadence.com/blog/msa2021-protect-your-board-against-electrical-fast-transients>
3. <https://www.infineon.com/dgdl/Infineon-AN80994_Design_Considerations_for_Electrical_Fast_Transient_(EFT)_Immunity-ApplicationNotes-v09_00-EN.pdf?fileId=8ac78c8c7cdc391c017d072b38ea5000>
4. <https://www.nxp.com/docs/en/application-note/AN2764.pdf>

### Data Busses

**Objectives:** To learn the **physical properties and common driver circuits** of different communication busses Onboard (SPI, I2C, UART, SWI, JTAG, and External RS485, CAN, LIN)

**Available materials:**

1. <https://advantech-bb.com/wp-content/uploads/2014/12/RS-422-RS-485-eBook.pdf>
2. <https://www.ti.com/lit/pdf/slla545>
3. <https://www.ti.com/lit/pdf/sloa101>
4. <https://lipowsky.com/downloads/Software/LIN-Basics_for_Beginners-EN.pdf>
5. <https://www.nxp.com/docs/en/application-note/AN10216.pdf>

## PCB Design

### PCB design Tool

**Objectives:** To perfect Altium Designer, from the schematic design, PCB and manufacturing files. In addition, to advanced topics to enable teamwork like component library management and reuse blocks.

**Available materials:**

Mostly videos with some documents so it is mainly training practices

1. [**https://www.altium.com/solutions/academic-programs/altium-designer-online-resources**](https://www.altium.com/solutions/academic-programs/altium-designer-online-resources)

### EMC compliant PCB design

**Objectives:**

1. To learn fundamental EMC tests, standards and design techniques especially (Conduced Emission, Radiated Emission, Conducted Immunity and Radiated Immunity)

**Available materials:**

1. <https://library.oapen.org/bitstream/handle/20.500.12657/60162/1/978-3-031-14186-7.pdf>
2. <https://aktif.net/en/electromagnetic-compatibility-emc-in-pcb-designs/>
3. <https://www.academyofemc.com/emc-design-guidelines>
4. <https://learnemc.com/emc-resources>
5. [**https://www.renesas.com/us/en/document/apn/cps-1848-pcb-design-app-note**](https://www.renesas.com/us/en/document/apn/cps-1848-pcb-design-app-note)

### Reliable PCB design and Static Life Time SLT estimation

**Objectives:**

1. To learn Reliability and life time estimation math and tools, in addition to learn how to assess the contribution of: Component type/ quality and the environmental factors and design margins

**Available materials:**

1. <https://www.quanterion.com/wp-content/uploads/2014/09/MIL-HDBK-217F.pdf>
2. <https://www.test-navi.com/eng/report/pdf/ApproachestoLifeEstimationofElectronicCircuits.pdf>
3. <https://www.chemi-con.co.jp/en/faq/detail.php?id=LifetimeCalc>
4. [**https://aldservice.com/Free-MTBF-Calculator.html**](https://aldservice.com/Free-MTBF-Calculator.html)

### High-Speed PCB Design - Signal Integrity

**Objectives:** To learn transmission line effects on PCB, Matching, Delay equalization

**Available materials:**

1. <https://picture.iczhiku.com/resource/eetop/wHIFhWWoIkGkuXXv.pdf>
2. <http://www.designer-iii.com/AppNotes/AN1051.pdf>
3. <https://www.ti.com/lit/scaa082>

### PCB design for Manufacturing

**Objectives:**

1. To learn how the production lines works and different rules to design for manufacturability DFM
2. To know tips for Flex PCB design

**Available materials:**

1. [**https://resources.pcb.cadence.com/blog/design-for-manufacturing-or-dfm-analysis-pcb-dfm-process-slp**](https://resources.pcb.cadence.com/blog/design-for-manufacturing-or-dfm-analysis-pcb-dfm-process-slp)
2. [**https://s3.amazonaws.com/static.projects.hackaday.com/3002781569442527864.pdf**](https://s3.amazonaws.com/static.projects.hackaday.com/3002781569442527864.pdf)
3. [**https://www.protoexpress.com/blog/5-must-knows-for-your-first-flex-design/**](https://www.protoexpress.com/blog/5-must-knows-for-your-first-flex-design/)

## Power Supply Design

### Linear Power Supplies

**Objectives:**

1. To learn different types of power supplies Linear Regulators
2. To Learn Component Sizing (Transformer, Bridge, Input and Output Caps
3. Regulator chip selection (LDO, Quiescent Current, Tolerance, Ripple rejection Stability)
4. Losses and expected temperature rise in different parts (Basics)

**Available materials:**

1. [Linear Power Supply (Internal construction, Parameters, Transformer, Bridge, Cap)](https://www.analog.com/en/app-notes/an-140.html)

### SMPS Power Supplies

**Objectives:**

1. To learn different types of SMPS Topologies (Isolated / Non-Isolated)
2. Component Parasitics and Sizing (Coils, Transformer, Bridge, Input and Output Caps, Stability,
3. Losses and expected temperature rise in different parts
4. How to design Magnetics (Coils and Transformers)

**Available materials:**

1. Buck Regulators
2. [Fly-back](https://www.tij.co.jp/jp/lit/slup254) Under the hood (TI App. note)
3. [Basic Heat sink sizing and selection](https://www.ti.com/lit/snva419)
4. [Accurate Thermal Calculations on the Back of a Napkin](https://www.ti.com/lit/pdf/slpa015#:~:text=The%20back%20of%20the%20napkin,PCB%20with%20only%20convection%20cooling).)
5. [Thermal Design By Insight, Not Hindsight](https://www.ti.com/lit/snva419)
6. [Practical Transistor Circuits (BJT, MOS Switches, Relay drivers)](https://www.talkingelectronics.com/projects/200TrCcts/200TrCcts.html)
7. Practical Passive/Active Component Characteristics Parasitic elements (Resistor/inductor/capacitor/Diodes/Thyristors/MOSFETs/IGBTs)
8. Protection circuit design (Overvoltage/under-voltage/overcurrent/short-circuit).
9. Design of measurement circuits (Current/Voltage/Temperature).
10. Power circuit design of Non-isolated DC/DC converters
11. Power circuit design of Isolated DC/DC converters
12. Modelling and control of DC/DC converters
13. Inductor and Transformer design for switching converters
14. EMI filter design for switching converters
15. Simulation of magnetic components
16. Efficiency analysis of switching converters

## Automotive Functional Safety FuSa

### Basics of ISO 2626 Safety Standard

### FuSa Concept level

### FuSa System Development level

### HW FuSa Safety Case Development (Fmeda)

# Tools

## SW Tools and Calculators

* [Free PCB Tool KiCAD](https://www.kicad.org/)
* Power Stage Designer: <https://www.ti.com/tool/POWERSTAGE-DESIGNER>
* [TI Webench](https://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html#design)
* [Fuji Design tool PDF and excel](https://www.fujielectric.com/products/semiconductor/model/power_supply/tool/fly-back_transformer_design.html) for Flyback Transformer design

## Low Cost and DIY HW Tools

### Oscilloscopes

* [Hantek](http://www.hantek.com/products/2)
* [Pico Technology](https://www.picotech.com/products/oscilloscope)
* [Rigol](https://int.rigol.com/products/products/oscilloscopes?utm_term=oscilloscope&utm_campaign=ME-IND+-+Search+-+Apr+2022&utm_source=adwords&utm_medium=ppc&hsa_acc=9509525127&hsa_cam=16810194182&hsa_grp=136068874475&hsa_ad=591585992586&hsa_src=g&hsa_tgt=kwd-10588251&hsa_kw=oscilloscope&hsa_mt=b&hsa_net=adwords&hsa_ver=3&gclid=Cj0KCQjw4NujBhC5ARIsAF4Iv6eWLO1vgWMEIsuNne74JdSjPHdCp6xacS0FsMADCK49ayBDLkIA92AaAgyhEALw_wcB)
* [ElecBee DIY Oscilloscope](https://www.elecbee.com/en-29604-NEW-13805K-DSO138-mini-200KHz-Digital-Oscilloscope-SMD-Soldered-Version-DC3-5V-6V?network=g&campaign=18719854073&adgroup=140153146062&creative=630917925115&keyword=&target=aud-694973216325:pla-296303633664&matchtype=&devicemodel=&placement=&feeditemid=&adpostition=&gclid=Cj0KCQjw4NujBhC5ARIsAF4Iv6fvqBPvDQlfno9dGjP22y8i63a_1WlHou4TBRp44PSo-O0XAmtUEg4aAgskEALw_wcB)
* [HS101: A HIGH QUALITY, AND CHEAP DIY OSCILLOSCOPE](https://www.electronics-lab.com/project/hs101-high-quality-cheap-diy-oscilloscope/)
* [Hackday DIY Oscilloscope](https://hackaday.com/tag/diy-oscilloscope/)
* RAM Electronics - [DSO138 Soldered Pocket Size Digital Oscilloscope Kit DIY 200KHz + Free Acrylic Case](https://ram-e-shop.com/product/kit-dso138-oscilloscope/)
* [DIY SmartPhone Oscilloscope using Raspberry Pi Pico](https://how2electronics.com/diy-smartphone-oscilloscope-using-raspberry-pi-pico/)

### PC based Logic Analyzers

* [Kingst Electronics](http://www.qdkingst.com/en)
* [Saleae](https://www.saleae.com/)

### Power Supplies

* [DIY programmable (SCPI) bench power supply](https://www.elektormagazine.com/labs/diy-programmable-scpi-bench-power-supply)
* [DIY Programmable (SCPI) Bench Power Supply](https://www.hackster.io/prasimix/diy-programmable-scpi-bench-power-supply-5e59d5)2
* Other projects from Elector Lab <https://www.elektormagazine.com/labs/>

### Function Generators

* [UNI-T Function/Arbitrary Waveform Generator UTG9005C-II](https://www.amazon.eg/-/en/Function-Arbitrary-Waveform-Generator-UTG9005C-II/dp/B0B7NVMR4R/ref=sr_1_10?adgrpid=131712090867&hvadid=554889746820&hvdev=c&hvlocphy=9073656&hvnetw=g&hvqmt=e&hvrand=7197550487641385584&hvtargid=kwd-314913006841&hydadcr=9784_2188516&keywords=function+generator+diy&qid=1685541196&sr=8-10)
* [UTG962E UNI-T](https://www.tme.eu/eg/en/details/utg962e/generators-and-frequency-meters/uni-t/?brutto=1&currency=USD&gclid=Cj0KCQjw4NujBhC5ARIsAF4Iv6c7v8TgQnvI0ZCCeRXmKy8r9DZpTtiprUMEGRLbxDqd2rS0n4oomUgaAlJhEALw_wcB)
* [Sgp1002s Digital Signal Generator DDS Function Generator Sine Wave Arbitrary Waveform Frequency Generator](https://www.elecbee.com/en-29536-SGP1002S-Digital-Signal-Generator-DDS-Function-Generator-Sine-Wave-Arbitrary-Waveform-Frequency-Generator?network=g&campaign=18719854073&adgroup=140153146062&creative=630917925115&keyword=&target=aud-384004394606:pla-296303633664&matchtype=&devicemodel=&placement=&feeditemid=&adpostition=&gclid=Cj0KCQjw4NujBhC5ARIsAF4Iv6dzto7_-zCS30vkYAsWuyPP3kOK1htdGxmD4Dnk3I6ijCdSNVstgE8aAsrgEALw_wcB)
* [DIY Function/Waveform Generator](https://www.instructables.com/DIY-FunctionWaveform-Generator/)
* [DIY Function Generator using XR2206 Kit : 1Hz-1MHz](https://how2electronics.com/diy-function-generator-using-xr2206-kit-1hz-1mhz/)
* [DDS Signal Generator FG-100 DDS Function Generator](https://www.amazon.eg/-/en/DDS-Signal-Generator-FG-100-Function/dp/B091D8GCS5/ref=sr_1_8?adgrpid=131712090867&hvadid=554889746820&hvdev=c&hvlocphy=9073656&hvnetw=g&hvqmt=e&hvrand=7197550487641385584&hvtargid=kwd-314913006841&hydadcr=9784_2188516&keywords=function+generator+diy&qid=1685541051&sr=8-8)

# Other References – Text Books

* Entry level, Theoretical approach:
* Fundamentals of Power Electronics
* Book by Dragan Maksimović and Robert Warren Erickson
* Entry level, Practical approach:
* Switching Power Supplies A - Z
* Book by Sanjaya Maniktala
* Experienced level:
* Troubleshooting Switching Power Converters: A Hands-on Guide
* Book by Sanjaya Maniktala
* Characteristics of Electrolytic Capacitors
* Characteristics of Ceramic Capacitors
* SW Tool of AVX Company: <https://spicat.kyocera-avx.com/mlcc>
* SW Tool of KEMET Company: <https://ksim3.kemet.com/capacitor-simulation>