PCB Anatomy

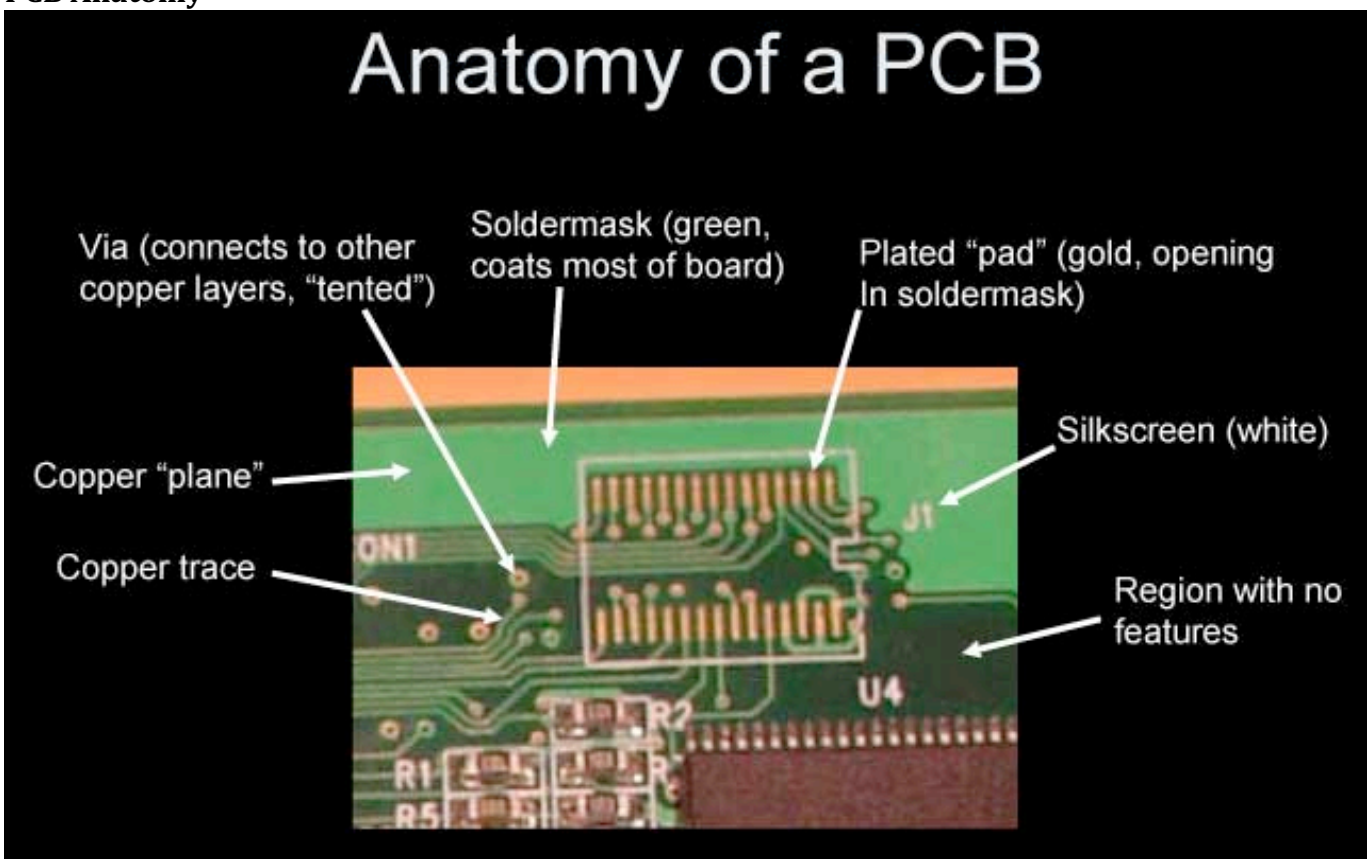

Figure 1. Image of a PCB with some features identified. ***Source: anekapcb.com***

Learning Objectives

Upon successful completion of this module, you will be able to:

- Identify the primary components of PCBs and their functions.
- List the materials and processes for PCB construction in the order they occur.
- Define the most important features of a simple PCB.
- Recognize some of the important component and circuit features in a cell phone.

Terminology

The terms printed wiring board (PWB) and printed circuit board (PCB) are synonymous, although PCB may refer to an assembled board with components soldered on. A PCB is a composite structure of organic and inorganic materials with internal and external wiring, allowing electronic components to be electrically interconnected and mechanically supported. A PCB must provide power to the attached components and conduct away heat when necessary. They may also be called motherboards or system-level boards, because they carry all of the components required for the system's function. They may be called backplanes when other daughter boards are attached. An example of this is when additional memory cards are added to a mother board to provide more system RAM (random access memory) to a computer or other device.

Construction

The terminology 'printed circuit' refers to the idea that the electrical circuit's conductive pathways or 'traces' can be created on the board surfaces via an image transfer process that resembles

printing techniques. The substrate or material that supports the system must be electrically insulating – most commonly a composite of woven glass fiber layers in a polymer matrix (a.k.a., fiber glass). The matrix material is often epoxy, or another polymer material which together with the reinforcement fiber provide strength and rigidity. A *rigid* board is one that has little flexibility while *flexible* boards are specifically designed to be bendable. The conductive material on top often begins as a sheet of **copper foil** bonded to one or both sides of the substrate. The most popular product in the rigid form is 'FR-4 board'. 'FR-4' refers to its flame retardation rating as 'self-extinguishing'.

Photo-tool
A thin, stencil-like **photo-tool** is made to represent the desired electrical traces using a computer aided design (CAD) system. The photo-tool may be a positive or negative image of the traces depending on whether positive or negative photoresist is employed. A *negative* photo-tool has transparent areas for the traces, but is opaque everywhere else.

Photoresist
To create the circuit pathways some areas of the Cu conductor must be removed and other areas retained as traces, solder pads, vias and test points. Commonly, a light-sensitive material called **photoresist** is applied to the Cu to mask off specific areas of the Cu to keep. Photoresist may be 'negative' or 'positive' type. ***Negative*** photoresist polymerizes (*hardens*) with assistance from light energy, often ultraviolet (UV). ***Positive*** photoresist is similar, but *softens* when exposed to light. Alternatives to photoresist exist to transfer the circuit image to the Cu board such as thermal bonding. This discussion describes a method using photoresist and a photo-tool.

UV Light & Chemical Developer
Next, intense **UV light** is shined through the pattern openings in the photo-tool onto the photoresist. UV energy hardens the exposed photoresist so that a **developer** chemical can then dissolve away the unexposed (unhardened) photoresist. Only hardened photoresist 'mask' remains over the Cu trace areas after developing.

Chemical Etchant
The unmasked Cu is then selectively removed by **acid etching**. The etching time depends on the acid used and other variables that affect removal of Cu to result in near-perfect circuit traces.

Chemical Stripper
Finally, the hardened photoresist masking material is **stripped** off chemically to reveal the bare copper circuit traces.

These processes can be repeated on the other side and multiple, two-sided layers stacked together to make complex PCBs of many layers thick.

Drilling
Depending upon the types of components to be attached and the complexity of the design, various holes are **drilled** in the board. Holes provide for mounting screws, component leads or to provide small pathways for communication between layers called **vias**.

Plating
The PCB could at this point be assembled with components, however bare Cu has poor oxidation resistance and rusts easily in air making soldering difficult. A layer of **solder plating** is usually applied over the Cu features to enhance manufacturability. A layer of gold may be applied to further protect the solder pads to ensure solderability.

Solder Mask
Solder mask or **solder resist** is a thin lacquer-like layer of polymer that is usually applied over the copper traces for protection against oxidation and to prevent solder bridges from forming between closely spaced solder pads. It is usually colored for aesthetic reasons.

Silkscreen
Finally, information markings are applied atop the solder mask via a silk-screening process using indelible ink. Reference designators, values, polarities, part numbers, manufacturing codes and advertising may be contained in the silkscreen layer.

The process just described is often called the **Print & Etch** technique. Many variations in the manufacturing processes for PCBs exist, but they share in that they provide an insulating substrate with specific conductive areas to carry power and signals throughout the system.

A video demonstrating the basics of circuit board manufacturing in the IME lab can be found here:

Print & Etch Video

https://www.youtube.com/watch?v=Ji8WMi7beRA&t=19s

Figure 2 below shows the top side of a finished PCB as-purchased, ready to be assembled with components by soldering. Many of the most important features and markings have been identified. There are exposed and unexposed (coated over with solder mask) conductors visible in the illustration. The solder pads (also called lands) are exposed Cu plated with solder to enhance solderability. A red plastic coating of solder mask covers the Cu conductor primarily to prevent solder from unintentionally 'bridging' between the pads, but is also for aesthetics. The topmost layer is for ink markings to provide component identification and placement information.

Some of the identification markings printed in white ink in Figure 2 include:
Reference Designators (R1, C1, IC1, etc.)
Component Values (1K, .33uF, etc.)
Polarities (+, -)
Part Numbers (LM805, OPA2134, etc.)
Pin/Pad Labels (12V, GND, Vin, etc.)
Manufacturer Codes (DMC)
Testing Instructions

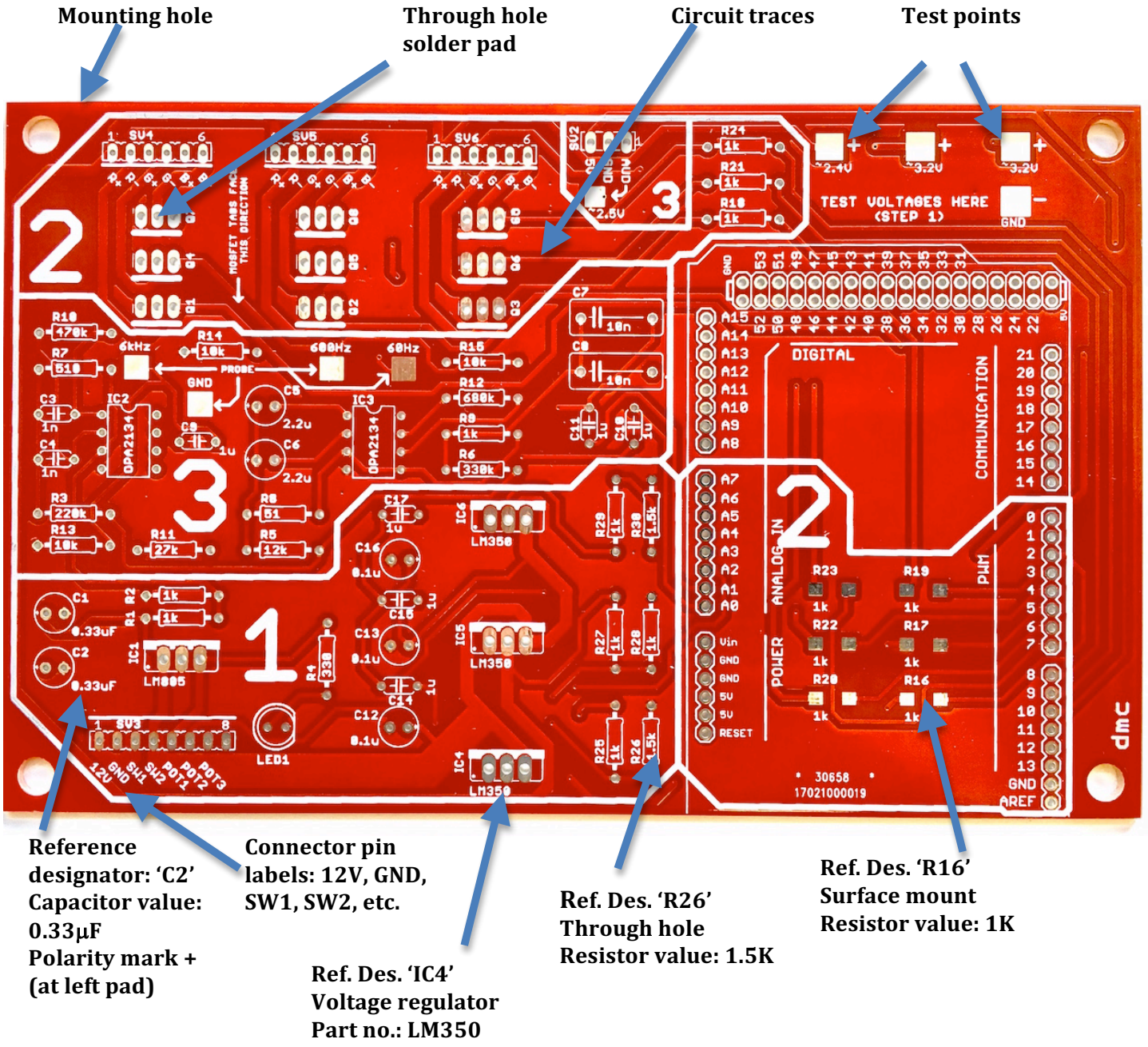

Figure 2. Prism lab project main board with several important features identified. This is a *mixed* assembly PCB – meaning it has mostly **through holes**, but also a few **surface mount pads** in Region 2.

Cell phones have one or more PCBs which may each have multiple layers. Cell phone PCBs are assembled with automated processes using mostly surface mount components. Although they look very different than a Prism PCB, they are fundamentally very similar.

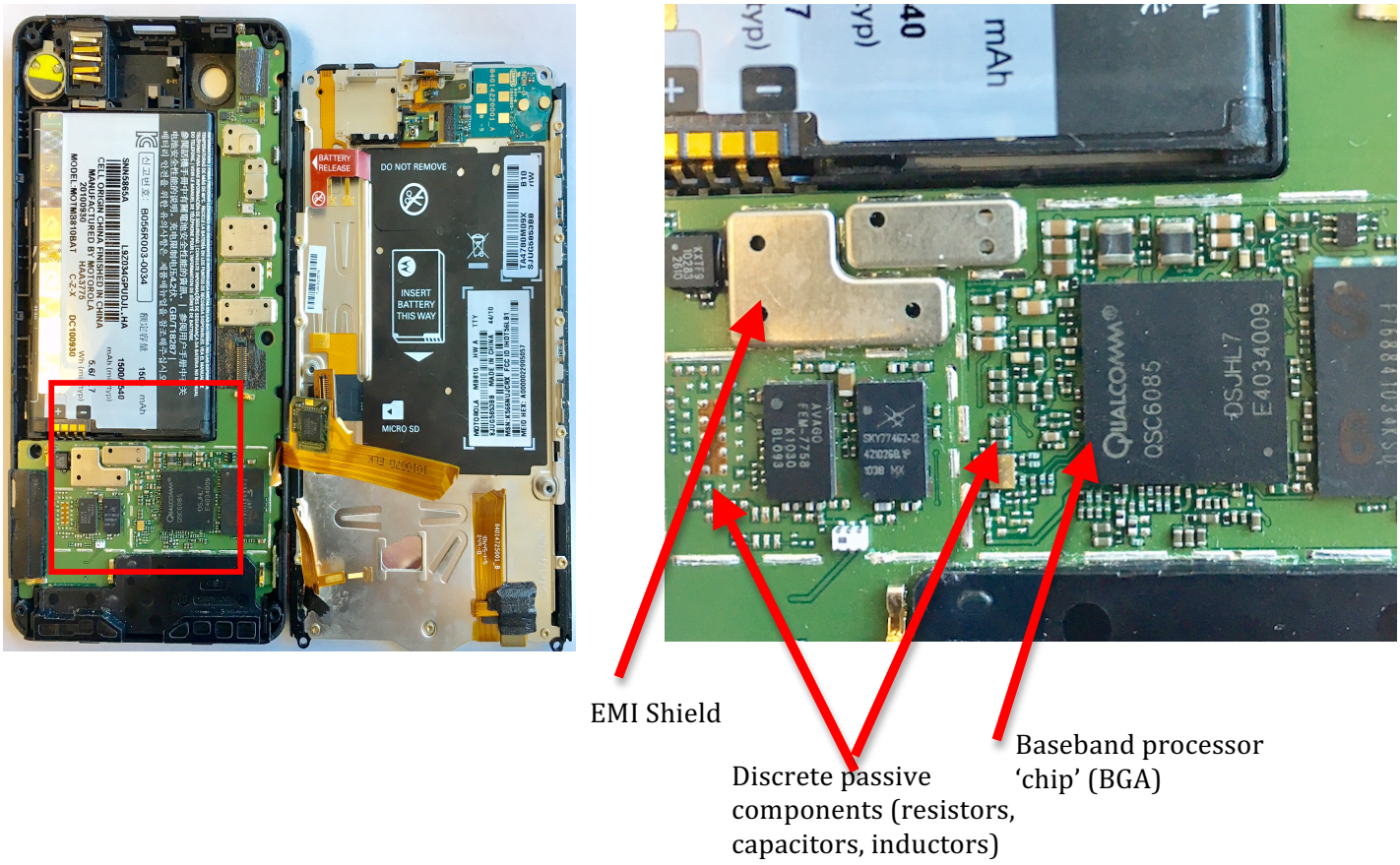

Figure 3. Mobile phone and its main PCB and display assembly (Left). Right image is enlargement of red square area in left showing circuit components on the PCB. RF communication components are covered by metallic shields (electro-magnetic interference (EMI) protection).

Review Exercises

Complete the exercises below to review the print & etch PCB manufacturing process and be able to identify key components and their functions.

Exercise 1
Order the following PCB construction processes chronologically by numbering the steps:

____ acid etch
____ ultraviolet light exposure
____ hole drilling
____ bond Cu foil to fiberglass/epoxy substrate
____ photoresist application
____ chemical stripping
____ developer chemical
____ silkscreen

Exercise 2
Identify the following PCB features as either **conductive**, **insulating or informational**:

SMOBC _____
FR-4 Board _____
Copper trace _____
Ink markings _____
Solder plating _____
Cu-plated thru holes _____
Solder joint _____
Component lead _____

Exercise 3
List the components/parts of a PCB system that enable the following functions:

Signal and power transmission

Communicate information

Minimize solder bridges

Confine RF transmission signals

Provide for attachment of PCB to chassis

Provide communication between PCB layers

Provide oxidation resistance and solderability