MAHAMAYA POLYTECHNIC OF IT

HATHRAS

SMART PHONE TESTING

(AN e-CONTENT FOR UPSKILLING DIPLOMA STUDENTS)

MS PATRIKA JAYANTI

LECTURER ELECTRONICS

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- Hardware Design Flow of Smart Phone
  - Smart Phone Design Flow Overview
  - System Platform Architecture
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  - Smart Phone Production Flow Overview
  - Production Checklist
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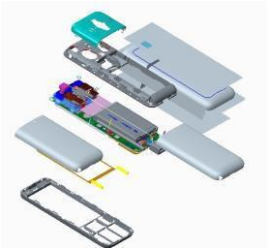
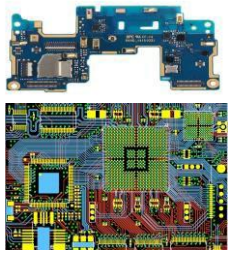
- Brief Introduction of OrCAD
  - Why do we use OrCAD
  - How to use OrCAD
  - Case Study

Overview of Smart Phone Development




System Architecture

- Feature evaluation
- System benchmark
- BOM cost evaluation
- ID & ME discussion
- Schedule planning

Design & Integration

- Schematic design
- Placement review
- PCB layout review
- Mechanical design
- BOM review
- PI/SI simulation
- Manufacture planning
- Software requirement

Design Validation

- Documents for production
- SMT profile verification
- System assembly review
- Production test coverage
- Test jig design
- Software validation
- Supply chain management

Mass Production

- **System Platform Architecture - Feature specification (1/2)**

Oppo A83

Released 2018, January
143g, 7.7mm thickness
Android 7.1
32GB storage, microSD card slot

11%
832,334 HITS

18
BECOME A FAN

5.7"
720x1440 pixels

13MP
1080p

4GB RAM
MT6763T Helio P23

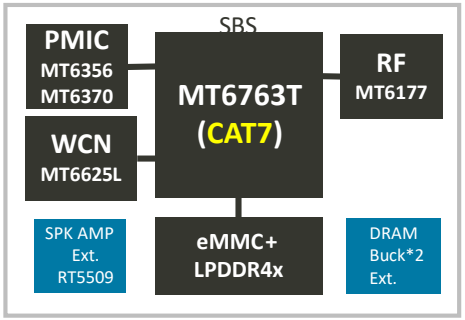
3180mAh
Li-Ion

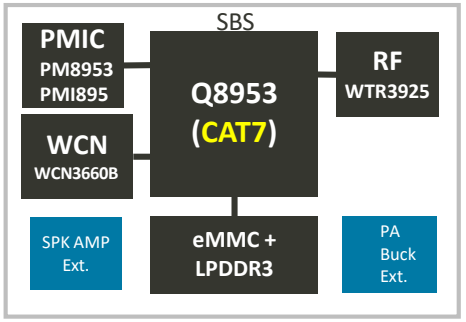
NETWORK	Technology	GSM / CDMA / HSPA / LTE COLLAPSE ▲
	2G bands	GSM 850 / 900 / 1800 / 1900 - SIM 1 & SIM 2
		CDMA 800 & TD-SCDMA - China
	3G bands	HSDPA 850 / 900 / 2100 - India, Thailand
		HSDPA 850 / 900 / 1900 / 2100 - China
	4G bands	LTE band 1(2100), 3(1800), 5(850), 8(900), 38(2600), 40(2300), 41(2500) - India, Thailand
		LTE band 1(2100), 3(1800), 5(850), 7(2600), 8(900), 34(2000), 38(2600), 39(1900), 40(2300), 41(2500) - China (A83t)
	Speed	HSPA, LTE
	GPRS	Yes
	EDGE	Yes
LAUNCH	Announced	2018, January
	Status	Available. Released 2018, January
BODY	Dimensions	150.5 x 73.1 x 7.7 mm (5.93 x 2.88 x 0.30 in)
	Weight	143 g (5.04 oz)
	Build	Front glass, aluminum body
	SIM	Dual SIM (Nano-SIM, dual stand-by)
DISPLAY	Type	IPS LCD capacitive touchscreen, 16M colors
	Size	5.7 inches, 83.8 cm^2 (~76.2% screen-to-body ratio)
	Resolution	720 x 1440 pixels, 18:9 ratio (~282 ppi density)
	Multitouch	Yes
		- ColorOS 3.2

- **System Platform Architecture - Feature specification (2/2)**

PLATFORM	OS	Android 7.1 (Nougat)
	Chipset	Mediatek MT6763T Helio P23
	CPU	Octa-core 2.5 GHz Cortex-A53
	GPU	Mali-G71 MP2
MEMORY	Card slot	microSD, up to 256 GB (dedicated slot)
	Internal	32 GB, 3 GB RAM or 4 GB RAM (China only)
CAMERA	Primary	13 MP, f/2.2, autofocus, LED flash
	Features	Geo-tagging, touch focus, face detection, HDR, panorama
	Video	1080p@30fps
	Secondary	8 MP, f/2.2
SOUND	Alert types	Vibration; MP3, WAV ringtones
	Loudspeaker	Yes
	3.5mm jack	Yes
		- Active noise cancellation with dedicated mic
COMMS	WLAN	Wi-Fi 802.11 a/b/g/n, dual-band, WiFi Direct, hotspot
	Bluetooth	4.2, A2DP, LE
	GPS	Yes, with A-GPS
	Radio	No
	USB	microUSB 2.0, USB On-The-Go
FEATURES	Sensors	Accelerometer, proximity, compass
	Messaging	SMS (threaded view), MMS, Email, Push Email
	Browser	HTML5
		- MP4/H.264 player - MP3/WAV/eAAC+/FLAC player - Document viewer - Photo/video editor
BATTERY		Non-removable Li-Ion 3180 mAh battery
MISC	Colors	Champagne, Black
	Price	About 200 EUR

- System benchmark & BOM cost evaluation
  - Below is an example only for reference in class but not a real case





Feature	MT6763T – CAT7 China 6M10B (CMCC/CU/CT CA) 32K-Less, No ET/AT BT/WiFi(2.4/5G) /GPS/FM GPS co-TMS eMMC + LPDDR4x 3A Charger FHD display / Front+Rear CAM SD/SIM1/SIM2 card Integrated audio codec/ external Smart PA USB 2.0 A+G/Pressure/M/ALPS sensors			Q8953 – CAT7 China 6M10B (CMCC/CU/CT CA) 32K-Less, No ET/AT BT/WiFi(2.4/5G) /GPS/FM GPS co-TSX eMMC + LPDDR3 3A Charger FHD display / Front+Rear CAM SD/SIM1/SIM2 card Integrated audio codec/ external Smart PA USB 2.0 A+G/Pressure/M/ALPS sensors		
	Count	Cost ($)	Area (mm^2)	Count	Cost ($)	Area (mm^2)
BB/AP	140	0.2	536.4	230	0.3	643.0
CLK	1	0.1	15.4	2	0.2	30.6
PMIC + Codec	110	1.6	444.1	100	1.5	420.6
Connectivity	2	0.6	53	50	0.7	102
RF	190	5.5	492	210	5.8	512
Main Chip	5	-	237	5	-	293
Total	477	8.0	1778	597	8.5	2001.2

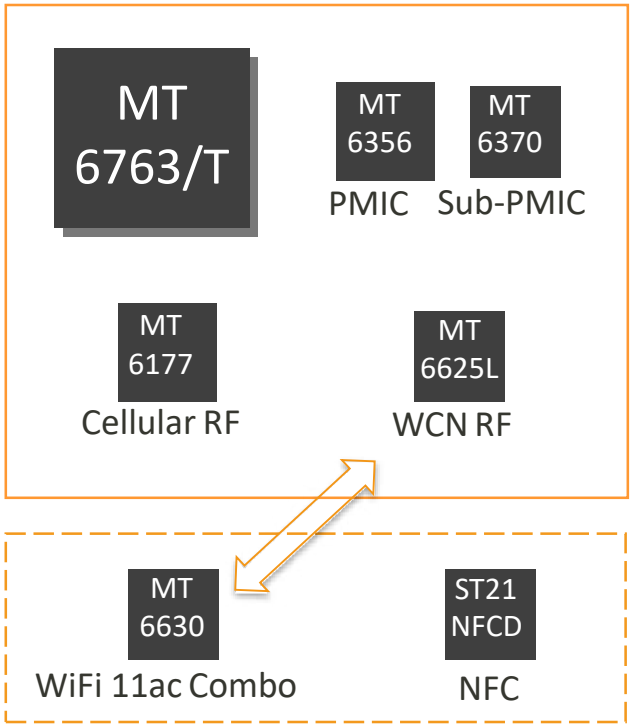
Schematic design – Platform specification (1/2)

- Take MT6763 as an example

	MT6763	MT6763T
Process	16nm	16nm
Apps CPU	8xCortex-A53 up to 2.0GHz	8xCortex-A53 up to **2.5GHz**
Memory	eMMC5.1 1xLP3 933MHz, 4GB or 2xLP4x 1500MHz, 6GB	eMMC5.1 1xLP3 933MHz, 4GB or 2xLP4x 1500MHz, 6GB
Camera	24MP @ 30fps w/ ZSD 13MP + 13MP @ 30fps Dual cam	24MP @ 30fps w/ ZSD 13MP + 13MP @ 30fps Dual cam
Video Dec.	1080p 30fps H.264/H.265	**4K 30fps H.264/265**
Video Enc.	1080p 30fps H.264	**4K 30fps H.264**
Graphics	ARM Mali G71 MP2 700MHz	ARM Mali G71 MP2 **770MHz**
Display	FHD+ (2160x1080)	FHD+ (2160x1080)
Modem	Cat-6	**Cat-7**
Transceiver	MT6177	MT6177
PMIC	MT6356 + MT6370	MT6356 + MT6370
Connectivity	MT6625L / MT6630(ac)	MT6625L / MT6630(ac)

Schematic design – Platform specification (2/2)

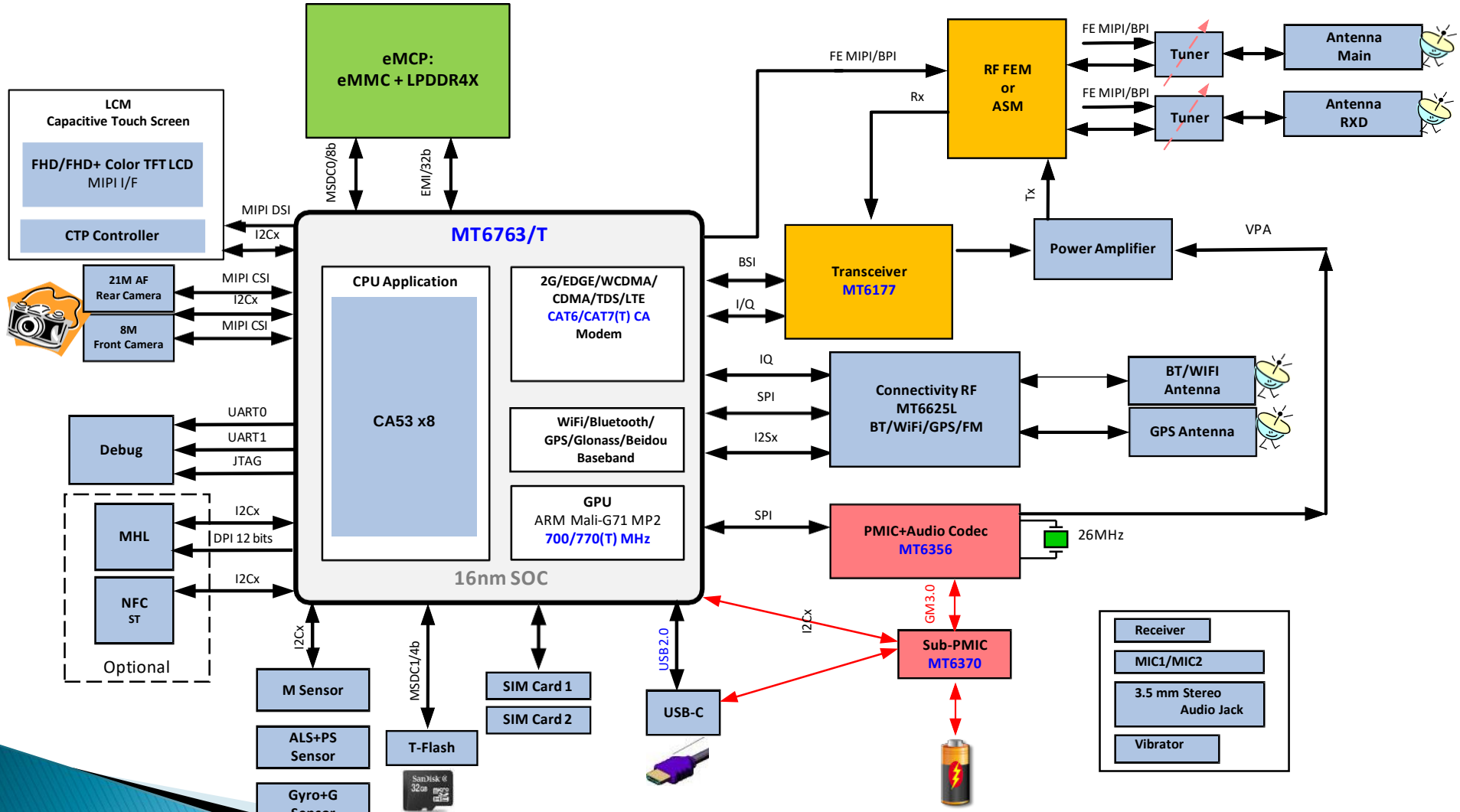
- Take MT6763 as an example in placement evaluation



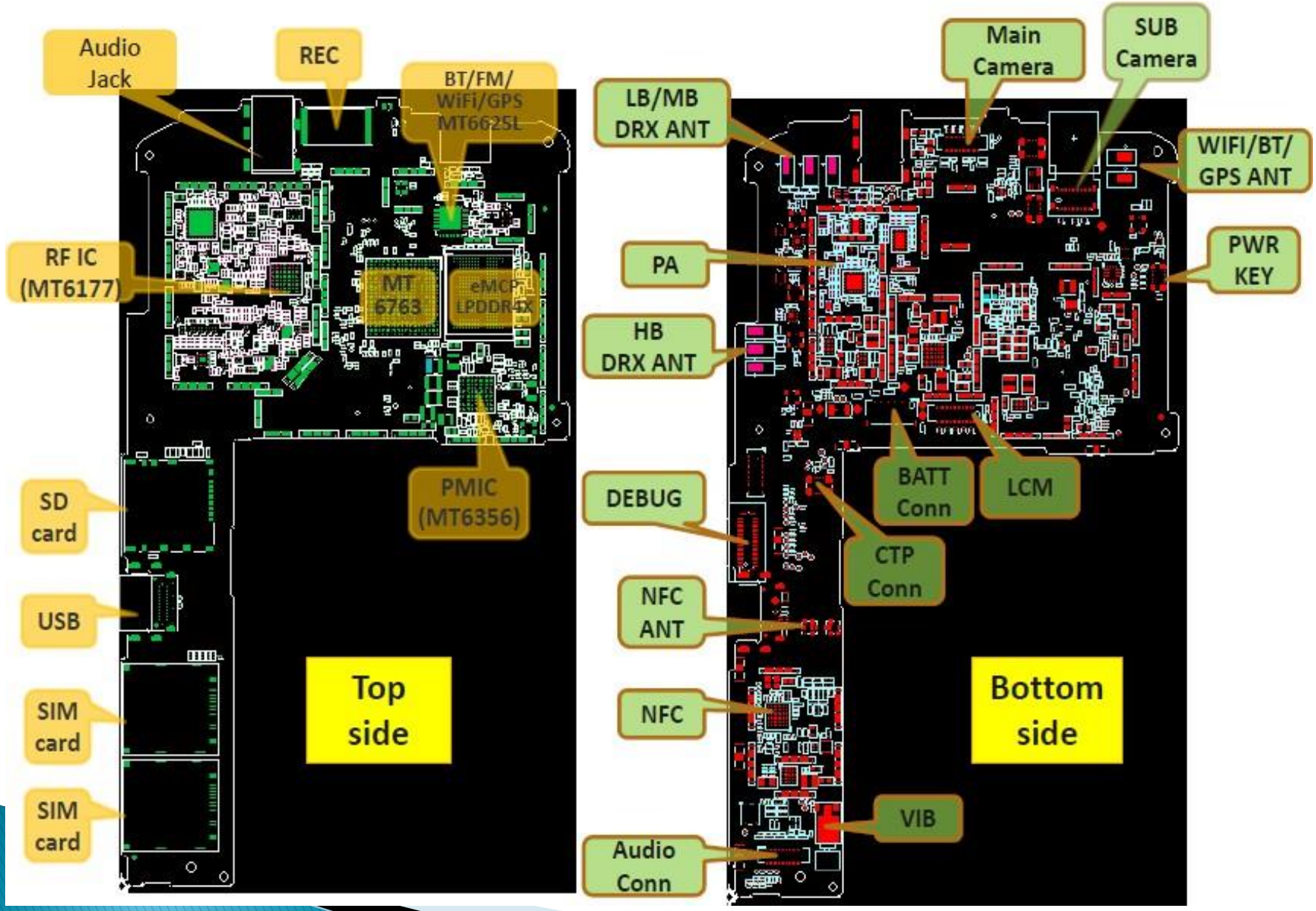
MT6763 platform		Package size	Type	Pitch	Pin #
BB	MT6763/T	11 x 11.8 x 0.9	FCCSP	0.4	566
RF	MT6177	5.0 x 5.4 x 0.7	FCCSP	0.4	144
WCN	MT6625L	5.0 x 5.0 x 0.85	QFN40	0.4	40
PMIC	MT6356	6.1 x 6.1 x 0.6	FOCSP	0.4	181
PMIC	MT6370	4.2 x 4.3 x 0.5	WLCSP	0.4	93

Optional Chips		Package size	Type	Pitch	Pin #
WCN	MT6630	5.0 x 5.0 x 0.5	WLCSP	0.4	113
NFC	ST21NFCD	4.0 x 4.0 x 0.8	WFBGA	0.4	64

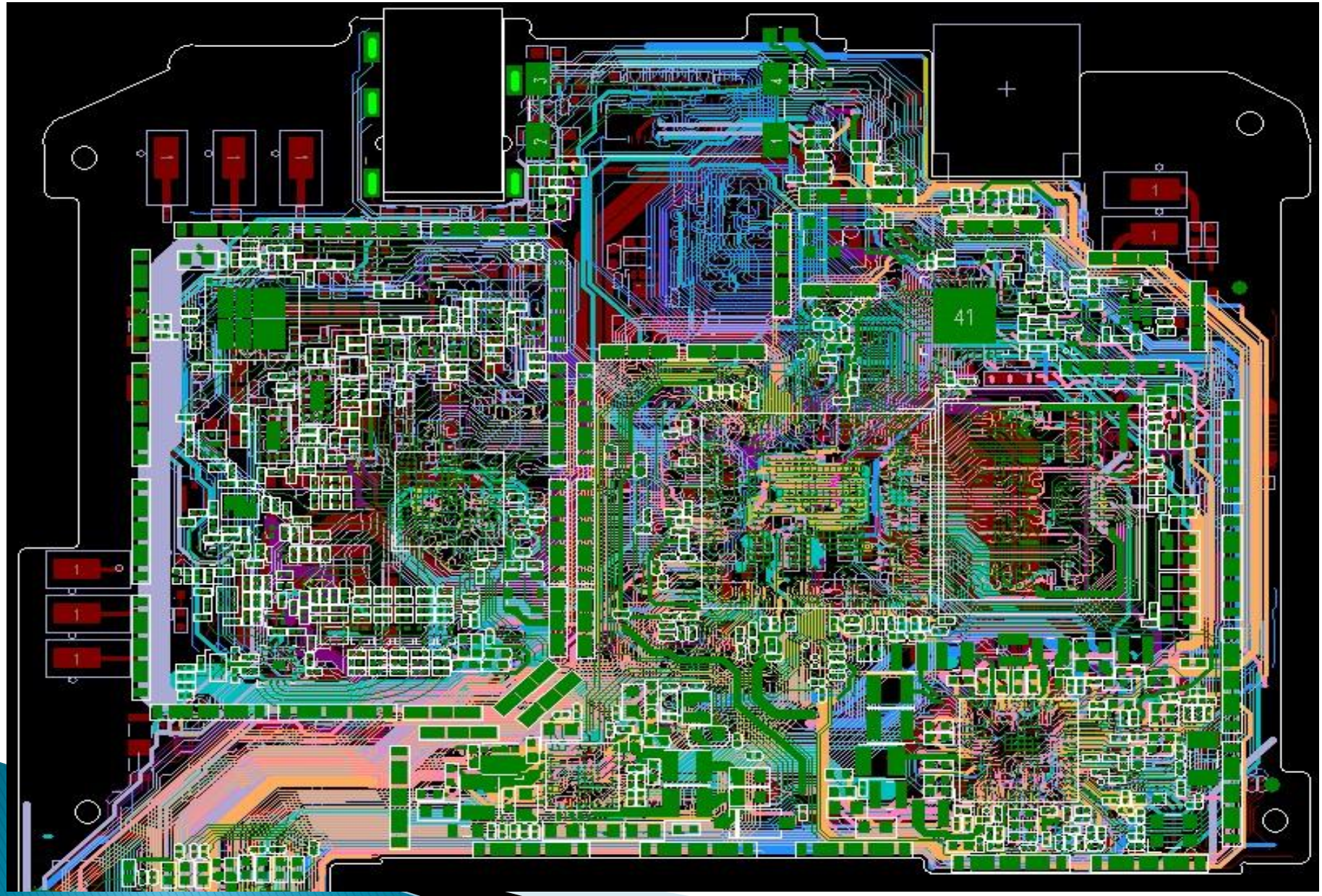
Schematic design – Block Diagram



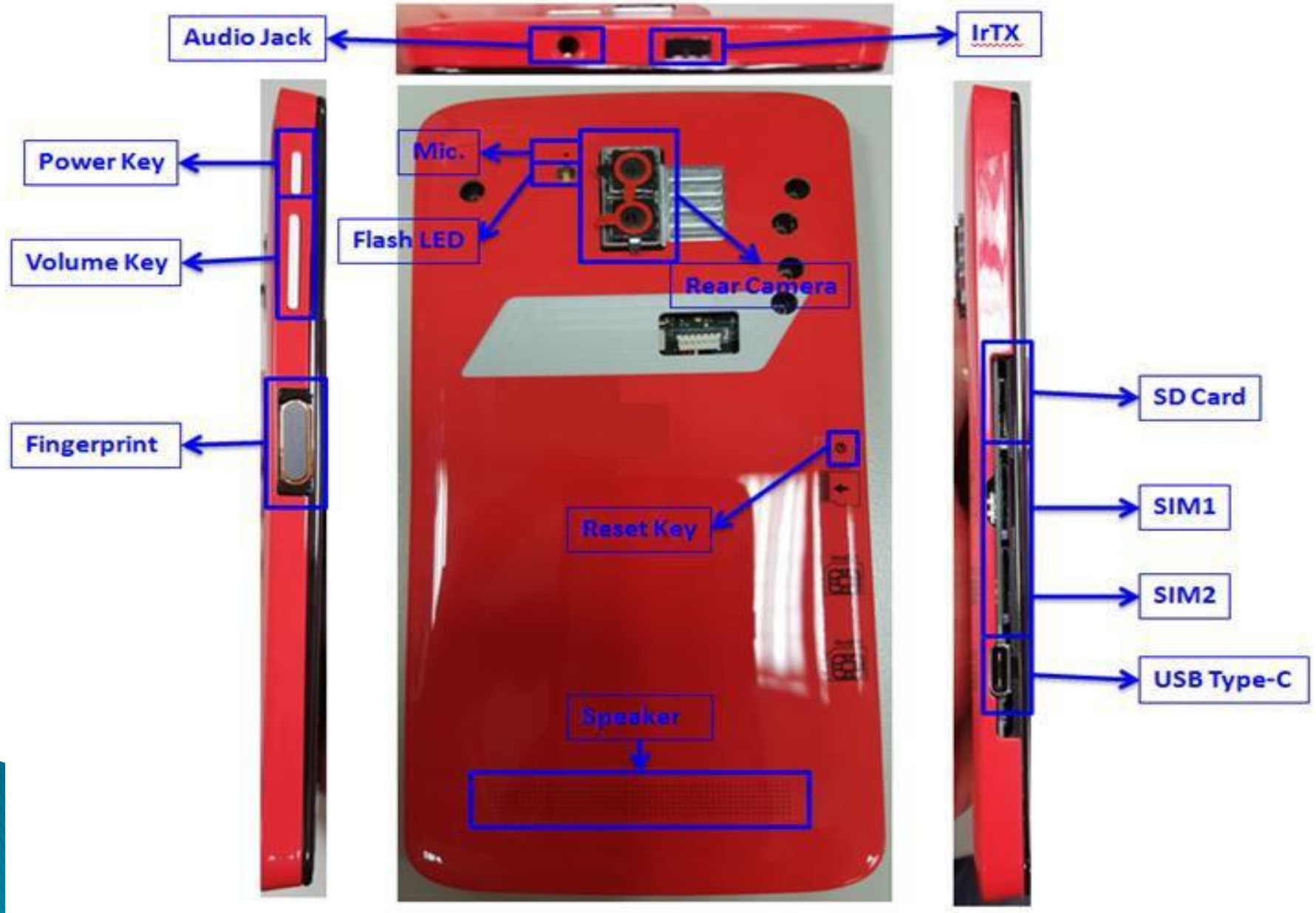
- Placement review



- PCB layout



- Mechanical design – System view



- BOM Review – BOM list review

Value	Vendor_PN	Vendor	Part Reference	Quantity	Description
C / 4.7 / nF / 0201	GRM033R61A472KA01D	Murata	C5006	1	0201 ± 10% 4.7nF X5R 10V
C / 4.7 / pF / 0201	GRM0335C1H4R7CA01D	Murata	M3337,M3340,M3361,M3425	4	0201 ± 0.25pF 4.7pF C0G 50V
C / 4.7 / uF / 0402	GRM155R61E475ME15D	Murata	C1124,C2006,C2009,C2017,C2018,C2111,C2114,C2115,C2119,C2211,C2219,C2222,C2303,C2308,C2311,C2323,C5	17	0402 ± 20% 4.7uF X5R 25V
C / 4.7 / uF / 0402	CL05A475MO5NUNC	Samsung	C3115,C3116,C4001,C4132,C6203,C6210	6	0402 ± 20% 4.7uF X5R 16V
C / 4.7 / uF / 0603	GRM188R61E475ME11D	Murata	C3508	1	0603 ± 20% 4.7uF X5R 25V
C / 47 / nF / 0402	GRM155R71E473KA88	Murata	C2305	1	0402± 10% 47nF X7R 25V
C / 470 / nF / 0201	GRM033R60J474ME90D	MuRata	C1006,C1008,C1010,C1012,C1025,C1027,C1029,C1031,C1041,C1042,C1048,C1050,C1052,C1054,C5118,C5121,C5	18	0201 ± 20% 470nF X5R 6.3V
C / 5 / pF / 0201	GRM0335C1H5R0CA01	Murata	C2215,M3215	2	0201 ± 0.25pF 5pF C0G 50V
C / 5.6 / pF / 0201	GRM0335C1H5R6CA01D	Murata	M3316	1	0201 ± 0.25pF 5.6pF C0G 50V
C / 560 / pF / 0402	GRM1555C1H561GA01	Murata	C5221,C5236	2	0402 ± 2% 560pF C0G 50V
C / 8.2 / pF / 0201	GRM0335C1H8R2DA01D	MuRata	C3245,C3252,C3319,C3327	4	0201 ± 0.5pF 8.2pF C0G 50V
Car_Kit / MM8130-2600	MM8130-2600	MuRata	CON3301,CON3302,CON3401,CON3402,CON5001	5	Car_Kit MM8130-2600 SMD Murata
CON / 10 / AXE510127	AXE510127	Panasonic	CON2302,CON6101,CON6401,CON6604	4	
CON / 10 / SCGD1B0314	SCGD1B0314	敦吉	CON6601,CON6603	2	
CON / 12 / TA-M017-012-07-811	TA-M017-012-07-811	SMART-CON ELECTRONICS	CON4001	1	SD CARD CONN 12P TA-M017-012-07-811 SMD Smart-Conn Elec
CON / 16 / 24-5804-016-000-829+	24-5804-016-000-829+	Kyocera	CON6002,CON6103	2	
CON / 24 / UT12123-1A501-7H	UT12123-1A501-7H	Foxconn	CON6501	1	USB CONN 24P UT12123-1A501-7H TypeC SMD Foxconn
CON / 24 / WP7A-S024VA1	WP7A-S024VA1	JAE	CON6602	1	24 pin Board to Board connector
CON / 30 / 24-5804-030-000-829+	24-5804-030-000-829+	Kyocera	CON6201,CON6301	2	
CON / 30 / AXT530124	AXT530124	Panasonic	CON6202	1	
CON / 34 / 24-5804-034-000-829+	24-5804-034-000-829+	KYOCERA	CON6102	1	
CON / 40 / AXT640124	AXT640124	Panasonic	CON9001	1	BTB CONN 40P AXT640124 header SMD Panasonic
CON / 5 / EJ-36952-10-GP	EJ-36952-10-GP	星赫	CON6001	1	
CON / 6 / CPL6506-0130ESZ	CPL6506-0130ESZ	SMK	CON2301	1	Battery CONN 6P CPL6506-0130ESZ SMD SMK
CON / MM5829-2700RJ4	MM5829-2700RJ4	Murata	CON3702,CON3703	2	
D / RB520ZS-30	RB520ZS-30	ROHm	D2101	1	DIODE SCHOTTKY RB520ZS-30 SMD ROHm
D / SDM1A40CSP-7	SDM1A40CSP-7	Diodes	D2302	1	DIODE SCHOTTKY Barrier SDM1A40CSP-7 2P SMD Diodes
EMI / DLM0NSN900HY2	DLM0NSN900HY2	Murata	EMI6101,EMI6102,EMI6103,EMI6104,EMI6105	5	
EMI / DLP11RN450UL2	DLP11RN450UL2	MuRata	EMI6501	1	
EMI / MCF08062G900-T	MCF08062G900-T	Taiyo	EMI6201,EMI6202,EMI6203,EMI6204,EMI6205,EMI6206,E	8	EMI filter 90ohm± 20% MCF08062G900-T SMD Taiyo
ESD / AZ4514-01F	AZ4514-01F	Amazing	D6501	1	ESD 2P 340pF 18V AZ4514-01F DFN1610P2E SMD Amazing
ESD / AZ5315-02F	AZ5315-02F	Amazing	ESD6506	1	ESD 3P 0.55pF 20V AZ5315-02F DFN1006P3X SMD Amazing
ESD / AZ5825-01F	AZ5825-01F	Amazing	VR2302	1	
ESD / DF2B6.8M1ACT	DF2B6.8M1ACT	Toshiba	ESD4001,ESD4002,ESD4003,ESD4004,ESD4005,ESD4006,ESD4007,ESD4008,ESD4009,ESD6004,ESD6006,ESD6014,ESD6503,ESD6504,ESD6601,ESD6602,ESD6603,ESD6604,ESD6	31	ESD Protection Diodes, VESD 15V, Ipp 2.5A
ESD / ESDALC5-1BM2	ESDALC5-1BM2	ST	ESD6005,ESD6007,ESD6008,ESD6009,ESD6010,ESD6011,ES	8	Single-line transient surge voltage suppressor for ESD protect
ESD / ESDAVLC8-1BM2	ESDAVLC8-1BM2	ST	ESD6002,ESD6003	2	Single-line transient surge voltage suppressor for ESD protect

- MTK design package (1/3) – DCC server on MTK website

- MTK design package
  - Datasheet
  - Ball map
  - GPIO table
  - Design notice
  - Reference Design
    - ✓ Schematic
    - ✓ Layout
  - SW package

Key Parts and PCBA Stacking

Outline

- Mobile phone overview
- Key Parts Introduction
- Evaluation of PCBA Stacking

Mobile phone overview –– Form factor

- **Bar phone** – Cuboid shape with rounded corners and edges
- **Flip phone** (clamshell) – Consist two sections connected by hinges
- **Slide phone** (slider) – Two sections pass each other on rails
- **Swivel** – Consist two segments, swivel pass each other about a central axis.
- **Touch screen slate** – Subset of bar form, with multi-touch interface, since 2010, almost all Smartphone come in touch-screen slate form.

Bar phone

Flip phone

Slide phone

Swivel

Touch screen slate

Mobile phone overview –– Development

- **1983-2018 (35 years)**

Motorola DynaTAC

1st commercial mobile phone

iPhone

Android 1.0

Now

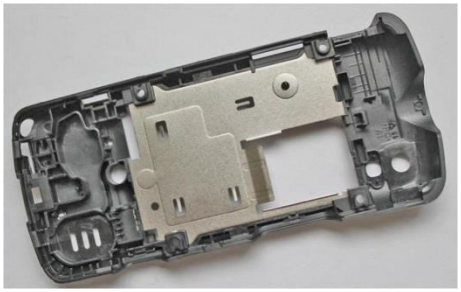
1983 2007 2008 2018

Key Parts

Classification	Key Parts
Mechanical and Antenna	1. Plastic and Metal housing 2. Antenna parts
Display	1. LCM 2. TP
Audio	1. Speaker 2. Receiver 3. Microphone
Sensor	1. Camera 2. Proximity sensor
Connector	1. SIM card 2. USB 3. B2B / ZIF
Others	1. Battery

Key Parts introduction

Classification	Key Part	Detail
Mechanical & Antenna	1. Plastic and Metal housing 2. Antenna parts	1. Phone ID trend : Slim and metalized look 2. Plastic Material : PC (polycarbonate), ABS, PC+ABS 3. Metal Material : Aluminum alloy, Stainless, Magnesium alloy 4. Producing process: Injection Molding, CNC, NMT



Key Parts introduction

Comparison	Plastic Housing	Metal Housing
Cost	Low	High
Wireless signal	Small impact	Big impact
Thermal conductivity	Normal	High
Strength	Normal	High
Look & Feel	Non-Premium	Premium (flagship devices)
MP product	 	  

Key Parts introduction

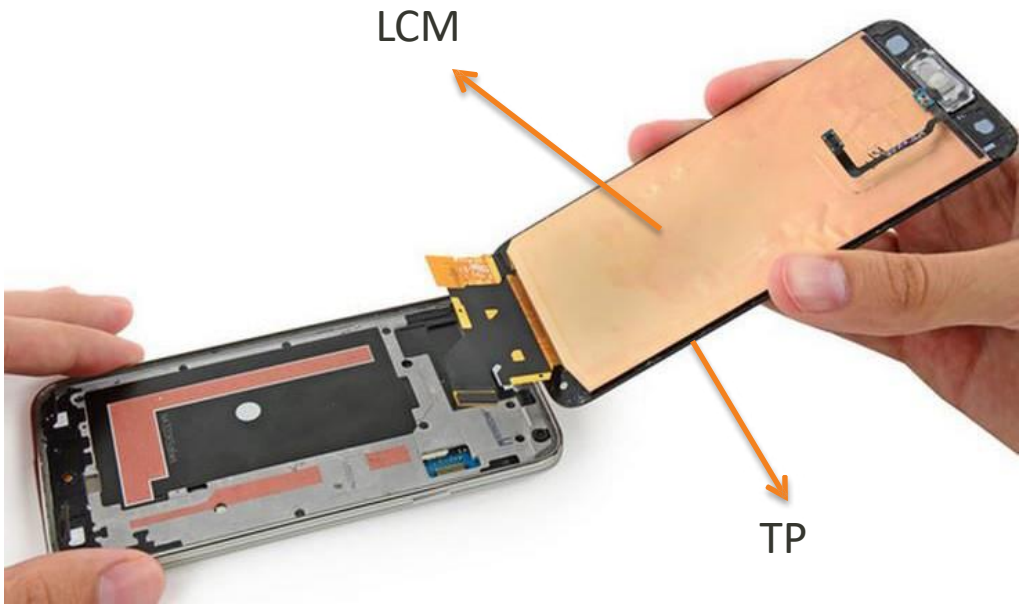
Category	Metal antenna	LDS antenna	Stamp antenna (FPC)
Characteristic	1. Metal cover is part of antenna 2. High stability	1. Combined with plastic cover 2. High stability	1. Individual with ID* 2. Acceptable variation
Price*			
General Performance			
MP phones			

Key Parts introduction

Category	Loop type	Co-design type	Metal cover type
Characteristic	1.Typical type 2.High stability	1. Co-design with other antenna 2. High stability	1. Slit on the metal cover for NFC function 2. High stability
General Performance	High	Mid.	Mid.
MP phones			

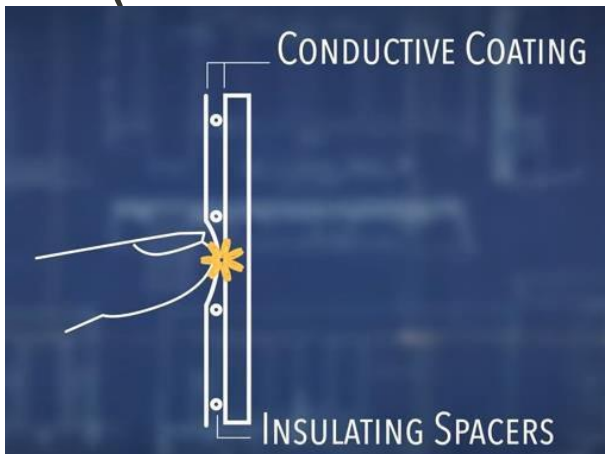
Key Parts introduction

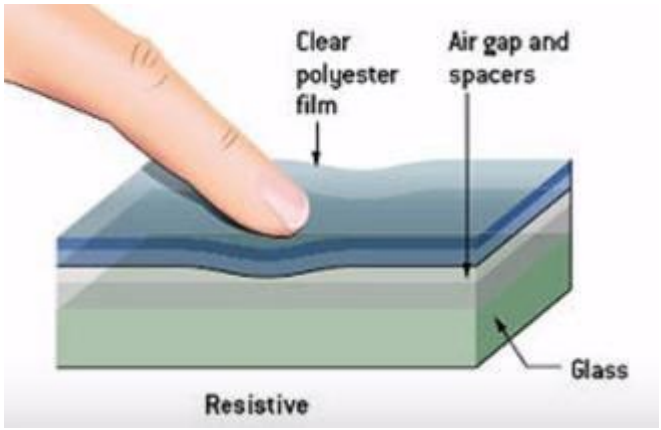
Classification	Key Part	Detail
Display	1. TP 2. LCM	1. TP introduction 2. RTP vs CTP 3. LCM introduction



Touch Panel (TP)

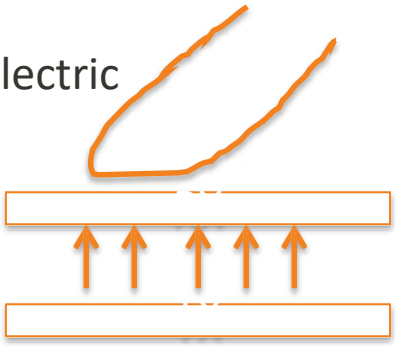
- TP (**T**ouch **P**anel)
  - RTP (**R**esistive **T**ouch **P**anel)

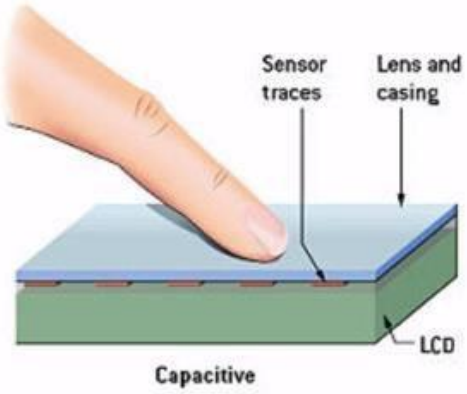




  - CTP (**C**apacitive **T**ouch **P**anel)

With a finger close to Rx sensor, the electric field line
from Tx to Rx decreased.
The capacitance is changed.

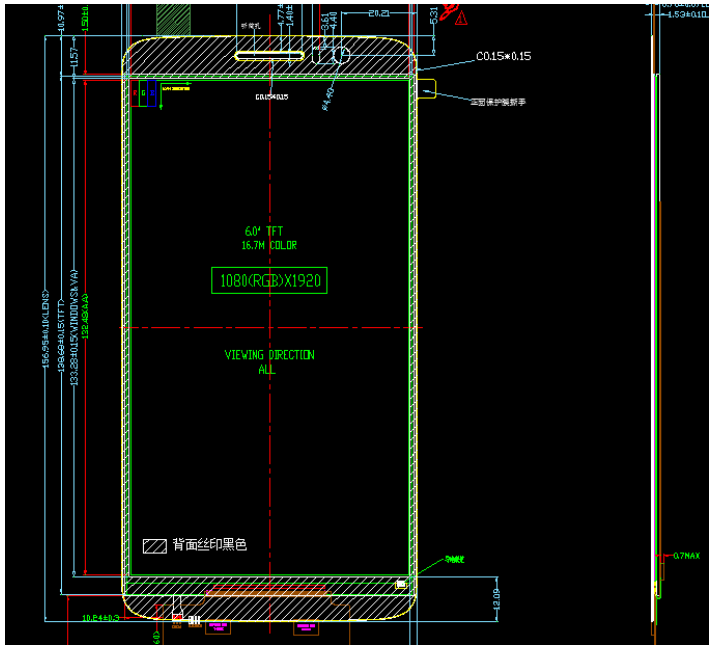




LCM (Liquid-Crystal display Module)

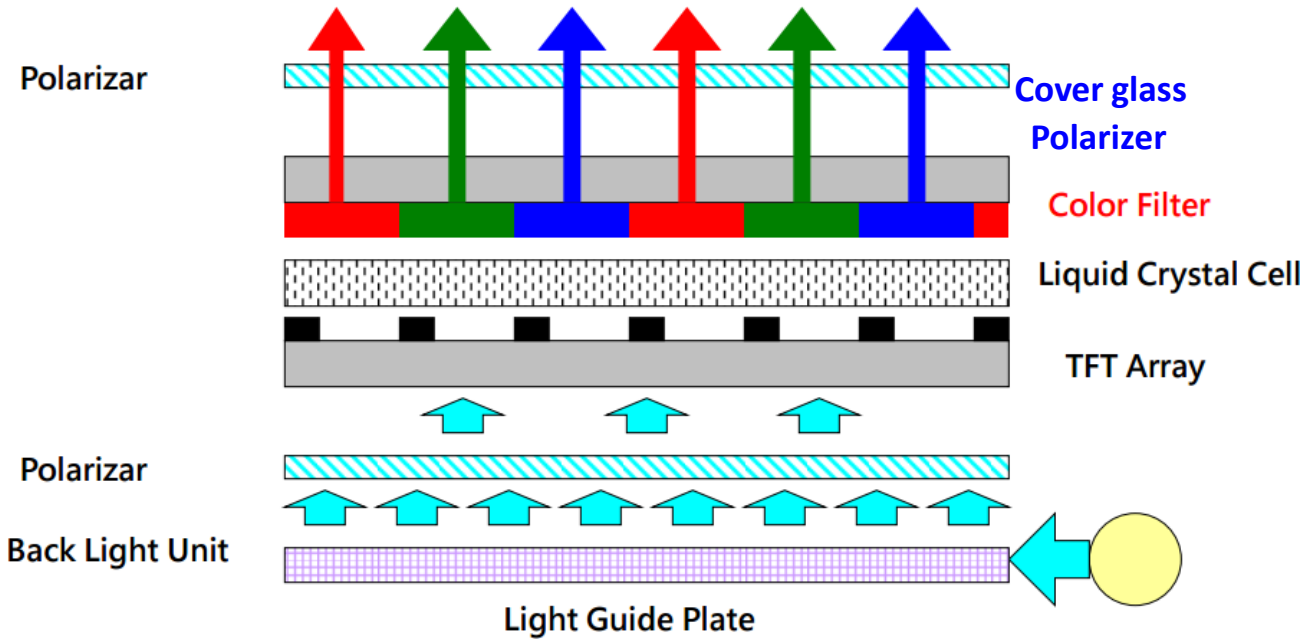
- Resolution
  - qHD : 960 x 540
  - HD : 1280 x 720 (720p)
  - HD+ : 1440 x720
  - FHD : 1920 x 1080 (1080p)
  - FHD+ : 2160x1080
  - WQHD : 2560 x 1440 (2K)
  - 4K : 3840 x 2160

- MT6763: FHD+



4K TV (3840×2160)	
1080p (1920×1080)	1080p (1920x1080)
1080p (1920×1080)	1080p (1920×1080)

LCM (Liquid-Crystal display Module)



LCD structure :

- Back light
- Polarizer
- Thin Film Transistor(TFT)
- Liquid crystal
- Color filter
- Cover glass

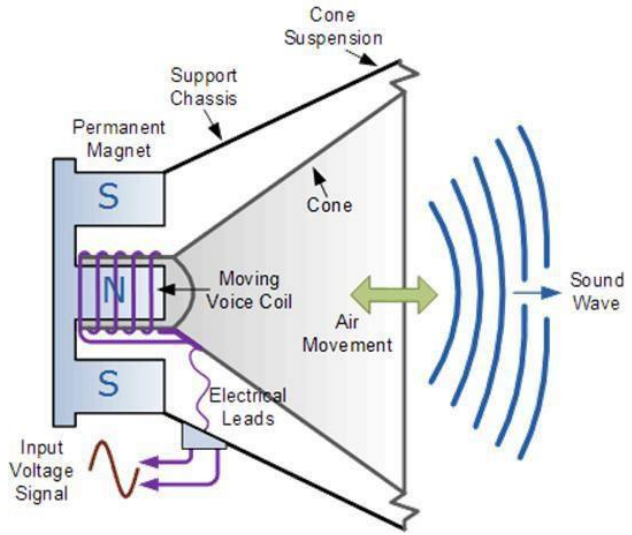
Key Parts introduction

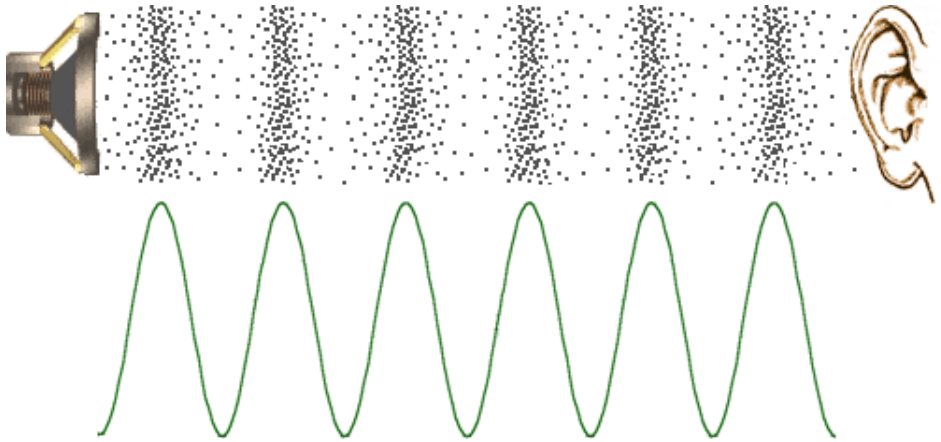
Classification	Key Part	Detail
Audio	1. Speaker 2. Receiver 3. Microphone	1. Speaker introduction 2. Receiver introduction 3. Microphone introduction

Comparison	Speaker	Receiver
Function	Music playback	
	Voice call (LoudSPK mode)	Voice call (Normal mode)

Speaker & Receiver

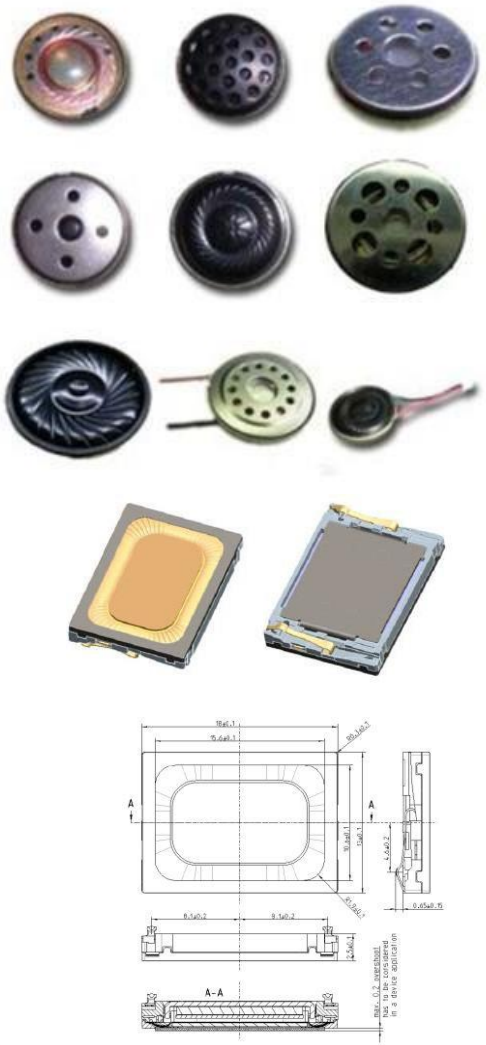
- Sound Transducer
  - Electromagnetic Induction

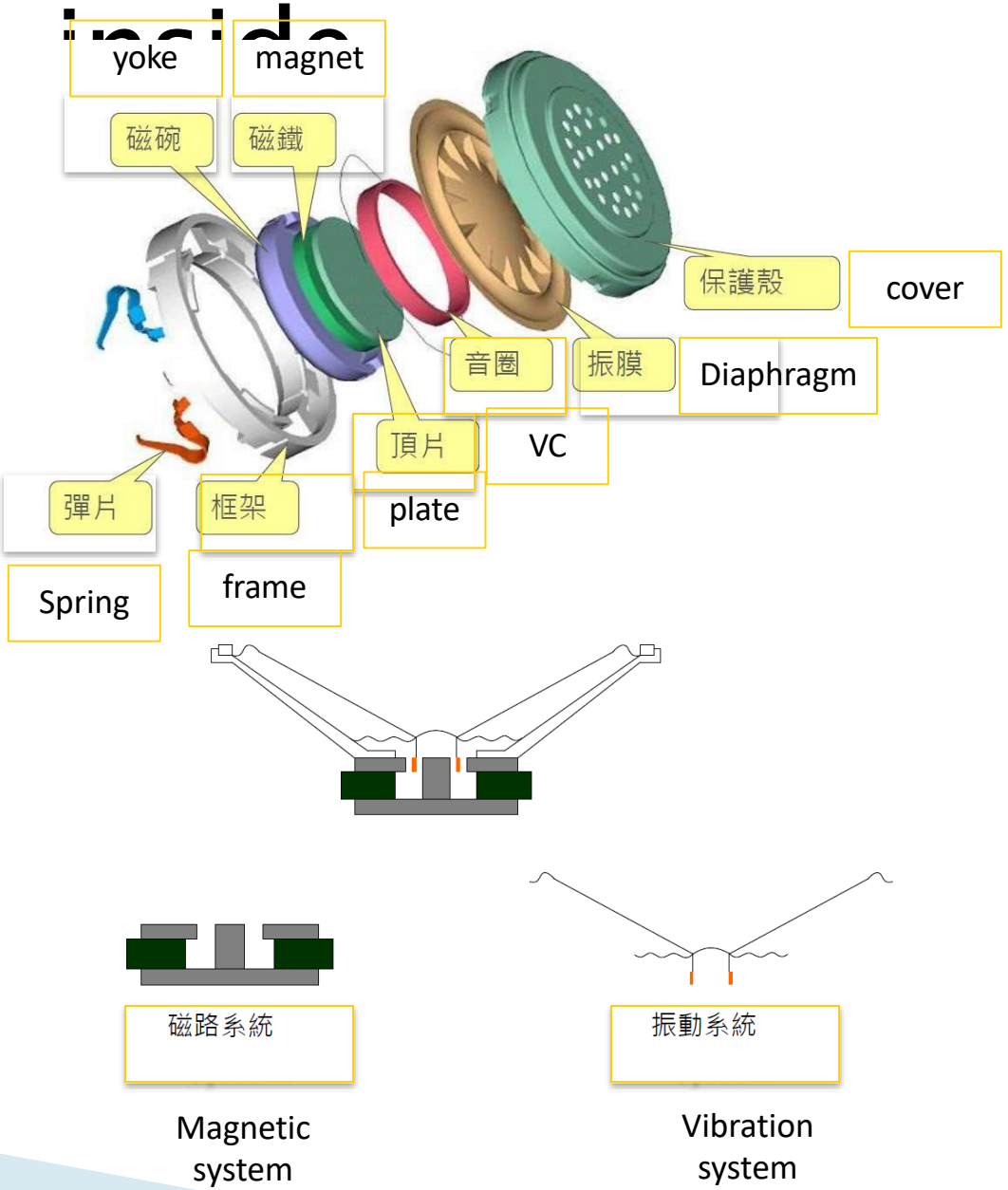




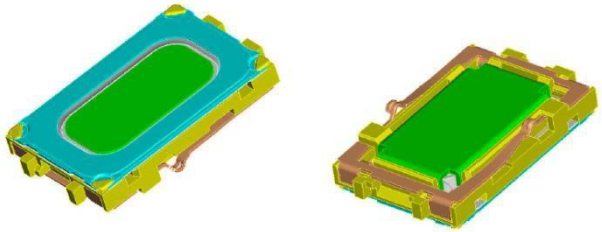
Electrical Signal → **Vibration** → **Pressure** → **Sound**

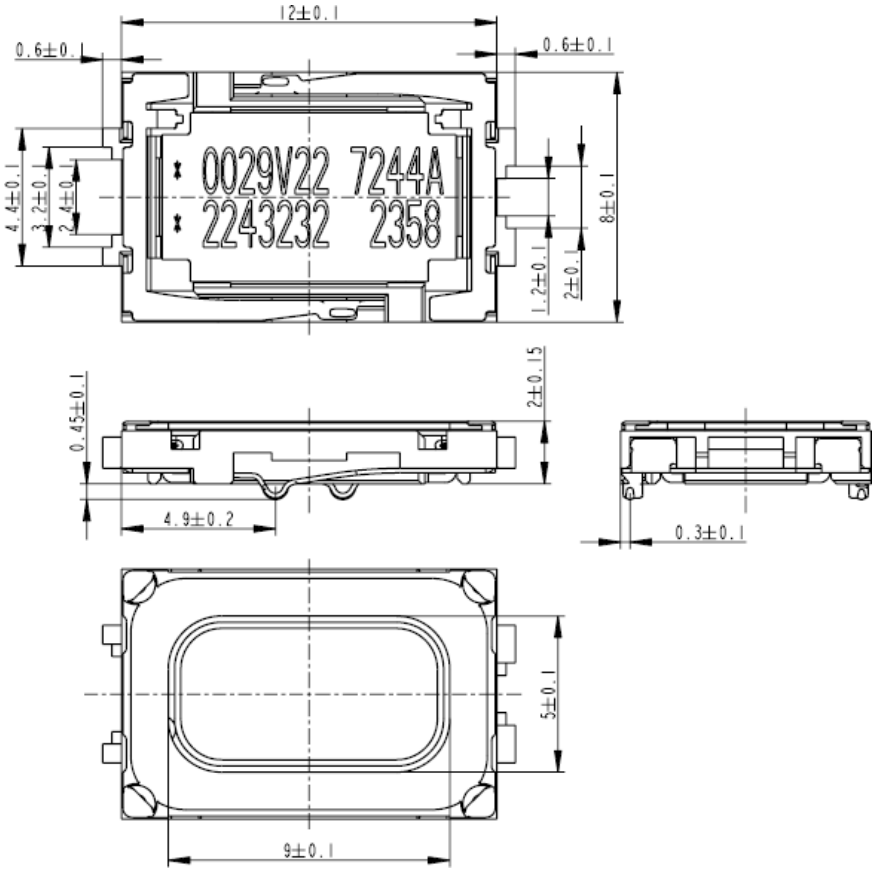
Speaker inside



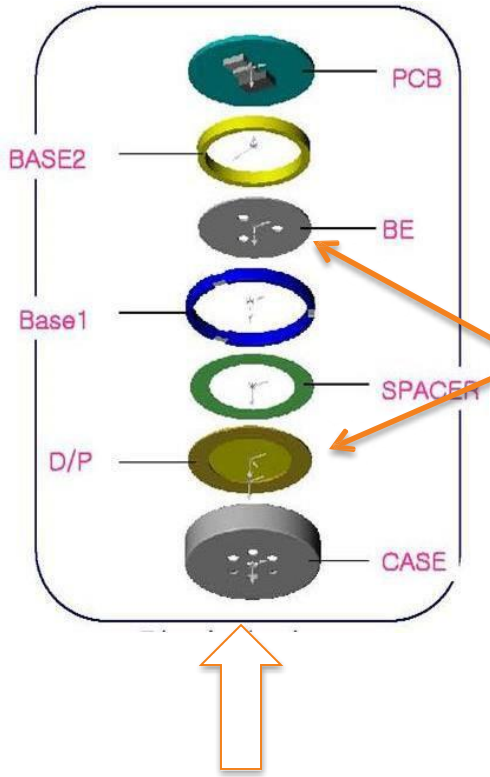


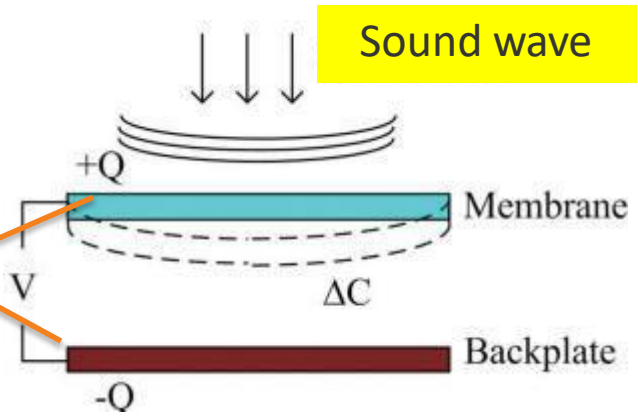
Receiver



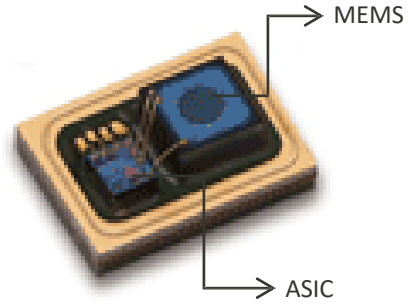

12±0.1
0.6±0.1
0.6±0.1
0029V22 7244A
2243232 2358
4.4±0.1
3.2±0.1
2.4±0.1
8±0.1
1.2±0.1
2±0.1
0.45±0.1
2±0.15
4.9±0.2
0.3±0.1
5±0.1
9±0.1

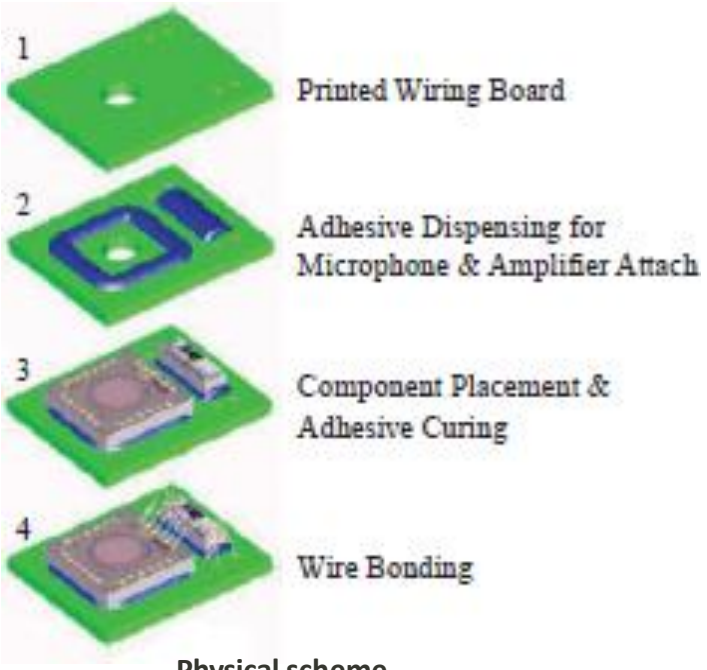
Microphone


PCB
BASE2
BE
Base1
SPACER
D/P
CASE
Sound wave


Sound wave
+Q
Membrane
V
ΔC
Backplate
-Q

Microphone



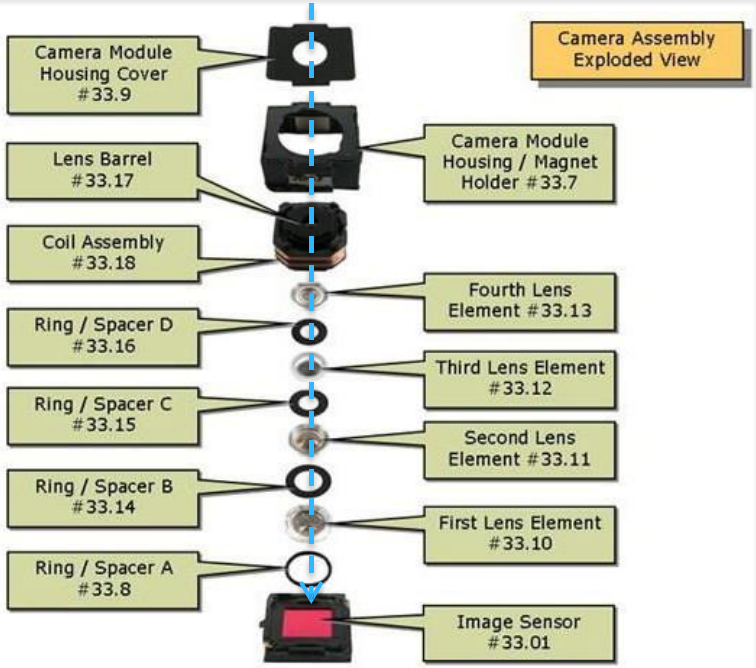


Physical scheme

Camera (inside)

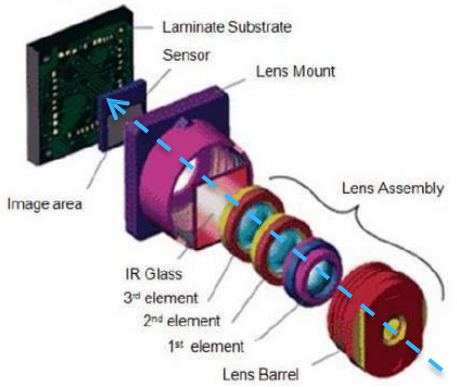
AF (Auto Focus)

- Housing
- VCM
- Lens
- Image Sensor

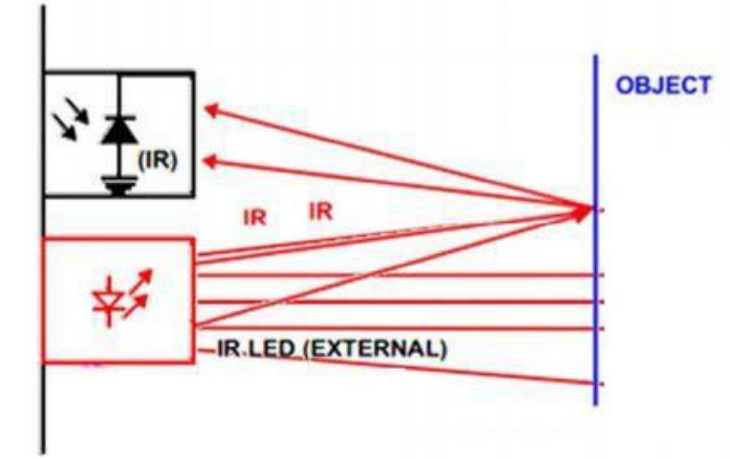


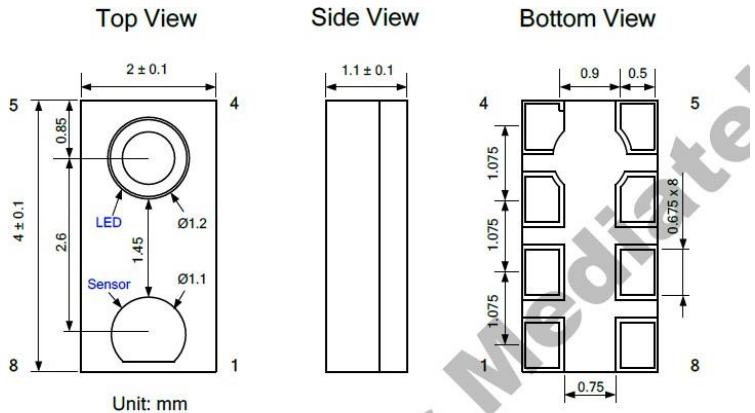
FF (Fixed Focus)

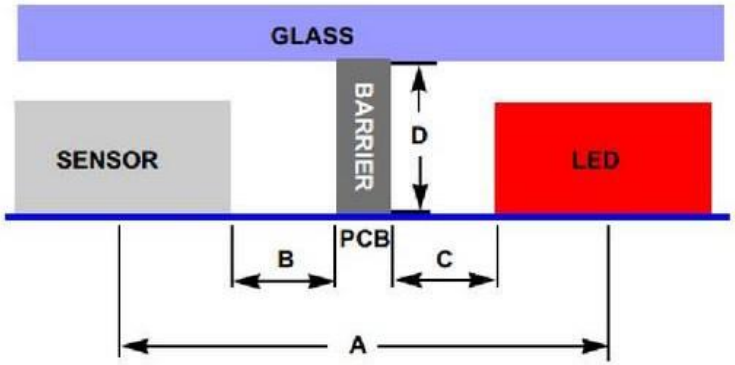
- Image Sensor
- Lens
- Housing



Proximity Sensor

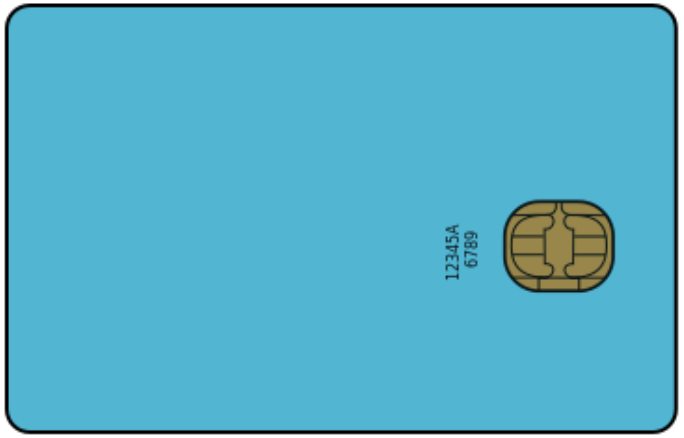




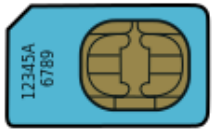


1	GND	5	Cathode
2	Cathode	6	INT
3	VDD	7	SDAT
4	Anode	8	SCLK

SIM



Full-size SIM



Mini-SIM

micro- SIM

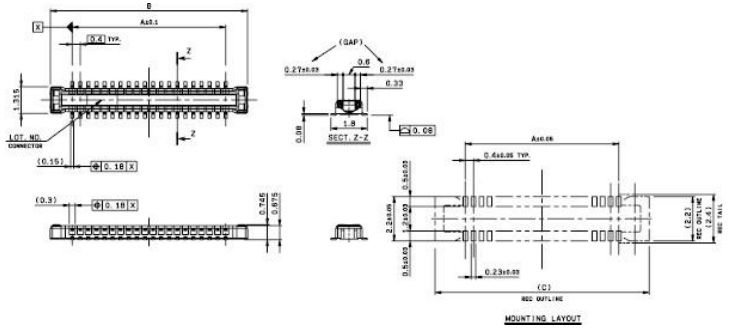
Nano-SIM

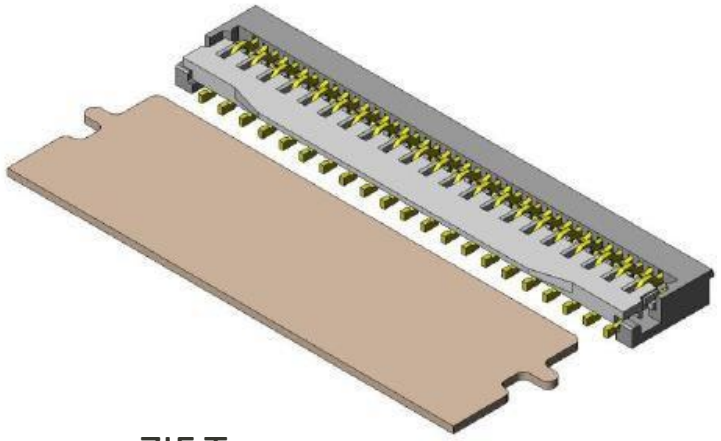
USB

TYPE C

- 24pins
- User friendly : Reversible insertion and extraction
- USB3.1 supported and compatible with lower version
- High Power delivery supported (5A)

Connector





ZIF Type

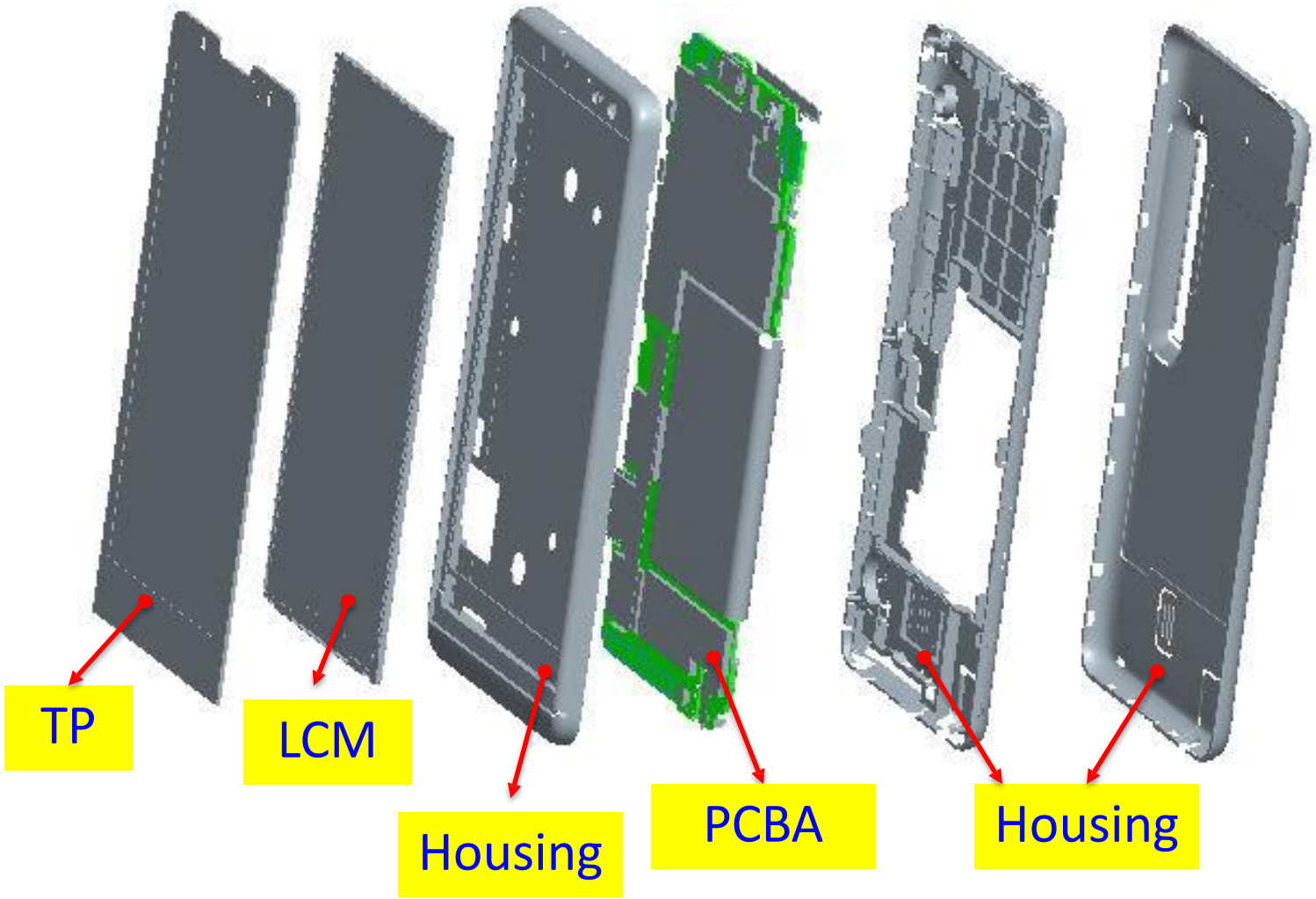
B2B Type

Battery

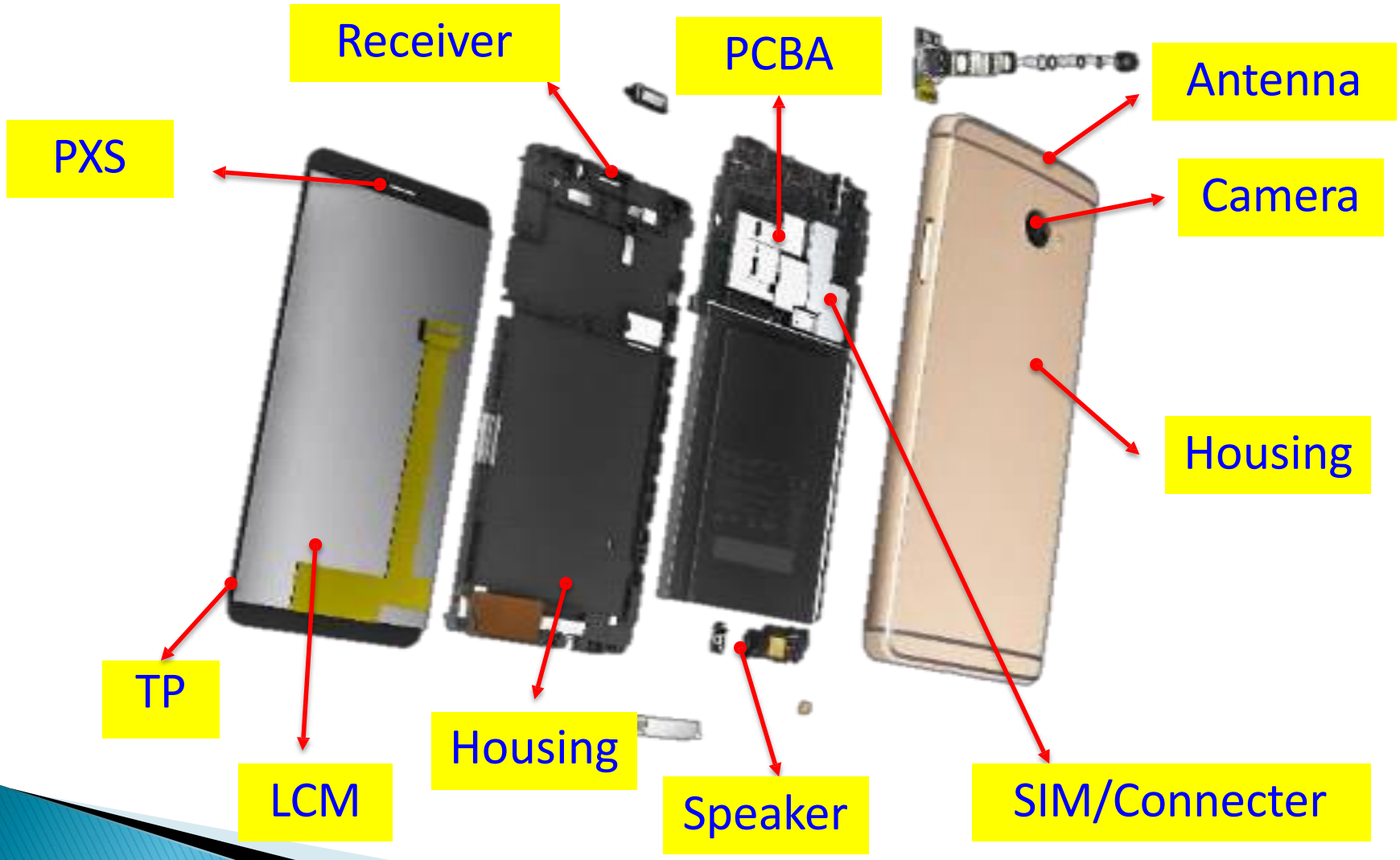
Removable Battery

Fixed Battery

Mobile Phone PCBA stacking (1 /3)



Mobile Phone PCBA stacking (2 / 3)

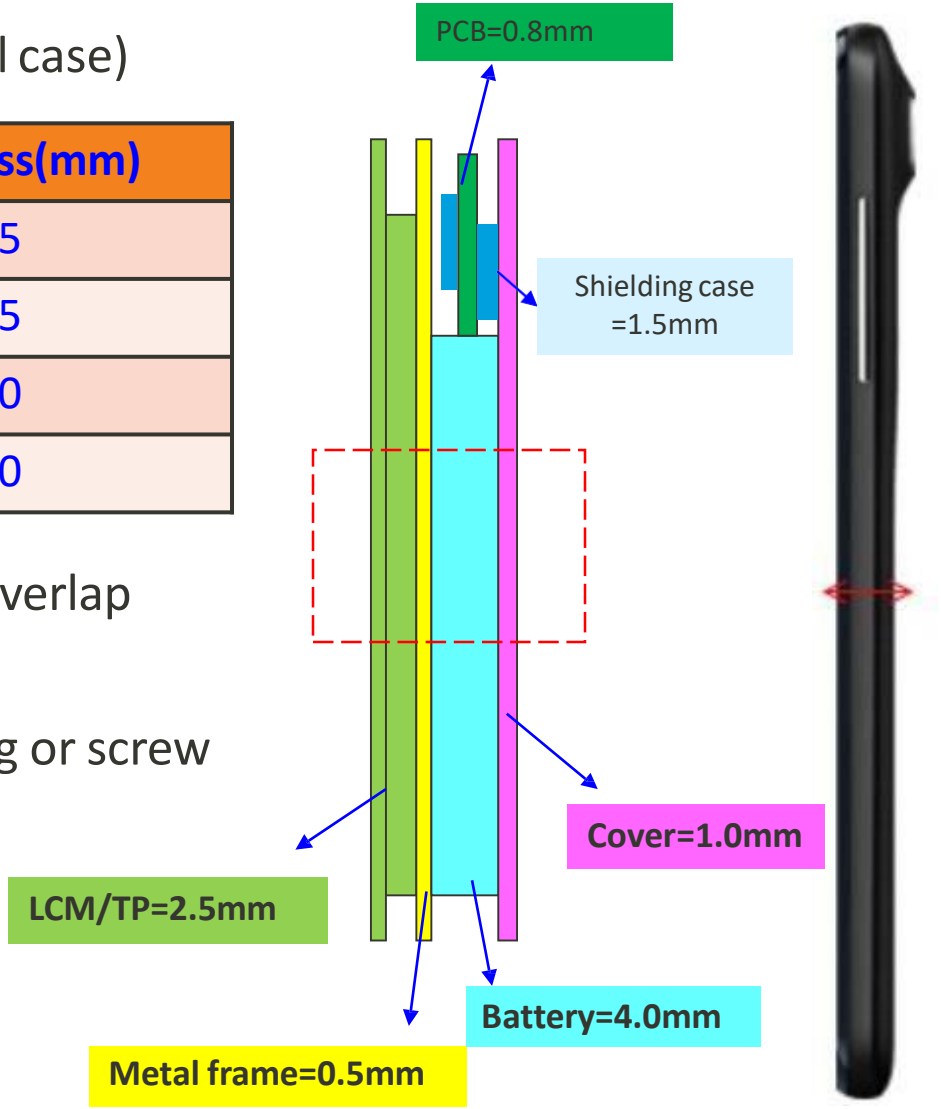


Mobile Phone PCBA stacking (3/3)

- Phone Thickness = 8.0mm (general case)

Component	Thickness(mm)
LCM/TP	2.5
Housing --Metal frame	0.5
Battery	4.0
Housing -- Cover	1.0

- PCBA and battery are usually not overlap
- Critical : LCM, TP, Battery, Cover
- Assembly method are glue bonding or screw

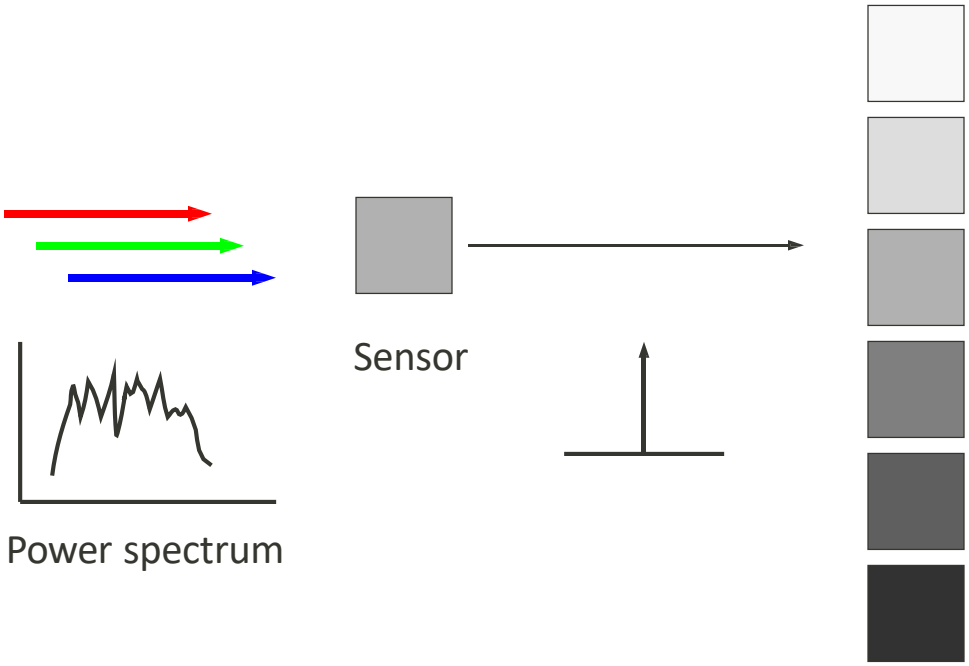


Camera Design Introduction

Outline

- Camera Overview
  - Image Sensor
  - Image Processing
- Camera Features
  - Special Sensor Support
  - Unique Acceleration Engines
- Dual Camera
  - Stereo Vision
  - Shallow Depth of Field
  - Dual Camera Image Enhancement
  - Dual Camera Zoom

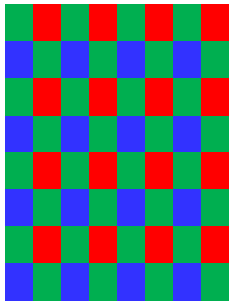
Image Sensor



- Sensor takes light strength not color
- Color filter array used to filter light

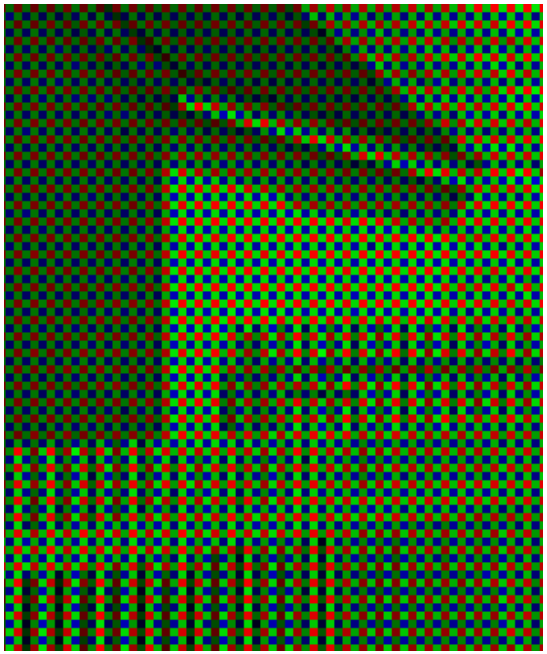
Bayer Pattern

Real Scene



Color Filter Array

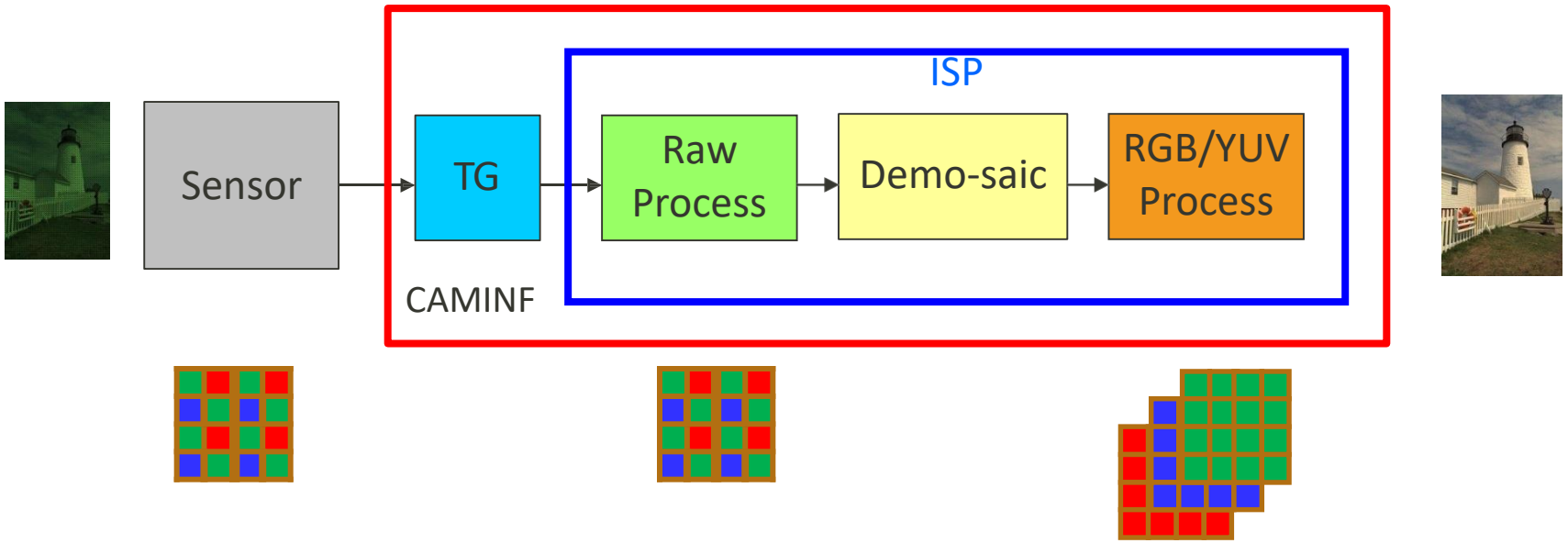
Sensor Image



CFA image

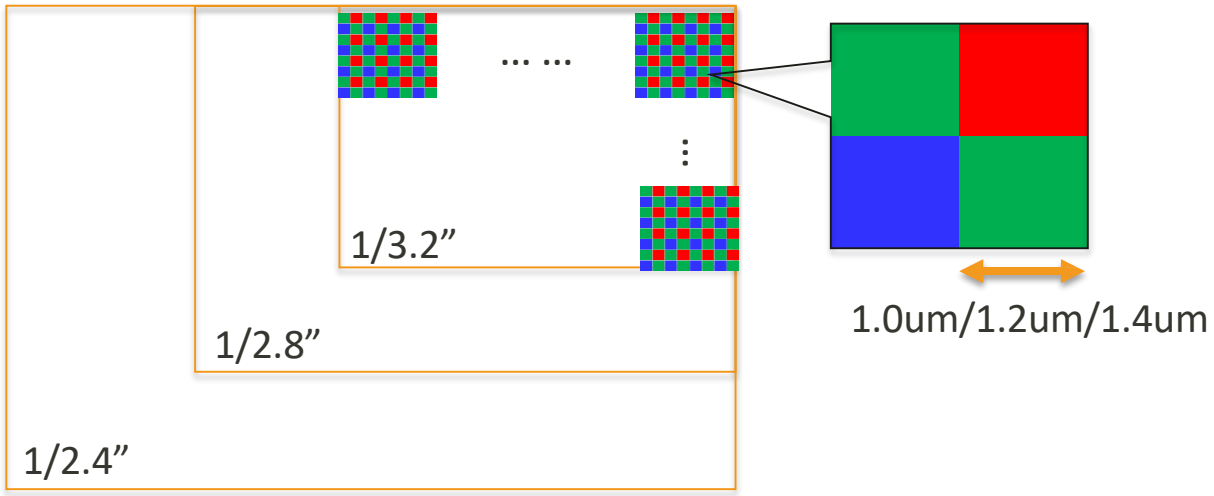
- Bayer Pattern : RGr/GbB patterned
- CFA : Color Filter Array, also called De-mosaic

ISP Pipeline



- Need Image Signal Processor (ISP) to re-construct the image
  - Raw Process : Compensate Lens, Sensor distortion and do 3A
  - De-mosaic : Reconstruct color image
  - RGB/YUV Process: Enhance Image color, noise, sharpness, and etc.

Sensor Size and Pixel Size



	Galaxy S6	Galaxy S7
Resolution	16MP	12MP
Sensor Size	1/2.6”	1/2.6”
Pixel Size	1.12um	1.4um

- Sensor size determined by
  - Photodiode size of each pixel (pixel size)
  - Number of photodiode on sensor (resolution)

Pixel Size and Noise Level

Image Details/Noise
Dynamic Range/Color

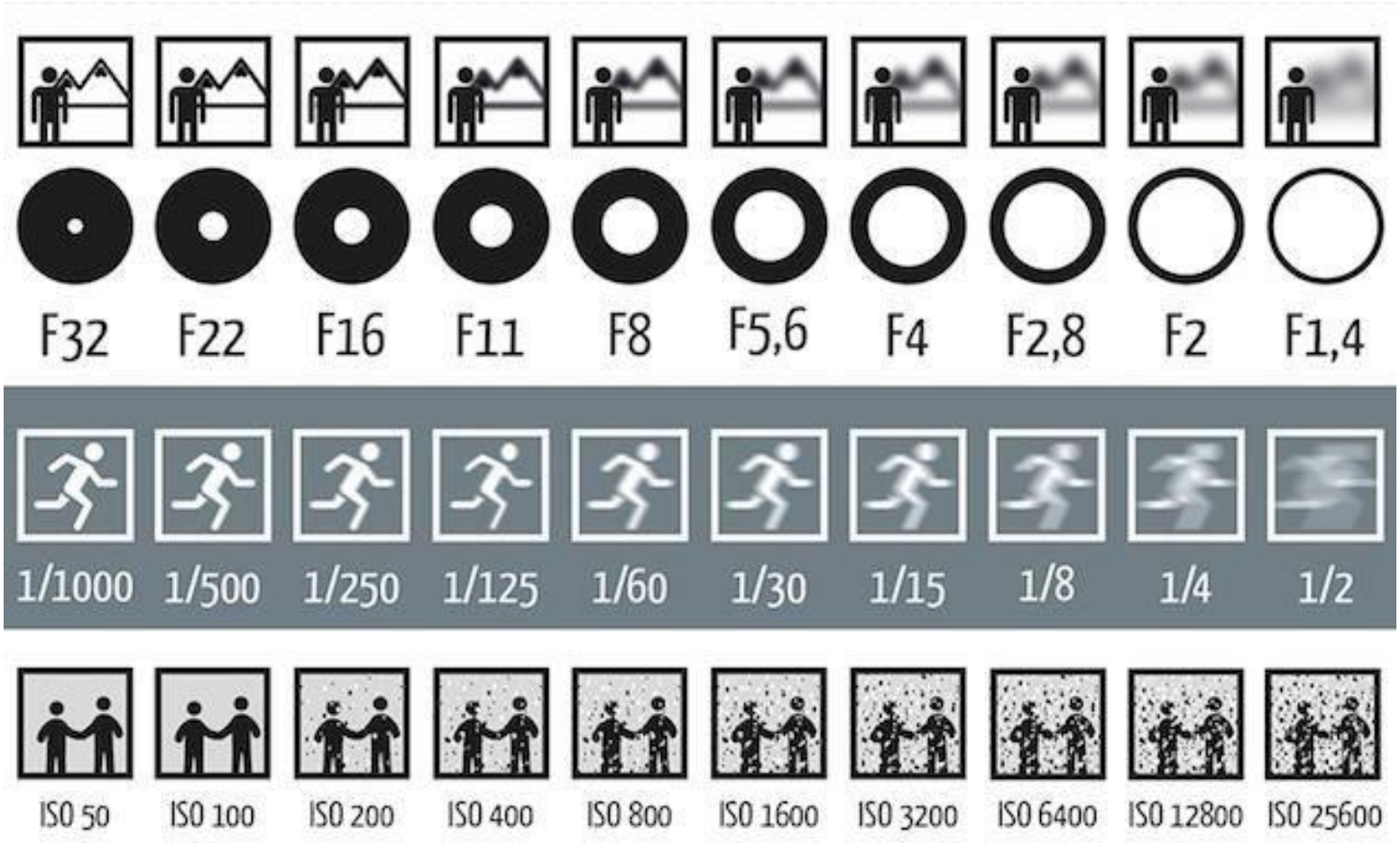
High Resolution
Small Pixel
High Noise Level

Low Resolution
Large Pixel
Low Noise Level

- Reduce noise and retain details are the basic operation of an ISP

Noise, ISO, andShutter Speed

Image
Details / Noise
Dynamic Range/Color

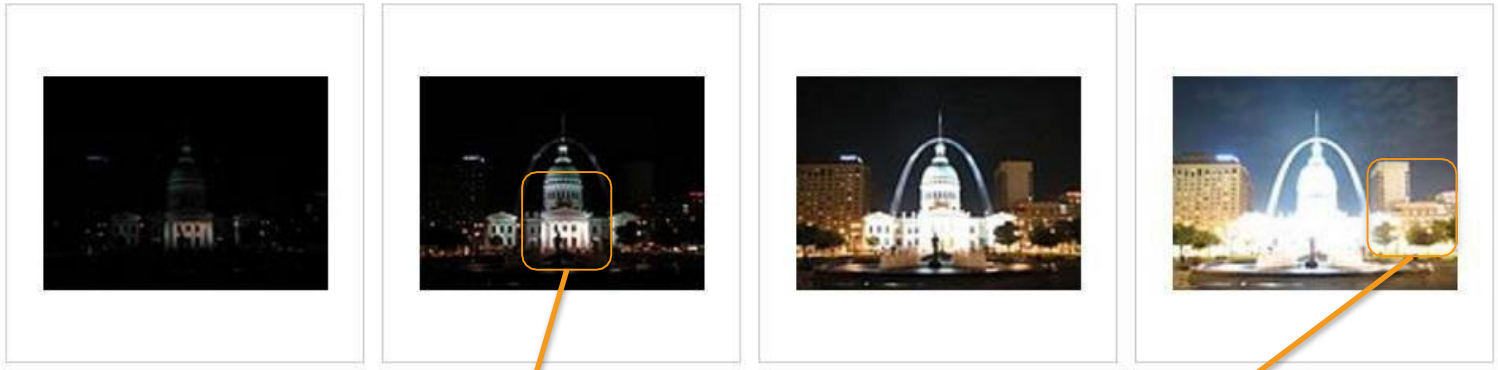


High Dynamic RangeImaging

Image Details/Noise

Dynamic Range/Color

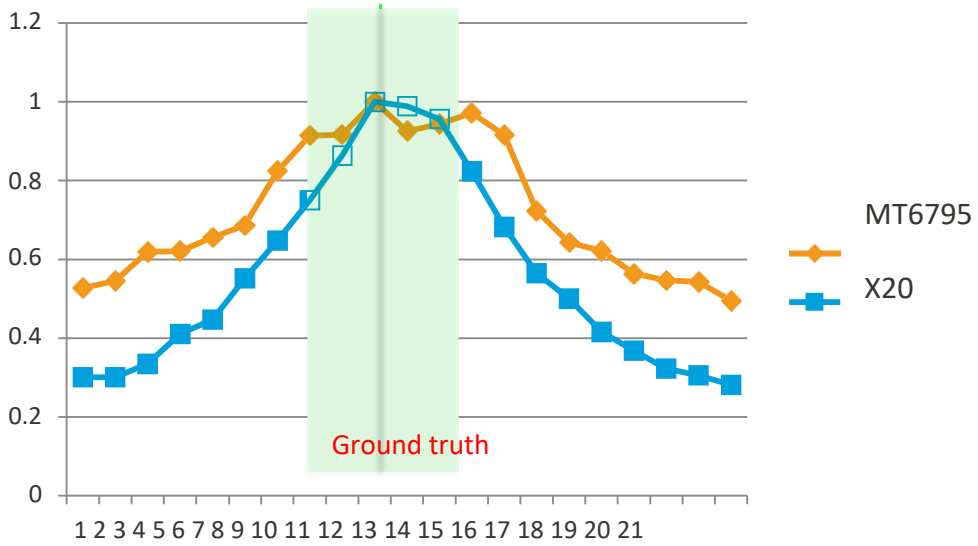
Photographs



–4 stops –2 stops +2 stops +4 stops

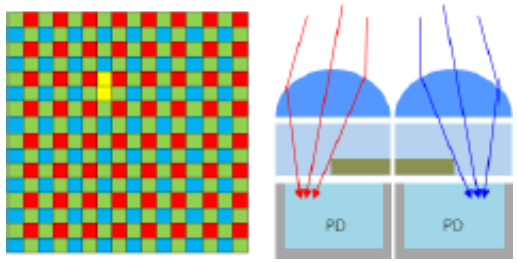
- Capture multiple images with different exposures
- Render new image by proper alignment and process moving object
- Lower noise comparing to local contrast enhancement

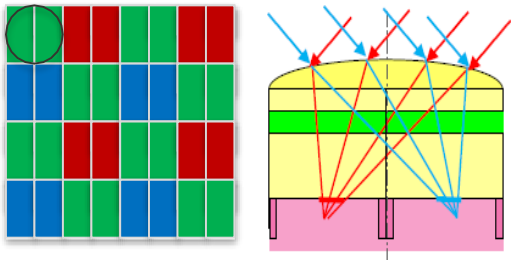
Auto-Focus Operation



- An iterative process
  - Calculate the contrast of target window
  - Compare response against other reference point
  - Move VCM to new position based on comparison result
- Obtain one response typically takes 70-100ms

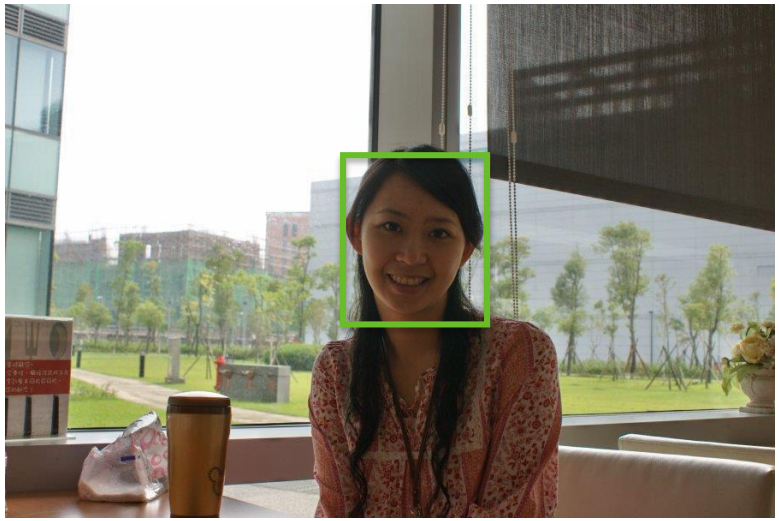
Different Types of PDAF Sensor





	PDAF	Dual PDAF
Working Lighting Condition	> 100lux	As low as 5lux
Characteristics	• Half of the light • PD on selected pixels • Smaller pixel	• No light blocking • PD on all pixels • Large pixel after merging
Focus Speed	•~2x faster than contrast-detect AF	• ~4x faster than contrast-detect AF

Face Detection

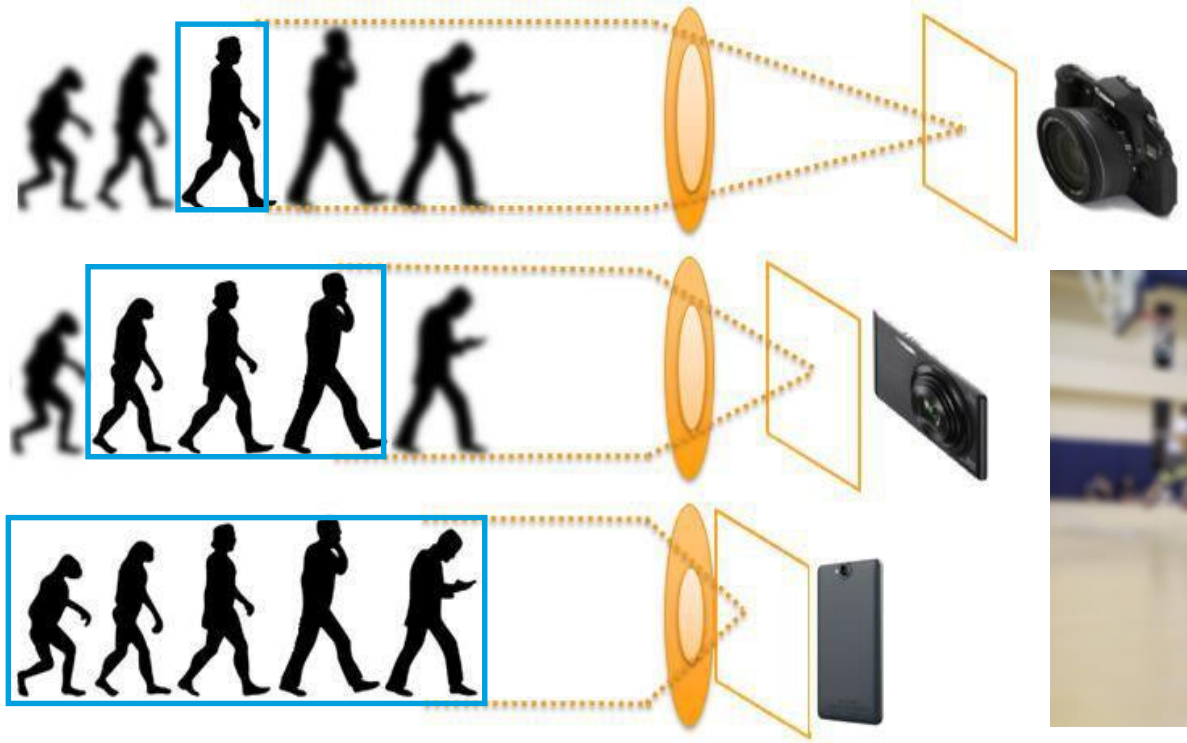


- 70%-80% probability to take facial picture in camera common use
  - Guide the focus and exposure
- Mediatek ISP provides hardware face detection engine on premium and mid-stream platform

FD Applications

- Smile detection
- Blink detection
- Red eye
- Face beauty
- Face recognition

Depth of View and Camera Thickness



- Subject stands out of a picture with a shallow depth of view
- Aperture size, so as to camera thickness, has to be compromise when pursuing shallow depth of view

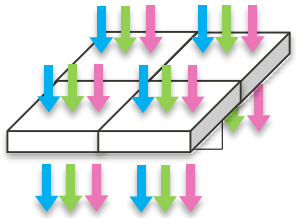
Shallow Depth of Field Effect

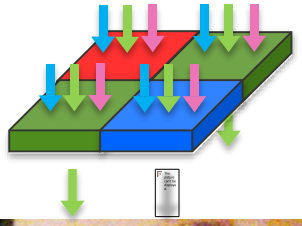
Canon 6D F1.4 (50mm)

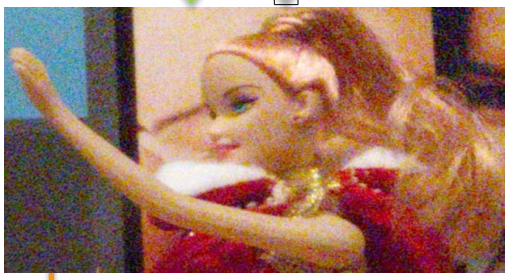
F1.4 (50mm-equivalent)

- Large aperture emulation based on depth information
- Single capture, no object movement limitation

Bayer + Mono Image Denoise







- Collect more light
- Higher resolution
- No color information

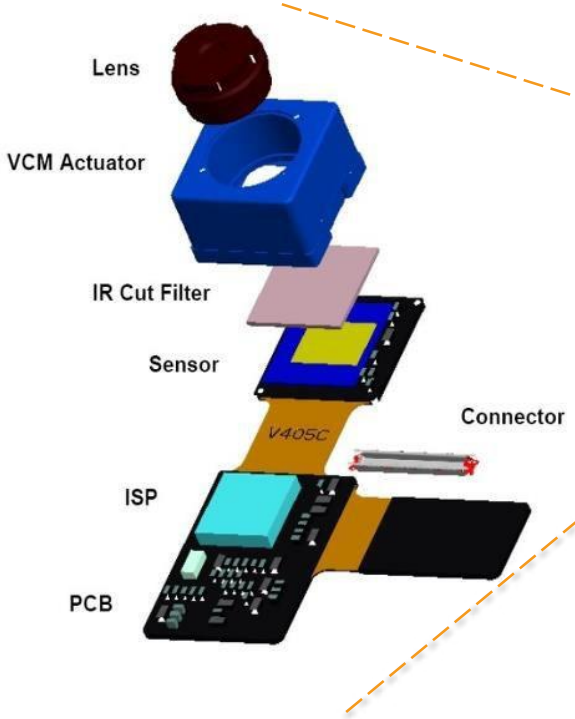
- Color information
- Lost Details
- Reject partial energy

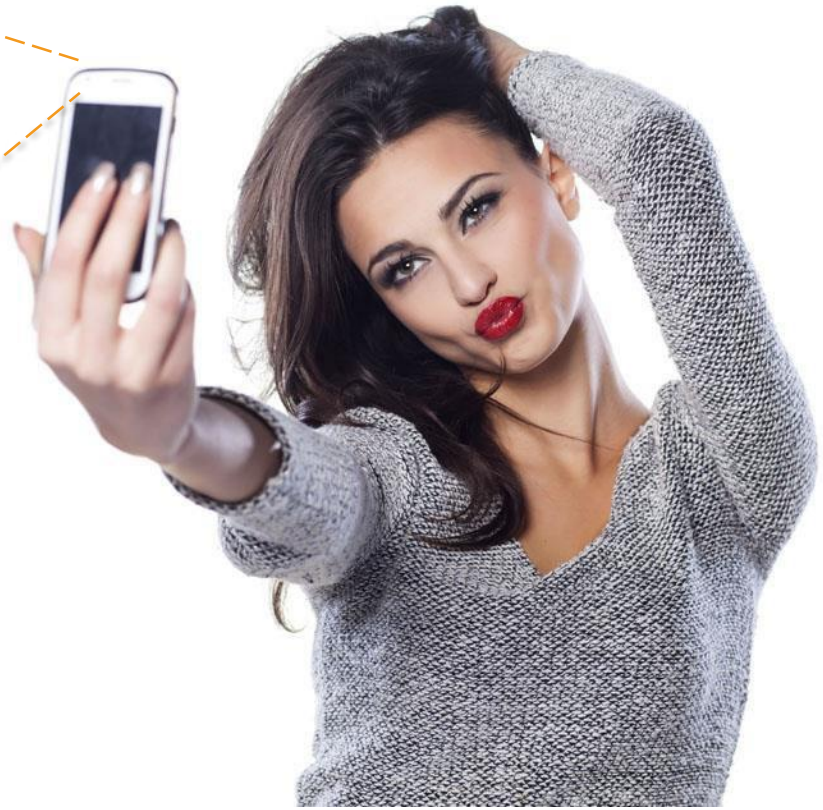
Image Enhancement

- Color information
- More clear
- Less noise

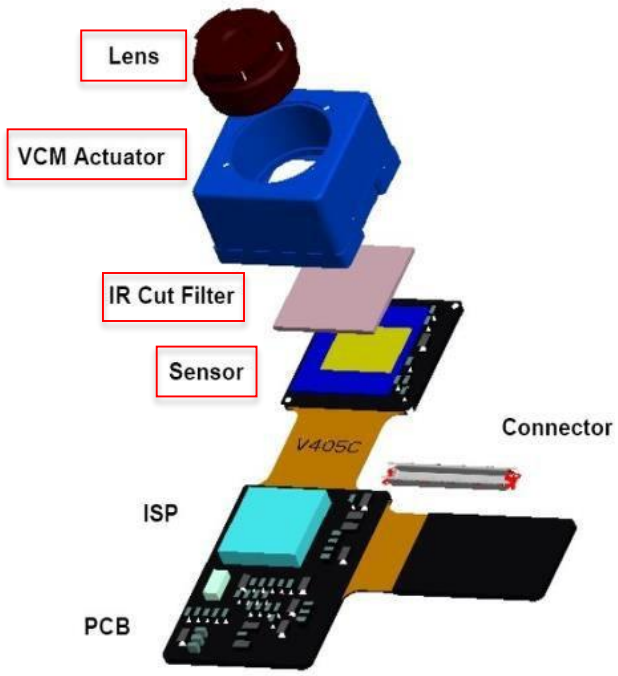
Camera Sensor & Module

Camera System

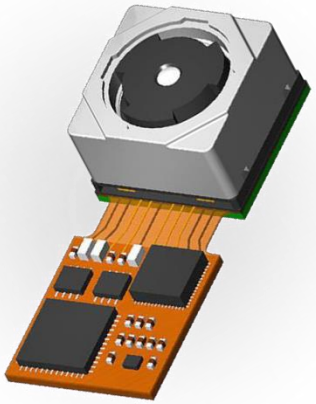




Raw Data Quality



Module house manufacturing ability



Component Pretest
(Lens, VCM + IC, Camera Sensor)

Module Quality Testing

MTK DRL

DRL (Driver Ready List)

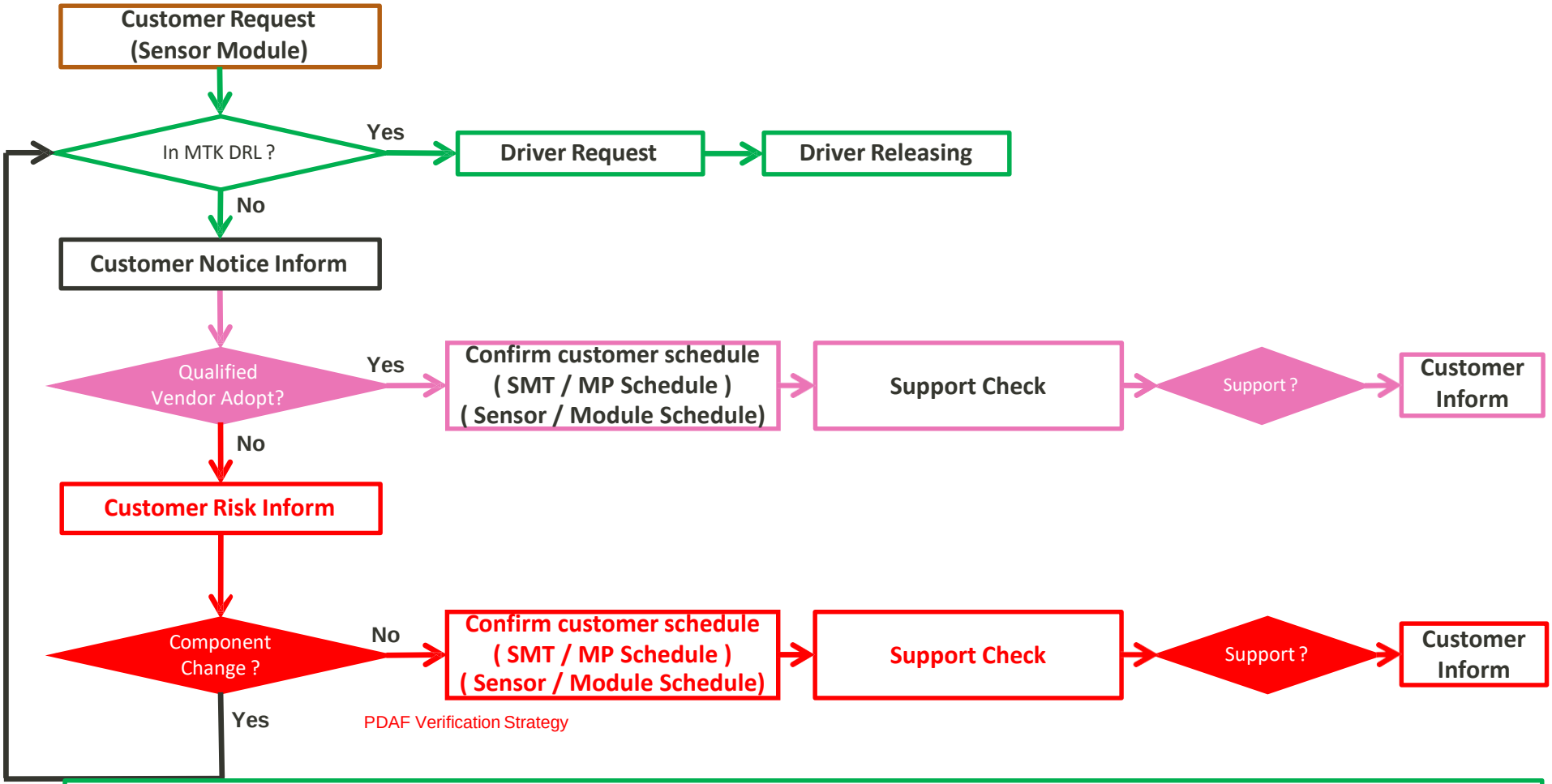
- MTK qualify module to confirm component's risk.
- MTK provide driver for sensor list on DRL.

Why DRL

- Customer reduce risk
- Customer speed up project development

MTK Verification (DRL)			
	Camera Sensor Verification	PDAF Verification	Dual Cam Verification
Verification Based	Sensor based	Module based	Module based
DRL	Sensor Information Only	Detail Module sub-component needed	Detail Module sub-component needed
Verify Focus on	Function	Function + Quality	Function + Quality

Camera Driver Support



[Low Risk] Customer select MTK PDAF DRL component

Customer adapt qualified sensor PD chip and qualified module house for product, 3 weeks needed for co-work after module sample manufactured done

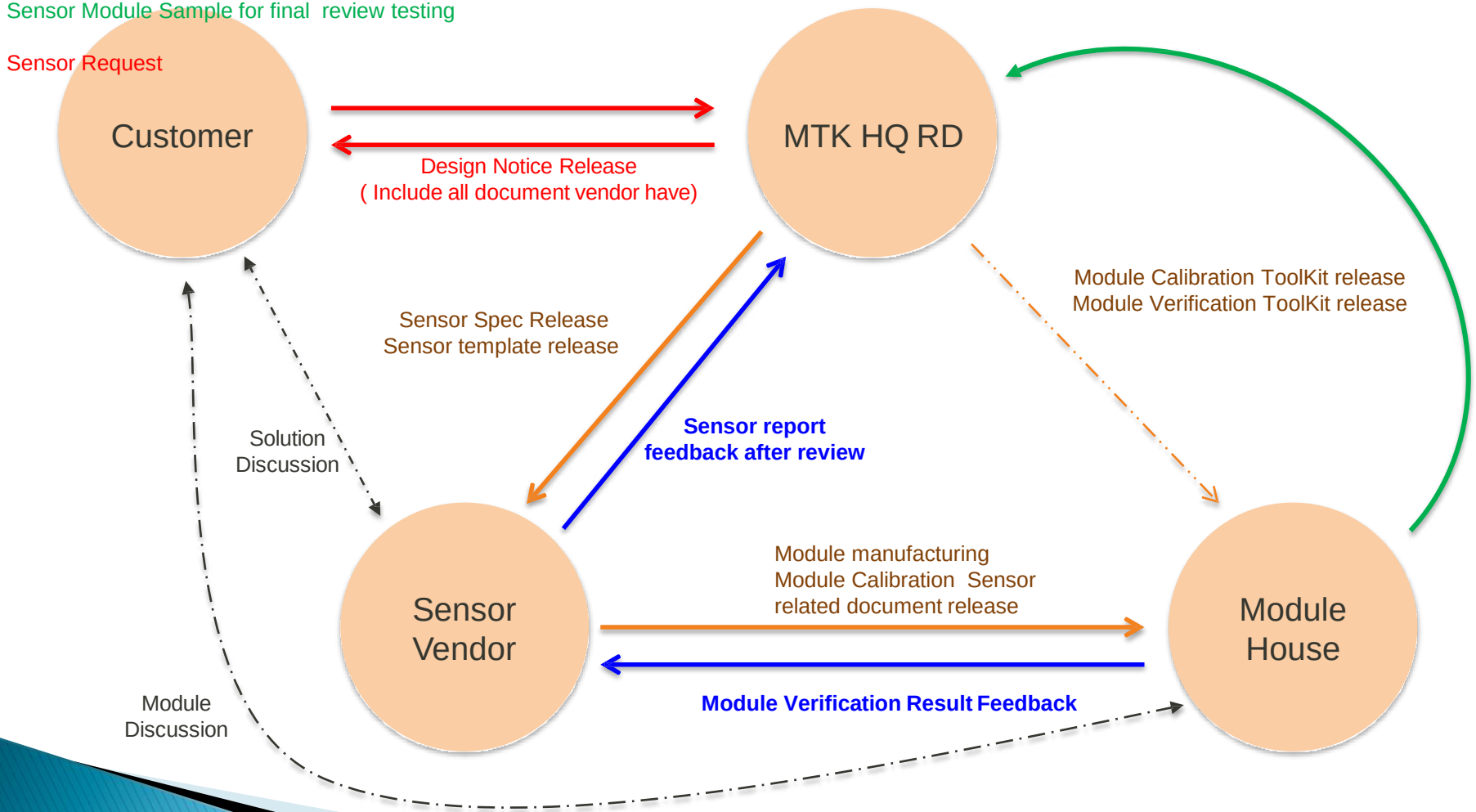
[High Risk] Customer select component by themselves, Not Recommend, Quality/Performance/Schedule all unknown, 5-8 weeks needed after module sample ready

Camera Verification Strategy

“ Customer select component by MTK DRL first ”

Sensor Module Sample for final review testing

Sensor Request



Camera Sensor DRL

- Camera Sensor DRL
  - Module information List
  - Key feature support list

Vendor	Vendor P/N	Spec.	Format	Chip	Qualify Status	Attachments	Publish Status	Schedule	I/F	Module Information	Per-Frame Control Support	HDR Support	Slow Motion Video Support	PDAF Support
Samsung	S5K3L8	13M	RAW	MT6735	Qualified	Samsung_S5K3L8_MIPI_RAW_4LANE_MT6735_W1540.1.r ar	Published	W1540	MIPI (4L)	Liteon - FRA-010647 Optical 1/3.06” (1.12um) Lens : F2.0 + 5 Plastic + AF	Yes	No	No	Yes

PDAF DRL

- PDAF DRL
  - Sub component List
  - Quality test list

MTK PDAF DRL												
Schedule Plan	Vendor	Resolution	Sensor	M/H	Module PN	Module Spec	Lens vendor	Lens PN	Driver IC vendor	Driver IC PN	VCM vendor	VCM PN
W1650	Samsung	13M	S5K3M2XXM	Sunny	F13S01B-201	Open loop 8.5X8.5X4.83	Largan	50069A3 (F# 2.0, 5P)	DW	DW9761B	TDK	TVF-668ABC (Open loop)
W1650	Samsung	16M	S5K2P8XXM	Primax	TG01X	Close loop (10.7x10.7x6.15)	Largan	9617B1 (F#2.2, 6P)	OnSemi	LC898212XD	MITSUMI	KAFF70SA5 (Close loop)

Common	Common	Qualify	Qualify	Qualify	Qualify	Qualify
Vendor	Vendor P/N	BPC Artifact Exist	CrossTalk Value	Sensitivity Level	Defect PD Pixel	PD to VCM Linearity
A	A	Yes	AVG: 1.5%, MAX:5.22%	AVG: 41.4%, MIN: 23.8%	Pass	AVG: 99.5%, MIN: 96.8%
B	B	NO	AVG: 0.58%, MAX:2.49%	AVG: 71.8%, MIN: 58.8%	Pass	AVG:99.6%, MIN: 97.5%
C	C	NO	AVG: 0.5%, MAX: 3.36%	AVG: 62%, MIN: 52%	Pass	AVG: 99.9%, MIN: 98.6%

Dual Cam DRL

- Dual Cam DRL
  - Sub component List

Vendor P/N	Module House	Module P/N	Spec.	Format	Chip	Qualify Status	Schedule	Layout Type	Baseline (mm)
IMX258_5E8_ODBC5F02	Ofilm	ODBC5F02	13M + 5M	RAW	MT6797	On-going		2	20
IMX258_5E8_S0513AA-S	Qtech	S0513AA-S	13M + 5M	RAW	MT6797	On-going		2	20

1st Cam - Sensor Vendor	1st Cam - Sensor P/N	1st Cam - Lens Vendor	1st Cam - Lens P/N	1st Cam - Driver IC Vendor	1st Cam - Driver IC P/N	1st Cam - VCM Vendor	1st Cam - VCM P/N	2nd Cam - Sensor Vendor	2nd Cam - Sensor P/N	2nd Cam - Lens Vendor	2nd Cam - Lens P/N	2nd Cam - Driver IC Vendor	2nd Cam - Driver IC P/N	2nd Cam - VCM Vendor	2nd Cam - VCM P/N
Sony	IMX-258-0AQH5-C	Largan	50065B21	On-Semi	LC898214XC	Shicoh	CLK01	Samsung	S5K5E8YX13-FGX2	Largan	50037A1	N/A	N/A	N/A	N/A
Sony	IMX-258-0AQH5-C	Largan	50065B8	On-Semi	LC898212XD-SH	mtsitek	30R6	Samsung	S5K5E8YX13-FGX2	Largan	50037A1	N/A	N/A	N/A	N/A

Camera Basic

Outline

Camera System Introduction

3A Introduction

- AE Introduction
- AWB Introduction
- AF Introduction
- Flash Introduction

ISP Introduction

- Shading Introduction
- Colour Introduction
- ISP Introduction

What is AE

- Brightness of environment can be adaptive by human eye so brightness of human vision is always suitable.
- Brightness of camera vision is based on exposure setting. Camera brightness isn't suitable unless exposure change to suitable exposure setting. Auto exposure, AE, play a role in suitable exposure setting modification automatically.

Human vision

Exposure setting A

image too bright or too dark

Auto Exposure

As Human vision

What is AWB

- AWB (Auto White Balance)
- Vision of digital camera is not like human vision on color.
- Auto white balance is performed to modify image color as human vision.

Human vision

Camera Vision

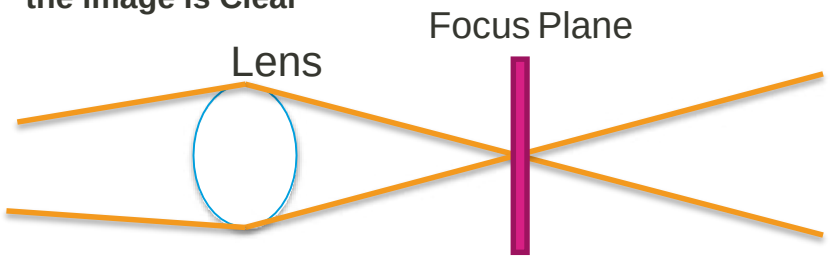
White balance

As Human vision

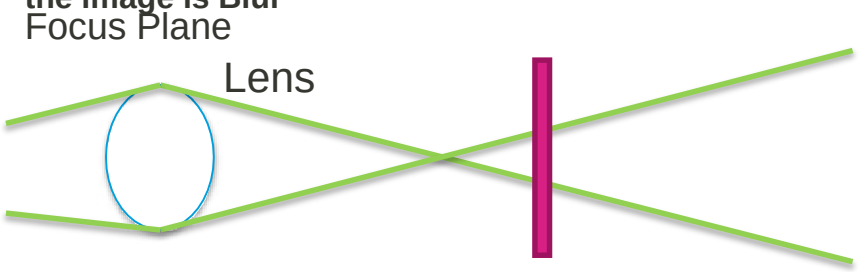
What is AF

- Control lens to move to a proper position to get a clear image, this behavior called auto focus (AF)

When Light focus on the focus point, the image is Clear



When Light not focus on the focus point, the image is Blur

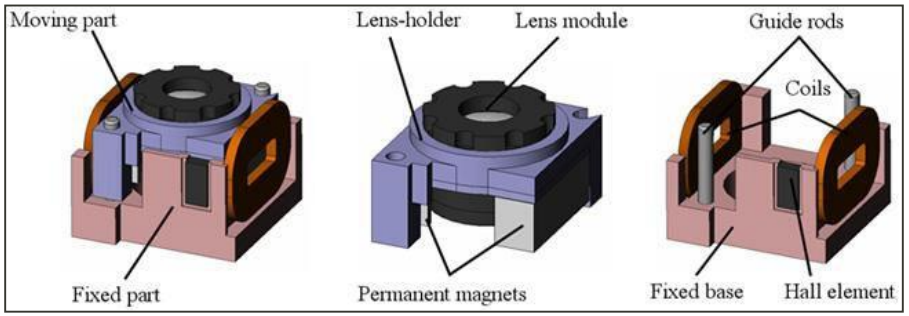


In focus - Clear Image

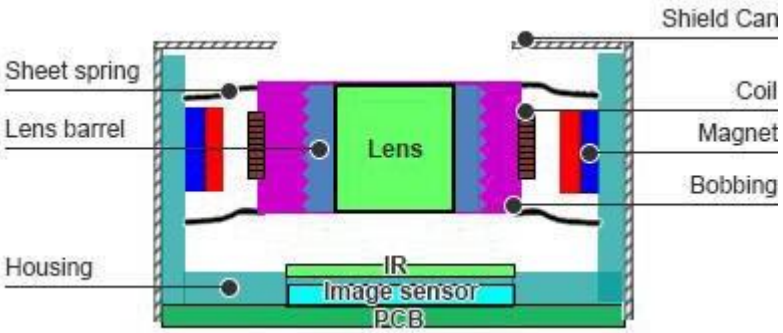
Out of focus – Blur Image

VCM

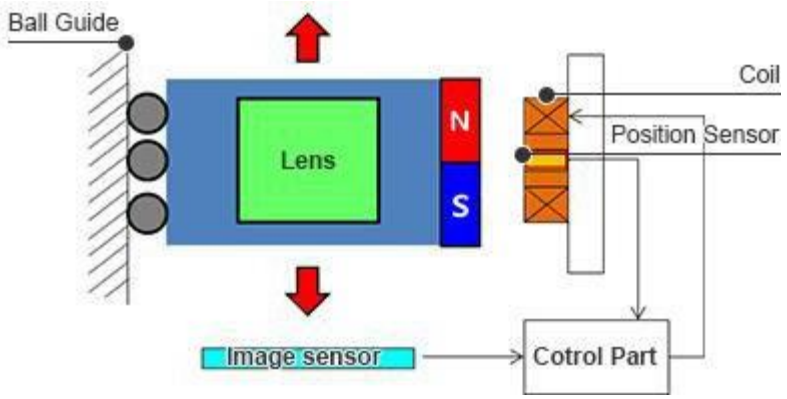
- Voice Coil Motors (VCM) is the simplest type of electric motors. It consists of two separate parts; the magnetic housing and the coil
- Applying a voltage across the terminals of the motor causes the motor to move to one direction



Module 1



Module 2



What is flash

- When the environment is too dark, we need some device which can provide enough brightness to take pictures.

- Currently, most of smart phone select LED because of its advantages.
  - Easier to control
  - Less wasted energy
  - Continuous light on

Without flash

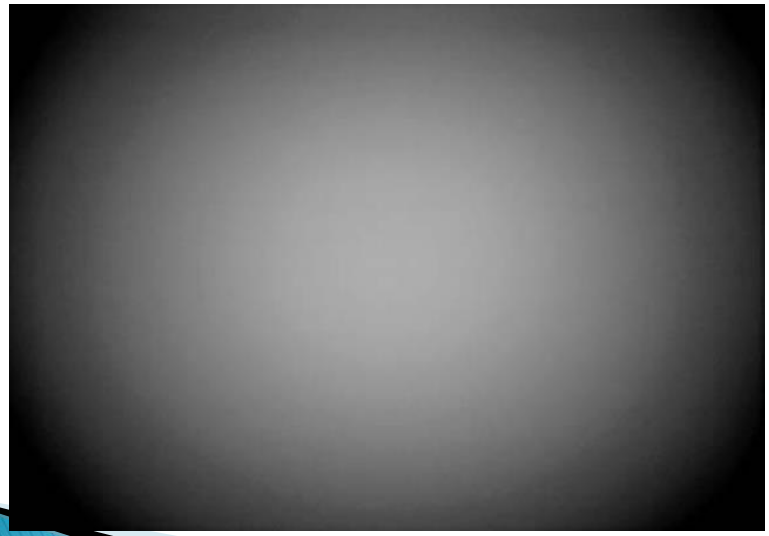
flash on

What is shading

- Lens shading is the reduction in light falling on the image sensor away from the optical center.

- Phenomenon
  - Brightness shading : The center is bright ; the corner is dark.
  - Color shading : The center color and corner color is different.

Brightness shading



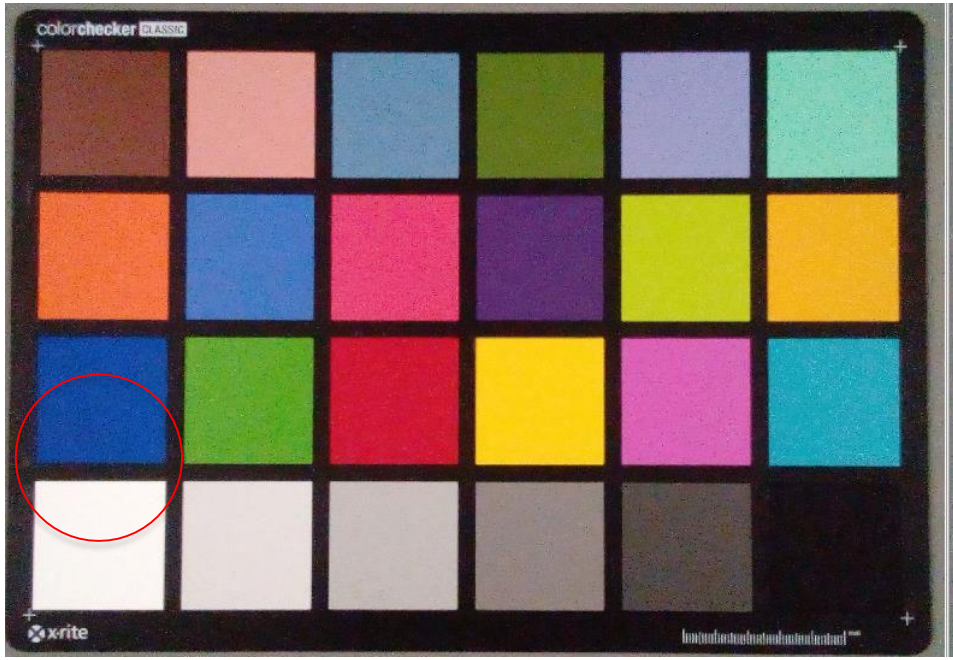
Color shading

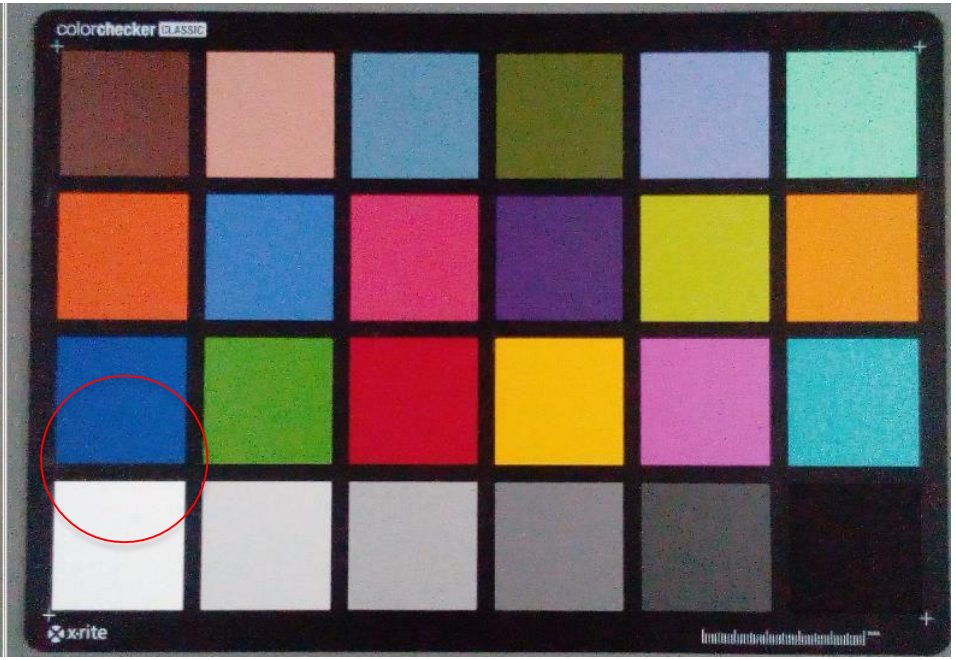
What is colour tuning

- Color present is important for human's vision.
- Color transform from bayer raw data need to be decided R,G,B ratio which can be changed by color correction matrix.
- If the ratio is weak, image will be dull or abnormal.

Why we need color tuning

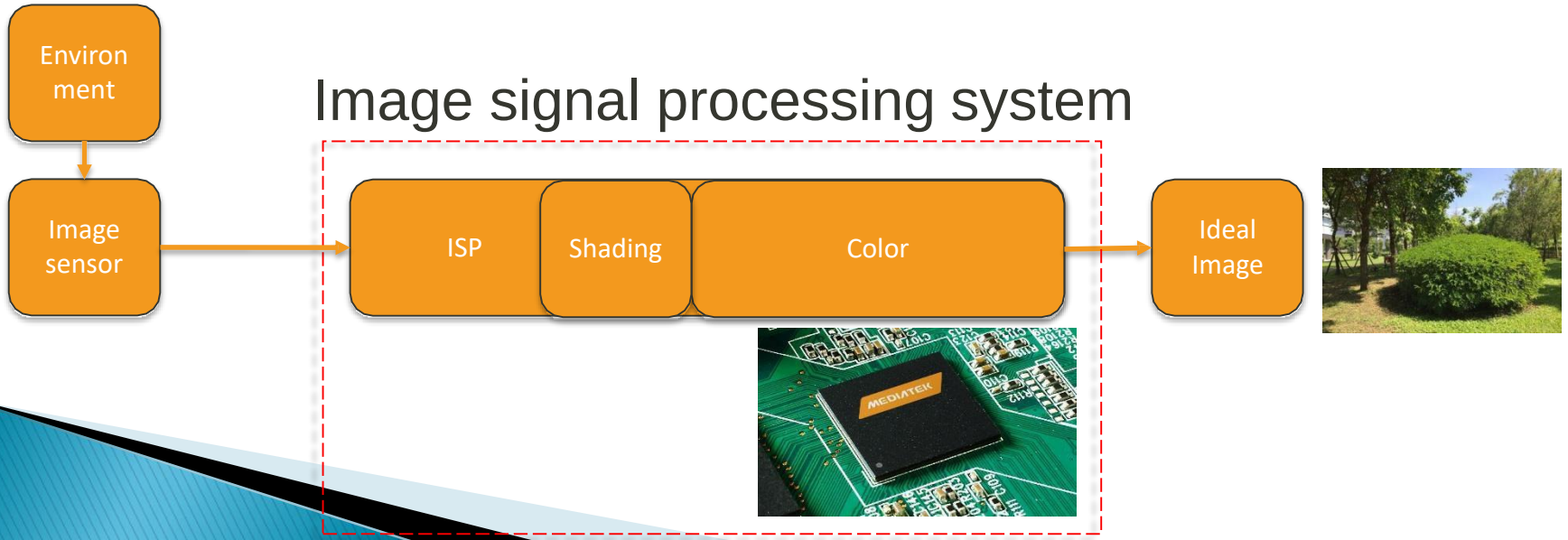
- Different sensor have different color sensitivity.
- Take a picture in the same environment by different camera, the color performance will be different.
- We expect the color should almost approach the international standards.
- For this goal, we need to tuned the color.





What is ISP

- An image's performance is not satisfied people, and the ISP system is created to process and optimize the image by digital solution.
- There are some ISP solutions as demosaic, de-noise, edge enhance and color tuning …etc.



Dual Camera Introduction

Outline

- Overview
- Dual camera configurations
- Dual camera feature introduction
  - Bokeh
  - Wide + Tele optical zoom

Dual camera configurations

- Bayer-Bayer
  - By shooting the same scene from two different cameras, the two images can be used to calculate the depth map, then can be used to general bokeh effects with depth map and clear image.
  - Most of dual cameras
- Wide-Tele
  - A wide angle camera and a telephoto lens camera are used. This setup enables optical zoom. By default the wide angle camera is used. When user zooms in, or to capture far-away objects, the telephoto lens is activated instead.
  - IphoneX, Samsung S9, OPPO R11, OPPO R11s
- Bayer-Mono
  - Monochrome camera sensor has better brightness and details information over than Bayer RGB sensor, especially in low-light. To fuse the Bayer and Mono images the image quality can be improved.

Bokeh

- What is it?
  - The way the lens renders out-of-focus points of light.
  - Blur the background and may have some circles of light and color.

MediaTek Imagiq™

F1.4 (50mm-equivalent)

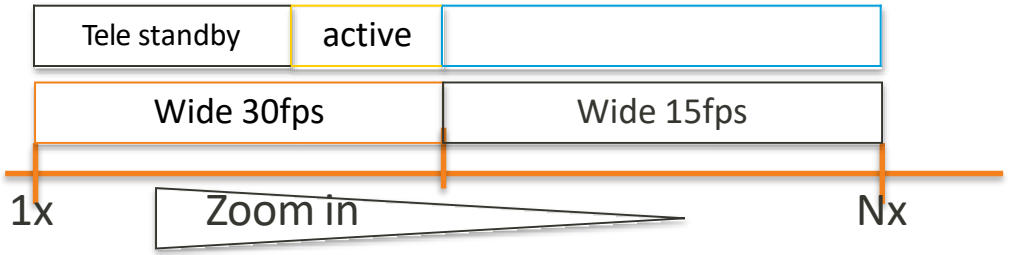
Bokeh feature requirement

- **Sensor Synchronization**
  - Stereo camera requires the two sensors imaging simultaneously. The two non-identical sensors have unequal frame rates.
    - **SW mechanism:** The timestamp different of the two images is only an approximation. (~1ms)
    - **HW mechanism:** The camera device supports frame timestamp synchronization at the hardware level, and the timestamp of image accurately reflects its start-of-exposure time. (<1ms)
- **3A Synchronization**
  - Stereo 3A (auto exposure, auto white balance and auto focus) is an active control mechanism to make the image pair as similar as possible.
- **Real time Processing**
  - The bokeh effect process is a heavy computational task. All post-processing must execute and finish during one exposure frame.

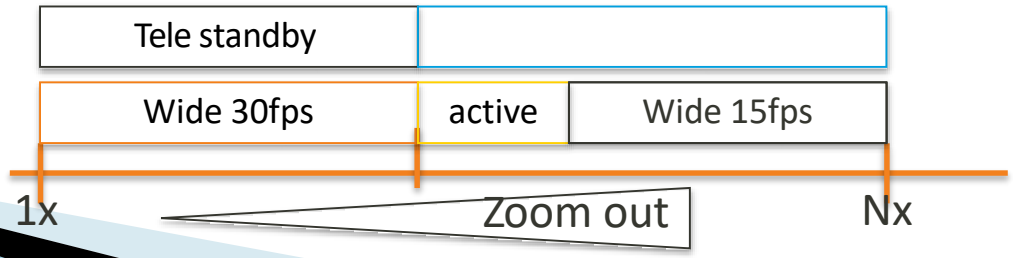
Wide + Tele optical Zoom

- What is it?
  - One wide angle lens and one tele photo lens with two identical sensors
- Principle
  - Normal images with wide FOV will be taken using the wide angle lens, while far away object or object requiring close-up zoom with narrower FOV will be taken using the tele photo lens.
- Digital zoom : uses software processing to bring the subject closer.

Zoom in



Zoom out



Camera Testing

Agenda

- **Auto Exposure (AE)**

[AE-1] AE Stability [AE-2] Dynamic range

- **Auto White Balance (AWB)**

[AWB-1] AWB (Color reproduction) [AWB-2] Shading (Luminance shading)

- **Auto Focus (AF)**

[AF-1] ISO12233 Resolution test

- The main test equipment introduction

[AE-1] Auto Exposure Stability

- Under the different brightness, the exposure need to be converged linearly.
- Method:

Using the Light Source Box to take photo, from dark to light (LV5 to LV13), totally 9 pictures.

And then, to calculate the brightness of each shot, to see if they have linear relationship

- **Description**
  1. Equipment
     - Subject： Light Source Box
     - Source of light：LV5 ~ LV13
  2. Condition
     - Distance of camera and subject: Full view
     - Reset camera setting (default setting)
     - Size/image quality: maximum
     - Strobe: off

Auto Exposure

Over exposed

This is a over exposure photo, its brightness is too high.

Correct exposure

This is a correct exposure photo, its brightness is close to what we really see.

[AE-2] Dynamic range

It ‘s the ability of the camera's sensor to identify the details of light and dark areas.

We check the ratio of the brightest to the darkest, the greater ratio,the higher the dynamic range.

Method:

Using D65 light source， take the photo of Q14 Grey Scale card, then check how many

Scale we can identify.

Description

1. Equipment
   - Subject：Kodak Grey Scale (Q-14) chart
   - Source of light：D65
   - Additionally： Imatest tool, visual check.
2. Condition
   - Distance of camera and subject: 80% view
   - Reset camera setting (default setting)
   - Size/image quality: maximum
   - Strobe: off

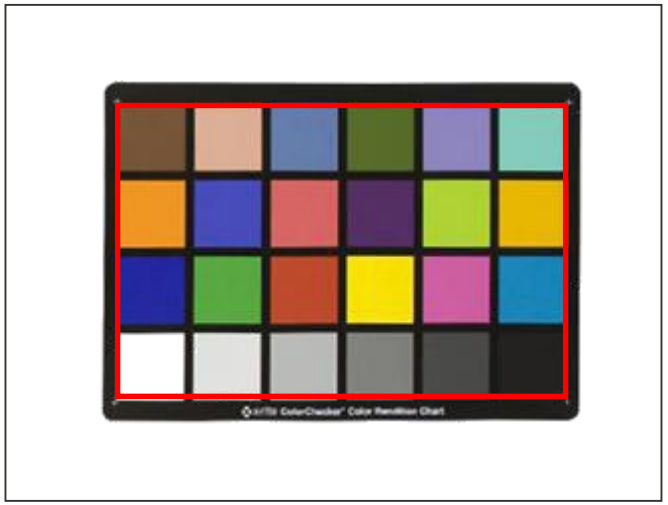
High dynamic range, you can see more details

Low dynamic range

High dynamic range

[AWB] Color reproduction

- **Description**
  1. Equipment
     - Subject：ColorChecker chart
     - Source of light：D65/ CWF/ TL84 /A
  2. Condition
     - Distance of camera and subject: 80% view
     - Reset camera setting (default setting)
     - Size/image quality: maximum
     - Strobe: off
  3. Method



(1)Using D65 light source, take a photo of ColorChecker (chart: 80% of screen)

(2)Calculate Delta E using the imatest tool

[AWB-2] Shading (Luminance shading)

- Ideally, the edge of a camera lens shall have the same light intensity of the center of a camera lens.
- However it’s not easy, and "dark corner“ situation happens.
- The larger the aperture, the easier the camera has such situation, so we need the algorithm to compensate it.
- Method

(1) Using the Light Source Box (LV10) to take a look at the dark corners (2)To calculate shading by using the image test tool

- **Description**

1. Equipment
   - Subject： Light Source Box
   - Source of light：LV10
2. Condition
   - Distance of camera and subject: Full view
   - Reset camera setting (default setting)
   - Size/image quality: maximum
   - Strobe: off

[AF] ISO12233 Resolution test

- Auto Focus is related to Image Resolution.
- Based on the digital axis resolution performance index of ISO image resolution test standard, we check the capability of image resolution。

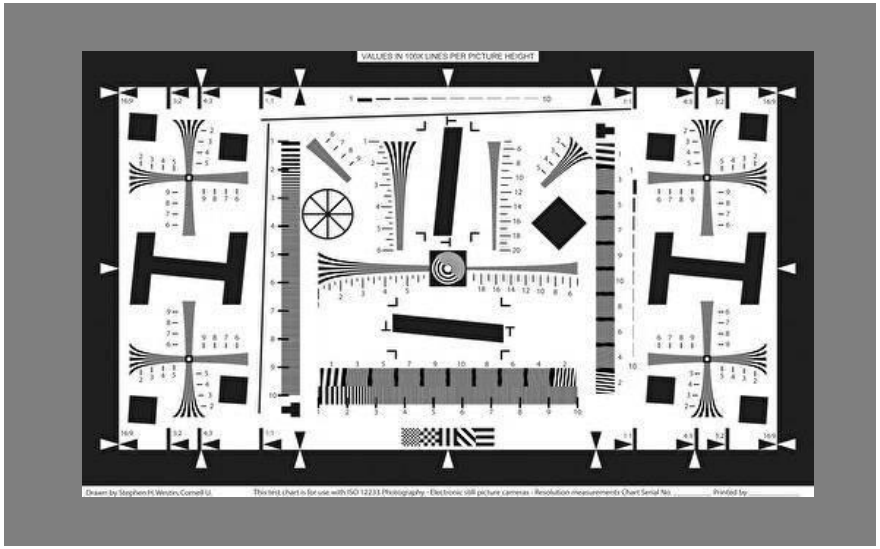
- Method:

  (1) To take photo of ISO12233 chart in the distance of 1 Meter, 2 meters and 3 meters.

  (2) To identify the number of horizontal TV line.

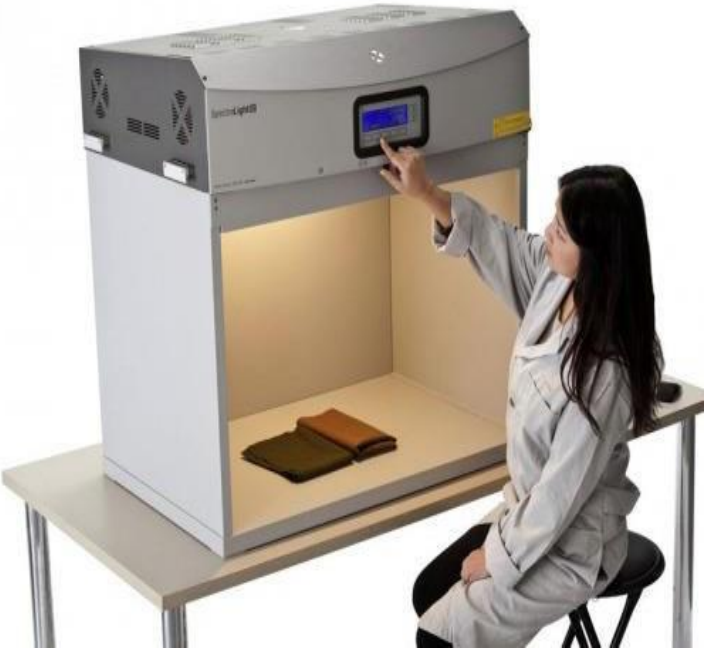
- **Description**

1. Equipment
   - Subject：ISO 12233 chart
   - Source of light：Lab light (1000Lx)
   - Additionally：Photoshop, visual check.
2. Condition
   - Distance of camera and subject: Full view
   - Reset camera setting (default setting)
   - Size/image quality: maximum
   - Strobe: off



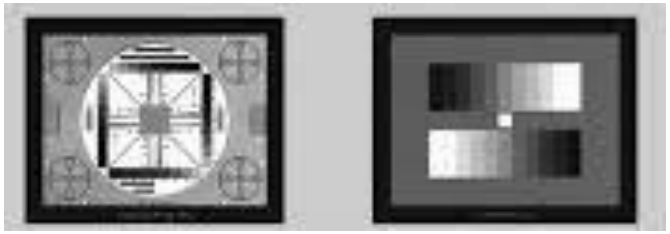
The main test equipment introduction

SPL-QC



LSB-111

DNP



LCD Introduction
and
Touch Introduction

LCD Introduction

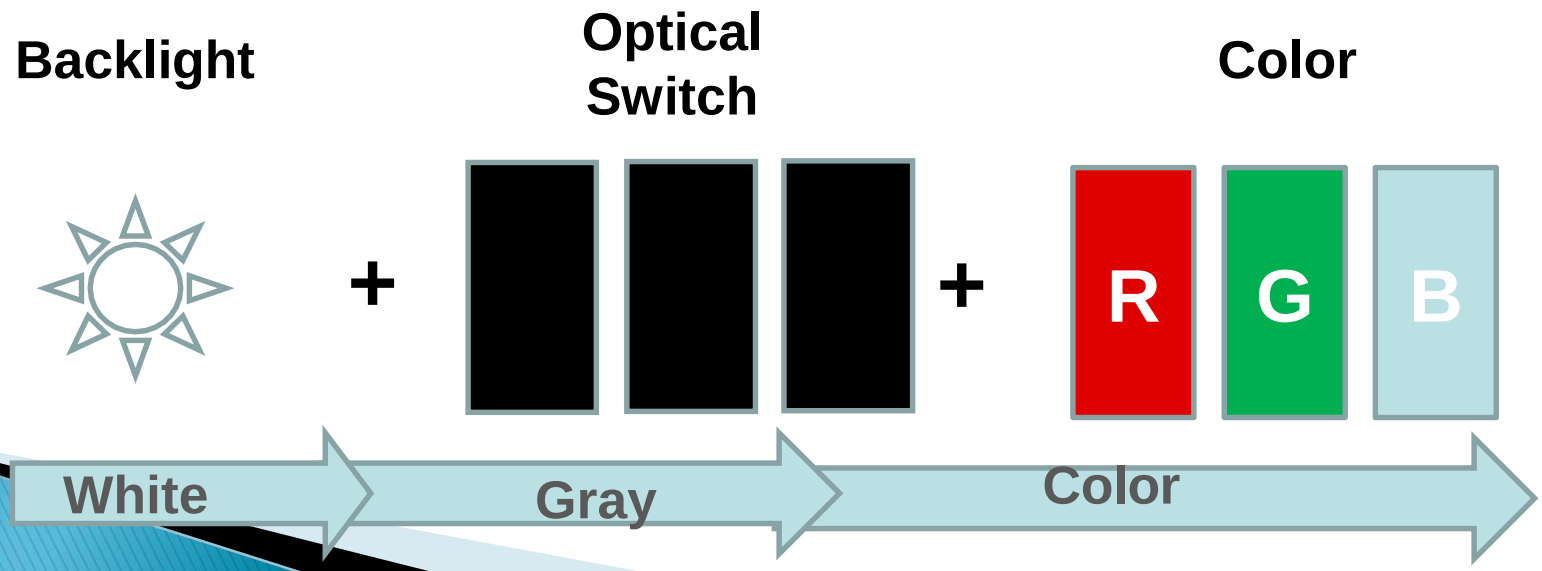
• A liquid crystal display is the most common display type among mobile phones because of its low power consumption and good image quality. They are generally easy to read, even under direct sunlight.

▪ The smallest element of an image displayed on a LCD is the pixel. Each pixel normally consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters.

Some of the types of LCD displays are STN, TFT and TFD. The first one, STN, offers low cost and low power consumption, but low image quality. TFT features greater image quality and response time, yet its displays are more expensive and need more power.

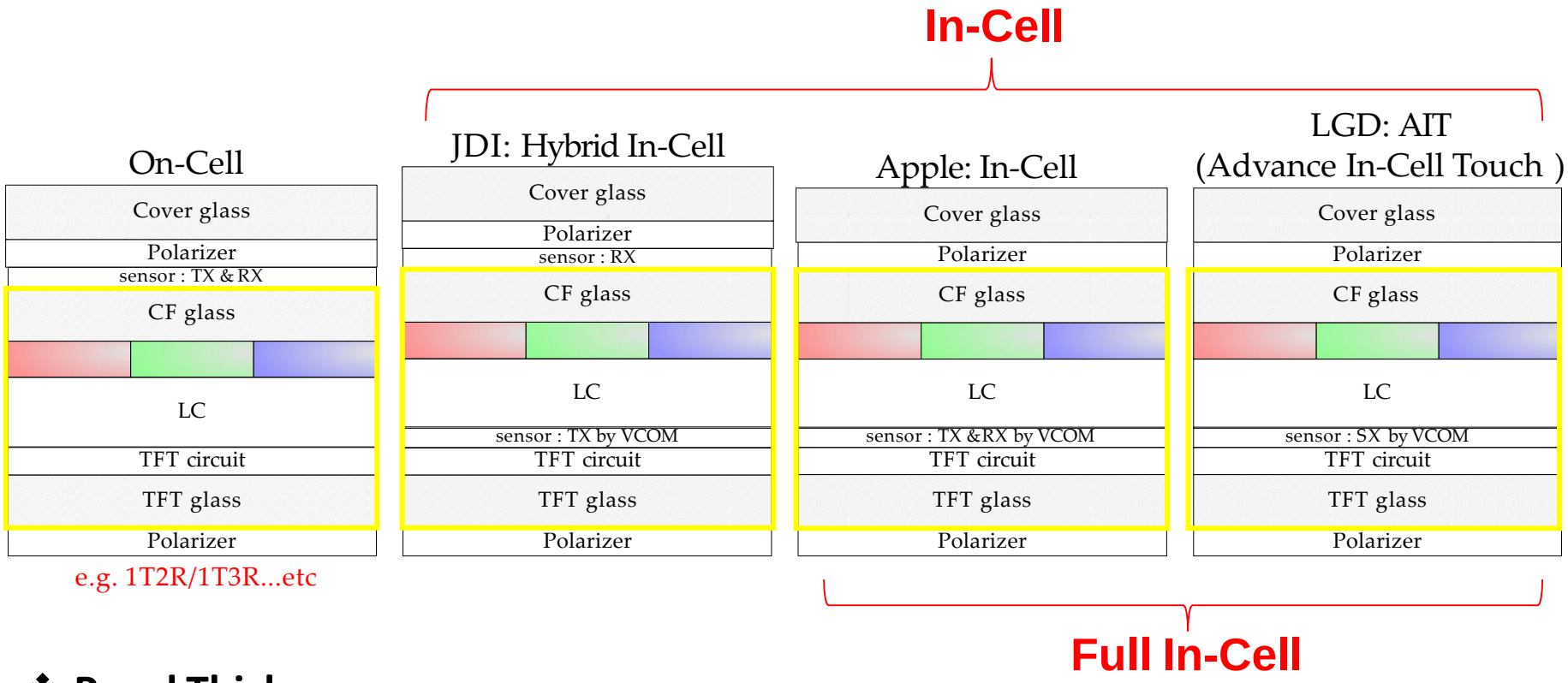
▪ Three other types of LCDs are transmissive, reflective, or transflective. Transmissive displays offer nicer image quality in low or medium ambient light, while reflective ones work best in bright ambient light. Transflective displays combine the best of both.

LCD Introduction



Touch Introduction

I ❤ Innovation



❖ **Panel Thickness**

- ✓ On-Cell & Hybrid In-Cell: ITO patterning is needed on CF backside，there is thickness limitation on glass slimming process (0.15~0.2mm)
- ✓ Full In-Cell: Thinnest! (~0.125mm)

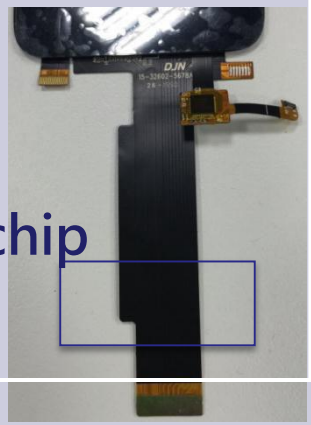
❖ **Display noise**

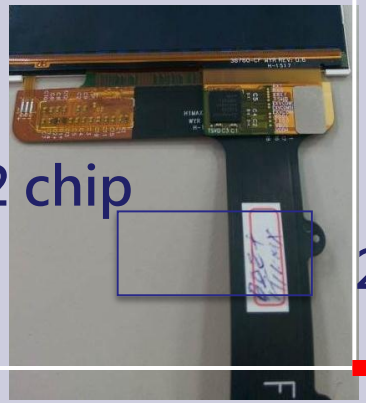
- ✓ In-Cell adopts Segmented VCOM driving technology, suppressed display noise brings better TP performance than On-Cell

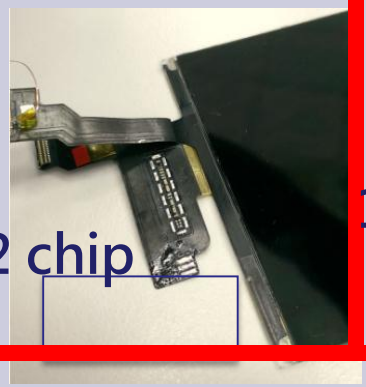
Touch

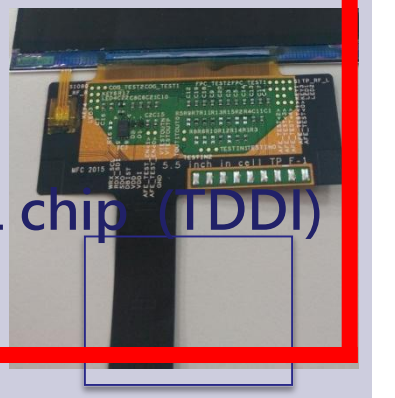
I ❤ Innovation

	On-Cell	Hybrid In-Cell	Full In-Cell Apple	Full In-Cell AIT
Mutual/self	Mutual/self	Mutual	Mutual	self
VCOM segment	No	Yes	Yes	Yes
TP Process	CF only	Both TFT & CF	TFT only	TFT only
FPC design	2 FPC (TFT+CF)	2 FPC (TFT+CF)	2 FPC (TFT)	1 FPC (TFT)









Best module BOM cost & easier assembly process!

Thank You