Row	Section	Module Pin / Signal	Connects To	Connect? (YES / NO)	Switch Needed?	Clear Explanation	
DISPLAY – ILI9341 (DISPLAY ONLY, ALWAYS WORKS)							
1	Display	VCC	ESP32 3V3	YES	No	Power for display	
2	Display	GND	ESP32 GND	YES	No	Common ground	
3	Display	CS	ESP32 GPIO5	YES	No	Display SPI select	
4	Display	DC	ESP32 GPIO2	YES	No	Data / Command	
5	Display	RST	ESP32 GPIO4	YES	No	Display reset	
6	Display	SCK	ESP32 GPIO18	YES	No	SPI clock (shared)	
7	Display	MOSI	ESP32 GPIO23	YES	No	SPI data in	
8	Display	MISO	ESP32 GPIO19	YES	No	SPI data out	
9	Display	LED	ESP32 3V3	YES	No	Backlight power	
TOUCH – XPT2046 (OPTIONAL FEATURE)							
10	Touch	T_CS	ESP32 GPIO15	YES (for touch)	YES	Enables / disables touch	
11	Touch	T_IRQ	ESP32 GPIO32	OPTIONAL	Optional	Touch interrupt or free GPIO	
12	Touch	T_CLK	Same as SCK	NO (separate)	No	Already connected via SCK	
13	Touch	T_DIN	Same as MOSI	NO (separate)	No	Already connected via MOSI	
14	Touch	T_DO	Same as MISO	NO (separate)	No	Already connected via MISO	
BATTERY & POWER							
15	Battery	BAT+	TP4056 B+	YES	No	Battery positive to charger	
16	Battery	BAT−	GND	YES	No	Battery ground	
17	Charger	TP4056 B+	Battery +	YES	No	Charging path	
18	Charger	TP4056 B−	GND	YES	No	Charging ground	
19	Charger	TP4056 OUT+	Power Switch IN	YES	No	Charger output to switch	
20	Power	Power Switch OUT	Regulator IN	YES	YES	Main device ON/OFF	
21	Charger	TP4056 OUT−	GND	YES	No	System ground	
22	Regulator	3.3 V OUT	ESP32 3V3	YES	No	Stable supply to ESP32	
23	Regulator	GND	GND	YES	No	Common ground	
EXPANSION / UNUSED ESP32 GPIOs							
24	Expansion	GPIO25	Header	Optional	No	Free GPIO	
25	Expansion	GPIO26	Header	Optional	No	Free GPIO	
26	Expansion	GPIO27	Header	Optional	No	Free GPIO	
27	Expansion	GPIO32	Header	Shared	Optional	Free GPIO	
28	Expansion	GPIO33	Header	Optional	No	Free GPIO	
29	Expansion	GPIO34	Header	Optional	No	Free GPIO	
30	Expansion	GPIO35	Header	Optional	No	Free GPIO	
31	Expansion	3V3	Header	Optional	No	External modules	
32	Expansion	GND	Header	Optional	No	External ground	

Row	Section	Item / Signal	Connection / Value	Mandatory?	Why This Is Required	
1	ESP32 Core	EN (Enable) pin pull-up	EN → 3.3V via 10kΩ resistor	YES	ESP32 will not boot reliably without this	
2	ESP32 Core	Reset button (optional)	EN → GND via push button	Optional	Manual reset for debugging	
3	Power	Bulk capacitor (ESP32)	10–47 µF between 3V3 & GND (near ESP32)	YES	Prevents Wi-Fi brownout resets	
4	Power	Decoupling capacitors	0.1 µF close to ESP32 VDD pins	YES	Noise suppression	
5	Regulator	Input capacitor	As per regulator datasheet (e.g. 10 µF)	YES	Regulator stability	
6	Regulator	Output capacitor	As per datasheet (e.g. 10–22 µF)	YES	Stable 3.3 V rail	
7	Regulator	Current capability	≥700 mA peak	YES	ESP32 + TFT + Wi-Fi load	
8	Battery	Battery protection	Protected cell OR DW01A circuit	Recommended	Prevent over-discharge	
9	USB	ESD protection	TVS diode on USB D+/VBUS	Recommended	Protect TP4056 & MCU	
10	PCB	Ground plane	Solid GND pour	Recommended	Noise & EMI control	

From (Pin)	To (Pin)	Component	Value	Why	
ESP32 EN	3.3V rail	Resistor	10kΩ	Keeps ESP32 enabled	
ESP32 EN	GND	Push Button (optional)	—	Manual reset	

From	To	Component	Value	Place Near	
ESP32 3V3	GND	Capacitor	10–47 µF	ESP32	
ESP32 3V3	GND	Capacitor	0.1 µF	ESP32	

From	To	Component	Value	Why	
TP4056 OUT+	Power Switch IN	Trace	—	Charger output	
Power Switch OUT	Regulator IN (VIN)	Trace	—	Main ON/OFF	
Regulator OUT (3.3V)	ESP32 3V3	Trace	—	Safe power	
Regulator GND	GND	Trace	—	Common ground	

From	To	Component	Value	Datasheet	
Regulator IN	GND	Capacitor	10 µF	Required	
Regulator OUT	GND	Capacitor	10–22 µF	Required	

From	To	Why	
Regulator 3.3V	TFT VCC	TFT runs on 3.3V	
Regulator 3.3V	TFT LED	Backlight	
GND	TFT GND	Return path	

Touch Pin	Action	Why	
T_CLK	Do nothing	Already SCK	
T_DIN	Do nothing	Already MOSI	
T_DO	Do nothing	Already MISO	
T_CS	ESP32 GPIO15	Touch enable	
T_IRQ	Optional → GPIO32	Interrupt	

From	To	Why	
Battery +	TP4056 B+	Charging	
Battery −	GND	Ground	

From	To	Why	
USB VBUS	TP4056 IN+	5V input	
USB GND	GND	Return	