ESP32 external antenna: U.FL to SMA

A short U.FL to SMA pigtail turns the module's tiny socket into a standard SMA connector. Get the genders right, keep the pigtail short, and plug the U.FL end once.

Genders and mating

Typical pigtail	U.FL plug → SMA male (nut + pin)	RG178 cable, rated DC–6 GHz, VSWR 1.5.
SMA female port	plugs straight in	SDRs, analyzers, many test antennas. N inputs via an N to SMA adapter.
SMA male antenna	add an SMA female–female barrel	Most screw-on antennas have an SMA male or RP-SMA male base.
RP-SMA male antenna	add SMA female to RP-SMA female	On an SMA barrel it screws on but makes no contact.

Loss and match

Level after the pigtail	$P_{out} = P_{in} - L$ (dBm, dB)	Both ways: cuts what the module sends and what it hears.
Power left	$P_{out}/P_{in} = 10^{-L/10}$	20 cm at 3 GHz, at most 0.83 dB: at least 82% left.
Losses in a path	$L_{tot} = L_1 + L_2 + \ldots$ (dB)	A cable at the other end of the link adds its loss too.
2.4 GHz Wi-Fi and Bluetooth	$1\,\text{GHz} < 2.4\,\text{GHz} < 3\,\text{GHz}$	The datasheet maximum lies between the 1 and 3 GHz columns: 20 cm, at most 0.83 dB.
Return loss from VSWR	$\text{RL} = 20 \log_{10} \frac{\text{VSWR}+1}{\text{VSWR}-1}$	Pigtail VSWR 1.50: about 14 dB. The antenna's match matters more.

Datasheet maximum loss of an RG178 U.FL–SMA pigtail

Length	1 GHz	3 GHz	Power left at 3 GHz
10 cm	0.28 dB	0.52 dB	at least 88%
20 cm	0.45 dB	0.83 dB	at least 82%

Watch out

- U.FL is made for few matings: press straight down until it clicks, lift straight up with a removal tool, never pull the cable. Fix the cable near the plug; do repeated plugging at the SMA end.
- U.FL and IPEX often name the same connector, but some IPEX series such as MHF4 are smaller and do not mate with U.FL. Check the module datasheet and which antenna port the firmware uses.
- Modules for products are certified with particular antennas; a higher-gain antenna can take a product outside what that covers. On the bench, stay within the local radiated power limit; with more gain you may need less transmit power.
- To test equipment instead of an antenna, put an attenuator in front of the instrument input. 30 cm is not listed; it falls between the 20 and 50 cm values. Loss values are datasheet maximums, not measurements.

Formulas and values from the chapter; conditions as stated there. Free to print and share.