





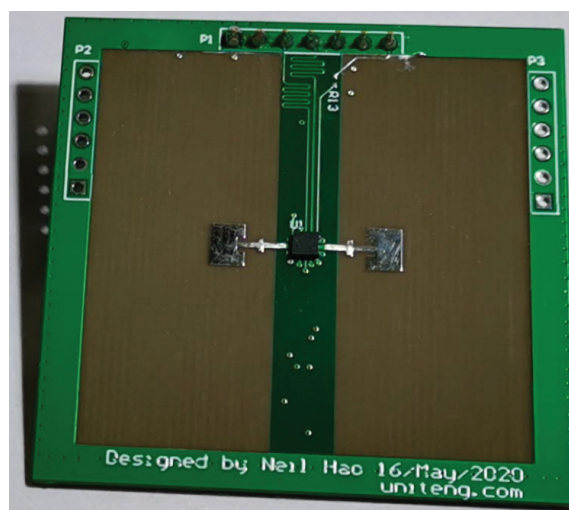


的 Er, Loss tangent 等参数，就无法对产品塑料外壳精确建模，也肯定无法设计出最优的天线。

此外，随着毫米波雷达技术的广泛运用，其成本逐渐降低。使用毫米波雷达解决光学 ToF 传感器对温控器面板外观的影响，成为一种可能。相对于目前成本依然偏高的 77GHz 毫米波雷达，24GHz 毫米波雷达在成本上已经具备了和传统光学运动检测传感器（PIR, TOF 等）竞争的条件。Infineon 公司的文档 Radar vs PIR: selecting the right solution [4] 指出了毫米波雷达和 PIR 传感器的优缺点对比。

Use case	Advantages of radar	Challenges of PIR
 Indoor lighting	<ul style="list-style-type: none"><li>› Increased detection range</li><li>› Energy efficient by turning lights off automatically</li><li>› Can be discretely designed behind casing</li></ul>	<ul style="list-style-type: none"><li>› Limited range compared to radar</li><li>› Limited coverage means more sensors required</li><li>› Unsightly design means PIR needs to be visible</li></ul>
 Automatic door	<ul style="list-style-type: none"><li>› Detects direction of travel so only opens when necessary</li><li>› Keeps the building energy efficient through reduced door opening</li></ul>	<ul style="list-style-type: none"><li>› Only detects movement, irrespective of person coming into building</li><li>› Cannot distinguish between people and animals</li></ul>
 Smart street lighting	<ul style="list-style-type: none"><li>› Increased detection range</li><li>› Precision object identification</li><li>› 24GHz works independent of hot weather</li></ul>	<ul style="list-style-type: none"><li>› Can be unreliable and impacted in harsh weather conditions</li><li>› Lack of object identification means false triggers</li><li>› No directional measurement</li></ul>
 Intruder alarm	<ul style="list-style-type: none"><li>› Increased detection range</li><li>› Reduce false alarms</li><li>› Detection sensitivity is adjustable</li></ul>	<ul style="list-style-type: none"><li>› Unsightly design means PIR needs to be visible</li><li>› Can be unreliable and impacted in harsh weather conditions</li><li>› Limited range/coverage means more sensors required</li></ul>

以下是我在业余时间设计的 24GHz Doppler 雷达，这个版本仅使用两个 Patch Antennas，雷达天线阵面可在 25mm\*5mm PCB 空间内实现，提供 5m 内的人体检测能力，可测出速度和运动方向。这个天线阵面尺寸和检测距离非常适合被嵌入智能家居设备。如果需要更远的检测距离，或控制检测方向，只需要实现更大的天线阵面并使用 lobe control 技术。



Radar Evaluation Board