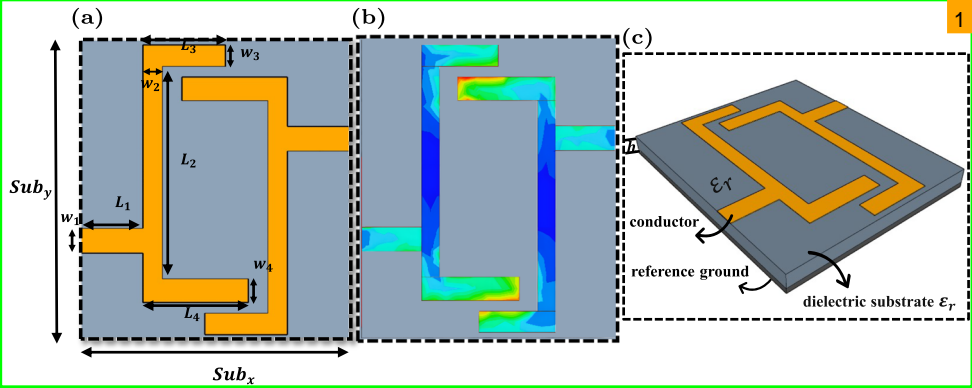**Fig. 7** Structure of the hairpin bandpass filter. **a,** Top view of the filter. **b,** The surface magnetic field distribution of the designed filter. **c,** The structure of the filter

Table 1 Original size of the hairpin filter (units/*mm*)

Sub_x	Sub_y	h	L_1	L_2	L_3	L_4	w_1	w_2	w_3	w
23.8	28	1.0	5.6	19.8	7.2	9.2	2.3	1.7	2.2	2.0

Table 2 Four task example with the PAAC-K model

Task	Passband /GHz	Center frequency /GHz	Insertion loss /dB	Reflection loss /dB	Filter size $L * W$(units/*mm*)
1	$2.6 \sim 2.9$	2.75	>-0.5	<-15	28*23.8
2	$3.0 \sim 3.3$	3.15	>-0.5	<-15	28*23.8
3	$2.3 \sim 2.5$	2.4	>-0.5	<-15	28*23.8
4	$2.0 \sim 2.3$	2.15	>-0.5	<-15	28*23.8
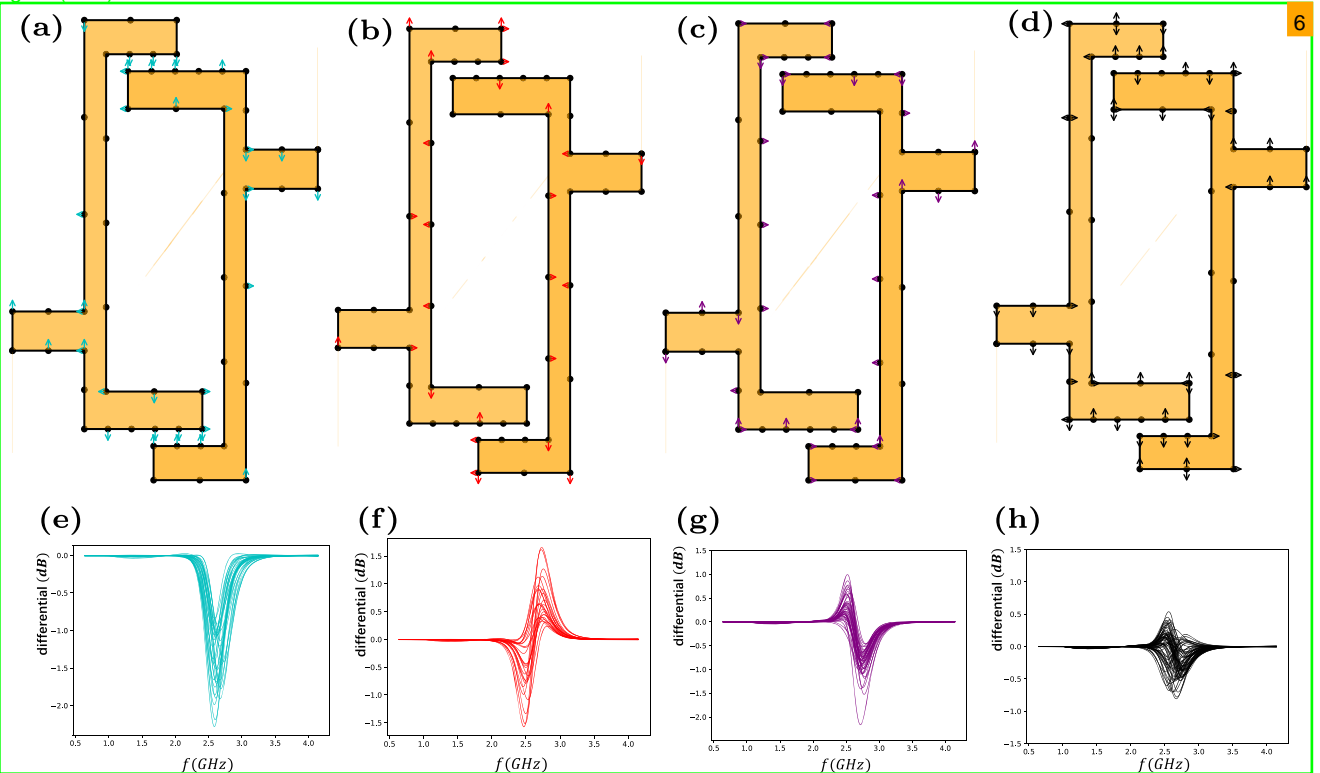
Fig. 8 Clustering results. **a-d,** Visualization of filters of typical action clusters. **e-h,** The differential S_{11} curves (new state curve with actions and the original curve without actions)