

We describe the procedure of the attacks on reduced-round KETJE MAJOR and compute the time complexity.

**6-round attack on instances of 960-bit padding** According to parameters set in Table 1, guess the 3 key bits listed, compute cube sums on variables  $v_0, \dots, v_{31}$ , zero cube sums suggest a right key (i.e. 3 guessed key bits in Table 1). It consumes  $2^3 \times 2^{32} = 2^{35}$  computations of 6-round initialization of KETJE MAJOR. According to the property of permutation, it is totally symmetric in  $z$ -axis. Thus we can obtain corresponding parameters set with any rotation of  $i$ -bit ( $0 \leq i < 64$ ) in  $z$ -axis. Therefore, 128 key bits can be recovered by 64 iterations for  $0 \leq i < 64$ , so the time complexity is  $64 \times 2^3 \times 2^{32} = 2^{41}$ .

**Table 1.** Parameters set for attack on 6-round KETJE MAJOR

<b>Ordinary Cube Variables</b>
$A[4][1][2] = A[4][4][2] = v_1, \quad A[4][1][4] = A[4][4][4] = v_2, \quad A[4][1][10] = A[4][4][10] = v_3,$ $A[4][1][11] = A[4][4][11] = v_4, A[3][0][14] = A[3][3][14] = v_5, A[3][0][17] = A[3][3][17] = v_6,$ $A[4][1][19] = A[4][4][19] = v_7, A[4][1][20] = A[4][4][20] = v_8, A[4][1][27] = A[4][4][27] = v_9,$ $A[3][0][28] = A[3][3][28] = v_{10}, A[4][1][28] = A[4][4][28] = v_{11}, A[3][0][33] = A[3][3][33] = v_{12},$ $A[3][0][36] = A[3][3][36] = v_{13}, A[3][0][37] = A[3][3][37] = v_{14}, A[4][1][38] = A[4][4][38] = v_{15},$ $A[3][0][45] = A[3][3][45] = v_{16}, A[4][1][59] = A[4][4][59] = v_{17}, A[4][1][60] = A[4][4][60] = v_{18},$ $A[2][2][18] = A[2][4][18] = v_{19}, A[2][2][19] = A[2][4][19] = v_{20}, A[2][2][51] = A[2][4][51] = v_{21},$ $A[2][2][27] = A[2][4][27] = v_{22}, A[2][2][28] = A[2][4][28] = v_{23}, A[2][2][52] = A[2][4][52] = v_{24},$ $A[2][2][53] = A[2][4][53] = v_{25}, A[2][2][36] = A[2][4][36] = v_{26}, A[2][2][37] = A[2][4][37] = v_{27},$ $A[2][2][39] = A[2][4][39] = v_{28}, A[2][2][55] = A[2][4][55] = v_{29}, A[2][2][60] = A[2][4][60] = v_{30},$ $A[2][2][62] = A[2][4][62] = v_{31}$
<b>Conditionals Cube Variables</b>
$A[3][0][0] = A[3][3][0] = v_0$
<b>Bit Condition</b>
$A[3][3][41] = k_1[42] + A[1][0][42] + A[3][0][41] + A[2][2][42] + A[1][3][42] + 1,$ $A[4][4][7] = A[3][0][7] + A[0][2][6] + A[3][3][7],$ $A[2][4][31] = k_1[31] + A[1][0][31] + A[3][0][30] + A[1][3][31] + A[3][3][30] + 1,$ $A[3][3][8] = A[3][0][8] + A[4][1][8] + A[0][2][7],$ $A[4][4][49] = A[2][1][50] + A[4][1][49] + A[2][2][50] + A[3][3][50] + A[2][4][50],$ $A[2][4][11] = A[2][1][11] + A[3][3][11] + 1,$ $A[2][4][61] = A[2][1][61] + A[2][2][61] + A[3][3][61],$ $A[0][2][38] = k_0[30] + k_1[38] + A[2][1][37] + 1,$ $A[4][4][12] = A[2][1][13] + A[4][1][12] + A[3][3][13] + A[2][4][13]$
<b>Guessed Key Bits</b>
$k_1[42], k_1[31], k_0[30] + k_1[38]$

**7-round attack on instances of 768-bit padding** According to parameters set in Table 2, guess the 16 key bits listed, compute cube sums on variables

$v_0, \dots, v_{63}$ , zero cube sums suggest a right key (i.e. 16 guessed key bits in Table 2). It consumes  $2^{16} \times 2^{64} = 2^{80}$  computations of 7-round initialization of KETJE MAJOR. Similar to the case above, 46 key bits can be recovered by 4 iterations for  $0 \leq i < 4$ , and the remaining 82 key bits can be recovered by exhaustive search. The time complexity is  $4 \times 2^{16} \times 2^{64} + 2^{82} = 2^{83}$ .

**Table 2.** Parameters set for attack on 7-round KETJE MAJOR

<b>Ordinary Cube Variables</b>
$A[3][2][0]=A[3][3][0]=v_1, A[1][0][1]=A[1][3][1]=v_2, A[4][1][4]=A[4][4][4]=v_3,$ $A[3][0][5]=v_4, A[3][2][5]=v_5, A[3][3][5]=v_4+v_5, A[1][0][7]=A[1][3][7]=v_6,$ $A[1][0][9]=A[1][3][9]=v_7, A[3][2][9]=A[3][3][9]=v_8, A[4][1][9]=A[4][4][9]=v_9,$ $A[3][0][10]=v_{10}, A[3][2][10]=v_{11}, A[3][3][10]=v_{10}+v_{11}, A[4][1][10]=A[4][4][10]=v_{12},$ $A[3][2][11]=A[3][3][11]=v_{13}, A[4][1][11]=A[4][4][11]=v_{14}, A[1][0][12]=A[1][3][12]=v_{15},$ $A[3][2][15]=A[3][3][15]=v_{16}, A[1][0][17]=A[1][3][17]=v_{17}, A[1][0][19]=A[1][3][19]=v_{18},$ $A[4][1][20]=A[4][4][20]=v_{19}, A[4][1][26]=A[4][4][26]=v_{20}, A[3][0][27]=A[3][2][27]=v_{21},$ $A[1][0][29]=A[1][3][29]=v_{22}, A[3][2][30]=A[3][3][30]=v_{23}, A[3][2][31]=A[3][3][31]=v_{24},$ $A[1][0][32]=A[1][3][32]=v_{25}, A[1][0][33]=A[1][3][33]=v_{26}, A[4][1][33]=A[4][4][33]=v_{27},$ $A[3][0][38]=A[3][2][38]=v_{28}, A[1][0][39]=A[1][3][39]=v_{29}, A[3][0][41]=A[3][3][41]=v_{30},$ $A[3][0][42]=A[3][2][42]=v_{31}, A[1][0][43]=A[1][3][43]=v_{32}, A[3][0][43]=A[3][3][43]=v_{33},$ $A[3][0][45]=A[3][2][45]=v_{34}, A[3][0][46]=v_{35}, A[3][2][46]=v_{36}, A[3][3][46]=v_{35}+v_{36},$ $A[3][0][47]=A[3][2][47]=v_{37}, A[3][0][48]=A[3][2][48]=v_{38}, A[3][0][49]=v_{39},$ $A[3][2][49]=v_{40}, A[3][3][49]=v_{39}+v_{40}, A[3][2][50]=A[3][3][50]=v_{41},$ $A[3][2][51]=A[3][3][51]=v_{42}, A[3][2][52]=A[3][3][52]=v_{43}, A[4][1][52]=A[4][4][52]=v_{44},$ $A[3][2][53]=A[3][3][53]=v_{45}, A[3][0][56]=v_{46}, A[3][2][56]=v_{47}, A[3][3][56]=v_{46}+v_{47},$ $A[3][2][60]=A[3][3][60]=v_{48}, A[4][1][61]=A[4][4][61]=v_{49}, A[1][0][62]=A[1][3][62]=v_{50},$ $A[3][2][63]=A[3][3][63]=v_{51}, A[2][2][20]=A[2][4][20]=v_{52}, A[2][1][26]=A[2][4][26]=v_{53},$ $A[1][0][4]=A[1][3][4]=v_{54}, A[2][2][33]=A[2][4][33]=v_{55}, A[2][1][35]=v_{56},$ $A[2][2][35]=v_{57}, A[2][4][35]=v_{56}+v_{57}, A[2][1][40]=A[2][2][40]=v_{58},$ $A[2][1][44]=A[2][2][44]=v_{59}, A[2][2][45]=A[2][4][45]=v_{60}, A[2][2][54]=A[2][4][54]=v_{61},$ $A[2][1][23]=A[2][2][23]=v_{62}, A[1][0][2]=A[1][3][2]=v_{63}$
<b>Conditional Cube Variables</b>
$A[1][0][0]=A[1][3][0]=v_0$
<b>Bit Condition</b>
$A[4][4][42]=k_1[41] + A[1][0][41] + A[4][1][42] + A[0][2][42] + A[1][3][41] + 1,$ $A[2][4][48]=k_0[38] + k_1[48] + A[1][0][48] + A[1][3][48] + A[0][2][46],$ $A[4][4][47]=k_1[46] + A[1][0][46] + A[4][1][47] + A[1][3][46] + 1,$ $A[3][3][58]=k_1[59] + A[1][0][59] + A[3][0][58] + A[2][1][59] + A[3][2][58] + A[1][3][59],$ $A[3][3][17]=k_0[8] + A[3][0][17] + A[0][2][16] + A[3][2][17],$ $A[3][3][26]=k_0[17] + A[3][0][26] + A[0][2][25] + A[3][2][26],$ $A[3][3][27]=k_0[18] + A[0][2][26], A[3][3][47]=k_0[38] + A[0][2][46],$ $A[3][3][7]=k_1[8] + A[1][0][8] + A[3][0][7] + A[3][2][7] + A[1][3][8],$ $A[3][3][48]=k_0[39] + A[0][2][47], A[4][4][44]=A[2][1][45] + A[4][1][44] + A[3][3][45],$ $A[3][3][55]=k_0[46] + A[3][0][55] + A[0][2][54] + A[3][2][55],$ $A[4][4][41]=A[2][0][42] + A[2][1][42] + A[4][1][41] + A[3][3][42] + A[2][4][42],$ $A[4][4][46]=k_1[45] + A[1][0][45] + A[4][1][46] + A[0][2][46] + A[1][3][45] + 1,$ $A[2][4][52]=k_1[52] + A[1][0][52] + A[3][0][51] + A[1][3][52],$ $A[0][2][43]=k_0[35] + k_1[43] + A[2][0][42] + A[2][1][42] + A[2][4][42] + 1,$ $A[1][3][61]=k_1[61] + A[1][0][61] + A[3][0][60] + A[2][1][61],$ $A[0][2][44]=k_1[43] + A[2][1][45] + A[3][3][45] + 1$
<b>Guessed Key Bits</b>
$k_1[41], k_0[38] + k_1[48], k_1[46], k_1[59], k_0[8], k_0[17], k_0[18], k_0[38], k_1[8], k_0[39], k_0[46],$ $k_1[45], k_1[52], k_0[35] + k_1[43], k_1[61], k_1[43]$