

## Chess : positions of reciprocal zugzwang with not more than six men

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This document describes a file ZUG3456.PGN which is believed to contain all chess positions with not more than six men which are reciprocal zugzwang (Black to move loses, but White to move cannot win). These can be divided into full-point reciprocal zugzwangs (whoever is to move loses) and half-point reciprocal zugzwangs (Black to move loses, White to move cannot win but can hold the draw).

The file is being distributed as a zipped file ZUG3456.ZIP of size approximately 16MB. When unzipped, this should yield a file ZUG3456.PGN of size approximately 180MB plus the present file ZUG3456README.PDF. The file ZUG3456.PGN should contain 932,789 positions.

### Presentation

The file has been designed for use and display by ChessBase and similar programs. As displayed in a ChessBase List, the White and Black men involved are shown under Players, the depths to win under Tournament, and the result with White to move in a column towards the right (so “½-½” denotes a half-point reciprocal zugzwang and “0-1” a full-point). Thus the first position in the file displays as

Ka6 Pb7 - Kb8                      DTM 9 with BTM, draw WTM                      ½-½

to indicate that the White king is on a6, there is a White pawn on b7, the Black king is on b8, and the depth to mate is 9 moves with Black to move. The first full-point reciprocal zugzwang in the file displays as

Ka7 Pb6 - Kc6 Pb7                      DTM 13 with BTM, 14 WTM                      0-1

to indicate that the depth to mate is 13 moves with Black to move and the depth to mate by Black is 14 moves with White to move, and the corresponding position with colours reversed appears as

Kc3 Pb2 - Ka2 Pb3                      DTM 14 with BTM, 13 WTM                      0-1

later in the file. Each full-point reciprocal zugzwang appears twice in this way unless the White men reflect the Black either on the file (three cases typified by White Kb1, Pa6/c6 against Black Kb8, Pa3/c3) or diametrically (again three cases, this time typified by White Kg1, Pa6/c6 against Black Kb8, Pf3/h3). In these six cases, flipping or turning the board and reversing the colours gives a position which is identical to the original, and so does not appear separately. For a statistical summary, see the Appendix.

The depth to win normally gives the number of White moves needed to force mate (DTM), but in the case of the five-against-one zugzwangs it gives the number of White moves needed to force any of mate, winning capture by White, losing capture by Black, or promotion (DTC). There is no significance in this distinction, which merely reflects the data that were available. Note that while DTM is necessarily positive, DTC may be zero (signifying a position where Black's only available moves are captures and each of his possible captures gives a lost ending with fewer men).

When a position is displayed by ChessBase, a single pass move “1.--” appears in the “moves” window. When an engine offered within ChessBase is used to analyse the position, the presence of this move allows the user to flip between “White to move” and “Black to move” analyses by using the left and right arrow keys.

### Sequencing and orientation

The positions are grouped by material, and are presented in a natural QRBNP sequence. Not every combination is represented, and the actual order is KP-K, KR-KB, KR-KN, KR-KP, KN-KP, KP-KB, KP-KN, KP-KP, KBP-K, KNP-K, KPP-K, KQ-KRB, KQ-KRN, KQ-KRP, and so on.

Pawnless positions are reflected so that the White king is within the triangle a8-a5-d5. If this puts it on the long diagonal, the position is further reflected so that the Black king lies on or above this diagonal; if the Black king also lies on this diagonal, the position is reflected so that the White queen lies on or above it; if the White queen is absent or also lies on it, the position is reflected so that the Black queen lies on or above it; and so on.

For positions with pawns, the squares are assumed to be ordered in sequence a7-b7-c7-...-h7-a6-b6-...-h2, and the position is reflected so that the White pawns are as near as possible to a7. If there are no White pawns, or if the White pawns are disposed symmetrically, the same criterion is applied to the Black pawns; if these too are disposed symmetrically, or if they are non-existent, the White king is placed in the left-hand half of the board.

Within a group of positions with the same material, the locations of the White pawns take first priority, then the locations of the Black pawns, then the White king, and so on. This means that all the positions with the same material and with the pawns in the same locations are grouped together.

### Searching for particular positions or sets of positions

Please note that this section relates to the versions of ChessBase and CQL installed on my own machine in January 2010. There may be more recent versions offering further facilities.

Some searches for particular positions can be done using either ChessBase or CQL, but searching for positions with the men in a particular relationship to each other can be conveniently done only using CQL, and searching for positions with a particular depth to the win can be done only using ChessBase.

Positions with particular material can be picked out in ChessBase by searching on Material and in CQL by using `:piececount`.

Searches for pawnless positions in which one or more men are on particular squares can be performed by CQL using `:flip` (and `:flipcolor` if appropriate). This will pick up the desired position irrespective of the orientation in which it is stored in the file. ChessBase is less flexible, and to find pawnless positions with (say) the White King on e1 it is necessary to put the king on e1, h4, h5, or e8 on the 'Or' board and to use V-Mirror, or to put it on all eight squares e1/h4/h5/e8/d8/a5/a4/d1.

Searches for positions with pawns in which one or more men are on particular squares can be performed by CQL using `:flipvertical` and by ChessBase using V-Mirror. Searches for positions with the key men in a particular relationship to each other (for example, the "trebuchet" position with White Ka5, Pb4 against Black Kc4, Pb5) can be performed by CQL using `:flipvertical` and `:shift`, but there is no convenient ChessBase equivalent.

Full-point zugzwangs can be found using either ChessBase or CQL by looking for positions with result 0-1.

Positions with a particular depth to mate or capture can be selected using ChessBase by specifying "n" under Tournament, bracketing it by spaces so that a search for say 1 does not also pick up 10, 11, 21, etc. There is no equivalent facility in CQL.

### Note regarding legality and retro-analytical effects

The positions have been analysed ignoring legality, possible retro-analytical effects, and castling. Specifically,

- each position is presented as an object in its own right, no account being taken of whether it could have been produced by a sequence of legal moves from the normal initial array;
- no account is taken of the possibility that the side to move may have the option of an "en passant" capture;
- it is assumed that neither side can still castle, even if its king and one or both of its rooks are in their normal game array positions.

Additionally, no account is taken of the "fifty-move rule"; any eventual mate is treated as a win, even if more than fifty moves between successive captures or pawn moves necessarily occur on the way to it.

### Sourcing and validation

My immediate source was a set of spreadsheets prepared by Guy Haworth and made available on the ICGA web site. These in turn, with the exception of that relating to five-against-one positions, were prepared from data extracted from the Nalimov depth-to-mate tablebases on Eiko Bleicher's web site [www.k4it.de](http://www.k4it.de) by programs written by Marc Bourzutschky and Eiko himself. The five-against-one spreadsheet was prepared from a depth-to-capture tablebase calculated by Marc. The spreadsheets include some "en passant" zugzwangs, where the player to move is assumed to have the option of a capture en passant, but these are not included in the present file.

The statistics for zugzwangs with up to five men were checked against the well-established figures presented in a note by Guy and others in the December 2001 issue of the *ICGA Journal* (pages 225-230), and appear to agree exactly. The statistics for zugzwangs with six men were checked against a further spreadsheet made available by Guy on the ICGA web site, and they appear to agree exactly except in some cases where both sides have pawns. Here, Guy's statistics include the "en passant" zugzwangs which I have excluded, and direct comparison is impossible. However, a paper "6-man Chess and Zugzwangs" by Eiko Bleicher and Guy, presented to a subsequent ICGA conference, included a table which enabled his statistics to be adjusted to exclude these, and if these adjustments are made our results again appear to agree exactly.

Additionally, spot checks were made to verify that some expected zugzwangs did indeed appear in the file, and it was confirmed that the zugzwangs in a small random sample from the file did indeed have the properties claimed for them.

Nearly all this work, including the verification of sample positions, depended on the validity of the Nalimov tablebases on Eiko Bleicher's web site. Some of these (for positions with up to five men, and for most pawnless positions with six men) repeated ground already covered by others, and various key parameters were verified against what was already known from other sources before they were posted. No previous data were available for six-man positions with pawns and for a time the Nalimov tablebases stood alone, but I am not aware of any respect in which they have been challenged and I think their validity is generally accepted.

### **Acknowledgements**

My contribution to this exercise has been entirely cosmetic, and my immediate acknowledgements are to Guy Haworth for his spreadsheets. Guy in turn makes extensive acknowledgements, citing initials which I read as referring to Eiko Bleicher, Marc Bourzutschky, Peter Karrer, Eugene Nalimov, John Tamplin, Ken Thompson, and Christoph Wirth, and I am sure that tracing back down the literature would identify further workers whose contributions, though now duplicated or overtaken, were significant advances at the time.

**Appendix : statistical summary**

The figures that follow have been pasted in from a log file produced by the program which generated the PGN file.

Numbers of two-against-one half-point reciprocal zugzwangs

K	
KP	80
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Total	80

Numbers of two-against-two half-point reciprocal zugzwangs (White men down, Black men across)

	KQ	KR	KB	KN	KP	Total
KQ	0	0	0	0	0	0
KR	0	0	5	18	12	35
KB	0	0	0	0	0	0
KN	0	0	0	0	22	22
KP	0	0	1	7	106	114
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Total	0	0	6	25	140	171

Numbers of two-against-two full-point reciprocal zugzwangs

	KQ	KR	KB	KN	KP	Total
KQ	0	0	0	0	0	0
KR		0	0	0	0	0
KB			0	0	0	0
KN				0	0	0
KP					15	15
-----						
Total	0	0	0	0	15	15

Numbers of three-against-one half-point reciprocal zugzwangs

K	
KBP	6
KNP	75
KPP	43
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Total	124

Numbers of three-against-two half-point and full-point reciprocal zugzwangs (White men down, Black men across)

	KQ	KR	KB	KN	KP	Total		KQ	KR	KB	KN	KP	Total
KQQ	0	0	0	0	0	0	KQQ	0	0	0	0	0	0
KQR	1	0	0	0	0	1	KQR	0	0	0	0	0	0
KQB	25	0	0	0	0	25	KQB	0	0	0	0	0	0
KQN	38	0	0	0	0	38	KQN	0	0	0	0	0	0
KQP	640	1	0	0	0	641	KQP	0	0	0	0	0	0
KRR	10	0	1	0	0	11	KRR	0	0	0	0	0	0
KRB	0	17	0	0	1	18	KRB	0	0	0	0	0	0
KRN	0	10	0	3	0	13	KRN	0	0	0	0	0	0
KRP	2	209	225	413	0	849	KRP	0	0	0	0	1	1
KBB	0	3	0	1	1	5	KBB	0	0	0	0	0	0
KBN	0	6	45	922	61	1034	KBN	0	0	0	0	0	0
KBP	0	4	160	2112	403	2679	KBP	0	0	0	0	1	1
KNN	0	0	0	362	3124	3486	KNN	0	0	0	0	0	0
KNP	0	23	640	4128	2281	7072	KNP	0	0	0	0	8	8
KPP	0	18	211	920	4179	5328	KPP	0	2	0	0	6	8
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Total	716	291	1282	8861	10050	21200	Total	0	2	0	0	16	18

Numbers of two-against-three half-point reciprocal zugzwangs (White men down, Black men across)

	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQ	0	0	0	0	0	0	372	455	241	1	1	16	229	52	2	1369
KR	0	0	0	0	0	0	0	0	0	0	2	302	25	1158	99	1586
KB	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3
KN	0	0	0	0	0	0	0	0	0	0	0	13	0	63	157	233
KP	0	0	0	0	0	0	0	0	2	0	1	2	19	14	52	90
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Total	0	0	0	0	0	0	372	455	243	1	4	333	273	1289	311	3281

Numbers of four-against-one half-point reciprocal zugzwangs

K	
KBPP	6
KNPP	93
KPPP	11
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Total	110

- Chess : positions of reciprocal zugzwang with not more than six men -

Numbers of three-against-three half-point reciprocal zugzwangs (White men down, Black men across)

	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQQ	8	15	2	3	4	0	0	0	0	0	0	0	0	0	0	32
KQR	0	236	1359	1722	1019	5	1	3	0	1	0	0	0	0	0	4346
KQB	0	6	21	76	1450	161	16	15	16	0	0	0	0	1	0	1762
KQN	0	3	34	149	2540	905	91	123	187	3	1	10	1	9	0	4056
KQP	0	11	313	1516	6652	1223	8489	10553	953	12	42	95	946	202	9	31016
KRR	0	0	15	26	316	4	499	697	105	15	57	73	41	16	0	1864
KRB	0	0	0	9	37	2	11	96	1059	376	1456	183	218	613	26	4086
KRN	0	0	0	0	22	0	7	69	669	801	7933	2113	8997	3316	171	24098
KRP	0	0	5	4	58	0	248	650	3794	1667	10807	12782	18954	20862	433	70264
KBB	0	0	0	0	0	2	2	5	171	0	16	79	817	1507	72	2671
KBN	0	0	0	0	0	0	2	7	251	0	16	1850	402	30304	1562	34394
KBP	0	0	0	0	8	6	11	50	79	36	317	2010	1368	16949	12232	33066
KNN	0	0	0	0	0	0	0	6	291	0	1	1562	32	12426	26532	40850
KNP	0	0	0	0	0	0	2	8	85	20	235	4819	739	28988	80091	114987
KPP	0	0	0	0	1	0	5	33	161	5	69	581	296	2482	32125	35758
Total	8	271	1749	3505	12107	2308	9384	12315	7821	2936	20950	26157	32811	117675	153253	403250

Numbers of three-against-three full-point reciprocal zugzwangs

	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KQR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KQB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KQN	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2
KQP	0	0	0	0	2	0	1	0	3	0	0	0	0	0	0	6
KRR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KRB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KRN	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
KRP	0	0	0	0	0	0	0	0	0	0	0	3	0	1	26	30
KBB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KBN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KBP	0	0	0	0	0	0	0	0	0	0	0	0	0	18	222	240
KNN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KNP	0	0	0	0	0	0	0	0	0	0	0	0	0	1	144	145
KPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2274	2274
Total	0	0	0	0	3	0	1	0	4	0	0	3	0	21	2668	2700

Numbers of four-against-two half-point and full-point reciprocal zugzwangs (White men down, Black men across)

	KQ	KR	KB	KN	KP	Total		KQ	KR	KB	KN	KP	Total
KQQQ	0	0	0	0	0	0	KQQQ	0	0	0	0	0	0
KQQR	0	0	0	0	0	0	KQQR	0	0	0	0	0	0
KQQB	0	0	0	0	0	0	KQQB	0	0	0	0	0	0
KQQN	0	0	0	0	0	0	KQQN	0	0	0	0	0	0
KQQP	0	0	0	0	0	0	KQQP	0	0	0	0	0	0
KQRR	0	0	0	0	0	0	KQRR	0	0	0	0	0	0
KQRB	2	0	0	0	0	2	KQRB	0	0	0	0	0	0
KQRN	2	0	0	0	0	2	KQRN	0	0	0	0	0	0
KQRP	31	0	0	0	0	31	KQRP	0	0	0	0	0	0
KQBB	67	0	0	0	0	67	KQBB	0	0	0	0	0	0
KQBN	283	0	0	0	0	283	KQBN	0	0	0	0	0	0
KQBP	3265	6	1	0	1	3273	KQBP	0	0	0	0	0	0
KQNN	1082	0	0	0	0	1082	KQNN	0	0	0	0	0	0
KQNP	9479	30	10	0	0	9519	KQNP	8	0	0	2	0	10
KQPP	7791	3	7	0	1	7802	KQPP	4	0	0	0	0	4
KRRR	1	0	0	0	0	1	KRRR	0	0	0	0	0	0
KRRB	191	0	0	0	0	191	KRRB	0	0	0	0	0	0
KRRN	739	0	0	0	0	739	KRRN	0	0	0	0	0	0
KRRP	3446	0	5	0	0	3451	KRRP	0	0	0	0	0	0
KRBB	222	10	0	0	3	235	KRBB	0	0	0	0	0	0
KRBN	983	87	2	0	3	1075	KRBN	0	0	0	0	0	0
KRBP	1827	1396	27	16	5	3271	KRBP	1	0	2	1	2	6
KRNN	198	84	6	0	5	293	KRNN	0	0	0	0	0	0
KRNP	5826	3933	212	24	1	9996	KRNP	2	0	0	10	0	12
KRPP	499	3344	74	128	5	4050	KRPP	1	2	0	2	0	5
KBBB	4	8	0	0	0	12	KBBB	0	0	0	0	0	0
KBBN	17	337	23	29	2	408	KBBN	0	0	0	0	0	0
KBBP	74	3138	231	4200	19	7662	KBBP	4	0	0	0	0	4
KBNN	7	628	124	91	58	908	KBNN	0	0	0	0	0	0
KBNP	315	21423	3731	10129	19	35617	KBNP	0	0	2	2	0	4
KBPP	63	4347	4242	17734	222	26608	KBPP	5	2	2	0	2	11
KNNN	1	82	1009	2115	173	3380	KNNN	0	0	0	0	0	0
KNNP	48	2807	14565	94991	511	112922	KNNP	0	0	0	4	0	4
KNPP	114	6317	27373	82148	1126	117078	KNPP	3	2	0	25	2	32
KPPP	10	744	7070	20995	3127	31946	KPPP	4	26	0	2	9	41
Total	36587	48724	58712	232600	5281	381904	Total	32	32	6	48	15	133

- Chess : positions of reciprocal zugzwang with not more than six men -

Numbers of two-against-four half-point reciprocal zugzwangs (White men across, Black men down)

	KQ	KR	KB	KN	KP	Total
KQQQ	0	0	0	0	0	0
KQQR	0	0	0	0	0	0
KQQB	0	0	0	0	0	0
KQQN	0	0	0	0	0	0
KQQP	0	0	0	0	0	0
KQRR	0	0	0	0	0	0
KQRB	0	0	0	0	0	0
KQRN	0	0	0	0	0	0
KQRP	0	0	0	0	0	0
KQBB	0	0	0	0	0	0
KQBN	0	0	0	0	0	0
KQBP	6	0	0	0	0	6
KQNN	0	0	0	0	0	0
KQNP	2	0	0	0	0	2
KQPP	12	0	0	0	1	13
KRRR	0	0	0	0	0	0
KRRB	0	0	0	0	0	0
KRRN	1	0	0	0	0	1
KRRP	68	0	0	0	0	68
KRBB	22	0	0	0	0	22
KRBN	411	0	0	0	0	411
KRBP	14253	0	0	0	1	14254
KRNN	730	0	0	0	0	730
KRNP	22448	1	0	0	1	22450
KRPP	5519	13	0	2	1	5535
KBBB	463	0	0	0	0	463
KBBN	3290	0	0	0	8	3298
KBBP	5092	46	0	2	3	5143
KBNN	3779	0	0	0	17	3796
KBNP	15755	78	1	0	96	15930
KBPP	932	930	3	71	8	1944
KNNN	2886	1	0	0	6	2893
KNNP	31143	174	15	0	209	31541
KNPP	2849	2829	46	299	33	6056
KPPP	129	1211	14	653	87	2094
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Total	109790	5283	79	1027	471	116650

Numbers of five-against-one half-point reciprocal zugzwangs

	K
KQNPP	58
KRNPP	58
KRPPP	2
KBNPP	58
KBPPP	11
KNPPP	89
KPPPP	17
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Total	293

Total number of reciprocal zugzwangs: 929929 (927063 half-point, 2866 full-point)

Number of full-point reciprocal zugzwangs reflected into themselves on the file: 3

Number of full-point reciprocal zugzwangs reflected into themselves diametrically: 3

Number of positions written to output file: 932789

Full-point zugzwangs reflected neither on the file nor diametrically have been written twice