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## HARMONIC INTERCHANGE NOTATION

### Objective

In order to produce an open source chord dictionary that is easily readable by both humans and machines, a number of notation systems need to be codified/formalized.

### Limitations

MIDI integers are a widely-used method of specifying notes, but a MIDI integer can not distinguish between enharmonic notes such as an F# and Gb, or B and Cb. Musical notation is a preferred way to convey harmonic principles, but there is no standard format for exchanging this visual information in software. A symbolic notation is needed that is richer than MIDI, but easily understood by musicians and parse-able by a broad array of existing software tools and programming languages.

### Solution

This document outlines a set of notation standards. Some of these standards exist already, like MIDI integers or Pitch Class notation. Others are ad hoc standards that I have codified. Commas and spaces are not used in harmonic interchange symbols as these characters are often used by software as list delineators.

In addition, I have developed a set of tools to process and convert these symbols using Max. Each notation system is followed with a list of table and abstractions that are used to convert and translate the symbols.

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# PITCH CLASS INTEGER NOTATION (PC)

## Description

Pitch Class is the translation of pitch chroma into whole numbers. Integer Notation is a modulo 12 (mod 12) representation of an octave-reduced chromatic scale.

Description	Pitch Class
C	0
C#/Db	1
D	2
D#/Eb	3
E	4
F	5
F#/Gb	6
G	7
G#/Ab	8
A	9
A#/Bb	10
B	11

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## MIDI INTEGER (MI)

### Description

MIDI note number integers are derived from the MIDI note channel voice message.

Oct	Notes											
	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
<b>-2</b>	0	1	2	3	4	5	6	7	8	9	10	11
<b>-1</b>	12	13	14	15	16	17	18	19	20	21	22	23
<b>0</b>	24	25	26	27	28	29	30	31	32	33	34	35
<b>1</b>	36	37	38	39	40	41	42	43	44	45	46	47
<b>2</b>	48	49	50	51	52	53	54	55	56	57	58	59
<b>3</b>	60	61	62	63	64	65	66	67	68	69	70	71
<b>4</b>	72	73	74	75	76	77	78	79	80	81	82	83
<b>5</b>	84	85	86	87	88	89	90	91	92	93	94	95
<b>6</b>	96	97	98	99	100	101	102	103	104	105	106	107
<b>7</b>	108	109	110	111	112	113	114	115	116	117	118	119
<b>8</b>	120	121	122	123	124	125	126	127				

Tool	Name	Description
bp.atom	absolute notation to midi	abstraction to convert AN to MIDI
bp.mtoa	midi integer to absolute notation	abstraction to convert MI+key to AN
bp.mtor	midi integer to relative notation	abstraction to convert MI+key to RN

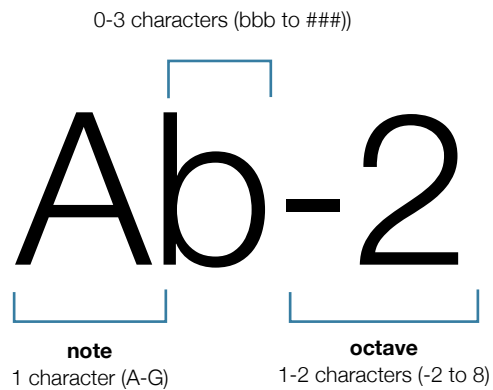
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# ABSOLUTE NOTATION (AN)

## Construction

Absolute Notation (AN) uses alphanumeric characters to name a note precisely, including enharmonic equivalents. Absolute Notation has three components with no spaces: a note name (A-G), an optional accidental (###, ##, #, b, bb, bbb) and an octave number (-2 to 8). The octave number mirrors the MIDI integer octave standard.



Absolute Notation	MIDI integer
C4	72
Cb-1	11
F4	77
C##2	50
Dbb3	60

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Tool	Name	Description
bp.atom	absolute notation to midi	abstraction to convert AN to MIDI
bp.mtoa	midi to absolute notation	abstraction to convert MIDI+key to AN
bp.rtoa	relative to absolute notation	abstraction to convert RN+key to AN

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# RELATIVE NOTATION (RN)

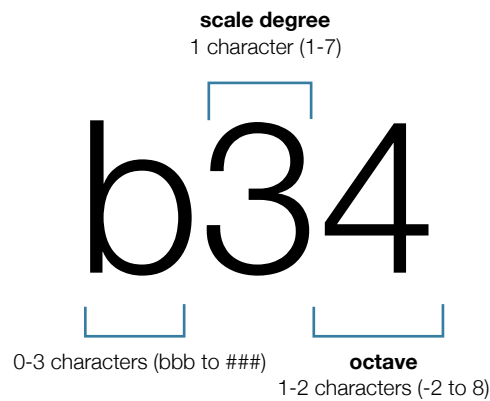
## Description

Relative Notation is used to describe intervallic relationships independent of key. When building a chord dictionary, you don't want to have to spell a C major chord, then a D major chord, and so on. You want to describe a major chord and be able to apply that chord to any root note.

Relative Notation plus a key is interchangeable with Absolute Notation without loss. Relative Notation plus a key can be resolved to a MIDI integer, however translating a MIDI integer to Relative Notation produces some ambiguity.

## Construction

Relative Notation has three components, an optional accidental (###, ##, #, b, bb, bbb), a scale degree number (integer 1-7) and an octave number (-2 to 8). The octave number mirrors the MIDI integer octave standard.



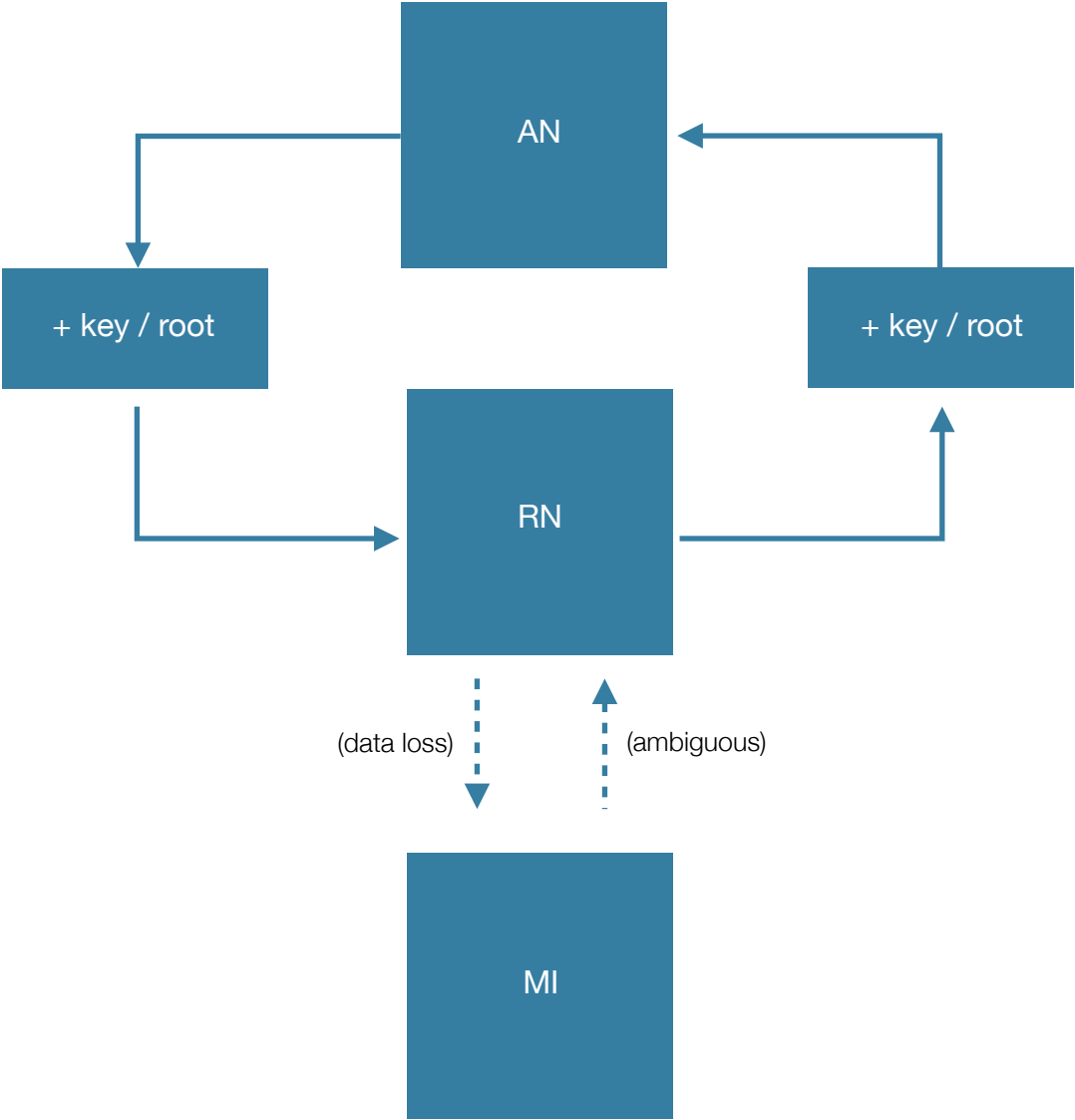
Relative Notation	Description	MIDI integer relative to C
b23	flat second degree, octave 3	61
14	first scale degree, octave 4	72
#5-2	sharp five scale degree, octave -2	8

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Tool	Name	Description
bp.mtor	midi to relative notation	abstraction to convert MIDI+key to RN
bp.unpack.rn	unpack relative notation	abstraction to separate RN into a list of three elements containing accidental, degree and oct
bp.rtoa	relative to absolute notation	abstraction to convert RN+key to AN

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# CHORD TYPE (CT)

## Description

Chord type is the standardized name given to a common chord. A chord type defines the components of a chord, but not the root note. A chord type is joined with an absolute or relative notation symbol to specify a root.

The standardized CT name is the key of the chord type dictionary.

## Construction

A chord type contains no spaces or commas. Traditionally, a C major triad can be identified by the chord symbol C. However, this is ambiguous when divorced from the root note. All chords must have a defined type, so major triads are always defined as maj.

Below is a chart of the standardized spelling of common chord types.

Triads	Add	Sevenths	Dominant
maj	sus2	maj7	dom7
min	sus4	minmaj7	dom7sus4
aug	maj6	min7	dom9
dim	min6	min7b5	dom13
		aug7	dom7b5
		dim7	dom7(#11)
		min9	dom7(#9)
		min11	dom7#5
			dom7(b5b13)
			dom7b5(b9)
			dom7b5(#9)
			dom7#5(b9)
			dom7#5(#9)

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Tool	Name	Description
bp.chord.dictionary.json	chord dictionary	json file that describes all chord types in RN and provides multiple voicing options

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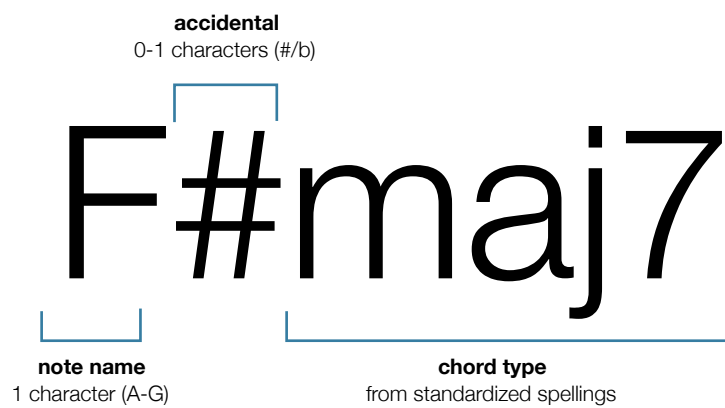
# ABSOLUTE CHORD SYMBOL (ACS)

## Construction

An Absolute Chord Symbol is a combination of Absolute Notation (AN) (sans oct) and Chord Type (CT)

## Examples

Fmaj7  
Abmin7  
D#dom7



Tool	Name	Description
bp.tttoacs.txt	twelve tone ID to absolute chord symbol	table to convert TT to ACS
bp.rcstoacs	relative chord symbol to absolute chord symbol	abstraction to convert RCS+key to ACS

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# ROMAN NUMERAL ANALYSIS (RNA)

## Construction

When referring to scale degrees, we use Relative Notation (RN) Roman Numeral Analysis (RNA) is used to refer to the root of a chord built on a scale degree. RNA uses the characters (**I** **v** **b** **#**)

All RNA symbols, major or minor, use upper case because the lower case i makes complete chord symbol parsing in perl problematic.

Major	Natural Minor	Harmonic Minor	Melodic Minor
I	I	I	I
II	II	II	II
III	bIII	bIII	bIII
IV	iv	iv	IV
V	V	V	V
VI	bVI	bVI	VI
VII	bVII	VII	VII

Tool	Name	Description
bp.rnatoa.txt	roman numeral analysis to absolute notation	table to convert RNA to AN

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# RELATIVE CHORD SYMBOL (RCS)

## Construction

A Relative Chord Symbol (RCS) is a combination of Roman Numeral Analysis (RNA) and Chord Type (CT). There are no spaces between the RNA and CT.

## Examples

Imaj7  
IImin7  
Vdom7



Tool	Name	Description
bp.rcstoacs	relative chord symbol to absolute chord symbol	abstraction to convert RCS+key to ACS
bp.unpack.rcs	unpack relative chord symbol	abstraction to separate a RCS into a list containing RNA and CT
bp.tttorcs.txt	tt to relative chord symbol	table to convert TT to RCS

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## TWELVE TONE CLUSTER ID (TT)

### Construction

A twelve tone cluster ID is a 12-bit number that represents every possible combination of the chromatic scale, starting with C as the most significant bit.

The 12-tone cluster ID has three manifestations that are all interchangeable without loss.

- A binary representation of the on or off state representing one octave of the chromatic scale starting at C
- A list of the present pitches of the cluster as a list
- An integer representation of the 12-bit list – this is the most common or compact version of the twelve tone cluster ID.

Some chords, especially sus4/sus2 and diminished chords built on differing root notes can sometimes share the same TT ID due to the collapsed of the enharmonic equivalents, so resolving a TT ID into a chord name is sometimes ambiguous.

Often complex chords will be voiced to omit the 5th degree so sometimes the same chord type name can have two TT IDs.

Likewise, relative modal scales will share the same TT ID.

Of the 4096 combinations, there are huge swaths of open, unnamed space because the combinations are not commonly used as a scale or a chord.

Description	12-bit	Pitch Class List	TT
Cmaj	100010010000	0 4 7	145
Dmin	001001000100	2 5 9	548
C ionian scale	101011010101	0 2 4 5 7 9 11	2741
D dorian scale	101011010101	0 2 4 5 7 9 11	2741

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Tool	Name	Description
bp.mtott	midi to twelve tone ID	abstraction to convert held midi notes (pitch and velocity) to TT
bp.ttorcs.txt	twelve tone ID to relative chord symbol	table to convert TT to RCS
bp.tttoacs.txt	twelve tone ID ot absolute chord symbol	table to convert TT to ACS
bp.cttott.txt	chord type and key to twelve tone ID	table to convert CT to TT
bp.tttopc	twelve tone ID to pitch class	abstraction to convert TT to PC

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## APPENDIX: TT ID OF COMMON CHORDS IN ALL KEYS

	C	C#/Db	D	D#/Eb	E	F	F#/Gb	G	G#/Ab	A	A#/Bb	B
maj	145	290	580	1160	2320	545	1090	2180	265	530	1060	2120
min	137	274	548	1096	2192	289	578	1156	2312	529	1058	2116
aug	273	546	1092	2184	273	546	1092	2184	273	546	1092	2184
dim	73	146	292	584	1168	2336	577	1154	2308	521	1042	2084
sus2	133	266	532	1064	2128	161	322	644	1288	2576	1057	2114
sus4	161	322	644	1288	2576	1057	2114	133	266	532	1064	2128
maj6	657	1314	2628	1161	2322	549	1098	2196	297	594	1188	2376
min6	649	1298	2596	1097	2194	293	586	1172	2344	593	1186	2372
maj7	2193	291	582	1164	2328	561	1122	2244	393	786	1572	3144
minmaj7	2185	275	550	1100	2200	305	610	1220	2440	785	1570	3140
min7	1161	2322	549	1098	2196	297	594	1188	2376	657	1314	2628
min7b5	1097	2194	293	586	1172	2344	593	1186	2372	649	1298	2596
aug7	2321	547	1094	2188	281	562	1124	2248	401	802	1604	3208
dim7	585	1170	2340	585	1170	2340	585	1170	2340	585	1170	2340
min9	1037	2074	53	106	212	424	848	1696	3392	2689	1283	2566
min11	1065	2130	165	330	660	1320	2640	1185	2370	645	1290	2580
dom7	1169	2338	581	1162	2324	553	1106	2212	329	658	1316	2632
dom7sus4	1185	2370	645	1290	2580	1065	2130	165	330	660	1320	2640
dom9	1173	2346	597	1194	2388	681	1362	2724	1353	2706	1317	2634
dom13	1685	3370	2645	1195	2390	685	1370	2740	1385	2770	1445	2890
dom7b5	1105	2210	325	650	1300	2600	1105	2210	325	650	1300	2600
dom7(#11)	1105	2210	325	650	1300	2600	1105	2210	325	650	1300	2600
dom7(#9)	1177	2354	613	1226	2452	809	1618	3236	2377	659	1318	2636
dom7#5	1297	2594	1093	2186	277	554	1108	2216	337	674	1348	2696
dom7(b5b13)	1361	2722	1349	2698	1301	2602	1109	2218	341	682	1364	2728
dom7b5(b9)	1171	2342	589	1178	2356	617	1234	2468	841	1682	3364	2633
dom7b5(#9)	1177	2354	613	1226	2452	809	1618	3236	2377	659	1318	2636
dom7#5(b9)	1299	2598	1101	2202	309	618	1236	2472	849	1698	3396	2697
dom7#5(#9)	1305	2610	1125	2250	405	810	1620	3240	2385	675	1350	2700



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## APPENDIX: SCALE DEGREES IN ALL KEYS

	C	C#	Db	D	D#	Eb	E	F	F#	Gb	G	G#	Ab	A	A#	Bb	B
1	C	C#	Db	D	D#	Eb	E	F	F#	Gb	G	G#	Ab	A	A#	Bb	B
2	D	D#	Eb	E	E#	F	F#	G	G#	Ab	A	A#	Bb	B	B#	C	C#
3	E	E#	F	F#	F##	G	G#	A	A#	Bb	B	B#	C	C#	C##	D	D#
4	F	F#	G	G	G#	Ab	A	Bb	B	Cb	C	C#	D	D	D#	Eb	E
5	G	G#	Ab	A	A#	Bb	B	C	C#	Db	D	D#	Eb	E	E#	F	F#
6	A	A#	Bb	B	B#	C	C#	D	D#	Eb	E	E#	F	F#	F##	G	G#
7	B	B#	C	C#	C##	D	D#	E	E#	F	F#	F##	G	G#	G##	A	A#

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## APPENDIX: ACCIDENTAL LADDER

	C	C#	Db	D	D#	Eb	E	F	F#	Gb	G	G#	Ab	A	A#	Bb	B
<b>bb</b>	Cbb	Cb	Dbbb	Dbb	Db	Ebbb	Ebb	Fbb	Fb	Gbbb	Gbb	Gb	Abbb	Abb	Ab	Bbbb	Bbb
<b>b</b>	Cb	C	Dbb	Db	D	Ebb	Eb	Fb	F	Gbb	Gb	G	Abb	Ab	A	Bbb	Bb
	C	C#	Db	D	D#	Eb	E	F	F#	Gb	G	G#	Ab	A	A#	Bb	B
<b>#</b>	C#	C##	D	D#	D##	E	E#	F#	F##	G	G#	G##	A	A#	A##	B	B#
<b>##</b>	C##	C###	D#	D##	D###	E#	E##	F##	F###	G#	G##	G###	A#	A##	A###	B#	B##

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## APPENDIX: ONE OCTAVE OF AN / RN IN KEY OF C

RN	AN	accidental	scale degree	octave
bb14	Cbb4	bb	1	4
bb24	Dbb4	bb	2	4
bb34	Ebb4	bb	3	4
bb44	Fbb4	bb	4	4
bb54	Gbb4	bb	5	4
bb64	Abb4	bb	6	4
bb74	Bbb4	bb	7	4
b14	Cb4	b	1	4
b24	D4	b	2	4
b34	E4	b	3	4
b44	F4	b	4	4
b54	G4	b	5	4
b64	A4	b	6	4
b74	B4	b	7	4
14	C4		1	4
24	D4		2	4
34	E4		3	4
44	F4		4	4
54	G4		5	4
64	A4		6	4
74	B4		7	4
#14	C#4	#	1	4
#24	D#4	#	2	4
#34	E#4	#	3	4
#44	F#4	#	4	4
#54	G#4	#	5	4
#64	A#4	#	6	4
#74	B#4	#	7	4
##14	C###4	##	1	4
##24	D###4	##	2	4
##34	E###4	##	3	4
##44	F###4	##	4	4
##54	G###4	##	5	4
##64	A###4	##	6	4
##74	B###4	##	7	4

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