STANFORD

Supplemental Lecture 11B

The 5G-LDPC Code

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JOHN M. CIOFFI

Hitachi Professor Emeritus (recalled) of Engineering

Instructor EE379A – Winter 2026

Agenda

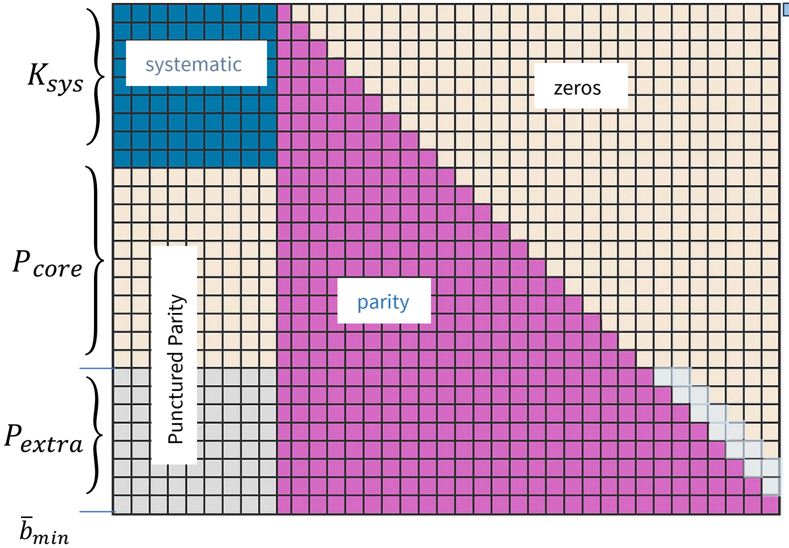
- Topics
  - 5G-LDPC Parity Matrices' Specification
  - Rate Selection and Puncturing
  - Matlab Programs

5G-LDPC Parity Matrices' Specification

Section 8.3.3

5G Code Parity Table

- Not quite a parity matrix, but close



$w_{i,j} \rightarrow \mathcal{J}^{w_{i,j}} \, (\tilde{b} \times \tilde{b})$

liftings

$$w' = \left\lfloor \frac{\tilde{b}}{384} \cdot w \right\rfloor$$

Triangular (almost)

index	$\tilde{b}.$
0	{2,4,8,16,32,64,128,256}
1	{3,6,12,24,48,96,192,384
2	{5,10,20,40,80,160,320}
3	{7,14,28,56,112,224}
4	{9,18,36,72,144,288}
5	{11,22,44,88,176,352}
6	{13,26,52,104,208}
7	{15,30,60,120,240}

- Base Matrix 1 (BM1) corresponds to $22\tilde{b}$ input bits and $68\tilde{b}$,
  - arranged as 22 + 24 + 22.
- Base Matrix 2 (BM2) corresponds to $10\tilde{b}$ input bits and $52\tilde{b}$,
  - arranged as 10 + 32 + 10.

Pick an index and group element
And a BM (1 or 2)

Example

EXAMPLE 8.3.6 **Finding scaling indices** Figure 8.36 's 6 boxes in have values

$$W_{sub} = \begin{bmatrix} 0 & 188 & -1 \\ 175 & 95 & 83 \end{bmatrix} \quad (8.163)$$

for $\tilde{b} = 8$ from index set 0. These become

w	$\frac{8}{384} \cdot w$	w'
0	0	0
188	3.92	3
-1	0	no pass
175	3.64	3
95	1.98	1
83	1.73	1

The H_{sub} corresponding entries would be

$$\begin{bmatrix} I_8 & \mathcal{J}_8^3 & \mathbf{0} \\ \mathcal{J}_8^3 & \mathcal{J}_8 & \mathcal{J}_8 \end{bmatrix} \quad (8.164)$$

- The -1 specifies all zeros.

BM1

$\mathbf{H}_{BG}$ Row index i	Column index j	$V_{i,j}$ Set index i_{LS} = 0	1	2	3	4	5	6	7
0	0	250	307	73	223	211	294	0	135
	1	69	19	15	16	198	118	0	227
	2	226	50	103	94	188	167	0	126
	3	159	369	49	91	186	330	0	134
	5	100	181	240	74	219	207	0	84
	6	10	216	39	10	4	165	0	83
	9	59	317	15	0	29	243	0	53
	10	229	288	162	205	144	250	0	225
	11	110	109	215	216	116	1	0	205
	12	191	17	164	21	216	339	0	128
	13	9	357	133	215	115	201	0	75
	15	195	215	298	14	233	53	0	135
	16	23	106	110	70	144	347	0	217
	18	190	242	113	141	95	304	0	220
	19	35	180	16	198	216	167	0	90
	20	239	330	189	104	73	47	0	105
	21	31	346	32	81	261	188	0	137
	22	1	1	1	1	1	1	0	1
	23	0	0	0	0	0	0	0	0
1	0	2	76	303	141	179	77	22	96
	2	239	76	294	45	162	225	11	236
	3	117	73	27	151	223	96	124	136
	4	124	288	261	46	256	338	0	221
	5	71	144	161	119	160	268	10	128
	7	222	331	133	157	76	112	0	92
	8	104	331	4	133	202	302	0	172
	9	173	178	80	87	117	50	2	56
	11	220	295	129	206	109	167	16	11
	12	102	342	300	93	15	253	60	189
	14	109	217	76	79	72	334	0	95
	15	132	99	266	9	152	242	6	85
	16	142	354	72	118	158	257	30	153
	17	155	114	83	194	147	133	0	87
	19	255	331	260	31	156	9	168	163
	21	28	112	301	187	119	302	31	216
	22	0	0	0	0	0	0	105	0
	23	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
2	0	106	205	68	207	258	226	132	189
	1	111	250	7	203	167	35	37	4
	2	185	328	80	31	220	213	21	225
	4	63	332	280	176	133	302	180	151
	5	117	256	38	180	243	111	4	236
	6	93	161	227	186	202	265	149	117
	7	229	267	202	95	218	128	48	179
	8	177	160	200	153	63	237	38	92
	9	95	63	71	177	0	294	122	24
	10	39	129	106	70	3	127	195	68
	13	142	200	295	77	74	110	155	6
	14	225	88	283	214	229	286	28	101
	15	225	53	301	77	0	125	85	33
	17	245	131	184	198	216	131	47	96
	18	205	240	246	117	269	163	179	125
	19	251	205	230	223	200	210	42	67
	20	117	13	276	90	234	7	66	230
	24	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
3	0	121	276	220	201	187	97	4	128
	1	89	87	208	18	145	94	6	23
	3	84	0	30	165	166	49	33	162
	4	20	275	197	5	108	279	113	220
	6	150	199	61	45	82	139	49	43
	7	131	153	175	142	132	166	21	186
	8	243	56	79	16	197	91	6	96
	10	136	132	281	34	41	106	151	1
	11	86	305	303	155	162	246	83	216
	12	246	231	253	213	57	345	154	22
	13	219	341	164	147	36	269	87	24
	14	211	212	53	69	115	185	5	167
	16	240	304	44	96	242	249	92	200
	17	76	300	28	74	165	215	173	32
	18	244	271	77	99	0	143	120	235
	20	144	39	319	30	113	121	2	172
	21	12	357	68	158	108	121	142	219
	22	1	1	1	1	1	1	0	1
	25	0	0	0	0	0	0	0	0
4	0	157	332	233	170	246	42	24	64
	1	102	181	205	10	235	256	204	211
	26	0	0	0	0	0	0	0	0
5	0	205	195	83	164	261	219	185	2
	1	236	14	292	59	181	130	100	171
	3	194	115	50	86	72	251	24	47
	12	231	166	318	80	283	322	65	143
	16	28	241	201	182	254	295	207	210

$\mathbf{H}_{BG}$ Row index i	Column index j	$V_{i,j}$ Set index i_{LS} = 0	1	2	3	4	5	6	7
15	1	96	2	290	120	0	348	6	138
	10	65	210	60	131	183	15	81	220
	13	63	318	130	209	108	81	182	173
	18	75	55	184	209	68	176	53	142
	25	179	269	51	81	64	113	46	49
	37	0	0	0	0	0	0	0	0
16	1	64	13	69	154	270	190	88	78
	3	49	338	140	164	13	293	198	152
	11	49	57	45	43	99	332	160	84
	20	51	289	115	189	54	331	122	5
	22	154	57	300	101	0	114	182	205
	38	0	0	0	0	0	0	0	0
17	0	7	260	257	56	153	110	91	183
	14	164	303	147	110	137	228	184	112
	16	59	81	128	200	0	247	30	106
	17	1	358	51	63	0	116	3	219
	21	144	375	228	4	162	190	155	129
	39	0	0	0	0	0	0	0	0
18	1	42	130	260	199	161	47	1	183
	12	233	163	294	110	151	286	41	215
	13	8	280	291	200	0	246	167	180
	18	155	132	141	143	241	181	68	143
	19	147	4	295	186	144	73	148	14
	40	0	0	0	0	0	0	0	0
19	0	60	145	64	8	0	87	12	179
	1	73	213	181	6	0	110	6	108
	7	72	344	101	103	118	147	166	159
	8	127	242	270	198	144	258	184	138
	10	224	197	41	8	0	204	191	196
	41	0	0	0	0	0	0	0	0
20	0	151	187	301	105	265	89	6	77
	3	186	206	162	210	81	65	12	187
	9	217	264	40	121	90	155	15	203
	11	47	341	130	214	144	244	5	167
	22	160	59	10	183	228	30	30	130
	42	0	0	0	0	0	0	0	0
21	1	249	205	79	192	64	162	6	197
	5	121	102	175	131	46	264	86	122
	16	109	328	132	220	266	346	96	215
	20	131	213	283	50	9	143	42	65
	21	171	97	103	106	18	109	199	216
	43	0	0	0	0	0	0	0	0
22	0	64	30	177	53	72	280	44	25
	12	142	11	20	0	189	157	58	47
	13	188	233	55	3	72	236	130	126
	17	158	22	316	148	257	113	131	178
	44	0	0	0	0	0	0	0	0
23	1	156	24	249	88	180	18	45	185
	2	147	89	50	203	0	6	18	127
	10	170	61	133	168	0	181	132	117
	18	152	27	105	122	165	304	100	199
	45	0	0	0	0	0	0	0	0
24	0	112	298	289	49	236	38	9	32
	3	86	158	280	157	199	170	125	178
	4	236	235	110	64	0	249	191	2
	11	116	339	187	193	266	288	28	156
	22	222	234	281	124	0	194	6	58
	46	0	0	0	0	0	0	0	0
25	1	23	72	172	1	205	279	4	27
	6	136	17	295	166	0	255	74	141
	7	116	383	96	65	0	111	16	11
	14	182	312	46	81	183	54	28	181
	47	0	0	0	0	0	0	0	0
26	0	195	71	270	107	0	325	21	163
	2	243	81	110	176	0	326	142	131
	4	215	76	318	212	0	226	192	169
	15	61	136	67	127	277	99	197	98
	48	0	0	0	0	0	0	0	0
27	1	25	194	210	208	45	91	98	165
	6	104	194	29	141	36	326	140	232
	8	194	101	304	174	72	268	22	9
	49	0	0	0	0	0	0	0	0
28	0	128	222	11	146	275	102	4	32
	4	165	19	293	153	0	1	1	43
	19	181	244	50	217	155	40	40	200
	21	63	274	234	114	62	167	93	205
	50	0	0	0	0	0	0	0	0
29	1	86	252	27	150	0	273	92	232
	14	236	5	308	11	180	104	136	32
	18	84	147	117	53	0	243	106	118
	25	6	78	29	68	42	107	6	103
	51	0	0	0	0	0	0	0	0
30	0	216	159	91	34	0	171	2	170
	10	73	229	23	130	90	16	88	199

	21	123	51	267	130	79	258	161	180
	22	115	157	279	153	144	283	72	180
	27	0	0	0	0	0	0	0	0
6	0	183	278	289	158	80	294	6	199
	6	22	257	21	119	144	73	27	22
	10	28	1	293	113	169	330	163	23
	11	67	351	13	21	90	99	50	100
	13	244	92	232	63	59	172	48	92
	17	11	253	302	51	177	150	24	207
	18	157	18	138	136	151	284	38	52
	20	211	225	235	116	108	305	91	13
	28	0	0	0	0	0	0	0	0
7	0	220	9	12	17	169	3	145	77
	1	44	62	88	76	189	103	88	146
	4	159	316	207	104	154	224	112	209
	7	31	333	50	100	184	297	153	32
	8	167	290	25	150	104	215	159	166
	14	104	114	76	158	164	39	76	18
	29	0	0	0	0	0	0	0	0
8	0	112	307	295	33	54	348	172	181
	1	4	179	133	95	0	75	2	105
	3	7	165	130	4	252	22	131	141
	12	211	18	231	217	41	312	141	223
	16	102	39	296	204	98	224	96	177
	19	164	224	110	39	46	17	99	145
	21	109	368	269	58	15	59	101	199
	22	241	67	245	44	230	314	35	153
	24	90	170	154	201	54	244	116	38
	30	0	0	0	0	0	0	0	0
9	0	103	366	189	9	162	156	6	169
	1	182	232	244	37	159	88	10	12
	10	109	321	36	213	93	293	145	206
	11	21	133	286	105	134	111	53	221
	13	142	57	151	89	45	92	201	17
	17	14	303	267	185	132	152	4	212
	18	61	63	135	109	76	23	164	92
	20	216	82	209	218	209	337	173	205
	31	0	0	0	0	0	0	0	0
10	1	98	101	14	82	178	175	126	116
	2	149	339	80	165	1	253	77	151
	4	167	274	211	174	28	27	156	70
	7	160	111	75	19	267	231	16	230
	8	49	383	161	194	234	49	12	115
	14	58	354	311	103	201	267	70	84
	32	0	0	0	0	0	0	0	0
11	0	77	48	16	52	55	25	184	45
	1	41	102	147	11	23	322	194	115
	12	83	8	290	2	274	200	123	134
	16	182	47	289	35	181	351	16	1
	21	78	188	177	32	273	166	104	152
	22	252	334	43	84	39	338	109	165
	23	22	115	280	201	26	192	124	107
	33	0	0	0	0	0	0	0	0
12	0	160	77	229	142	225	123	6	186
	1	42	186	235	175	162	217	20	215
	10	21	174	169	136	244	142	203	124
	11	32	232	48	3	151	110	153	180
	13	234	50	105	28	238	176	104	98
	18	7	74	52	182	243	76	207	80
	34	0	0	0	0	0	0	0	0
13	0	177	313	39	81	231	311	52	220
	3	248	177	302	56	0	251	147	185
	7	151	266	303	72	216	265	1	154
	20	185	115	160	217	47	94	16	178
	23	62	370	37	78	36	81	46	150
	35	0	0	0	0	0	0	0	0
14	0	206	142	78	14	0	22	1	124
	12	55	248	299	175	186	322	202	144
	15	206	137	54	211	253	277	118	182
	16	127	89	61	191	16	156	130	95
	17	16	347	179	51	0	66	1	72
	21	229	12	258	43	79	78	2	76
	36	0	0	0	0	0	0	0	0
15	0	40	241	229	90	170	176	173	39

	13	120	260	105	210	252	95	112	26
	24	9	90	135	123	173	212	20	105
	52	0	0	0	0	0	0	0	0
31	1	95	100	222	175	144	101	4	73
	7	177	215	308	49	144	297	49	149
	22	172	258	66	177	166	279	125	175
	25	61	256	162	128	19	222	194	108
	53	0	0	0	0	0	0	0	0
32	0	221	102	210	192	0	351	6	103
	12	112	201	22	209	211	265	126	110
	14	199	175	271	58	36	338	63	151
	24	121	287	217	30	162	83	20	211
	54	0	0	0	0	0	0	0	0
33	1	2	323	170	114	0	56	10	199
	2	187	8	20	49	0	304	30	132
	11	41	361	140	161	76	141	6	172
	21	211	105	33	137	18	101	92	65
	55	0	0	0	0	0	0	0	0
34	0	127	230	187	82	197	60	4	161
	7	167	148	296	186	0	320	153	237
	15	164	202	5	68	108	112	197	142
	17	159	312	44	150	0	54	155	180
	56	0	0	0	0	0	0	0	0
35	1	161	320	207	192	199	100	4	231
	6	197	335	158	173	278	210	45	174
	12	207	2	55	26	0	195	168	145
	22	103	266	285	187	205	268	185	100
	57	0	0	0	0	0	0	0	0
36	0	37	210	259	222	216	135	6	11
	14	105	313	179	157	16	15	200	207
	15	51	297	178	0	0	35	177	42
	18	120	21	160	6	0	188	43	100
	58	0	0	0	0	0	0	0	0
37	1	198	269	298	81	72	319	82	59
	13	220	82	15	195	144	236	2	204
	23	122	115	115	138	0	85	135	161
	59	0	0	0	0	0	0	0	0
38	0	167	185	151	123	190	164	91	121
	9	151	177	179	90	0	196	64	90
	10	157	289	64	73	0	209	198	26
	12	163	214	181	10	0	246	100	140
	60	0	0	0	0	0	0	0	0
39	1	173	258	102	12	153	236	4	115
	3	139	93	77	77	0	264	28	188
	7	149	346	192	49	165	37	109	168
	19	0	297	208	114	117	272	188	52
	61	0	0	0	0	0	0	0	0
40	0	157	175	32	67	216	304	10	4
	8	137	37	80	45	144	237	84	103
	17	149	312	197	96	2	135	12	30
	62	0	0	0	0	0	0	0	0
41	1	167	52	154	23	0	123	2	53
	3	173	314	47	215	0	77	75	189
	9	139	139	124	60	0	25	142	215
	18	151	288	207	167	183	272	128	24
	63	0	0	0	0	0	0	0	0
42	0	149	113	226	114	27	288	163	222
	4	157	14	65	91	0	83	10	170
	24	137	218	126	78	35	17	162	71
	64	0	0	0	0	0	0	0	0
43	1	151	113	228	206	52	210	1	22
	16	163	132	69	22	243	3	163	127
	18	173	114	176	134	0	53	99	49
	25	139	168	102	161	270	167	98	125
	65	0	0	0	0	0	0	0	0
44	0	139	80	234	84	18	79	4	191
	7	157	78	227	4	0	244	6	211
	9	163	163	259	9	0	293	142	187
	22	173	274	260	12	57	272	3	148
	66	0	0	0	0	0	0	0	0
45	1	149	135	101	184	168	82	181	177
	6	151	149	228	121	0	67	45	114
	10	167	15	126	29	144	235	153	93
	67	0	0	0	0	0	0	0	0

BM2

H_{BG}		$V_{i,j}$							
Row index i	Column index j	Set index i_{LS}							
		0	1	2	3	4	5	6	7
0	0	9	174	0	72	3	156	143	145
	1	117	97	0	110	26	143	19	131
	2	204	166	0	23	53	14	176	71
	3	26	66	0	181	35	3	165	21
	6	189	71	0	95	115	40	196	23
	9	205	172	0	8	127	123	13	112
	10	0	0	0	1	0	0	0	1
	11	0	0	0	0	0	0	0	0
1	0	167	27	137	53	19	17	18	142
	3	166	36	124	156	94	65	27	174
	4	253	48	0	115	104	63	3	183
	5	125	92	0	156	66	1	102	27
	6	226	31	88	115	84	55	185	96
	7	156	187	0	200	98	37	17	23
	8	224	185	0	29	69	171	14	9
	9	252	3	55	31	50	133	180	167
	11	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0
2	0	81	25	20	152	95	98	126	74
	1	114	114	94	131	106	168	163	31
	3	44	117	99	46	92	107	47	3
	4	52	110	9	191	110	82	183	53
	8	240	114	108	91	111	142	132	155
	10	1	1	1	0	1	1	1	0
	12	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0
3	1	8	136	38	185	120	53	36	239
	2	58	175	15	6	121	174	48	171
	4	158	113	102	36	22	174	18	95
	5	104	72	146	124	4	127	111	110
	6	209	123	12	124	73	17	203	159
	7	54	118	57	110	49	89	3	199
	8	18	28	53	156	128	17	191	43
	9	128	186	46	133	79	105	160	75
	10	0	0	0	1	0	0	0	1
	13	0	0	0	0	0	0	0	0
4	0	179	72	0	200	42	86	43	29
	1	214	74	136	16	24	67	27	140
	11	71	29	157	101	51	83	117	180
	14	0	0	0	0	0	0	0	0
5	0	231	10	0	185	40	79	136	121
	1	41	44	131	138	140	84	49	41
	5	194	121	142	170	84	35	36	169
	7	159	80	141	219	137	103	132	88
	11	103	48	64	193	71	60	62	207
	15	0	0	0	0	0	0	0	0
6	0	155	129	0	123	109	47	7	137
	5	228	92	124	55	87	154	34	72
	7	45	100	99	31	107	10	198	172
	9	28	49	45	222	133	155	168	124
	11	158	184	148	209	139	29	12	56
	16	0	0	0	0	0	0	0	0
7	1	129	80	0	103	97	48	163	86
	5	147	186	45	13	135	125	78	186
	7	140	16	148	105	35	24	143	87
	11	3	102	96	150	108	47	107	172
	13	116	143	78	181	65	55	58	154
	17	0	0	0	0	0	0	0	0
8	0	142	118	0	147	70	53	101	176
	1	94	70	65	43	69	31	177	169
	12	230	152	87	152	88	161	22	225
	18	0	0	0	0	0	0	0	0
9	1	203	28	0	2	97	104	186	167
	8	205	132	97	30	40	142	27	238
	10	61	185	51	184	24	99	205	48
	11	247	178	85	83	49	64	81	68
	19	0	0	0	0	0	0	0	0
10	0	11	59	0	174	46	111	125	38
	1	185	104	17	150	41	25	60	217
	6	0	22	156	8	101	174	177	208
	7	117	52	20	56	96	23	51	232
	20	0	0	0	0	0	0	0	0
11	0	11	32	0	99	28	91	39	178
	7	236	92	7	138	30	175	29	214
	9	210	174	4	110	116	24	35	168
	13	56	154	2	99	64	141	8	51
	21	0	0	0	0	0	0	0	0
12	1	63	39	0	46	33	122	18	124
	3	111	93	113	217	122	11	155	122
	11	14	11	48	109	131	4	49	72
	22	0	0	0	0	0	0	0	0
13	0	83	49	0	37	76	29	32	48
	1	2	125	112	113	37	91	53	57
	8	38	35	102	143	62	27	95	167
16	26	0	0	0	0	0	0	0	0
17	1	254	158	0	48	120	134	57	196
	5	124	23	24	132	43	23	201	173
	11	114	9	109	206	65	62	142	195
	12	64	6	18	2	42	163	35	218
	27	0	0	0	0	0	0	0	0
18	0	220	186	0	68	17	173	129	128
	6	194	6	18	16	106	31	203	211
	7	50	46	86	156	142	22	140	210
	28	0	0	0	0	0	0	0	0
19	0	87	58	0	35	79	13	110	39
	1	20	42	158	138	28	135	124	84
	10	185	156	154	86	41	145	52	88
	29	0	0	0	0	0	0	0	0
20	1	26	76	0	6	2	128	196	117
	4	105	61	148	20	103	52	35	227
	11	29	153	104	141	78	173	114	6
	30	0	0	0	0	0	0	0	0
21	0	76	157	0	80	91	156	10	238
	8	42	175	17	43	75	166	122	13
	13	210	67	33	81	81	40	23	11
	31	0	0	0	0	0	0	0	0
22	1	222	20	0	49	54	18	202	195
	2	63	52	4	1	132	163	126	44
	32	0	0	0	0	0	0	0	0
23	0	23	106	0	156	68	110	52	5
	3	235	86	75	54	115	132	170	94
	5	238	95	158	134	56	150	13	111
	33	0	0	0	0	0	0	0	0
24	1	46	182	0	153	30	113	113	81
	2	139	153	69	88	42	108	161	19
	9	8	64	87	63	101	61	88	130
	34	0	0	0	0	0	0	0	0
25	0	228	45	0	211	128	72	197	66
	5	156	21	65	94	63	136	194	95
	35	0	0	0	0	0	0	0	0
26	2	29	67	0	90	142	36	164	146
	7	143	137	100	6	28	38	172	66
	12	160	55	13	221	100	53	49	190
	13	122	85	7	6	133	145	161	86
	36	0	0	0	0	0	0	0	0
27	0	8	103	0	27	13	42	168	64
	6	151	50	32	118	10	104	193	181
	37	0	0	0	0	0	0	0	0
28	1	98	70	0	216	106	64	14	7
	2	101	111	126	212	77	24	186	144
	5	135	168	110	193	43	149	46	16
	38	0	0	0	0	0	0	0	0
29	0	18	110	0	108	133	139	50	25
	4	28	17	154	61	25	161	27	57
	39	0	0	0	0	0	0	0	0
30	2	71	120	0	106	87	84	70	37
	5	240	154	35	44	56	173	17	139
	7	9	52	51	185	104	93	50	221
	9	84	56	134	176	70	29	6	17
	40	0	0	0	0	0	0	0	0
31	1	106	3	0	147	80	117	115	201
	13	1	170	20	182	139	148	189	46
	41	0	0	0	0	0	0	0	0
32	0	242	84	0	108	32	116	110	179
	5	44	8	20	21	89	73	0	14
	12	166	17	122	110	71	142	163	116
	42	0	0	0	0	0	0	0	0
33	2	132	165	0	71	135	105	163	46
	7	164	179	88	12	6	137	173	2
	10	235	124	13	109	2	29	179	106
	43	0	0	0	0	0	0	0	0
34	0	147	173	0	29	37	11	197	184
	12	85	177	19	201	25	41	191	135
	13	36	12	78	69	114	162	193	141
	44	0	0	0	0	0	0	0	0
35	1	57	77	0	91	60	126	157	85
	5	40	184	157	165	137	152	167	225
	11	63	18	6	55	93	172	181	175
	45	0	0	0	0	0	0	0	0
36	0	140	25	0	1	121	73	197	178
	2	38	151	63	175	129	154	167	112
	7	154	170	82	83	26	129	179	106
	46	0	0	0	0	0	0	0	0
37	10	219	37	0	40	97	167	181	154
	13	151	31	144	12	56	38	193	114
	47	0	0	0	0	0	0	0	0
38	1	31	84	0	37	1	112	157	42
	5	66	151	93	97	70	7	173	41

	13	222	166	26	140	47	127	186	219
	23	0	0	0	0	0	0	0	0
14	1	115	19	0	36	143	11	91	82
	6	145	118	138	95	51	145	20	232
	11	3	21	57	40	130	8	52	204
	13	232	163	27	116	97	166	109	162
	24	0	0	0	0	0	0	0	0
15	0	51	68	0	116	139	137	174	38
	10	175	63	73	200	96	103	108	217
	11	213	81	99	110	128	40	102	157
	25	0	0	0	0	0	0	0	0
16	1	203	87	0	75	48	78	125	170
	9	142	177	79	158	9	158	31	23
	11	8	135	111	134	28	17	54	175
	12	242	64	143	97	8	165	176	202
	11	38	190	19	46	1	19	191	105
	48	0	0	0	0	0	0	0	0
39	0	239	93	0	106	119	109	181	167
	7	172	132	24	181	32	6	157	45
	12	34	57	138	154	142	105	173	189
	49	0	0	0	0	0	0	0	0
40	2	0	103	0	98	6	160	193	78
	10	75	107	36	35	73	156	163	67
	13	120	163	143	36	102	82	179	180
	50	0	0	0	0	0	0	0	0
41	1	129	147	0	120	48	132	191	53
	5	229	7	2	101	47	6	197	215
	11	118	60	55	81	19	8	167	230
	51	0	0	0	0	0	0	0	0

Analysis – gap is roughly 1dB

- Error rate is approximated by $\bar{P}_b \cong \frac{E_{ave}}{n} \cdot P_e$

- For $n \cong 26000$

P_e	E_{ave}	$\bar{P}_b$
10^{-2}	2000 (8%)	8×10^{-4}
10^{-4}	100	4×10^{-6}
10^{-6} (floor)	20	8×10^{-8}

- Matlab has encoder and decoder functions – see Section 8.3.3.4

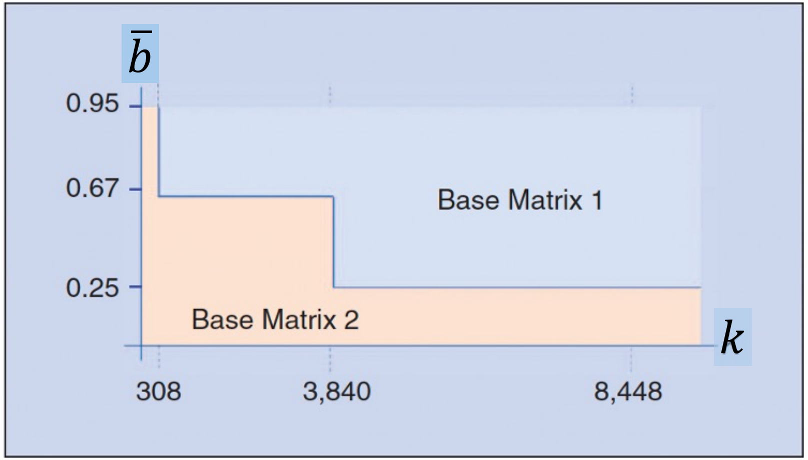
```
C = 2;          % 2 codewords
k = 2560;    %   for RM2, this means btilde is 256
F = 36;         % number of filler bits
cbs = ones(k-F,C);
fillers = -1*ones(F,C);
cbs = [cbs;fillers];

bgn = 2;
codedcbs = nrLDPCEncode(cbs,bgn);
size(codedcbs)
12800  2
```

Rate Selection and Puncturing

Section 8.3.4

Base Matrix Code Choice

- BM1 is largely for high rates
- While BM2 is largely for low rates



EXAMPLE 8.3.7 BM1 rate possibilities This table illustrates BM1 possibilities for $\tilde{b} = 384$ and obeying $k_{max} \leq 8448$:

$\bar{b}$	b	$\tilde{b}$	BM1 use
0.25	25,344	66	not allowed
0.50	8448	22	recommended
0.67	4161	11	near limit
0.90	939	3	recommended
0.95	445	2	recommended

All the table entries except the first correspond to Figure 8.37's recommended uses.

$b = 384$ and obeying $k_{max} \leq 3840$:

$\bar{b}$	b	$\tilde{b}$	BM2 use
0.25	25,344	32	recommended
0.50	3840	10	recommended
0.67	1891	5	near limit
0.90	427	2	not allowed

Puncturing Examples

- High rate for BM1 with $\tilde{b} = 8$:
  - $\bar{b} = .95$
  - $\tilde{p} = \left\lceil 22 \cdot \left(\frac{1}{.95} - 1\right)\right\rceil = 2$
  - Send all systematic and $c_{0:15}$. All other core and extra bits omitted
- Mid rate for BM1 with $\tilde{b} = 384$:
  - $\bar{b} = .67$
  - $\tilde{p} = \left\lceil 22 \cdot \left(\frac{1}{.67} - 1\right)\right\rceil = 11$
  - Send all systematic and $c_{0:4223}$. All other core and extra bits omitted.
- mid rate for BM2 with $\tilde{b} = 16$:
  - $\bar{b} = .5$
  - $\tilde{p} = \left\lceil 10 \cdot \left(\frac{1}{.5} - 1\right)\right\rceil = 10$
  - Send all systematic and $c_{0:159}$. All other core and extra bits omitted.

Retransmission and low rates (see also L12)

- The entire codeword is not resent if there is a CRC violation (24 bits of payload is CRC)

- Instead roughly 1/3 of bits are sent
  - Rv=0 (full codeword)
  - Rv=1 – just resend systematic bits
  - Rv=2 – send roughly ½ the parity bits
  - Rv=3 – send roughly the other half of parity

- Rv can be used also without CRC to lower data rate through retransmission.
  - Repeats the information or parity bits (for the same already sent)
  - Can increase reliability and reduce rate to 10%

- For segmentation of larger payload blocks, see Section 8.3.3.4
  - Uses filler bits.

End Supplementary Lecture S11B