# AMI and HDB1 Line Codes - VHDL Implementation.

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**Abstract**

Line codings are methods for coding digital data for making them less susceptible to signal losses during transmission. This project implements the AMI — Alternate Mark Inverse — and HDB1 — High Density Bipolar of order 1 codings. This file documents their implementation.

## 1 Specification.

**AMI.** This coding takes a binary sequency into a ternary sequency having the signals 0, +1, -1 by the following way:

- Inputs of 1 are coded as +1 or -1 alternately.
- Inputs of 0 are coded always as 0.

Example:

```
Input
 1 0  1 0  1  1 0 0 0  1 0  1  1 0 0  1 0  1 0 0 0  1  1  1
Output
+1 0 -1 0 +1 -1 0 0 0 +1 0 -1 +1 0 0 -1 0 +1 0 0 0 -1 +1 -1
```

**HDB1.** This coding takes a binary sequency into a ternary sequency having the signals 0, +1, -1 by the following way:

- Inputs of 1 are coded as either +1 or -1.
- Paired inputs of 0 are coded as either +1+1 or -1-1.
- Isolated inputs of 0, ie, inputs of 0 not followed by 1 which weren't paired to another 0 (thus forming +1+1 or -1-1) are coded as 0.
- Outputs have always alternate signals. If the last output was -1 and the input is 00, the next output is coded as +1+1, if the last output was -1-1 and the input is 1, the next output is +1.

Example:

```
Input
 1 0  1 0  1  1  0  0 0  1 0  1  1  0  0  1 0  1  0  0  0  0  1  1
Output
+1 0 -1 0 +1 -1 +1 +1 0 -1 0 +1 -1 +1 +1 -1 0 +1 -1 -1 +1 +1 -1 +1
```

## 2 AMI Encoder.

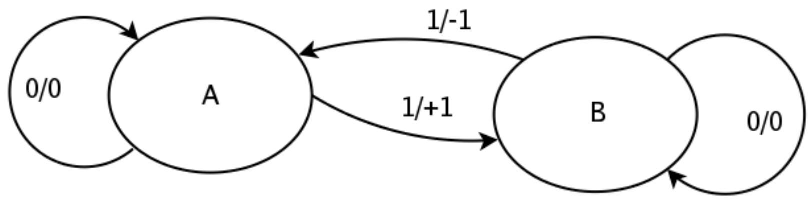


Figure 1: State Map.

Truth Table:

| $q$ | $e$ | $S_0$ | $S_1$ | $q^+$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |

Karnaugh Map isn't necessary:

$S_0 = e \cdot q'$
$S_1 = e \cdot q$
$q^+ = e \oplus q$

## 3 AMI Decoder.

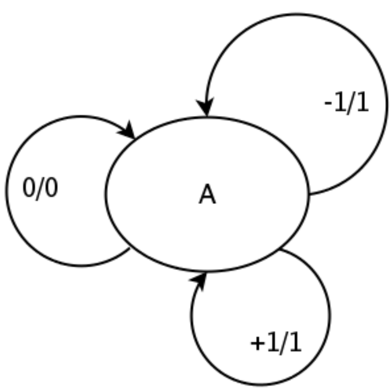


Figure 2: State Map.

Truth Table:

| $e_0$ | $e_1$ | $S$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | $X$ |

Karnaugh Map isn't necessary:

$S = e_0 + e_1$

# 4 HDB1 Encoder.

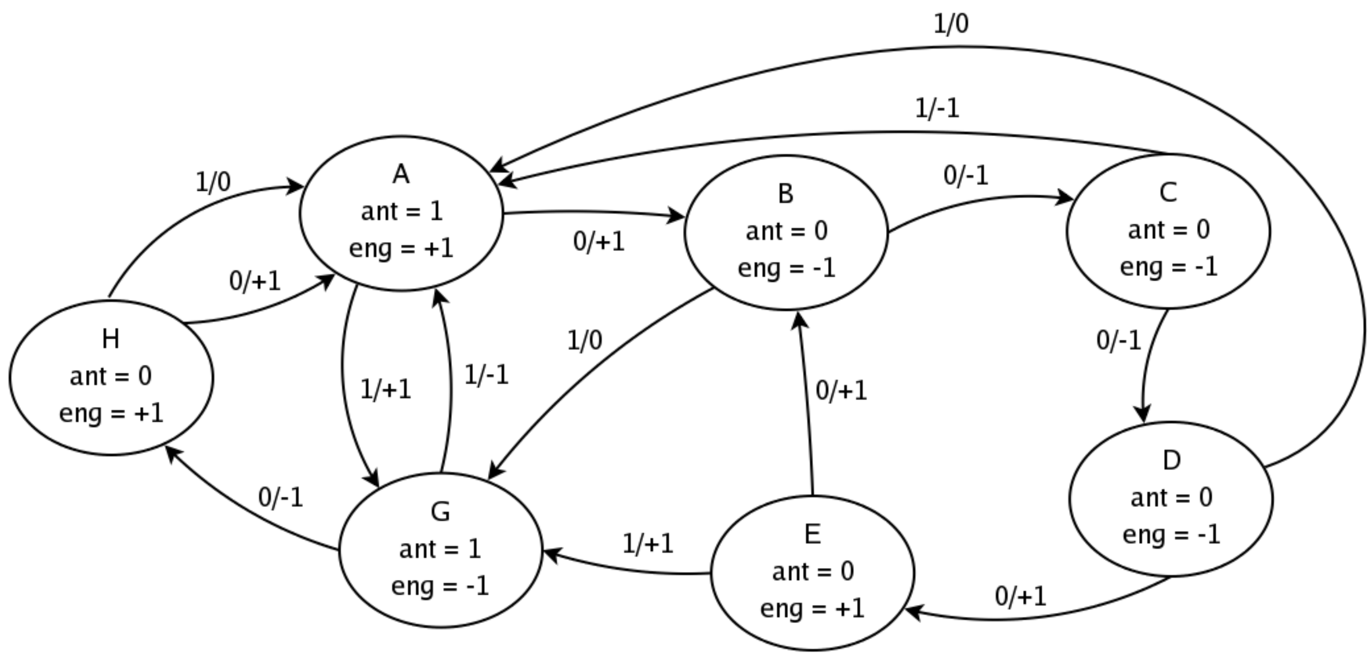


Figure 3: State Map.

Truth Table:

| $E$ | $q_0$ | $q_1$ | $q_2$ | $q_0^+$ | $q_1^+$ | $q_2^+$ | $S_0$ | $S_1$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| X | 1 | 0 | 1 | X | X | X | X | X |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |

$q_0^+$:

| $q_1 q_2$ \ $Eq_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | 1 | 1 |
| 01 | | $X$ | $X$ | 1 |
| 11 | 1 | | | |
| 10 | | 1 | | |

$$q_0^+ = E.q_1' + E'.q_0'.q_1.q_2 + E'.q_0.q_1.q_2'$$

$q_1^+$:

| $q_1 q_2$ \ $Eq_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | 1 | 1 |
| 01 | 1 | $X$ | $X$ | 1 |
| 11 | | | | |
| 10 | 1 | 1 | | |

$$q_1^+ = E.q_1' + q_1'.q_2 + E'.q_1.q_2'$$

$q_2^+$:

| $q_1 q_2$ \ $Eq_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 1 | | |
| 01 | | $X$ | $X$ | |
| 11 | | | | |
| 10 | 1 | 1 | | |

$q_2^+ = E'.q_2'$

$S_0$:

| $q_1q_2$ \ $Eq_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 1 | 1 | 1 |
| 01 | | $X$ | $X$ | |
| 11 | 1 | 1 | | |
| 10 | | | | |

$S_0 = q_1'.q_2' + E'.q_1.q_2$

$S_1$:

| $q_1q_2$ \ $Eq_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | | |
| 01 | 1 | $X$ | $X$ | |
| 11 | | | | |
| 10 | 1 | 1 | 1 | 1 |

$S_1 = q_1.q_2' + E'.q_1'.q_2$

# 5 HDB1 Decoder.

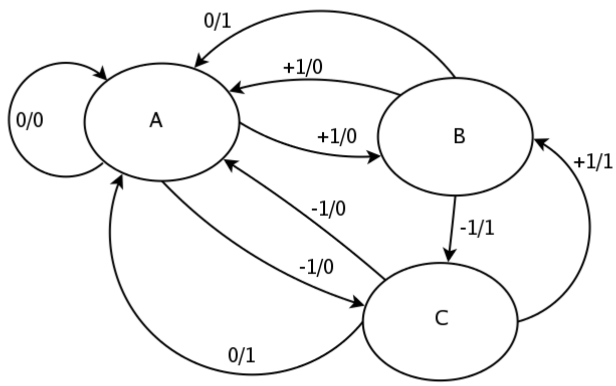


Figure 4: State Map.

Truth Table:

| $e_1$ | $e_0$ | $q_1$ | $q_0$ | $q_0^+$ | $q_1^+$ | $S$ |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | $X$ | $X$ | $X$ |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 1 | 1 | $X$ | $X$ | $X$ |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | $X$ | $X$ | $X$ |
| 1 | 1 | 0 | 0 | $X$ | $X$ | $X$ |
| 1 | 1 | 0 | 1 | $X$ | $X$ | $X$ |
| 1 | 1 | 1 | 0 | $X$ | $X$ | $X$ |
| 1 | 1 | 1 | 1 | $X$ | $X$ | $X$ |

$q0$:

| $e_0e_1$ \ $q_1q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | $X$ | |
| 01 | | | $X$ | |
| 11 | $X$ | $X$ | $X$ | $X$ |
| 10 | | 1 | $X$ | |

$q_0^+ = q_0'.e_0$

$q1$:

| $e_0e_1$ \ $q_1q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | $X$ | |
| 01 | 1 | | $X$ | 1 |
| 11 | $X$ | $X$ | $X$ | $X$ |
| 10 | 1 | | $X$ | |

$q_1^+ = q_1'.e_1$

$S$:

| $e_1e_2$ \ $q_1q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | 1 | $X$ | 1 |
| 01 | | | $X$ | 1 |
| 11 | $X$ | $X$ | $X$ | $X$ |
| 10 | | 1 | $X$ | |

$S = q_0.e_0' + q_1.e_1'$