ICEEP

Iran Center of ESL Education and Promotion

Reed-Solomon Encoder/ Decoder

Contents

1- Introduction

The Reed-Solomon Encoder and Decoder cores provide a customizable solution allowing forward error correction in many design applications. This core allows designers to focus on the application rather than the Reed-Solomon Encoder, resulting in faster time to market. Reed-Solomon codes are widely used in various applications for forward error correction and detection. Figure 1 shows the Reed-Solomon Encoder.

2- Architecture

Reed-Solomon Encoder

The Multiplier Array does the Galois field multiplication between the generator coefficients and the addition of input data and feedback (modulo 2). This multiplication is an optimized multiplication between the generator coefficients, which are constants, and the input of the Multiplier Array. This optimization is done when processing the core. The Adder Array performs addition (modulo 2) on the data from the previous element of the Remainder Array and the result of the corresponding Galois field multiplication from the Multiplier Array. The outputs from the Adder Array are latched into the mainder Array on each clock cycle. Then, the Remainder Array is a shift register array. It stores the remainder polynomial after the polynomial division. The remainder polynomial becomes the check symbols once all information symbols have been processed. The Remainder Array shifts in the data from the Adder Array until no information symbols remain. When all the information symbols have been received, the polynomial multiplication stops and the contents of the Remainder Array are output to d_out

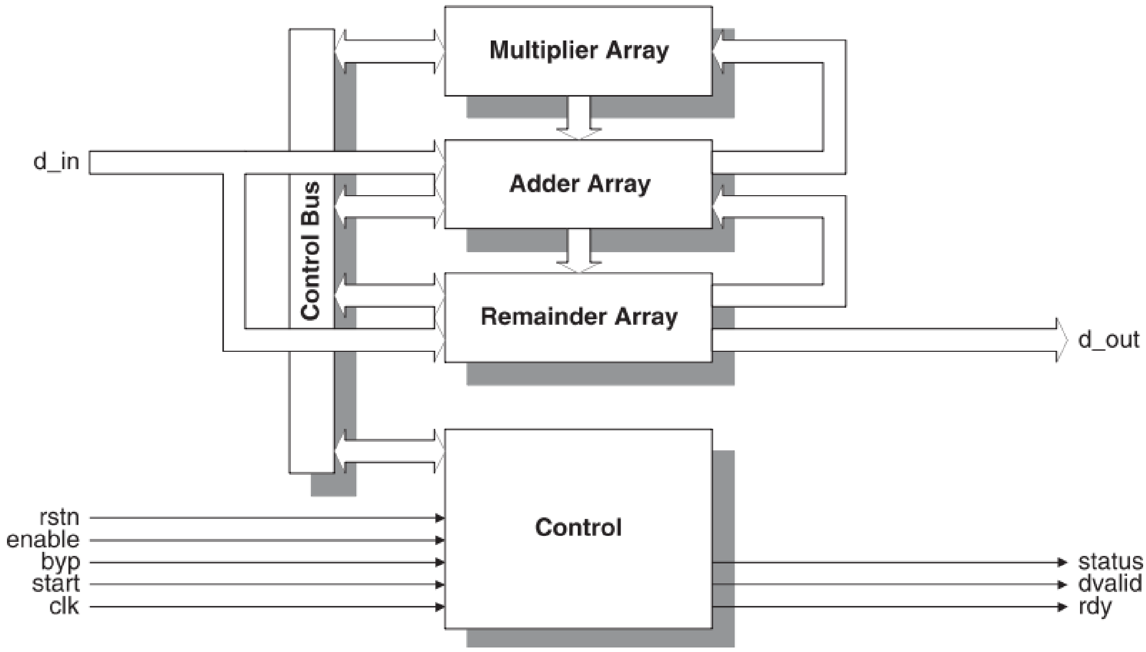

Figure 1 - Reed-Solomon Encoder Core Block Diagram

The control block generates all control signals and determines the state of the Reed-Solomon Encoder. The inputs control the state of the encoder. The control signals from the control block are sent through the control bus to determine when data should be transmitted to the encoder.

Table 1- Reed-Solomon Encoder Default Field Polynomial

Symbol Width	Default Field Polynomial	Decimal Value
3	$x^3 + x + 1$	11
4	$x^4 + x + 1$	19
5	$x^5 + x^2 + 1$	37
6	$x^6 + x + 1$	67
7	$x^7 + x^3 + 1$	137
8	$x^8 + x^4 + x^3 + x^2 + 1$	285
9	$x^9 + x^4 + 1$	529
10	$x^{10} + x^3 + 1$	1033
11	$x^{11} + x^2 + 1$	2053
12	$x^{12} + x^6 + x^4 + x + 1$	4179

Reed-Solomon Decoder

The data received by the RS Decoder is Reed-Solomon encoded data. This data is a representation of a polynomial in a Galois Field. If there are no errors in the received data, the data polynomial will evaluate to zero at the roots of the generator polynomial. This result is obtained because the roots of the generator polynomial and received data polynomial are the same when no errors are present. If the received data has been corrupted during the transmission, the polynomial will not evaluate to zero. The RS Decoder can construct the syndrome polynomial by evaluating the received polynomial at all the roots of the generator polynomial. Once the syndrome polynomial has been constructed, it can be used to solve the Error Locator polynomial and Error Evaluator polynomial. Using these two polynomials, the decoder can find the error locations and magnitudes. Finally, the decoder can correct the errors in the received data, provided the errors are in the range of possible correction (determined by the level of encoding that has been performed).

If there are errors in the received codeword, it can be expressed as follows:

$r(x) = c(x) + e(x)$

where:

- $c(x)$ is the Transmitted codeword.
- $r(x)$ is the Received codeword.
- $e(x)$ is the Error polynomial.

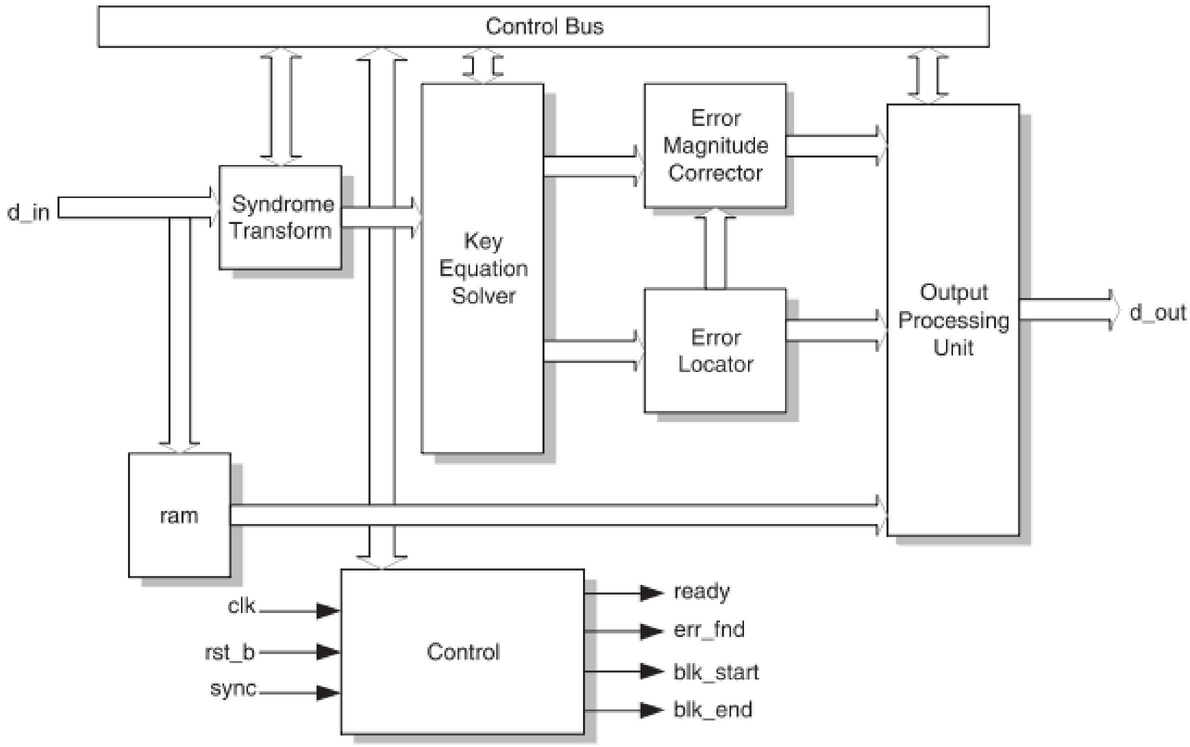

Figure 2-Reed-Solomon Decoder Block Diagram

This block is implemented using the Chien-search method. Essentially, this method evaluates the Error Locator polynomial at all the elements in the Galois Field. The Error Locator polynomial evaluates to zero at its roots. The Chien-search takes m cycles, where m is the number of elements in the Galois Field. After m cycles, all roots have been determined. If the roots are determined before the m cycles are over, the search is terminated early.

3- References

[1] Reed-Solomon Decoder Data Sheet, Lattice Semiconductor Corporation, 2002.