# Comments and Corrections

## Comments on "On Decoding of the (89, 45, 17) Quadratic Residue Code"

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### I. Corrections and Comments on the Flowchart of Algorithm 2

We would like to make some comments on the flowchart of the Chase-based soft-decision decoding algorithm, i.e., Algorithm 2, in our previous paper [1]. We note that there is a mistake in Fig. 1 in [1]; that is, $v_1$ is initialized to $z$ where $z$ denotes the hard-decision vector of the channel observation $r$. In our previous simulations, we initially set $\lambda(r,v_1) = \lambda(r,z) = +\infty$ which guarantees that $v_2$ rather than $z$ is chosen where $v_2$ represents the first decoded codeword. Then $v_2$ will be compared with other valid codewords obtained from different test patterns. Nevertheless, perhaps the first valid codeword $v_2$ and the initial $v_1$ (namely $z$) satisfy condition (13) in [1] and thus terminate the decoding process. In this case, the codeword $v(v = v_2)$ may not be the optimal candidate of the soft-decision decoder since Theorem 1 in [1] is correct if and only if $v_1$ and $v_2$ are both valid codewords and meet condition (13).

Fortunately, the performance curves of the (89, 45, 17) QR code presented in [1] were accurate despite the mistake mentioned above. In reality, the true error-rate performance can also be obtained for the (73, 37, 13) and (71, 36, 11) QR codes by utilizing the flowchart of Algorithm 2 in [1]. However, we observed a significant performance gap as illustrated in Fig. 1 when the (23, 12, 7) QR code, i.e., the Golay code, was considered. We guess that such a loss results from the Golay code's 'perfect code' property.

It is worth to note that the decoding flowchart in [1] is not optimal from decoding speed point of view since the second valid codeword still needs to be solved even if the first one is the maximum-likelihood (ML) codeword. Actually, it is often the case at high signal-to-noise ratio (SNR). To overcome this, a new flowchart which integrates two different sufficient optimality conditions is developed in the next section.

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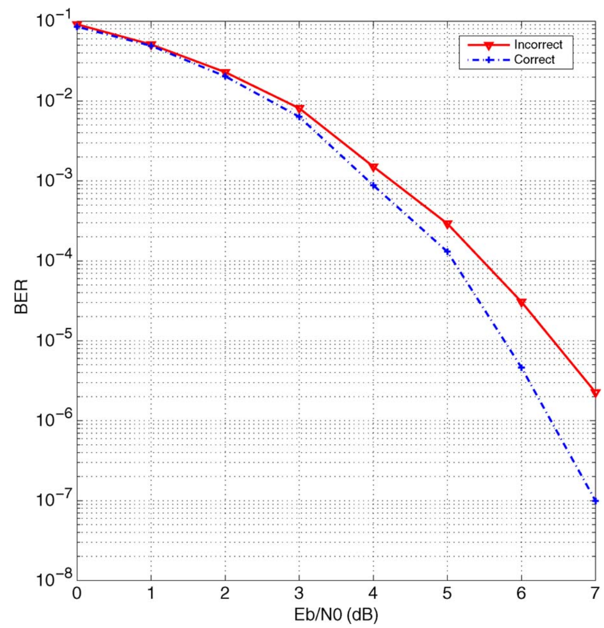


Fig. 1. BER curves of soft-decision decoding for the (23, 12, 7) Golay code. The solid curve corresponds to the incorrect decoding flowchart (namely Fig. 1 in [1]), and the other is obtained from the correct flowchart.

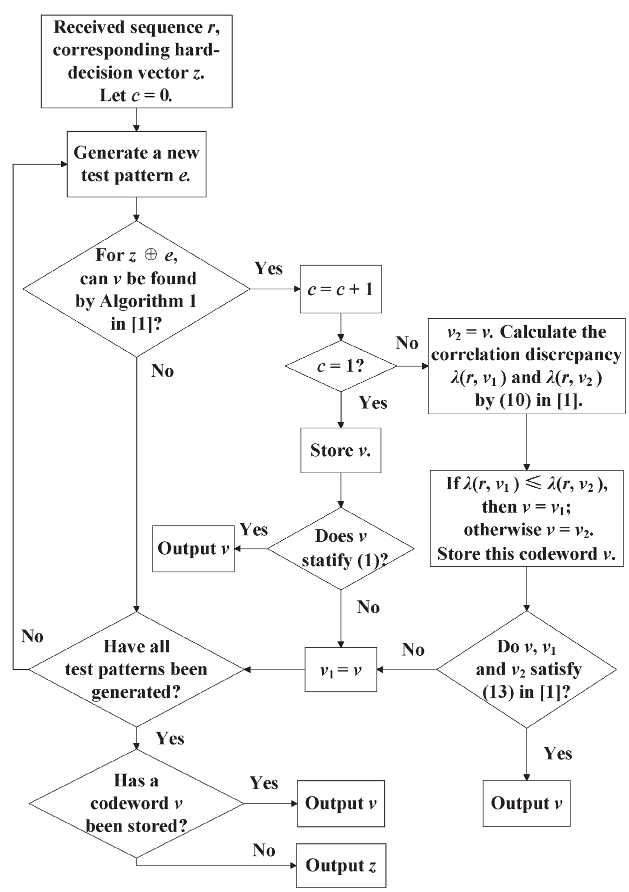


Fig. 2. Flowchart of soft-decision decoding.

## II. A New Decoding Flowchart

In the high SNR region, the first valid codeword output by the soft-decision decoder is often the ML codeword. Therefore, a sufficient optimality condition based on one valid codeword derived by Taipale *et al.* [2], [3] can be inserted into the decoding procedure of Algorithm 2 in [1] as a stopping criterion. If this condition is not met, the condition mentioned previously based on two codewords is considered instead. It avoids determining the second codeword when the first one is already the ML codeword thereby reducing the decoding time. In what follows, we rewrite Taipale *et al.*'s condition as a lemma. For ease of presentation, the same notations defined in [1] are used.

*Lemma 1:* Let $v$ be a codeword in $C$. Define $\delta \triangleq d - n(v)$ and $G_T(v,d) \triangleq \sum_{i \in D_0^{(\delta)}(v)} |r_i|$. If

$$\lambda(r,v) \leq G_T(v,d), \tag{1}$$

then $v$ is the ML codeword of $r$.

*Proof:* For detailed proof, see [2]. ■

The complete decoding flowchart of Chase-II soft-decision decoding which combines the above two conditions is depicted in Fig. 2.

## References

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