Spacetime algebra without reference to a metric signature

Define spacetime basis vectors by $|\gamma_\mu^2| = 1$ and $\gamma_0^2 = -\gamma_i^2$. Define reciprocal basis vectors by $\gamma^\mu := \gamma_\mu^{-1}$. Define the pseudoscalar $I := \gamma_0\gamma_1\gamma_2\gamma_3$.

Define relative vectors $\sigma_i := \gamma_i\gamma^0$ so that

$$
\begin{aligned}
\sigma_i^2 &= \gamma_i\gamma^0\gamma_i\gamma^0 \\
&= -(\gamma_i)^2(\gamma^0)^2 \\
&= -\gamma_i^2\left(\gamma_0^2\right)^{-1} \\
&= -\gamma_i^2\left(-\gamma_i^2\right)^{-1} = 1
\end{aligned}
$$

and

$$
\begin{aligned}
\sigma_1\sigma_2\sigma_3 &= \gamma_1\gamma^0\gamma_2\gamma^0\gamma_3\gamma^0 \\
&= \gamma^0\gamma_1\gamma_2\gamma_3\gamma^0\gamma^0 \\
&= \gamma_0\gamma_1\gamma_2\gamma_3\gamma_0\gamma^0 \\
&= \gamma_0\gamma_1\gamma_2\gamma_3 = I
\end{aligned}
$$

Define $\sigma^i = \sigma_i^{-1}$ and find $\sigma^i = \gamma_0\gamma^i$ so that $\sigma_i\sigma^i = \gamma_i\gamma^0\gamma_0\gamma^i = 1$.

Relation to vector cross product

If $\times$ is the $\mathbb{R}^3$ cross product, then for $\vec{E} = E^i\sigma_i$ and $\vec{B} = B^i\sigma_i$ we have

$$
\begin{aligned}
\left\langle\vec{E}\vec{B}\right\rangle_2 &= \sum_{i,j} E^iB^j\langle\sigma_i\sigma_j\rangle_2 \\
&= \sum_{i\neq j} E^iB^j\sigma_i\sigma_j \\
&= \sum_{i\neq j} E^iB^j\sigma^k I\varepsilon_{ijk} = \left(\vec{E}\times\vec{B}\right)I
\end{aligned}
$$