TABLE I

THE SET OF BITWIDTH DEPENDENT REWRITES SUPPLIED TO EGG. LEFT SUBSCRIPT NOTATION, ${}_p x$, DENOTES A BITVECTOR x WITH LENGTH p BITS. THE $*$ OPERATION REPRESENTS BOTH $\{+, \times\}$. THE SQUARE BRACKETS REPRESENT VERILOG BIT SLICING, WHERE $a[x:y]$ MEANS WE TAKE BITS x DOWN TO y OF a. THE RULES ARE CONDITIONALLY APPLIED ACCORDING TO COLUMN 4, WHICH IS SUFFICIENT BUT NOT ALWAYS NECESSARY.

Class	Name	Left-hand Side $\rightarrow$ Right-hand Side	Sufficient Condition
Bitvector Arithmetic Identities	Commutativity	${}_r({}_p a * {}_q b) \rightarrow {}_r({}_q b * {}_p a)$	True
	Mult Associativity	${}_t({}_u({}_p a \times {}_r b) \times {}_s c) \rightarrow {}_t({}_p a \times {}_q({}_r b \times {}_s c))$	$(q \geq t \vee r + s \leq q)$ $\wedge (u \geq t \vee p + r \leq u)$
	Add Associativity	${}_t({}_u({}_p a + {}_r b) + {}_s c) \rightarrow {}_t({}_p a + {}_q({}_r b + {}_s c))$	$(q \geq t \vee \max(r,s) < q)$ $\wedge (u \geq t \vee \max(p,r) < u)$
	Distribute Mult over Add	${}_r({}_p a \times {}_q({}_s b + {}_t c)) \rightarrow {}_r({}_u({}_p a \times {}_s b) + {}_v({}_p a \times {}_t c))$	$\min(q,u,v) \geq r$
	Sum Same	${}_q({}_p a + {}_p a) \rightarrow {}_q({}_2 2 \times {}_p a)$	True
	Mult Sum Same	${}_r({}_s({}_p a \times {}_q b) + {}_q b) \rightarrow {}_r({}_t({}_p a + {}_1 1) \times {}_q b)$	$t > p \wedge s \geq p + q$
	Add Zero	${}_p({}_p a + {}_q b) \rightarrow {}_p(a)$	$b \equiv 0 \mod 2^p$
	Sub to Neg	${}_r({}_p a - {}_q b) \rightarrow {}_r({}_p a + {}_q(-{}_q b))$	True
	Mult by One	${}_p({}_p a \times {}_q b) \rightarrow {}_p(a)$	$b \equiv 1 \mod 2^p$
	Mult by Two	${}_r({}_p a \times {}_2 2) \rightarrow {}_r({}_p a << {}_1 1)$	True
Bitvector Logic Identities	Merge Left Shift	${}_r({}_u({}_p a << {}_q b) << {}_s c) \rightarrow {}_r({}_p a << {}_t({}_q b + {}_s c))$	$t > \max(q,s) \wedge u \geq r$
	Merge Right Shift	${}_r({}_u({}_p a >> {}_q b) >> {}_s c) \rightarrow {}_r({}_p a >> {}_t({}_q b + {}_s c))$	$t > \max(q,s) \wedge u \geq p$
	Redundant Sel	${}_p({}_1 b ? {}_p a : {}_p a) \rightarrow {}_p a$	True
	Neg Not	${}_r(-{}_p a) \rightarrow {}_r({}_p(\sim({}_p a)) + {}_1 1)$	$r \leq p$
	Not over Con	${}_r(\sim({}_{q+s}\{{}_q a, {}_s b\})) \rightarrow {}_r\{{}_q(\sim({}_q a)), {}_s(\sim({}_s b))\}$	$q + s \geq r$
Constant Expansion	Mult Constant	${}_r({}_q c \times {}_p x) \rightarrow$ ${}_r({}_r({}_q 2 \times {}_{q-1} c[q-1:1]) \times {}_p x) + {}_p({}_1 c[0] \times {}_p x))$	c constant
	One to Two Mult	${}_p({}_1 1 \times {}_p x) \rightarrow {}_p({}_q({}_2 2 \times {}_p x) - {}_p x)$	$q > p$
Arithmetic Logic Exchange	Left Shift Add	${}_r({}_s({}_p a + {}_q b) << {}_t c) \rightarrow {}_r({}_u({}_p a << {}_t c) + {}_u({}_q b << {}_t c))$	$(s \geq r \vee \max(p,q) < s) \wedge u \geq r$
	Add Right Shift	${}_r({}_p a + {}_q({}_t b >> {}_u c)) \rightarrow {}_r({}_v({}_s({}_p a << {}_u c) + {}_t b) >> {}_u c)$	$q \geq t \wedge s \geq p + 2^u - 1$ $\wedge v > \max(s,t)$
	Left Shift Mult	${}_r({}_t({}_p a \times {}_q b) << {}_u c) \rightarrow {}_r({}_v({}_p a << {}_u c) \times {}_q b)$	$t \geq r \wedge v \geq r$
	Sel Add	${}_r({}_1 e ? {}_r({}_p a + {}_q b) : {}_r({}_p c + {}_q d)) \rightarrow$ ${}_r({}_p({}_1 e ? {}_p a : {}_p c) + {}_q({}_1 e ? {}_q b : {}_q d))$	True
	Sel Add Zero	${}_p({}_1 e ? {}_p({}_p a + {}_q b) : {}_p c) \rightarrow {}_p({}_p({}_1 e ? {}_p a : {}_p c) + {}_q({}_1 e ? {}_q b : {}_q 0))$	True
	Move Sel Zero	${}_r({}_p({}_1 b ? {}_p 0 : {}_p a) \times {}_q c) \rightarrow {}_r({}_p a \times {}_q({}_1 b ? {}_q 0 : {}_q c))$	True
	Concat to Add	${}_r\{{}_p a, {}_q b\} \rightarrow {}_r({}_s({}_p a << {}_u q) + {}_q b)$	$s \geq p + 2^u - 1 \wedge u \geq \lceil \log_2(q+1) \rceil$
Merging Ops	Merge Additions	${}_{q_1}({}_{p_1} a1 + {}_{q_2}({}_{p_2} a2 + {}_{q_3}({}_{p_3} a3 + ... + {}_{p_n} an) ...)) \rightarrow$ ${}_{q_1}(\texttt{SUM}({}_{p_1} a1, {}_{p_2} a2, ..., {}_{p_n} an))$	$q_i > \max(p_i, q_{i+1}), i = 1, ..., n-2$ $\wedge q_{n-1} > \max(p_{n-1}, p_n)$
	Mux Array	${}_t({}_s({}_q a \times {}_r b) + {}_s({}_q c \times {}_r(\sim({}_r b))))$ $\rightarrow {}_t(\texttt{MUXAR}({}_r b, {}_q a, {}_q c))$	$s \geq q + r \wedge t > s$
	FMA Merge	${}_t({}_s({}_p a \times {}_q b) + {}_r c) \rightarrow {}_t(\texttt{FMA}({}_p a, {}_q b, {}_r c))$	$s \geq p + q \wedge t > \max(s,r)$