INTRAPULSE FREQUENCY MODULATION AND THE AN-FPN/64 TRANSMITTER

Dr. Paul Johannessen
Andrei Grebnev
Erik Johannessen

Megapulse, Inc.

Presented at ILA 30 - St.Germain-en-Laye

IFM CHALLENGES

Narrow band Loran transmitting antenna:
625 ft. TLM: F = 1.7 kHz @ - 3 dB, or Q = 60

- if not re-tuned synchronously with modulated signal, losses are inevitable

Solutions:

- increase transmitter power to compensate for losses, or

- re-tune transmitting antenna

IFM CHALLENGES (cont'd)

Modulation schemes

Phase sweeping

- requires continuous change of signal's phase in a predetermined manner and,
- transmitting antenna has to be re-tuned synchronously to avoid loss in signal amplitude
- implementation is a real challenge

Frequency jumping

- instant increase/decrease of antenna inductance or capacitance will result in frequency jump and linear change of signal's phase
- any required phase can be achieved at desired time by selecting one of predetermined frequencies
- relatively easy to implement in AN/FPN 64

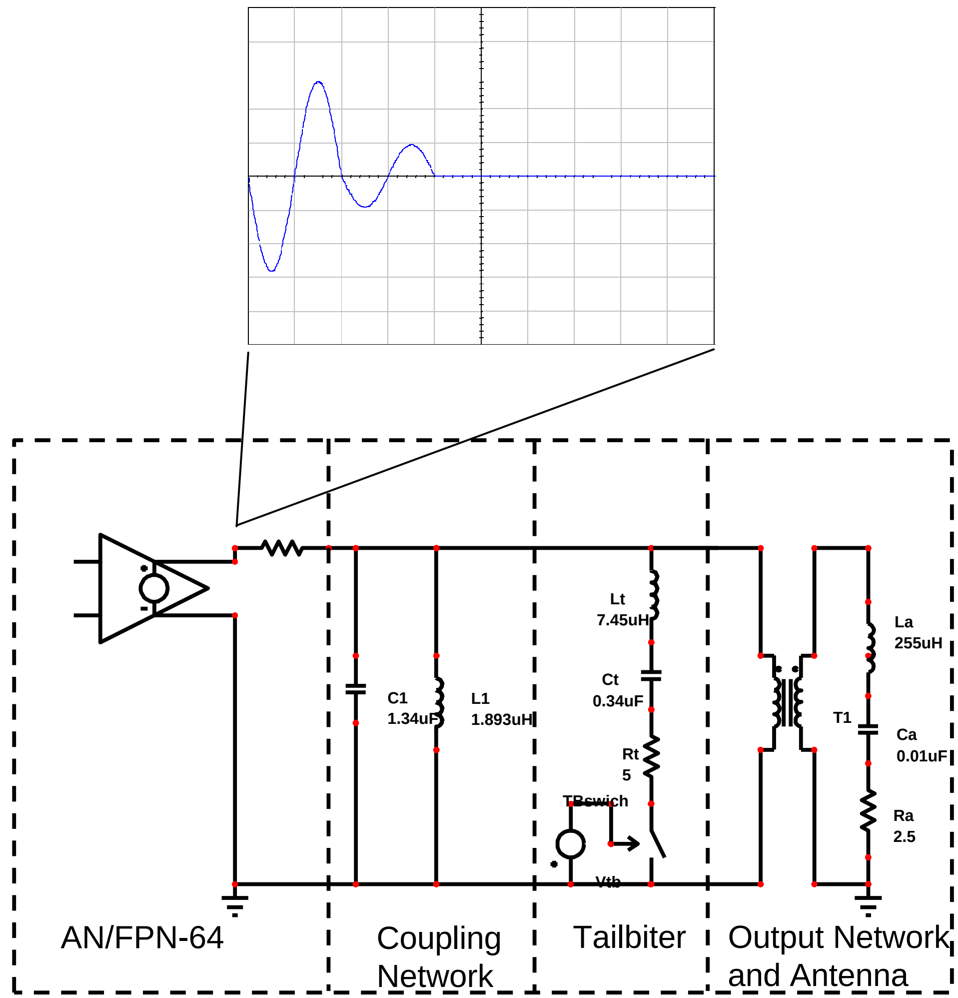
AN/FPN-64 OPERATION

- four Drive Half Cycles (DHC's) are delivered to Coupling Network and Antenna circuit during first 20 usec

- tuned Coupling/Antenna circuitry resonates at 100 kHz

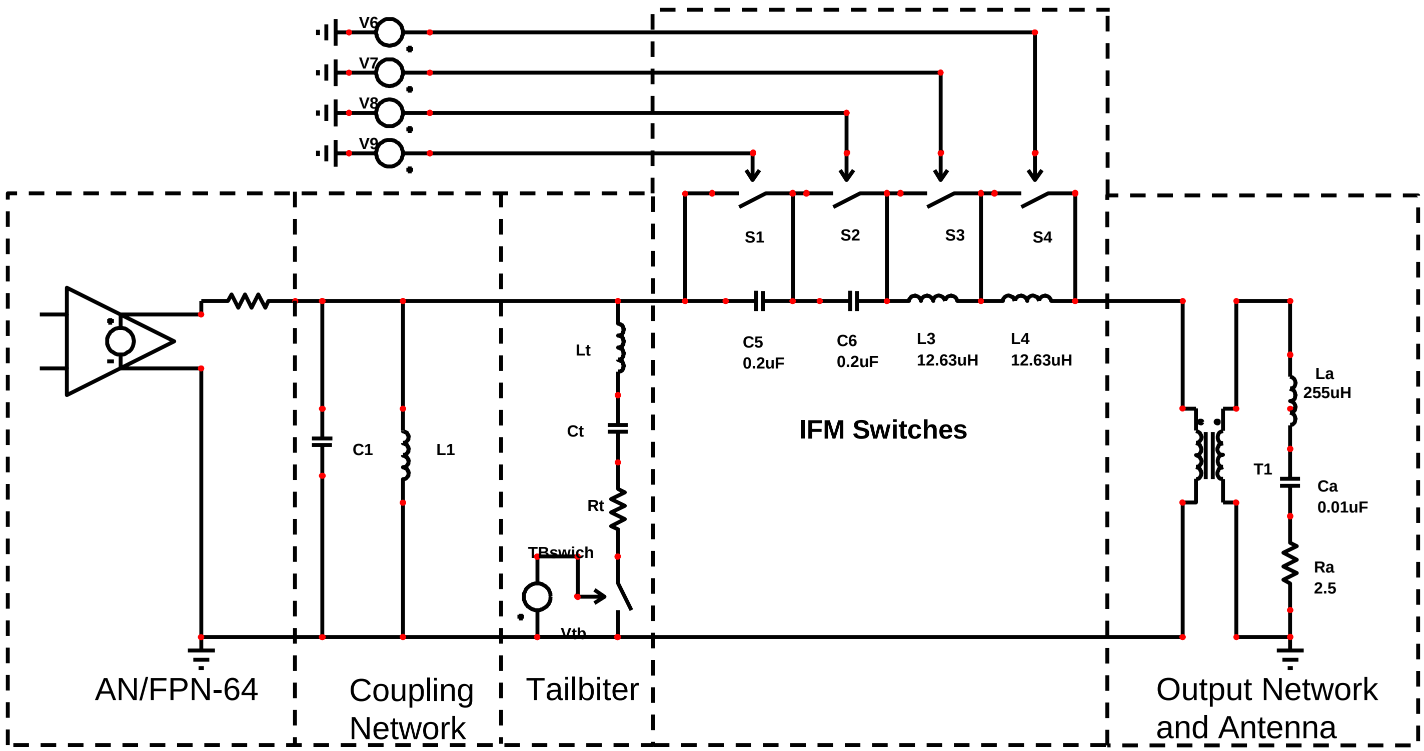
- changing the amount of energy in DHC's allows for precise generation of Loran-C signal

- addition of more DHC's will result in overall change of signal shape



SINGLE LEVEL IFM IMPLEMENTATION

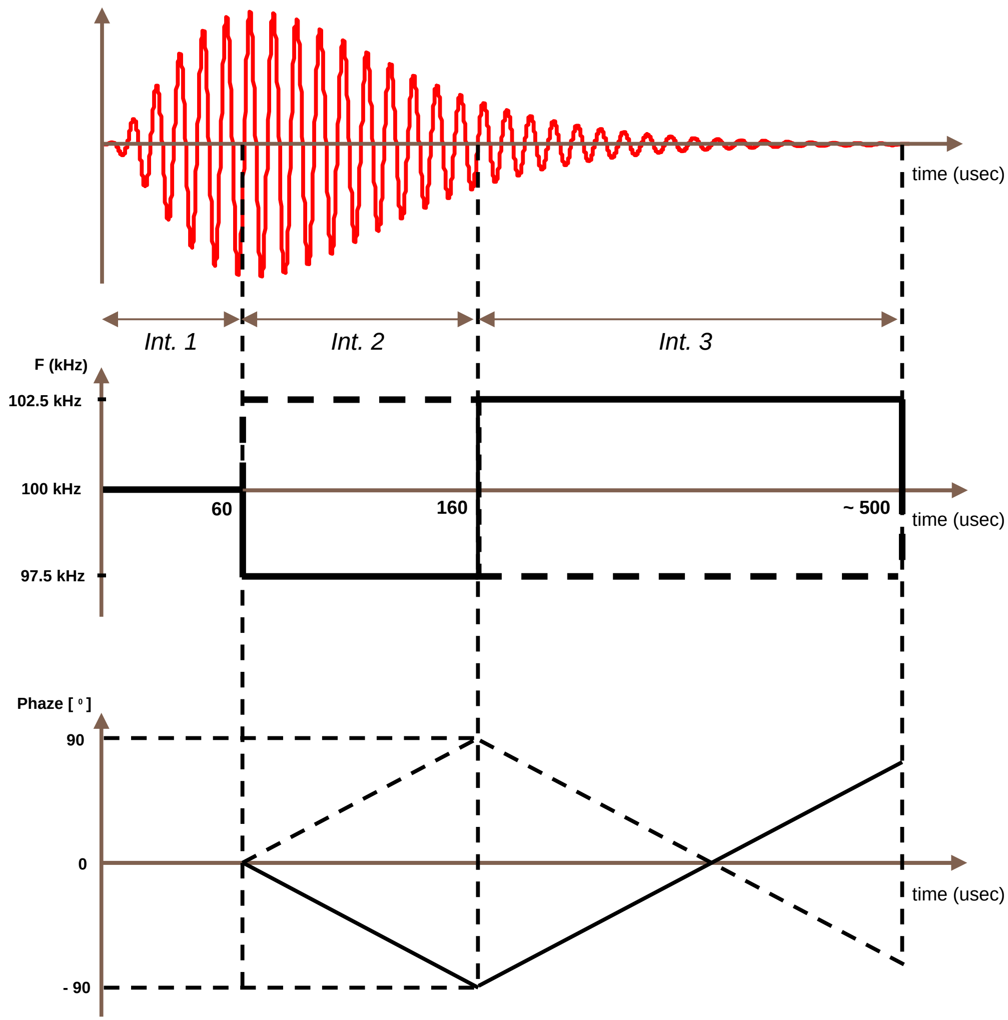
Simplified IFM schematic



- Two capacitors and two inductors are added in series with antenna: closing the capacitor switch (S1 or S2) results in lower frequency; closing the inductor switch (S3 or S4) results in higher frequency

SINGLE LEVEL IFM IMPLEMENTATION

Frequency and Phase Shift



102.5 to 97.5 kHz

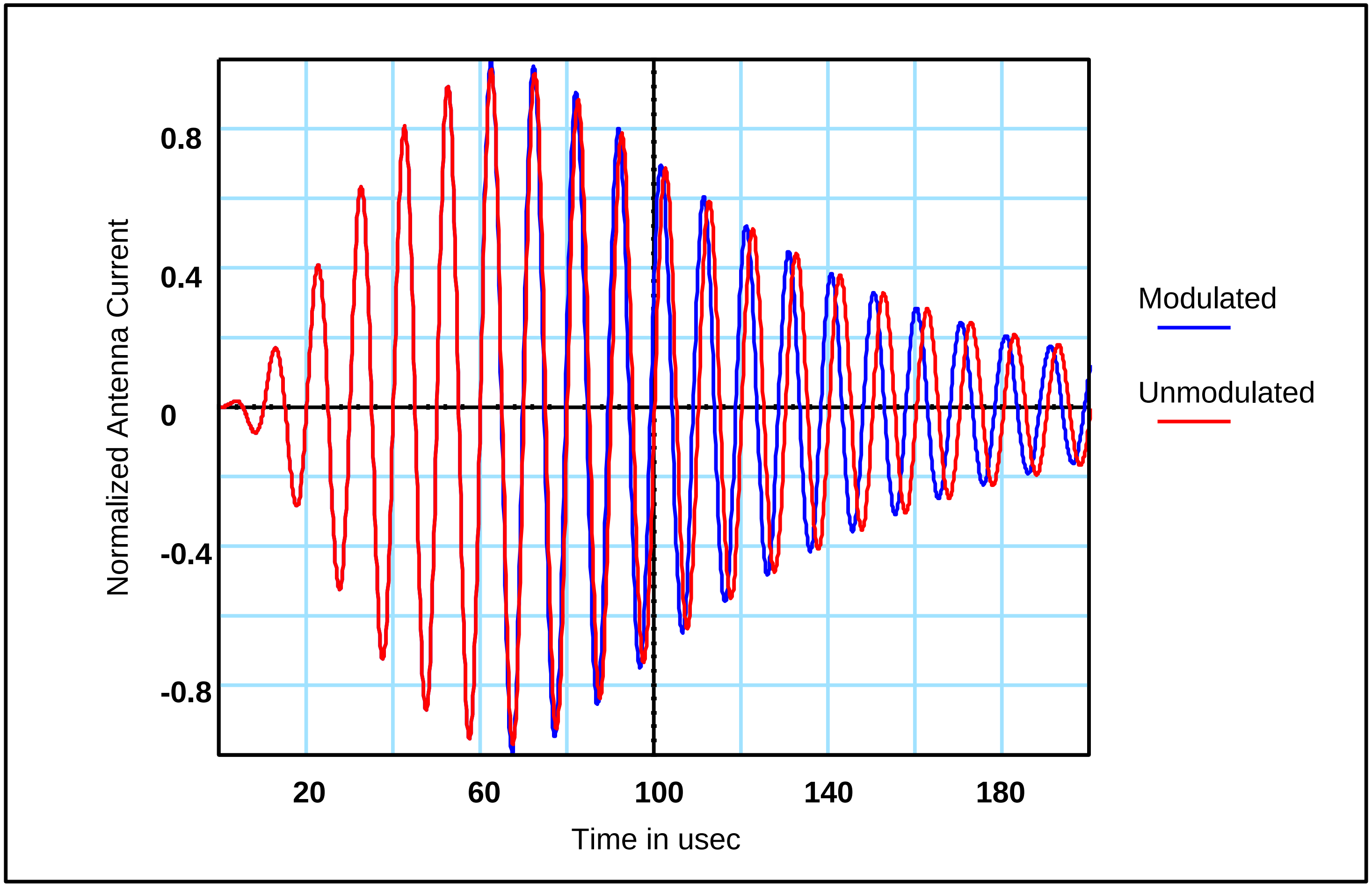
Int. 1 - S1-S4 opened;
Int. 2 - S3 closed;
Int. 3 - S1and S2 closed;
at the end of Int. 3 all switches opened

97.5 to 102.5 kHz

Int. 1 - S1-S4 opened;
Int. 2 - S1 closed;
Int. 3 - S3 and S4 closed;
at the end of Int. 3 all switches opened

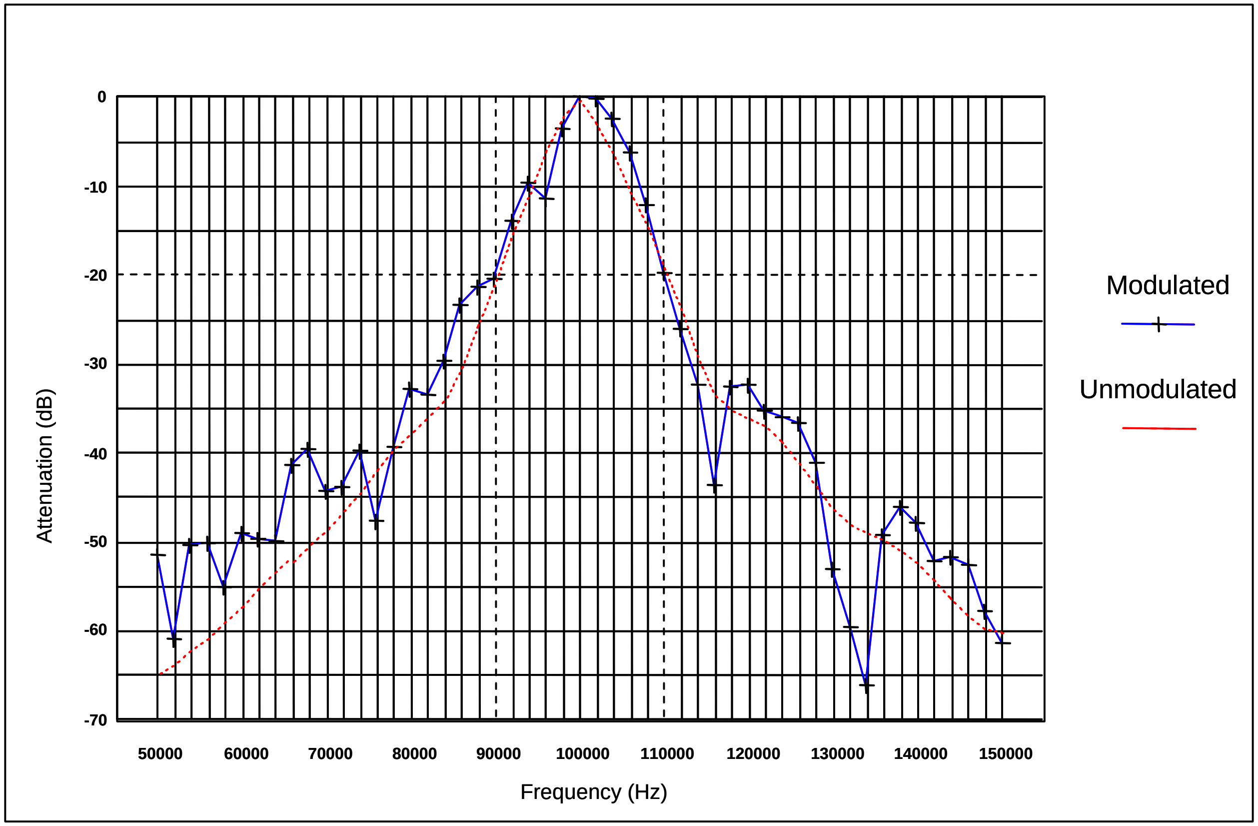
SINGLE LEVEL IFM IMPLEMENTATION

Modulated vs unmodulated signals



SINGLE LEVEL IFM IMPLEMENTATION

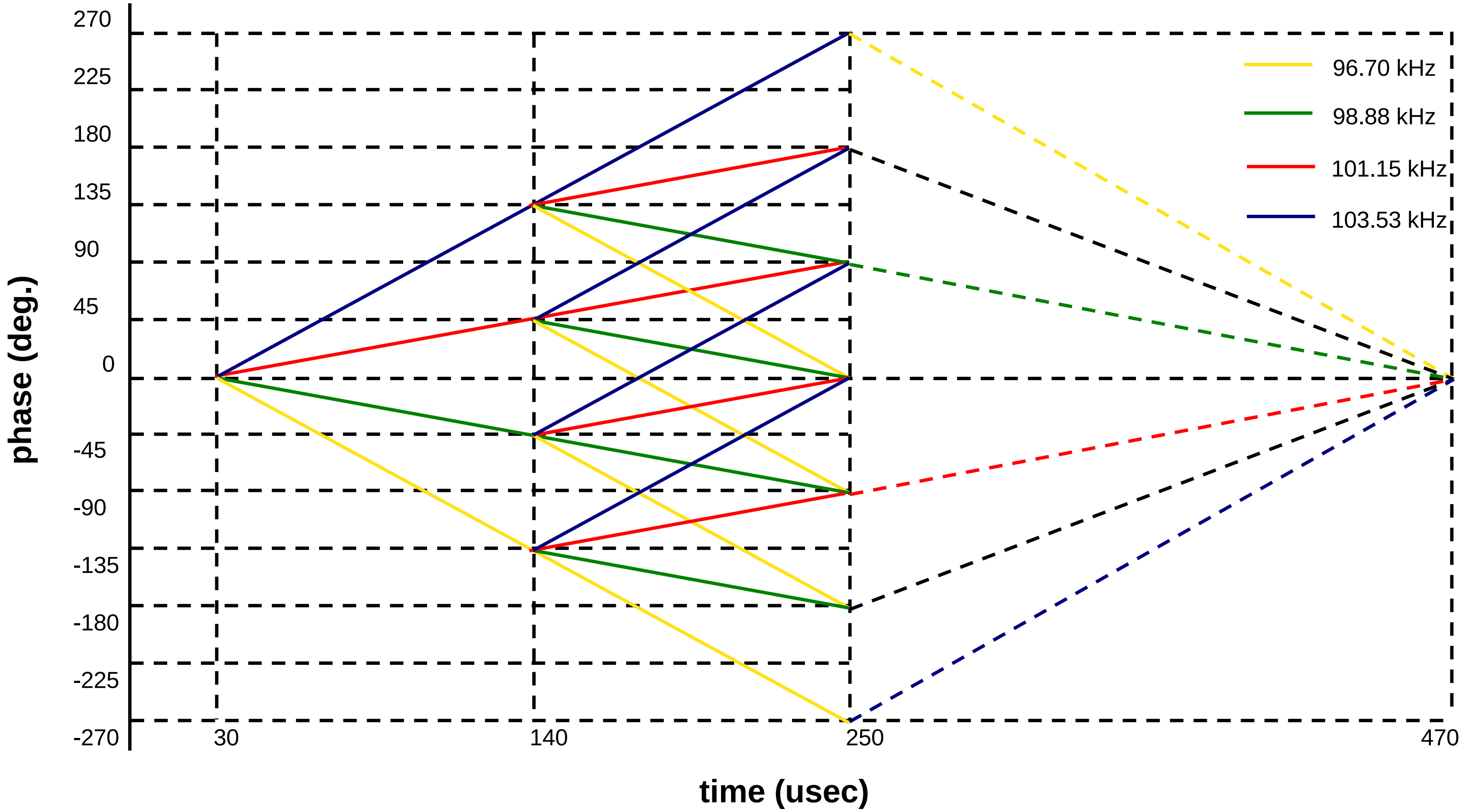
Modulated vs unmodulated signal spectrum



(102..5 kHz from 60 to 160 usec; 97.5 kHz from 160 to 500 usec)

MULTI LEVEL IFM

Proposed Modulation Scheme



MULTI LEVEL IFM

Advantages of the Proposed Scheme

The beginning of all modulation patterns from 0 phase eliminates "time shifted" pulses which in turn minimizes the effect on legacy receivers

Longer 1st modulation window - 110 usec vs 80 usec - allows for longer "averaged" pulse, which will make search and acquisition by legacy receivers more reliable

All required phase magnitudes are achieved by using only four frequencies (by making modulation windows lengths equal)

Easier to implement in Solid State Transmitter because all switches are identical

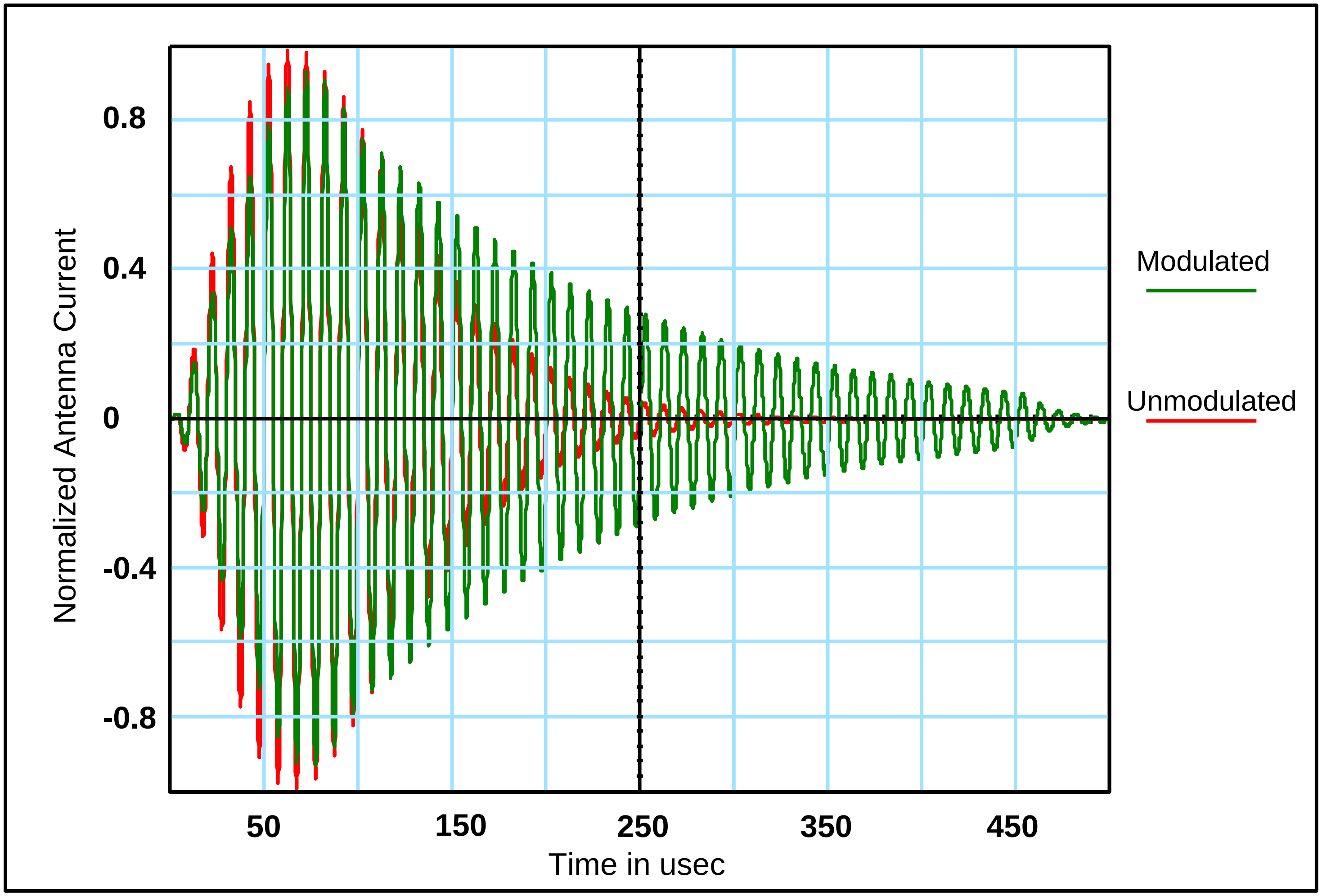
MULTI LEVEL IFM

Possible Signal Shape Enhancements

More energy in the tail of the pulse without adding more HCG's (16 HCG transmitter)

DHC's re-distributed:

from: 6-6-2-2
to: 5-5-1-1-2-2

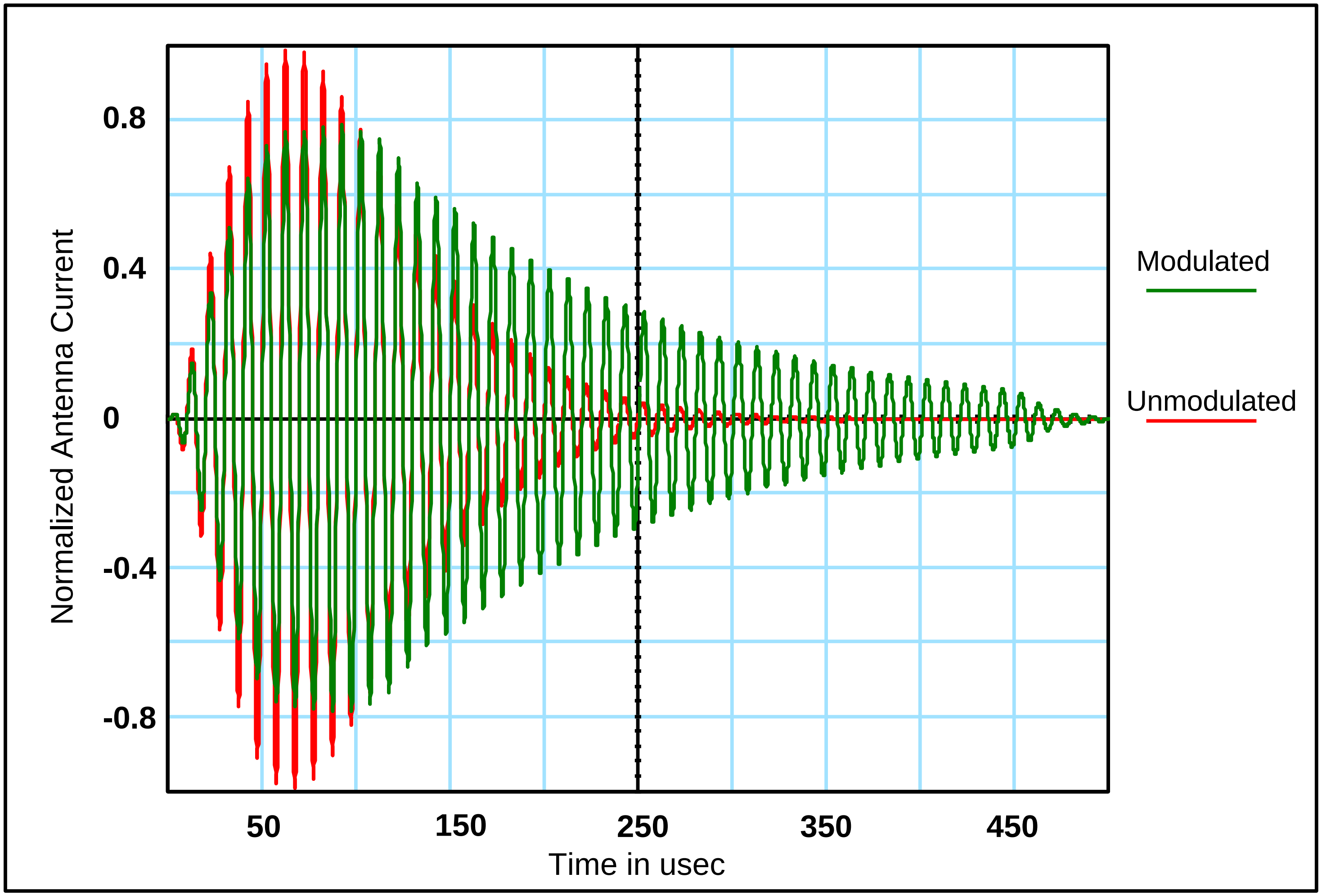


MULTI LEVEL IFM

Possible Signal Shape Enhancements

More energy in the tail of the pulse with addition of 8 HCG's (16 HCG transmitter).

Additional DHC's are applied at 65, 70, 80 and 85 usec to produce a flat "top" of the pulse

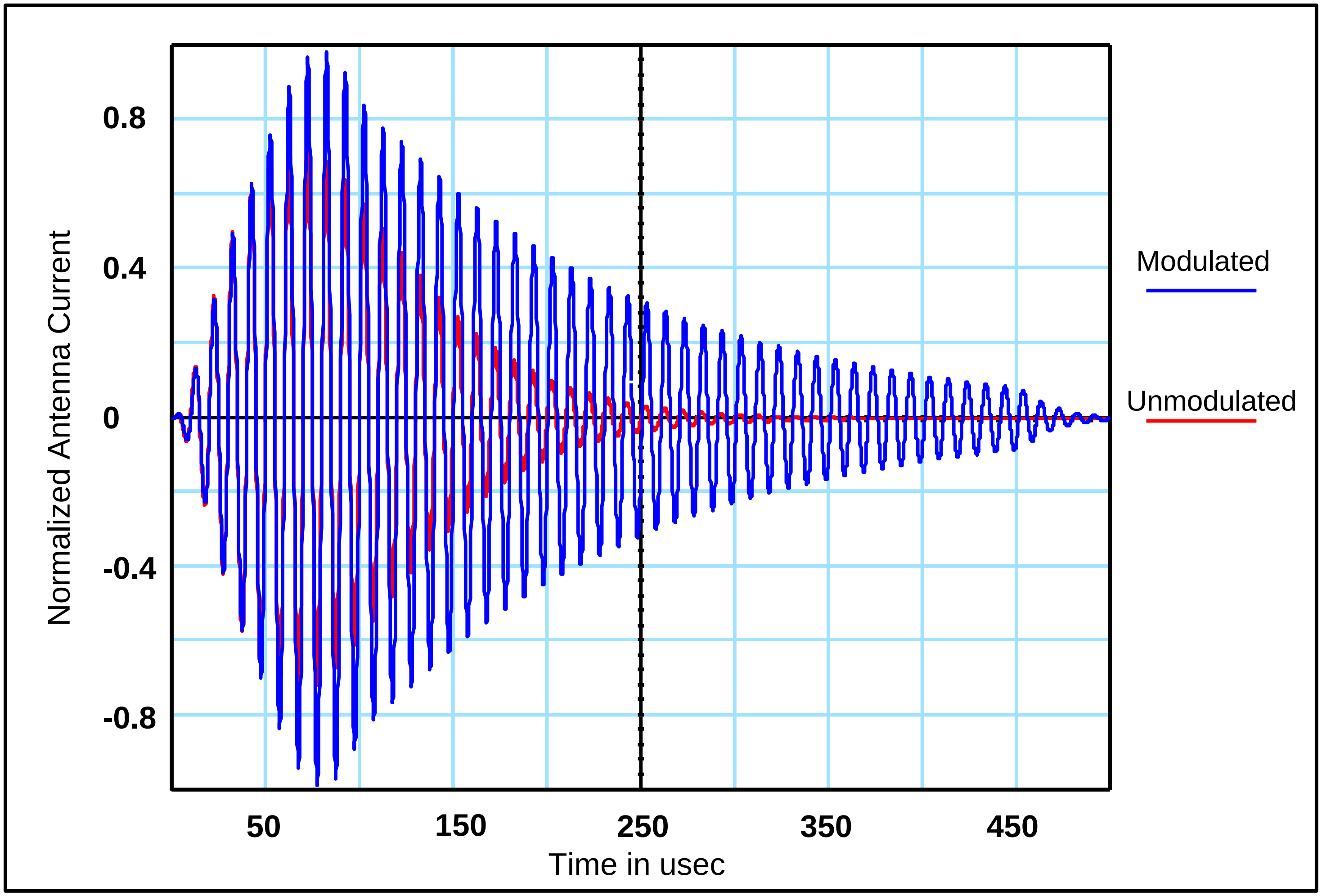


MULTI LEVEL IFM

Possible Signal Shape Enhancements

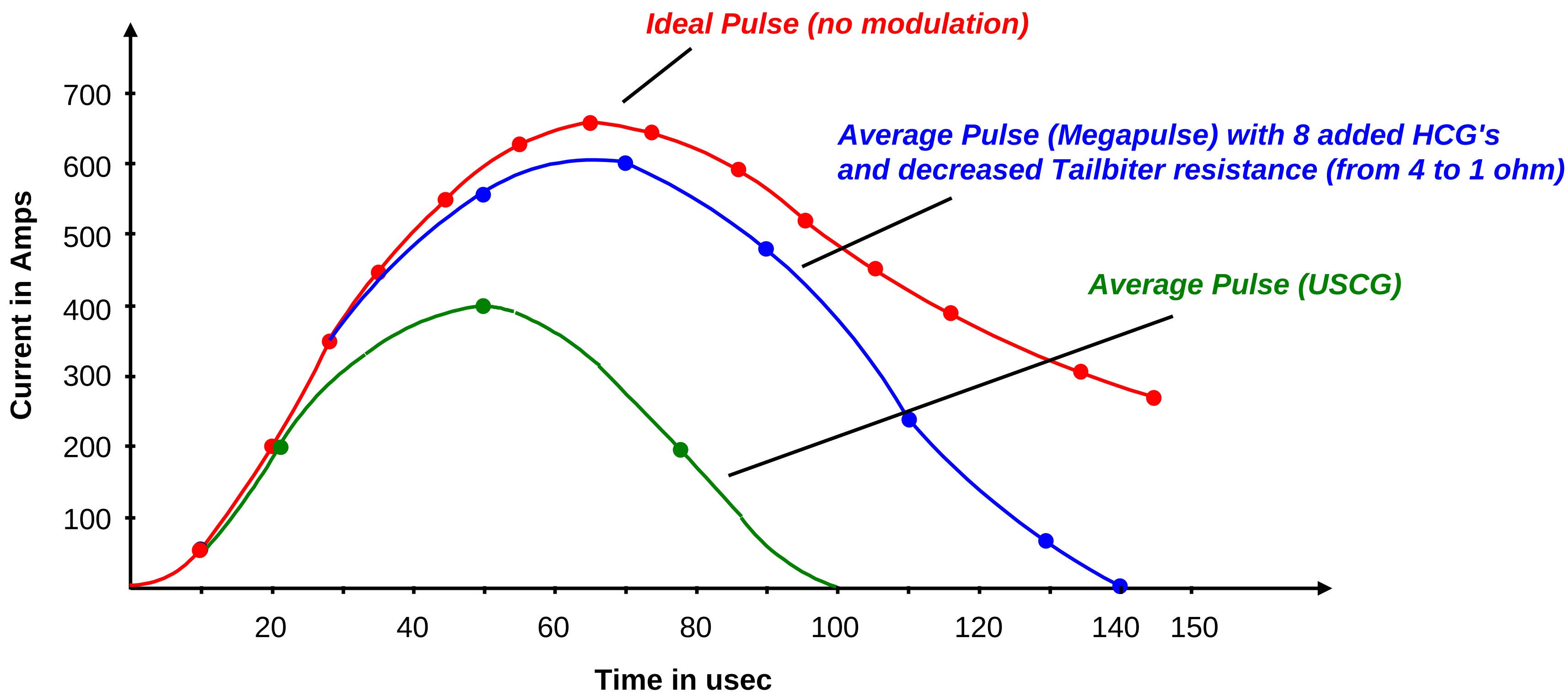
More energy in the tail of the pulse with addition of 8 HCG's (16 HCG transmitter).

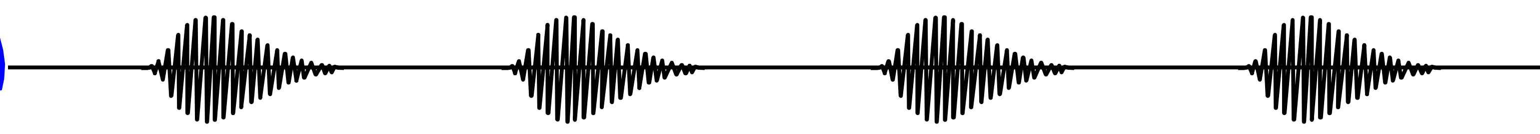
Additional DHC's are applied at 40, 45, 50 and 55 usec, resulting in more energy not only in the tail but max. radiated power



MULTI LEVEL IFM

Averaged Signal Envelope Shapes





DESIGN OF IFM SWITCH

IFM Switch Simplified Schematic

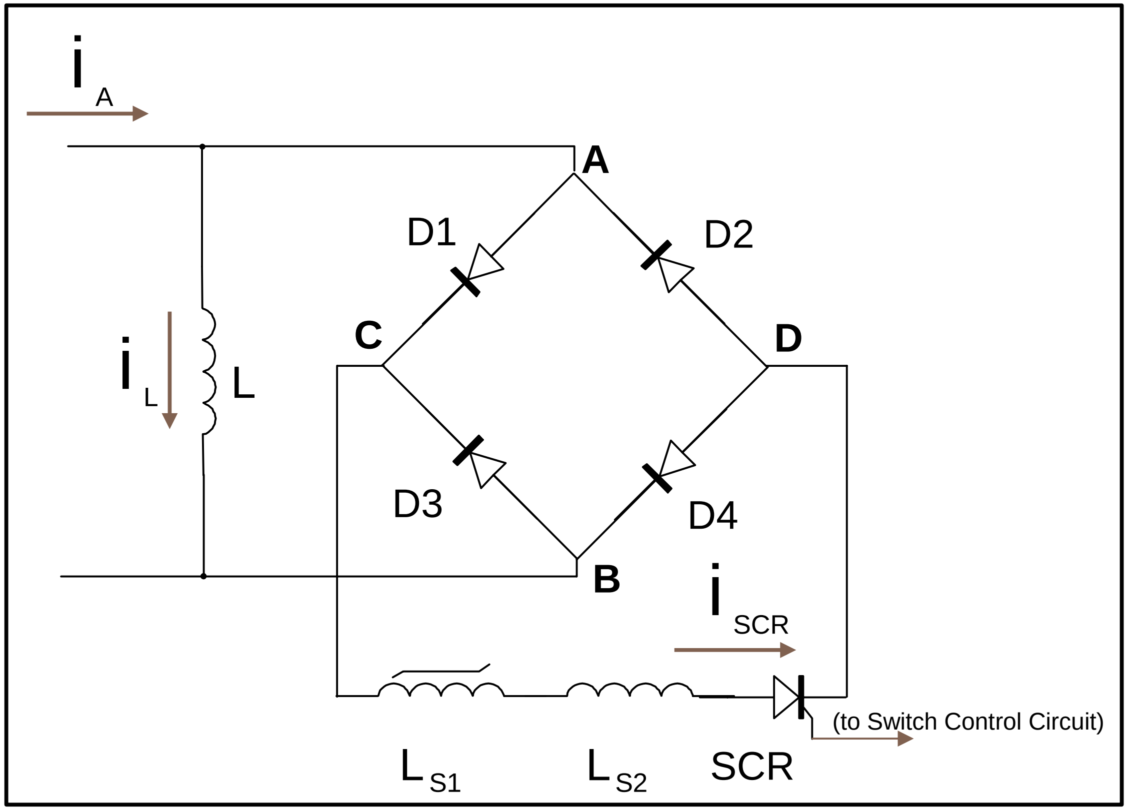
General Principle of Operation

SCR Gate signal is applied

At the peak of antenna current, fully rectified voltage V_{CD} is applied to inductors L_{S1} and L_{S2}, causing the current i_{SCR} to increase rapidly (5 usec) to its peak value

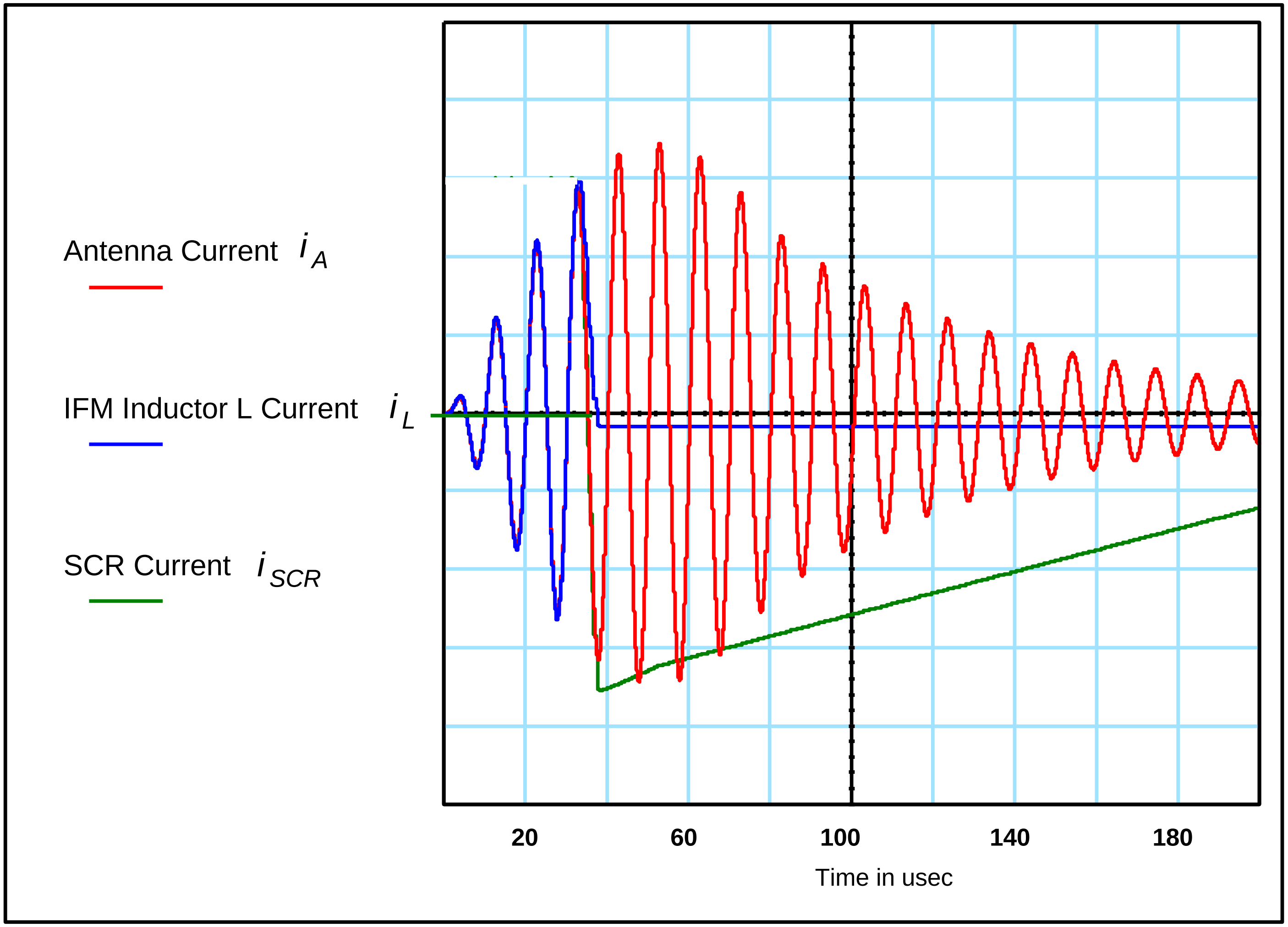
This peak value is greater than peak antenna current, thus causing the diode bridge to be a short circuit for the antenna current I_A

SCR current decreases to 0 at appr. 500 usec, thus turning the SCR off



DESIGN OF IFM SWITCH

IFM Switch Simulated Waveforms

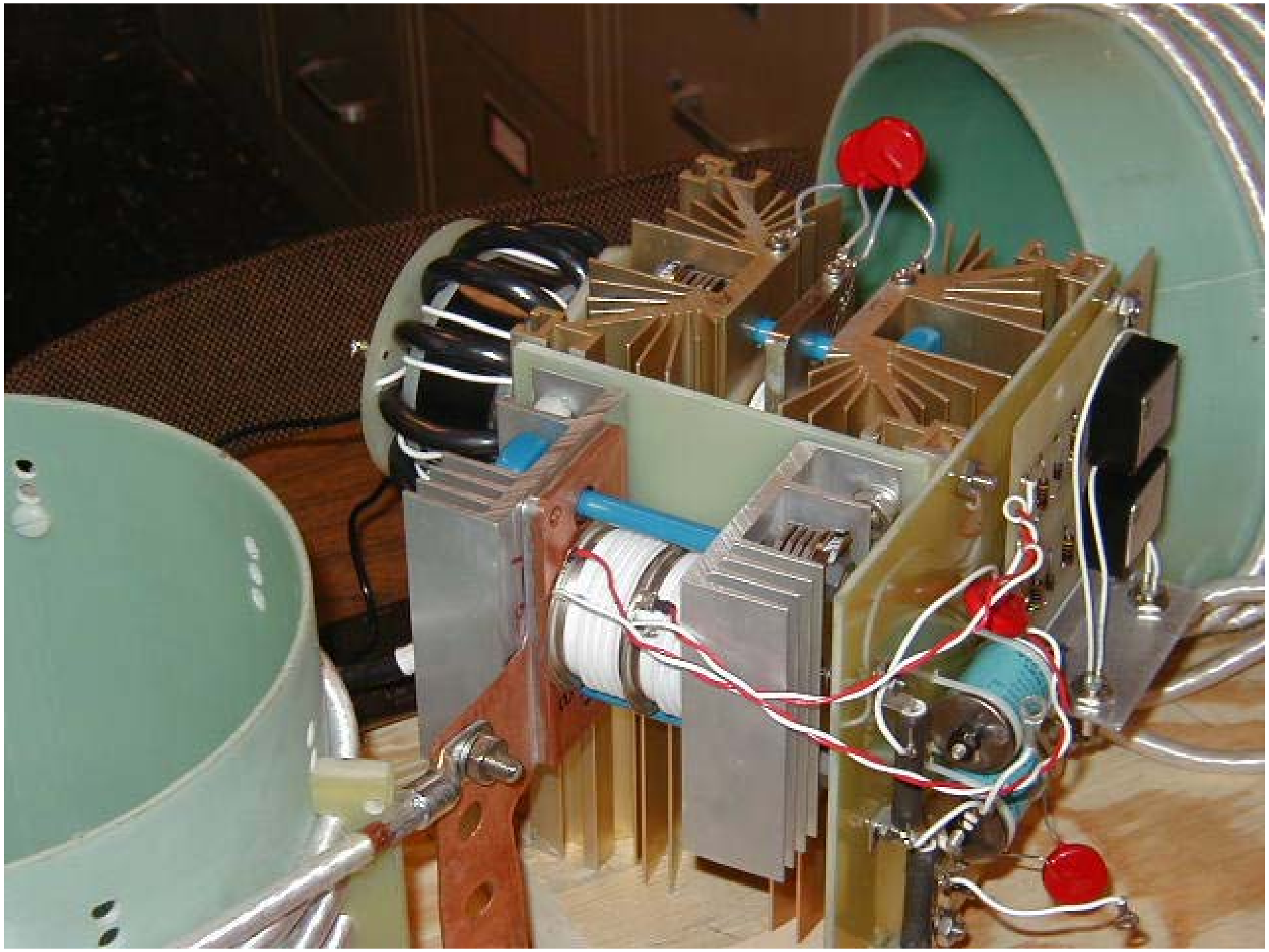


DESIGN OF IFM SWITCH

IFM Switch Tests

DESIGN OF IFM SWITCH

IFM Switch Tests



DESIGN OF IFM SWITCH

Status of Work

Single HCG Test Transmitter, Coupling Network and Antenna Equivalent (including IFM additional inductance) were built and fully tested

IFM Switch Engineering Model was connected and a first set of tests were performed

IFM Switch performed <u>precisely</u> as predicted by Spice simulations

Additional work is under way - DC power supply is being integrated with the Switch to enhance the performance

CONCLUSION

Megapulse modulation scheme can provide required phase shifts.

Antenna retuning circuitry allowing for minimal future changes in AN/FPN-64 transmitter was evaluated and tests are under way.

Additional work is required to evaluate spectrum effects/constraints.