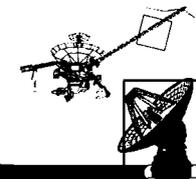


TELECOMMUNICATIONS AND MISSION OPERATIONS

OFFSET QPSK CARRIER SYNCHRONIZATION



**CARRIER SYNCHRONIZATION OF OFFSET QPSK
FOR DEEP SPACE TELEMETRY**

PETER W. KINMAN

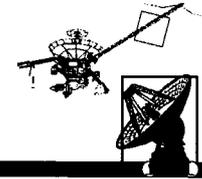
CASE WESTERN RESERVE UNIVERSITY

JEFF B. BERNER

JET PROPULSION LABORATORY

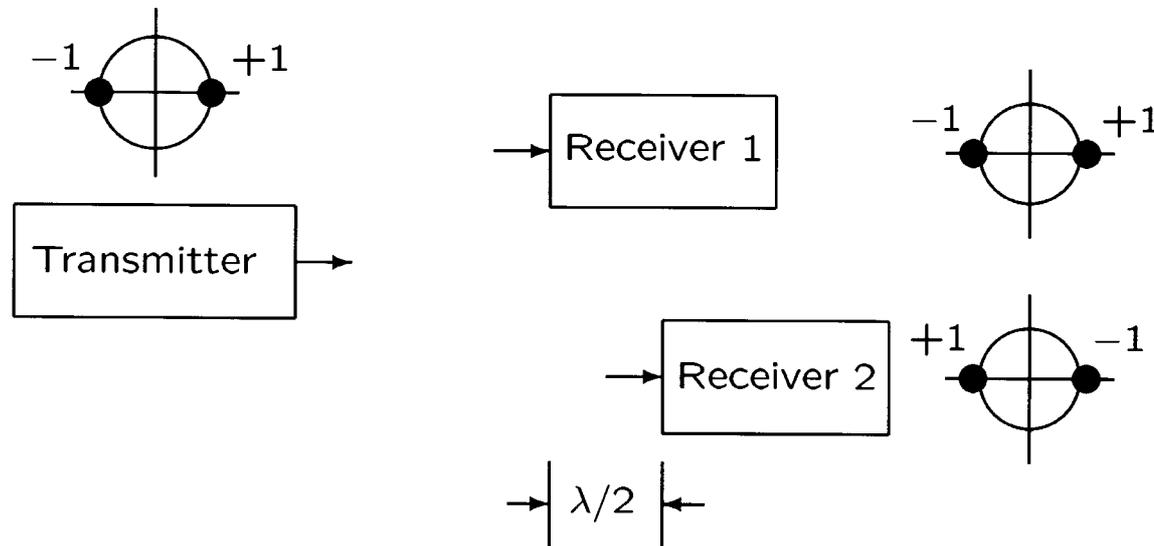
CALIFORNIA INSTITUTE OF TECHNOLOGY

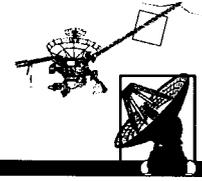
MARCH 11, 2002



OFFSET QPSK CARRIER SYNCHRONIZATION

BPSK: TWO-FOLD PHASE AMBIGUITY

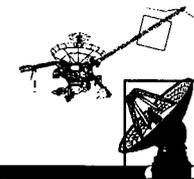




OFFSET QPSK CARRIER SYNCHRONIZATION

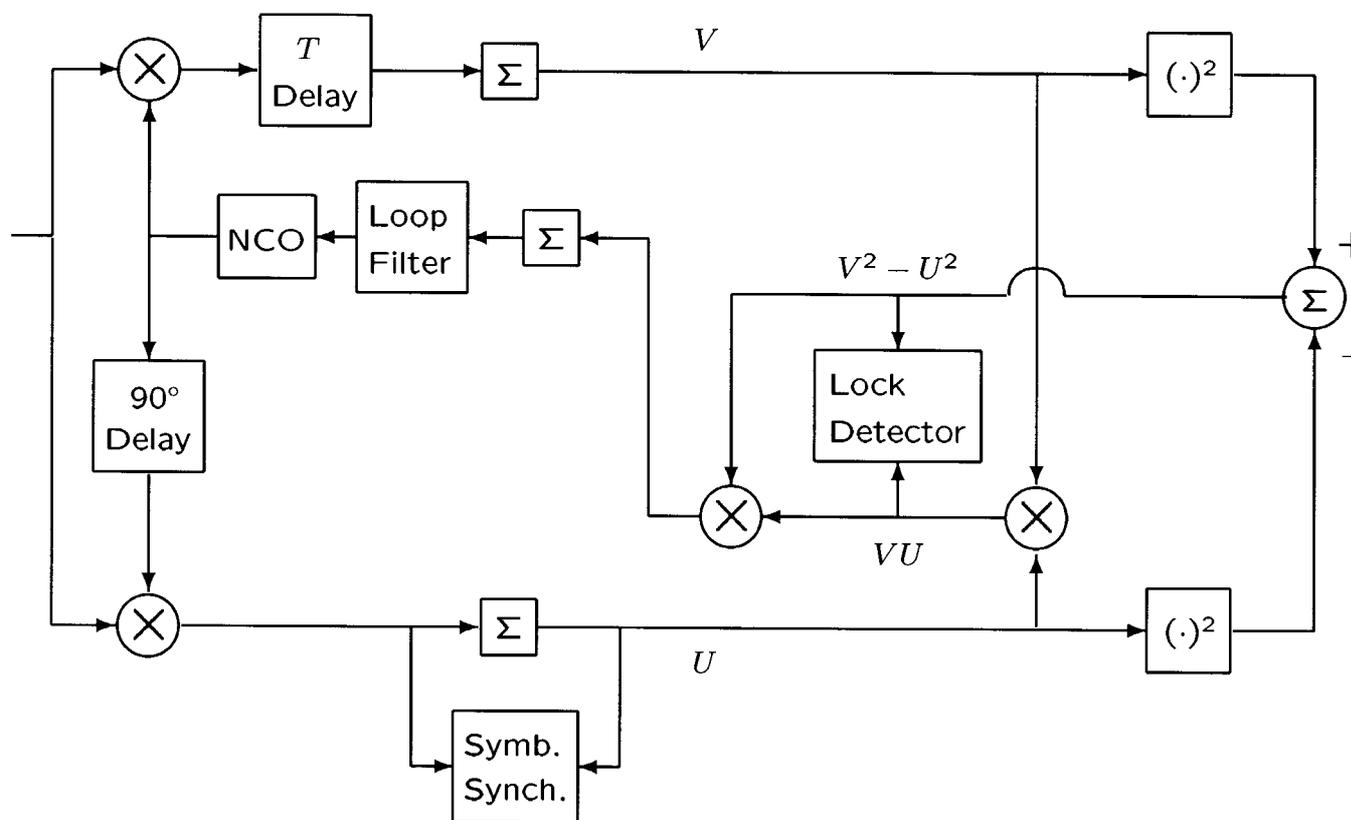
RESOLUTION OF TWO-FOLD PHASE AMBIGUITY

1. PILOT TONE
2. BINARY DIFFERENTIAL ENCODING
3. UNIQUE WORD DETECTION



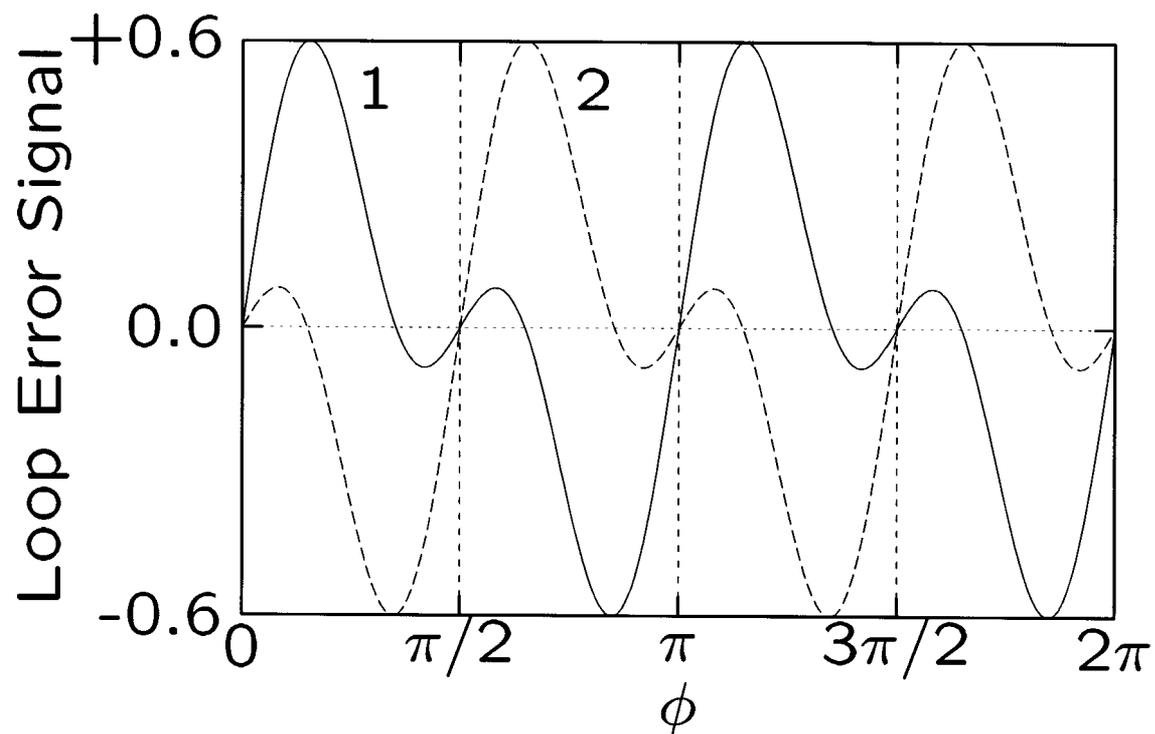
OFFSET QPSK CARRIER SYNCHRONIZATION

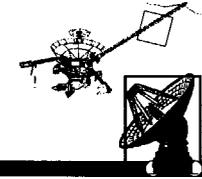
OFFSET QPSK CARRIER LOOP FOR THE BLOCK-V RECEIVER



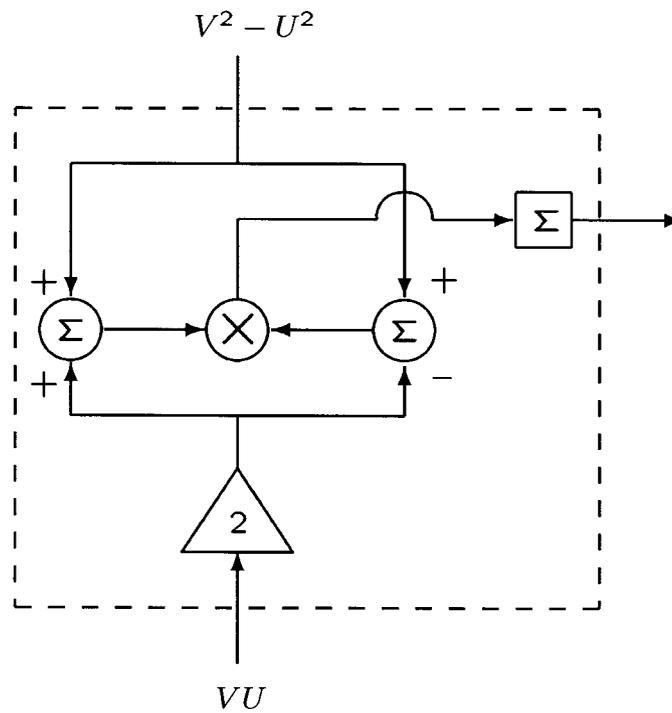
**OFFSET QPSK CARRIER SYNCHRONIZATION**

LOOP ERROR SIGNAL

CURVE 1: $\phi = 0$ AND $\phi = \pi$ CURVE 2: $\phi = \pi/2$ AND $\phi = 3\pi/2$ 

**OFFSET QPSK CARRIER SYNCHRONIZATION****JPL**

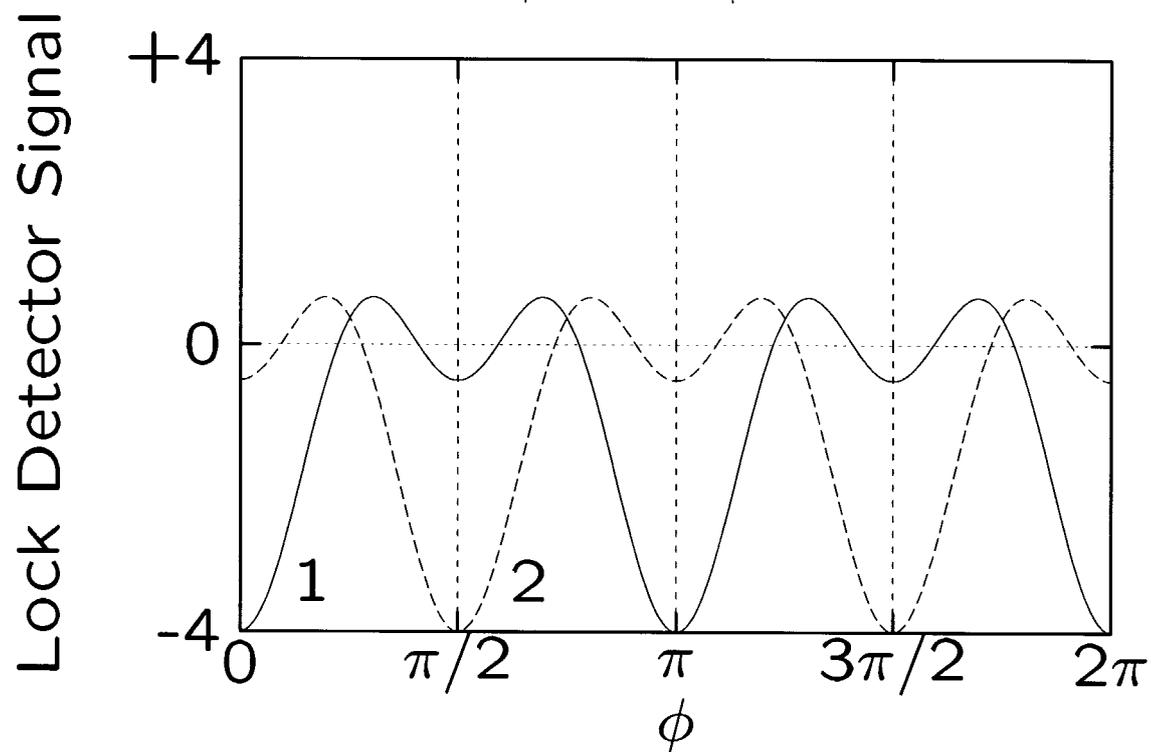
LOCK DETECTOR





OFFSET QPSK CARRIER SYNCHRONIZATION

LOCK DETECTOR SIGNAL

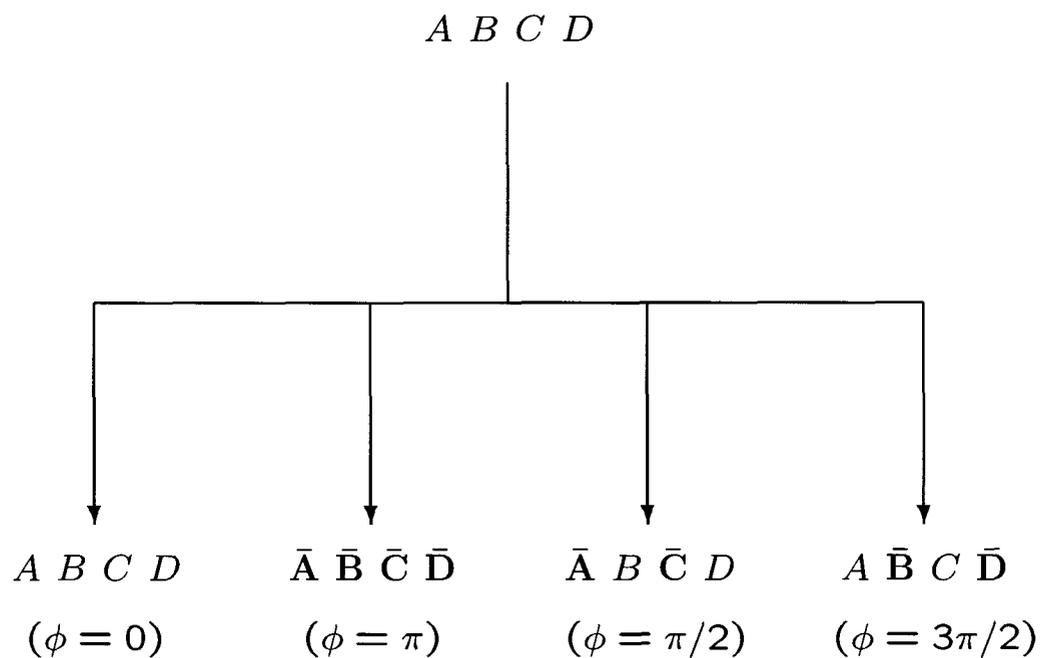
CURVE 1: $\phi = 0$ AND $\phi = \pi$ CURVE 2: $\phi = \pi/2$ AND $\phi = 3\pi/2$ 

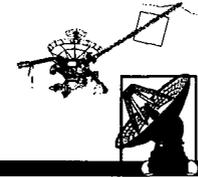


OFFSET QPSK CARRIER SYNCHRONIZATION

OFFSET QPSK WITH BLOCK-V RECEIVER

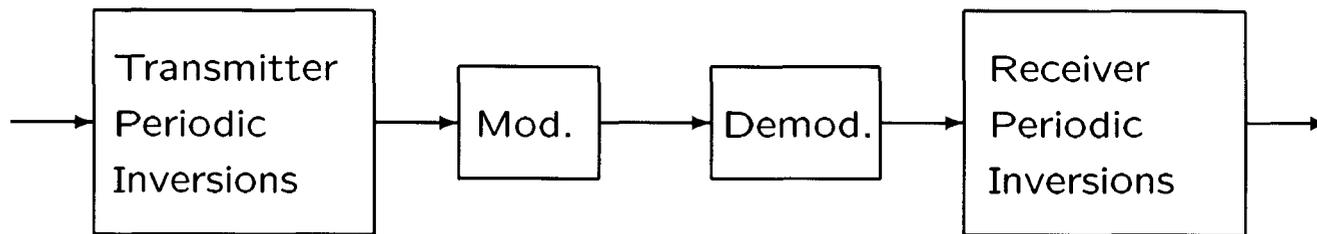
FOUR-FOLD PHASE AMBIGUITY

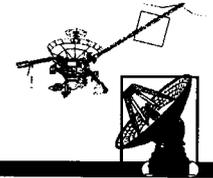




OFFSET QPSK CARRIER SYNCHRONIZATION

REDUCTION OF PHASE AMBIGUITY TO TWO-FOLD

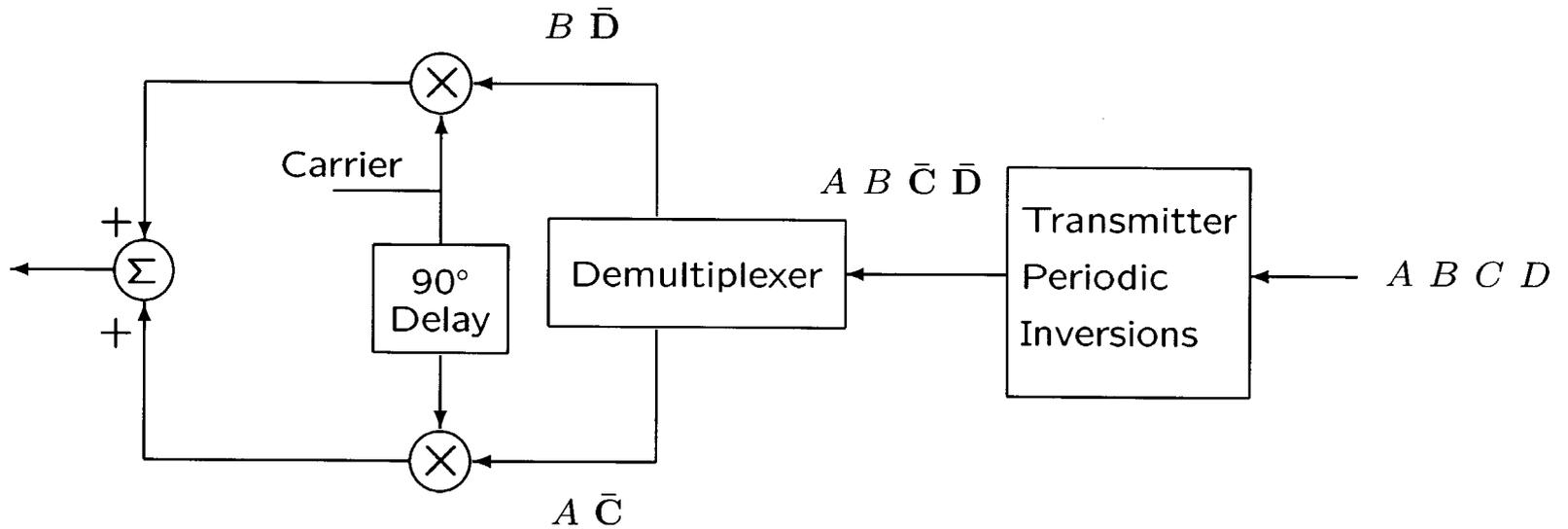


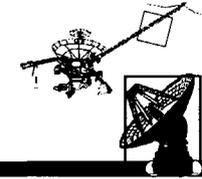


OFFSET QPSK CARRIER SYNCHRONIZATION



TRANSMITTER PERIODIC INVERSIONS





OFFSET QPSK CARRIER SYNCHRONIZATION

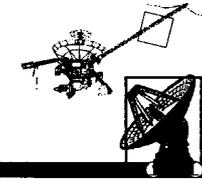
RECEIVER PERIODIC INVERSIONS

IF $U(n-1)$ PASSED WITHOUT CHANGE,

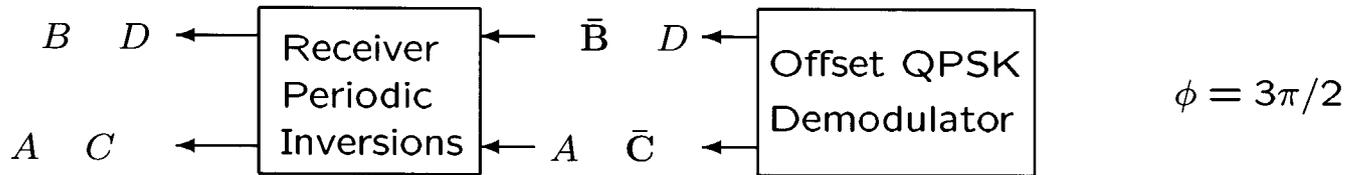
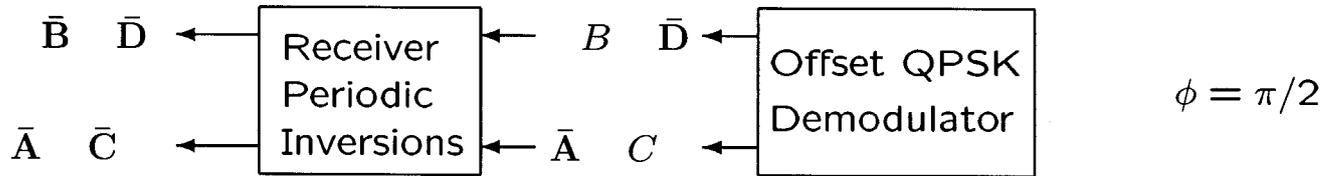
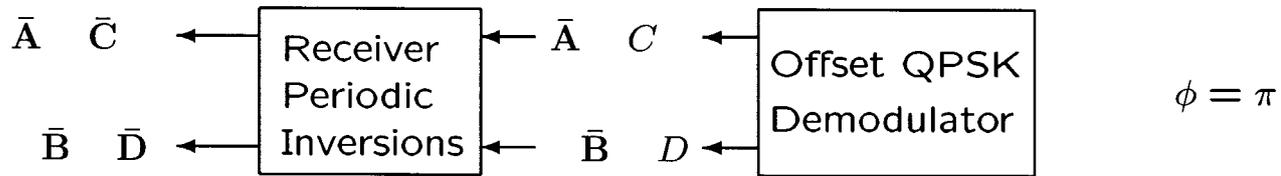
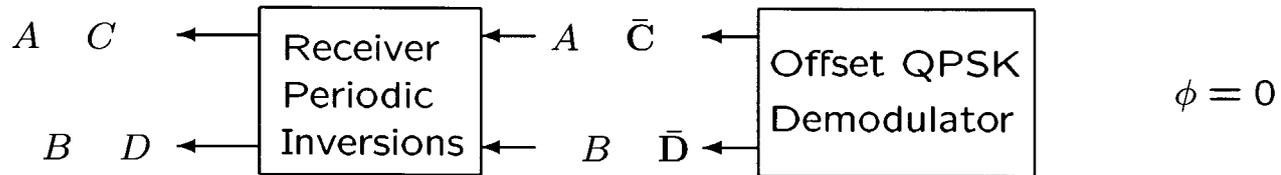
$V(n)$ AND $U(n)$ NEGATED

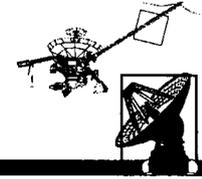
ELSE,

$V(n)$ AND $U(n)$ PASSED WITHOUT CHANGE



OFFSET QPSK CARRIER SYNCHRONIZATION





OFFSET QPSK CARRIER SYNCHRONIZATION

CONCLUSIONS:

1. QPSK LOOP WITH ADDED DELAY DETECTS OFFSET QPSK SIGNAL WITH FOUR-FOLD PHASE AMBIGUITY.
2. SIMPLE SIGNAL PROCESSING BEFORE MODULATOR AND AFTER DEMODULATOR REDUCES PHASE AMBIGUITY TO TWO FOLD.